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# Global Investment Failures and Transformations: A Review of Hyped *Jatropha* Spaces

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**Abstract:** There was a heightened global interest in large-scale *Jatropha* cultivation for the past few decades, and this incited investment toward the crop in many developing countries. Many saw *Jatropha* as a green fuel that could possibly be an alternative to fossil fuel, which has adverse implications to deal with the impacts of climate change. However, *Jatropha* investments failed to meet global expectations, leading to unexpected social, environmental, and economic transformations in the investment spaces. This paper reviews and synthesizes the transformations and complexities in failed *Jatropha* spaces in six previous major *Jatropha* investment destinations across the world—Mexico, India, China, Ethiopia, Mozambique, and Ghana—by employing qualitative data analysis. The findings generally show that, in all of the countries studied, promoters of *Jatropha* investments, including the central government and private investors, subscribed to a "wait-and-see" approach with positive expectations. The review revealed that the intended goal of establishing global *Jatropha* investments to serve as an alternative source of fuel failed because of the unexpected complexities of the hype, which dwelled much on the deferment option of the "wait-and-see" approach for global *Jatropha* investments. Failure of the investments along with unmet expectations led to land-use changes from *Jatropha* to the cultivation of other crops (often food crops) or total land abandonment. Although we are not totally pessimistic about the economic and production viability of *Jatropha* as a biofuel feedstock, we emphasize the importance of paying considerable attention to other feedstocks that might have a better future as alternatives to fossil-based energy for the deployment of sustainable bioenergy. Furthermore, our findings provide meaningful justification for policy- and decision-makers in the development space to tacitly reflect and appraise new investment initiatives or interventions before endorsement.

**Keywords:** biofuel; *Jatropha*; investment; transformation; government; corporate; hype; bust

## 1. Introduction

Over the past decade, investment options toward large-scale *Jatropha* investments gained prominence around the globe. This was driven by the outrageous prices of oil in the international market, a desire to ensure energy security, and the quest to reduce the emissions of harmful gases leading to climate change [1]. According to Openshaw [2], *Jatropha* was favored by investors because

the crop has many attributes, multiple uses, and great potential for meeting the global anticipation. For instance, the by-products of *Jatropha* can be transformed into a fuel source [3] and used for preparing soaps and candle wax [4]. The crop could also be used to impede soil erosion caused by rainwater and fencing, as well as to reclaim degraded lands [2,5]. Under this expectation, governments, multilateral organizations, and investors all entered into *Jatropha* investments [6].

According to Jingura et al. [7] and Tsegaye and Glantz [8], with growing global demand for climate-friendly transport fuels, countries and continents notably underwent large-scale land acquisition and investment for biofuels including African countries (Ghana, Ethiopia, Mozambique, etc.), Asia (China, India, etc.), and South America (Mexico, Brazil, etc.). Hence, governments in Africa, Asia, and South America partnered with countries, notably, Brazil and India, which are known to have considerable experience in biofuel development, to transfer technology into their biofuel sectors to invest in cultivating biofuel crops such as *Jatropha*, sugarcane, teak, and oil palm [8]. The interest of governments was further heightened by the acclaimed indications that *Jatropha* could improve local livelihoods, alleviate poverty, and kindle local development [9]. *Jatropha* investment took the center stage of agricultural investments in many countries south of the globe due to its immense contribution to socioeconomic development [10,11].

Historically, the origin/home of *Jatropha* is Mexico, and its knowledge and use were initiated by the Olmeca people of Mexico 5000 years ago [12], who planted *Jatropha* for medicinal purposes [13]. *Jatropha* then moved to Brazil and some portions of Central America. According to Henning [14], the Portuguese seafarers distributed *Jatropha* through the Cape Verde Islands to Africa and Asia. Openshaw [2] indicates that the potential of *Jatropha* as an oil-producing crop was long acknowledged in the form of demonstration farms in countries such as Nepal, Zimbabwe, Mali, and Brazil for the utilization of the oil. One of the first wide-scale productions of *Jatropha* was the Austrian–Nicaraguan project instituted in 1990. This project failed as investors saw it to be unprofitable [15]. Interest in energy security and climate change concerns re-ignited interest in *Jatropha* in the early 2000s. International funding bodies started to robustly support investors to invest in *Jatropha* [6,16] with the anticipation of ensuring sustainable energy security whilst having a positive impact on climate change mitigation [17]. *Jatropha* is argued to be a "marvelous crop" with huge potential for economic growth [2] and environmental management attributes [2,3] since it strives well even on less productive lands due to its lower requirements for water and non-competition for nutrients with other crops [18].

During the 2010s, there were burgeoning studies on the effects of large-scale *Jatropha* investments on environment and socioeconomic development [10,11,19,20]. The findings from these studies are mixed. On one hand, Bosch and Zeller [10] and the Food and Agriculture Organization (FAO) [11] showed that such investments enhanced employment opportunities, improved biodiversity, and increased revenue in the host communities. On the other hand, Schoneveld et al. [21] and Hughes et al. [20] provided evidence to suggest that the investments led to impoverishment, since the households' access to non-timber forest products, which are often considered as common-pool resources, is curtailed by such investments. The international Non-Governmental Organization (NGO), Action Aid [22], also disclosed that *Jatropha* investments created unintended consequences on total food production and the aggravation of poverty in investment-centered communities. These revelations, together with the quest to deal with energy poverty and climate change, motivated governments to support and allow large-scale *Jatropha* investments without sound preparation and arrangements. Preparations and arrangements in terms of studies on available and suitable lands, the legal incorporation of social and economic benefits, and conceptualized scientific studies were virtually absent [22]. Many of the countries did not have legal mechanisms to protect the interest, rights, welfare, and livelihoods of the rural population [23]. Even during the *Jatropha* investments, Skutsch et al. [24] and Birega [25] confirmed their doubt in *Jatropha* in terms of its potential to bolster Africa's rural development. The *Jatropha* hype without commensurate arrangements for its investments led to poor development outcomes including negative environmental implications, land alienation, rural livelihood loss, food insecurity, conflict, and high investment losses.

According to Timko et al. [26] and Hamenoo [27], outcomes of initial *Jatropha* investment were negative on local land tenure systems, food production, and livelihoods. The annual output of farmers declined due to their use of parcels of land that were smaller than the ones they had access to before the large-scale *Jatropha* plantations were established [28]. However, little was discussed about the relationship between the initial drivers of *Jatropha* investments, which were intended to do good, and the environmental and socioeconomic development outcomes of the investments and transformation patterns after the *Jatropha* investment failures, and how and why the *Jatropha* investments failed to generate the expected positive environmental and socioeconomic development outcomes, as well as what prospects the land had for future investments. This article presents a critical review of the published articles and literature on the *Jatropha* hype and bust, most of which were derived from the Sustainability journal special issue, dubbed "Global Jatropha Hype-Drivers and Consequences of the Boom and Bust of a Wonder Crop". This paper reviews and synthesizes the *Jatropha* investment transformation experiences and the drivers influencing *Jatropha* investment initiatives, government-driven initiatives, and private sector-driven initiatives impacting the production approaches of *Jatropha* investment, as well as how the transformation experienced influenced the environment, social, and economic systems in the six previous major *Jatropha* investment destinations of Mexico, India, China, Ethiopia, Mozambique, and Ghana.

*Transformation and Investment Debates*

Transformation theories are not entirely new in research dispensation, as they were long identified [29] in other fields, but are new in land grab and investment debates. The term transformation can elicit reactions ranging from organizational change and leadership to land-based investment intervention changes. According to Deming [30] and Daszko and Sheinberg [31], transformation is like a never-traveled journey and, as such, its destination is unknown, is tentative, and cannot be predicted, but welcomes new learning and actions based on new discoveries. Transformations in land spaces are a phenomenon of uncertainties engulfed with development decision-making at any given time [32]. Several models of decision-making under uncertainty were proposed including modern investment policy decisions [33]. In recent times, investment hypes like *Jatropha* were driven by uncertainties, randomness, and unpredictable events [34,35], and some uncertainties occurring in transformations are expected. Therefore, in the phenomenon of uncertainties in investment trends in such transformations, nothing happens out of nowhere, but outcomes are induced by cause–effect relationships with their attributed challenges. In some instances, unexpected events come on board by mere chance and/or an accident with or without recourse to modern investment, thereby adding to the risk element in modern investment. Even though the futuristic outcomes of transformations are unknown, predictions such as goal-setting are key in modern investment. According to Deming [30], predictions without information and knowledge constitute guessing, which leads to crisis-related risk. Muys et al. [36] support Deming's assertions and postulated that policy measures toward the adoption and promotion of new initiatives should hinge on multiple, interconnected, and viable data. Therefore, interconnected and viable data to predict policies and develop policy are key to promoting new initiatives. Lempert [37] revealed that a single policy implementation is usually insufficient to tackle a particular development problem and risk. Farazmand [29] highlights the more persuasive nature of risks associated with crisis in these contemporary times than before. The outcomes in modern large-scale investments include land grabbing, with significant changes in the transformation of property relationships and social relationships of production [38,39]. Kenny-Lazar [39] also postulated that modern large-scale investments may result from a variety of agrarian problems such as land degradation, larger firms out-pricing smallholder crops on the market, or the availability of more lucrative off-farm employment, which, before the investment, could not be predicted most probably due to the lack of an indigenous knowledge of the system. Keijzer and Lundsgaarde [40] did not consider whether unforeseen or unintended changes occurred, but instead focused on two lenses of why they occurred: (1) the occurrence of un-intendedness linked to human errors made in planning

and implementing development interventions, and (2) the idea that reality is inherently complex to the extent that unintended effects would be unavoidable even when assuming the possibility of planning and implementing a perfect development intervention [41].

## 2. Methodology

To understand the outcomes of how *Jatropha* investments transformed global systems socio-economically and environmentally during and after the hype of *Jatropha*, our research reviewed the existing literature by employing qualitative data analysis. This was done through a case study design involving six countries that witnessed major *Jatropha* development (Mexico, India, China, Ethiopia, Mozambique, and Ghana) to describe the pattern of transformation in terms of undesired socio-economic and environmental outcomes. These countries were selected because they served as countries that witnessed major *Jatropha* development in a world where *Jatropha* investments were intensified through a mixed bag of government and corporate interventions. Again, after *Jatropha* was abandoned for almost a decade in these countries, no relevant studies were conducted to understand the transformational complexities of endorsing other crops. It, therefore, became very necessary to integrate the divergent unintended development consequences and transformational complexities of *Jatropha*. The qualitative data analysis helped provide insightful knowledge and understanding in a pragmatic manner [42,43] on investment transformation, which has very rare theoretical bedrocks and literature in the land grabbing debate. Secondary data collected through the review of literature from the Sustainability journal special issue "The Global Jatropha Hype-Drivers and Consequences of the Boom and Bust of a Wonder Crop" were reviewed to derive major themes as endorsed by Morse and Field [44] and Miles and Huberman [45] in tandem with each country by capturing the precise word that captured the key thought considered as "transformation in Mexico, transformation in India, transformation in China, transformation in Ethiopia, transformation in Mozambique, and transformation in Ghana". Based on the major themes, the findings were organized into a meaningful and logical cluster as suggested by Patton [46]. Furthermore, the analysis helped ensure that other relevant research findings were addressed in the discussion section of the study to inform the policy actions and academic thinking in a concretized manner.

## 3. Review of Country Cases: Transformations during the *Jatropha* Regime

A review of country-specific transformations for this article in the *Jatropha* space during the hype implies how approaches from investment sources transformed socio-economic and environmental systems during the era of *Jatropha*. Governments became the major driving force behind *Jatropha* investment during the *Jatropha* investment hype [47]. Government policies led to two main investment approaches and sources: (i) government-led investment approaches, and (ii) corporate-led investment approaches, which eventually defined the productions approach and investment sources, as well as the transformations emerging from these approaches (Figure 1).

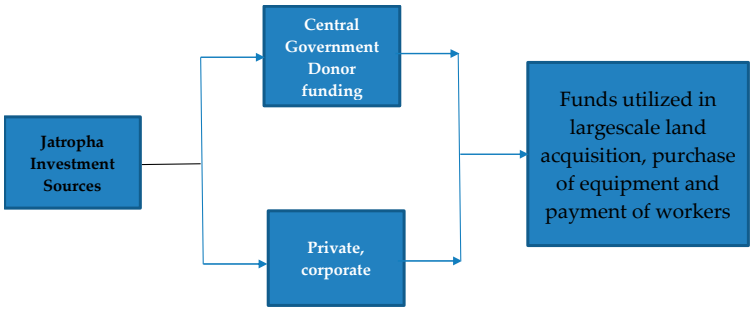


**Figure 1.** *Jatropha* investment sources and utilization.

### *3.1. Transformations in Mexico*

In Mexico, the *Jatropha* investment sources and approaches were government-led. Mexico is known as the "home" of *Jatropha*, but the potential of *Jatropha* in producing biofuels was unknown until the early 1990s. The renewal in interest in *Jatropha* cultivation started in 2003, when its potential contributions to sustainable energy security drew global attention to invest in the crop [1,25]. As the "home" of *Jatropha*, the Mexican government enacted a national biofuel law, the 2008 Bioenergy Promotion and Development Act, as a quick response to (i) diversify Mexico's domestic energy production, (ii) commit to reducing greenhouse gases, (iii) rehabilitate and reforest degraded land through the ProArbol program of Comisón Nacional Forestal (CONAFOR), the National Forestry Commission, (iv) enhance rural employment, (v) stimulate rural development, and (vi) produce biofuel energy for local and global needs [24,47,48]. The primary focus of the law was to contribute to energy diversification and the sustainable development of the country's agriculture sector whilst making Mexico a prominent center of biofuel energy in the world, as well as contributing to the global goal of reducing greenhouse gases (GHGs) [48]. To sustainably move the 2008 act forward with biases, the Bioenergy Interministerial Strategy (2009–2012) was introduced with the aim of reducing political favoritism in other districts which lacked agronomical requirements to cultivate *Jatropha* [24]. The government had the task of obtaining additional energy sources for export [47,49], with the expectation of spearheading the future provision of additional energy sources to countries in the north. The drive for the biofuel policy was to enhance competitiveness and to "open the gate" for locals to utilize economic opportunities associated with biofuel investments. The government initiated *Jatropha* projects in the Chiapas state through the National Forestry Commission and instituted subsidies to achieve positive outcomes. Other states were Colima, Michoacán, Morelos, Oaxaca, Sinaloa, and Yucatan [50,51]. The government strategically encouraged *Jatropha* amidst other biofuel crops such as castor and oil palm, which were already known. *Jatropha* was tagged as the preferred feedstock for biofuel investment [52]. This preference was strengthened by the revelation that *Jatropha* could be successful on marginal lands [53] and the intention of the government to increase forest area [24].

The labor-intensive approach to investment was adopted to allow for the engagement of large-scale farmers to enhance their livelihoods through job creation and income provisions [24,54]. Both local and international private investors and agro-industries were also motivated to invest in *Jatropha* on a large scale, but the intention of the government was to limit their dominance [53]. The locals were, thus, made the key actors in *Jatropha* production. Farmers engaged in bean and maize production also resorted to the production of *Jatropha* [54,55]. Agro-businesses were involved in the production process, but the locals had a greater platform for *Jatropha* production.

Generally, *Jatropha* was invested in for more than three years in Mexico [25]; however, the investment outcomes were poor [55]. In states such as Michoacán, Veracruz, Chiapas, Quintana Roo, and Yucatan, the use of marginal land for the cultivation of *Jatropha* yielded poor returns [56]. It was expected that the use of marginal lands for *Jatropha* would not lead to negative implications on food production in the country [57], but bean and maize farmers moving into the *Jatropha* field contributed to falls in the production levels of these crops [24,53–55]. In addition, new diseases that caused harm to the production of other food crops affected *Jatropha* production [58], and *Jatropha* investment did not make any meaningful impacts on local livelihoods. Although new jobs were created for farmers [24], they could not obtain adequate and expected profits from their newly found jobs.

Valero et al. [55] highlighted that, in Chiapas, the motivation of the participants was to earn enough income through the sale of the *Jatropha* seeds. This motivation behind the farmers in Chiapas was similar to the Mexicans in Quintana Roo, who were selling the seeds for biofuel production and export for revenue [49,59,60]. With frustration growing from the investment, some local individuals and agro-industries opted out of the production of *Jatropha*, and, in Chiapas State, authorities forewent the *Jatropha* project. Institutions and refinery centers that were previously created were closed down [58] as the production could not lead to a substantial reduction in poverty as proclaimed in many studies, but instead deepened the levels of poverty of its actors [24].

The environmental implications of *Jatropha* were generally a mixture of positive and negative outcomes [24]. Regarding positive environmental implications, the *Jatropha* project led to afforestation/reforestation in Yucatan; for instance, Skutsch et al. [24] observed that about 2000 hectares and 350 hectares of lands were used in two different commercial ranches to expand the forest. However, in Michoacán, the *Jatropha* farmers adopted a shifting cultivation approach, which saw a significant number of farmers clearing the secondary forest on a rotational basis for *Jatropha* plantations. Mexico's government, corporate investors, and individual local farmers felt disappointed in the outcome of *Jatropha* in terms of spearheading economic transformation and meeting energy needs [55]. As a result, the National Biofuel Policy shifted its ultimate attention from *Jatropha* to focus on other biofuel crop research projects and development (Mexican Bioenergy Network as in GAIN [61]). Investors withdrew their investments and some *Jatropha* lands currently lie idle, whilst others are being used for food crop production by previous *Jatropha* farmers [58].

### *3.2. Transformations in India*

In India, *Jatropha* investment sources and approaches were government-led initiatives through the Indian Government's declaration of National Mission on Biofuels in 2003 [62]. The global interest in biofuel investments aroused the awareness of the Indian Government to invest in *Jatropha*, [63] as in the case of Mexico. The government saw *Jatropha* cultivation as a means to improve soil fertility, contribute to the reduction of soil erosion, help in the rehabilitation of lands through greening, and create jobs for local members [63]. Even though several biofuel crops such as palm trees, maize, and sugar cane had higher attention from the government, *Jatropha* was ranked as the most preferred biofuel crop based on the following reasons: the easy cultivation of *Jatropha*; the faster growth and hardy nature of *Jatropha*; the seeds of *Jatropha* are easy to collect as they are always ready to be plucked before the rainy season; *Jatropha* plants are not very tall, but cannot be browsed by animals; the crop is rich in nitrogen; and the seed cake is a source of plant nutrients. Based on the attributes of *Jatropha*, the government realized that the cultivation of the crop could help the country achieve the 20% blending target [62,64]. About 11.2 million hectares of land was needed for the cultivation of *Jatropha* in the country [64].

Although the major source of investment was expected from the government through its policy which revealed its total commitment in supporting local actors in *Jatropha* enterprises, the implementation saw corporate local actors and farmers using their financial resources for the cultivation of *Jatropha* [64].The government policy paid credence to massive local involvement, as well as the engagement of private and corporate investment through minimum support price mechanizations, which were proposed in the Biofuel Policy of India [65]. To ensure active and massive local participation in the production of *Jatropha*, the government proposed a special support package for the locals who wanted to be involved in *Jatropha* cultivation. This proposed support was quite different from Mexico's case, as the government never promised to directly incentivize local *Jatropha* farmers. In the Andhra Pradesh State of India, the government promoted *Jatropha* through incentives in the form of free seedlings provided for farmers, a 90% subsidy for the installation of drip irrigation systems, and free land preparation under the Food for Work and Assigned Land Development program [62]. Poor farmers who were assigned lands owned by the government were to be provided with full financial assistance by the government with 40% secured as a bank loan for the cultivation of *Jatropha*. In the state of Tamil Nadu, companies and non-governmental organizations were encouraged to partake in the cultivation of *Jatropha*. Thus, India's *Jatropha* cultivation was made up of massive local participation, as well as a few other private entities that were mainly local companies and organizations, due to the government's enticing proposals in its policy.

Axlesson and Frazen [62] found that, in certain parts of India, *Jatropha* was cultivated on productive lands, but still failed. Therefore, it became very complex for stakeholders to explain why such production could not yield enough output. Studies also acknowledged that *Jatropha* has positive environmental outcomes by reducing the emissions of greenhouse gases [3]. *Jatropha* production was perceived to have an insignificant contribution to climate change [66] since the number of plants per

hectare of Indian farms was unlikely to have an important effect on the uptake of carbon [64]. This revelation supports the position of Prueksakorn and Gheewala [67] that the cultivation of *Jatropha* has insignificant adverse impacts on climate change. Indian engagement in *Jatropha* production led to intense pressure on the limited water resources, which was due to the demand of water for irrigation purposes. Although it is perceived that *Jatropha* is a drought-resistant crop, farmers realized that water was needed for positive yields. The government developed a financial plan with the quest to provide financial incentives, as well as input to support the production of *Jatropha* by the locals [62]. The government's failure to deliver its promises affected *Jatropha* cultivation, and the locals were forced to use their limited financial resources for the production process, to a point where they could no longer finance their investments. As a result, they withdrew their efforts. Additionally, the farmers also had very limited knowledge concerning the cultural practices and maintenance of *Jatropha* plantations. Extension officers failed to periodically visit to educate the farmers on the maintenance practices needed for successful outputs, which also contributed to the disappointing yields. The national biofuel policy failed to provide clear marketing plans for *Jatropha* products such as biodiesel, and there were no communication plans and strategies drawn and implemented to ensure the flow of marketing information between the farmers and biodiesel producers to ensure sustained demand. This led to the absence of a market for *Jatropha* products and made the *Jatropha* business unattractive for the local farmers to engage in. Thus, instead of *Jatropha* investment contributing to poverty alleviation, it further exacerbated it [62].

Axlesson and Frazen [62] further elaborated that poor cultural practices due to lack of requisite technical management support from agricultural extension officers paved the way for pests and diseases to attack *Jatropha* crops. In Tamil Nadu State, for instance, the pest attacks were generally mild and could have been tackled with the use of pesticides; however, in a few instances, the attacks were more severe than expected and this adversely affected the growth of the *Jatropha* plants, leading to their forced removal. The common pest identified was the mealy bug, which destroyed several crops. *Jatropha* production saw the creation of jobs, but this did not really contribute to advancements in local livelihoods. Issues on land alienation were virtually absent as the government largely promoted private land use for the cultivation of *Jatropha* and incentivized local farmers to use their own land for the cultivation of *Jatropha*, which were government lands in some cases [62]. The government, investors, and local members halted *Jatropha* investment, and some *Jatropha* lands are now occupied by local members, whilst others are yet to be approached. The government subsequently lifted its focus on *Jatropha* to a wide array of potential feedstocks including palm trees and sugarcane, with the hope of producing biofuels at a cost-convenient level [68].

### *3.3. Transformations in China*

Even though China has a centrally controlled economic system, *Jatropha* investment sources and approaches leant toward a corporate-led production scheme with close monitoring by the government. According to Li et al. [69], in 2005, the government of China took the lead in developing a policy environment to allow for biofuel cultivation, one being the "Renewable Energy Industry and Development Supervision" policy. This policy paid credence to supporting biofuel plantations through the selection of a better variety of crops. The government's initial attention was geared toward technological research and demonstration projects. Therefore, the government passed the National Forest Construction Plan in 2006, which aimed to provide about 13 million hectares of energy forest by 2020, as well as supply raw materials for about six million tons of biodiesel. In 2007, several plans of actions were developed, where significant among them was the "Medium–Long-Term Development Plan on Renewable Energy", which paid attention to (i) the production of biofuel plants; (ii) the establishment of *Jatropha*-breeding biodiesel experiments in some selected provinces; (iii) an increase in the yearly target for the utilization of biofuel with an expected increment of 1.8 million liters by 2020; and (iv) the management instruction on financial subsidies supporting crops for energy. In 2011, the Chinese Biofuel Policy on *Biodiesel Fuel Blend* had the aim of blending 2–5% biodiesel with 95–98%

diesel. With these government policies, several governmental bodies were engaged, including the Chinese Ministry of Finance and the Ministry of Agriculture, to promote the development of *Jatropha* production across the country. In Sichuan Province, about 14,667 hectares of land was acquired for *Jatropha* cultivation in 2007. Other provinces were Guanjxi and Yunnan. Concerned ministries came together to coordinate how best the country could engage in the investment of *Jatropha* to meet their energy demands and for export [70]. Furthermore, there were plans to increase the cultivation of *Jatropha* [70]. The southwestern part of China was seen as a suitable avenue for *Jatropha* due to the numerous hectares of unproductive lands for cultivation [71].

The investment sources of *Jatropha* were from investors in collaboration with the government. The government mainly played a supportive role, but the actual funds for *Jatropha* cultivation came from the investors. The government had an interest in enhancing well-being and dealing with poverty amongst the rural population; hence, the plan was to allow the locals to engage in the production of *Jatropha*. Corporate bodies could employ locals and train them in the production process, thus ensuring higher yields whilst enhancing the living conditions of the people [69]. Corporate bodies, including international investors and individuals, were engaged in *Jatropha* production. Two provinces, Sichuan and Guanjxi, were the two predominant centers for the cultivation of *Jatropha* in China. Corporate bodies employed community members to work as field workers/laborers for the production process; thus, the production approach was to make *Jatropha* production labor-intensive to allow for employment generation and advancement in local livelihoods.

The Chinese government was unable to achieve its expectation of meeting the growing energy needs of the local people using *Jatropha*. According to Li et al. [69], the poor government support, the limited demand for biofuels produced from *Jatropha*, and the severe frost led to the withdrawal of corporate investment, which contributed to the poor outcomes. The poor investment outcomes made the corporate entities leave without compensating the farmers for their services. In Guangxi, for instance, a private corporate company known as the Guangxi Zhilian Renewable Energy Company was involved in the *Jatropha* investment. The company employed farmers using a contract farming scheme. The company withdrew its investment within a short period of operation because the company needed subsidies from the central government, which were not forthcoming. During the periods of operation, the companies paid the workers through an investor–government coordinated system. This, however, failed and, as a result, the workers' livelihoods did not see massive improvements [69]. It is purported that the heightened interest in biofuel investment led to dynamics in land-use rights and land tenure security of the local participants [23,72]. However, in China, the *Jatropha* investment did not alter land-use rights and tenure security [69]. This was because the lands used were government-acquired land, and, as such, community members were not affected. However, *Jatropha* production and processing expenses escalated its market value higher than fossil products, thereby affecting demand and profitability. This blocked the investors' interest, as the government failed to grant them subsidies, leading to the *Jatropha* bust [69].

### *3.4. Transformations in Ethiopia*

Even though Ethiopia has a centralized controlled economic system, the *Jatropha* investment sources and approaches leant toward a corporate-led production scheme with close monitoring by the government using the "Open-Door Policy" [73–76]. The *Jatropha* era saw Ethiopia as an attractive destination for advanced countries to undertake large-scale investment in biofuel production, particularly in *Jatropha*. Faced with global pressures from foreign-based investors, the government was concerned about how the country could take advantage of the *Jatropha* hype to create a greener economy and produce energy to meet the local needs. The government developed the Biofuel Strategy to ensure that its aims were achieved [73]. The strategy paid attention, first and foremost, to ensuring a green economy using *Jatropha* biofuel production, as well as improving agriculture, ensuring natural resource management, and alleviating poverty in the country [74]. *Jatropha* investment was fueled by two main forces: the government's quest to secure energy through local production and global forces

due to the increase in demand for biofuels on the international market [75]. In 2006, a biofuel company known as Sun Biofuels in the United Kingdom (UK) started its *Jatropha* investment in the country. By 2010, Ethiopia had about 83 licensed foreign companies to invest in biofuel production [76]. Bossio et al. [77] revealed that foreign direct investments in *Jatropha* amounted to 50% of the total foreign investment in the country in 2011. A land deal matrix in 2012 indicated that about 1,360,670 hectares of land was released for biofuel projects with more than 700,000 hectares being used for *Jatropha* investment [78]. The global interest and pressure on Ethiopia influenced the government to make two main policy changes. The first was the government's introduction of the Ethanol Blending Policy, and the second was the changes made to the agriculture development and taxation policies, making the country an attractive center for foreign biofuel investors. This policy, from the perspective of Rahmato [79], was known as the "Open-Door Policy". In 2007, the government further developed a "desperate" policy dubbed the Biofuels Development and Utilization Strategy [75]. The policy spelt out the approach to enhance biofuel production and use within the country, and marginal lands of about 23.2 million hectares were earmarked for commercial *Jatropha* production [80].

The major source of investment was from foreign investors. The investors acquired large land sizes for *Jatropha* enterprises, and the government played a facilitating and supporting role in the entire *Jatropha* experience [75,76]. The flexible and open-door policy of the Ethiopian government saw the influx of foreign investors acquiring large hectares of land for *Jatropha*. The corporate investors employed the local people to work on the plantations on a paid scheme. Some of the locals were permanent workers whilst others were temporal. The production approach involved the use of both labor and machines on the plantation farms [81].

The government was very much interested in ecological integrity, which explains why the Climate-Resilient Green Economy Strategy was developed. The *Jatropha* investment did not make any significant contribution to a greener economy in Ethiopia after the bust, but Portner et al. [73] indicated that the *Jatropha* production had great potential of reducing soil erosion and retaining water for agriculture production in Ethiopia. In terms of livelihood benefits, *Jatropha* failed, as its production did not make any substantial impact on positive livelihood transformations. *Jatropha* could not be used to alleviate poverty, which explains why Portner et al. [73] elaborated that, for farmers to have economically benefited from *Jatropha*, there had to have been measures placed on their workloads, the local processing of seeds, training programs, and market interconnectedness for *Jatropha*. The investment saw the local farmers' land alienation, which served as their economic asset. Power holders and investors did not have respect for local land rights, and, as such, individuals whose farms were on the investors' acquired land were alienated, and this worsened the poverty in the project-affected communities [7]. Some local communities did not support the *Jatropha* project and/or were promised developmental co-benefits such as basic infrastructure and employment opportunities. The findings confirmed the assertion of the UN-Energy[1] [82] that biofuel production such as *Jatropha* plantations did not entirely benefit the poor farmers; rather, they put them into "deeper" poverty. This explains why Openshaw [2] indicated his doubt in *Jatropha* as a "poor man's crop". In the direction of the implications of the *Jatropha* investment on food production, the study by von Maltilz et al. [81] in Niqel, a *Jatropha* investment destination in Ethiopia, revealed changes in food availability and accessibility due to income received from the involvement of the locals in the *Jatropha* production process. According to their study, the changes were mixed. In some areas, food production was negatively affected, as farmers using grazing and farmlands for rotational farming were alienated. The widespread outcome of *Jatropha* was negative, as investment proved impracticable to continue. Hence, they abandoned their acquired lands, thus allowing local farmers to utilize some areas of the *Jatropha* land for food crops [81].

### *3.5. Transformations in Mozambique*

Even though Mozambique has a centralized economic system, *Jatropha* investment sources and approaches leant toward a corporate-led production scheme with close monitoring by the government.

Mozambique is amongst the countries where *Jatropha* investment took place. As indicated by Mataveia [83], the country is highly dependent on the international market with about 700,000 cubic meters in the annual consumption of petroleum products. During the phase of global forces for the widespread production of biofuel crops such as *Jatropha*, Mozambique also needed to enhance its energy security and reduce its over-dependence on international oil products. According to Schut et al., [57] the National Biofuel Policy and Strategy (NBPS) for the country was, therefore, developed in 2009 based on the following motivations: the unstable and volatile nature of oil prices in the world market; biofuel as an alternative energy product to reduce the dependency on fossil fuels; and the reduction in the emission of greenhouse gases (GHGs), as well as encouraging the use of safe and clean energy in the country [83]. The policy further emphasized poverty reduction and focused on encouraging private sector participation through collaboration and networking with the government, ensuring cross-sectoral coordination in the country through strengthening inter-institutional collaborations and frameworks comprising ministries, departments and agencies, tertiary institutions (notably, universities), financial bodies, non-governmental organizations, and civil groups in biofuel development. The country further deployed the Kyoto Protocol Mechanisms and other international instruments with the quest to speed up the utilization of green fuels and to make an impact on the environment through the reduction of greenhouse gases (GHS) [83].

The major sources of investment were from the central government's coffers and corporate funding. The government established a network with interested private investors both locally and internationally to ensure effective investment in *Jatropha* enterprises in the country [81]. The government allowed the private sector to take dominance in *Jatropha* cultivation, which allowed the locals to obtain employment in the *Jatropha* companies. The private companies partnered with the government during the production processes, and the local people participated in *Jatropha* cultivation on individual farms. The government had the intention to collaborate with the tertiary institutions to provide theoretical footprints to support the investment [81], but this was unsuccessful. During the production processes, the government mainly focused on small holders and communities by supporting them to cultivate *Jatropha*. Key production actors were foreign investors, local private entities, and individual farmers, who either worked for the investors or planted *Jatropha* on their own.

The government of Mozambique showed great commitment to *Jatropha*. Even with poor initial production outcomes in 2007, the government encouraged investors to continue with the *Jatropha* project by providing tax incentives [84]. Regardless of such incentives, *Jatropha* failed as a biofuel crop. *Jatropha* business was unprofitable, and the farmers withdrew their investment and efforts [85]. Instead of *Jatropha* becoming a safety net, it became a huge risk venture for the local people. Mozambique was noted to have used large hectares of land for *Jatropha* cultivation [86–88], and, during the investment, issues on land rights and tenure security became a critical development challenge in the country. Aggrieved community members closer to the investment sites did not support the project since their lands were taken from them without their due consent. Mozambique also had issues with the influx of diseases and pests [84], where the adverse effects of these diseases and pests are yet to be made known. Generally, van Eijck et al. [89] noted that *Jatropha* production in Mozambique received mixed results on the farmers' food production. This is because, whilst some community members stated that *Jatropha* production adversely affected their food production, others witnessed improvements in meeting their food needs. Schut et al. [57] realized that the outputs and income obtained from *Jatropha* production were lower compared to other crops; thus, it was better to utilize available land space to produce cash or food crops instead of *Jatropha*. In terms of job creation, Bos et al. [85] postulated that many of the locals were employed by investors during the *Jatropha* experience. The study by Romijn et al. [90] confirmed that more than 500 permanent jobs were created due to the investment decision in favor of *Jatropha*.

### *3.6. Transformations in Ghana*

*Jatropha* investment sources and approaches in Ghana were similar to those in Mozambique and Ethiopia, where there was a corporate-led production scheme with some monitoring mechanisms and interest from the government. The *Jatropha* investment in Ghana was started by a corporate entity known as Annuanom Industrial Project Limited [91]. In 2003, this entity called on the government to consider *Jatropha* investment as an innovative avenue to ensure local development transformations [92]. Through background studies, the government was convinced to commit its resources to *Jatropha* investments. According to Ahmed et al. [93], a National *Jatropha* Project Planning Committee was set up to assist in establishing *Jatropha* plantations in the country. The committee recommended pilot *Jatropha* plantations in 53 districts over a period of five to six years, on unproductive and dormant lands [94,95]. The government was expected to lead the *Jatropha* investment initiative by engaging local farmers to transform their livelihoods positively [92]. The committee suggested that these farmers should be trained extensively by Ghana's agriculture ministry [96] to ensure that they gained knowledge on the agronomy practices of *Jatropha*. A market strategy specified that the government should purchase the outputs of the farmers as the biofuel policy-mandated government-owned vehicles were to run on biodiesel on a minimum of B20 [96].

Technoserve [97] unveiled that the Ghanaian government had two biofuel crops to choose from: oil palm and *Jatropha*. The government made its choice in favor of *Jatropha* and decided to pump funds toward its cultivation. The Ghana Energy Commission [98] confirmed that the government was dedicated to *Jatropha* investment because of the huge importation cost of crude oil in 2004, which ranged from around United States dollars (USD) 516.8 million to USD 816.1 million. Unfortunately, the intended *Jatropha* project to be implemented by the government in the selected districts came to a halt when Ghana discovered crude oil in 2007. Therefore, both foreign and local investors were granted the opportunity to invest in *Jatropha* [99]. These investors acquired large stretches of land for *Jatropha* plantations [21,91] through negotiations with the chiefs [100]. Energy-inclined civil society groups such as the Kumasi Institute of Technology, Energy, and Environment (KITE-Ghana), the Gratis Foundation, and New Energy-Ghana also engaged in *Jatropha* investment, but on a smaller scale with funding support from United Nations Development Programme (UNDP). These organizations had an interest in using *Jatropha* to have a positive impact on communities [101,102].

*Jatropha* investment in Ghana generally unfolded transformations as unsatisfactory development outcomes for both investors and local communities. In a study conducted by Timko et al. [26], several outcomes were identified in some selected *Jatropha* investment sites in Ghana. Firstly, an average of 55.5 acres of land utilized by farmers were taken over by investors for large-scale *Jatropha* production. The takeover of farmers' land was never expected, as the motivation for the push for *Jatropha* was that *Jatropha* could be successful on marginal lands (supported by Reference [53]). Hence, there was the stance that local farmers would not be alienated from their farmlands [103]. Most of the large-scale investments were featured on productive lands, leading to the alienation of farmers. The second revelation by Timko et al. [26] was the failure of large-scale *Jatropha* investments to massively impact infrastructure growth and expansion. Except for the Jimle/Kpachaa investment destination, the *Jatropha* investment communities never benefited from the investors in terms of infrastructural provisions. This revelation runs parallel to the stance of Brittaine and Lutaladio [104] that *Jatropha* investment could trigger the provision of rural-based infrastructure for local transformation. In many of the *Jatropha* centers, jobs were created, but this did not have substantial economic improvements in affected communities. In fact, community members were generally worse off due to the large-scale *Jatropha* cultivation [105].

*Jatropha* investments also led to conflict of varying types [105] amongst the various interest groups, including investors, farmers, traditional authorities, and government agencies. The cause of the conflict was triggered by the following conditions: the lack of community participation and official notifications of the affected individuals during the periods of *Jatropha* investments; the meager and inconclusive compensation packages; the lack of transparency in the lease arrangements; the lack of trust in the

overall negotiation process for *Jatropha* investments; ambiguous land ownership structure; and the lack of alternative productive agricultural lands for dispossessed farmers. Acheampong and Campion [105] vied that Ghana's *Jatropha* investment outcomes in the initial stages were indications that large-scale *Jatropha* plantations may not help the country attain the proposed ecological and livelihood benefits from *Jatropha* as widely spread in secondary sources.

## 4. Discussion

This review shows that, in all of the previously *Jatropha*-producing countries considered, none of them were committed to initiating scientific studies on the crop before jumping into its investment [47]. The general enticing attributes granted to the crop were enough to lure these countries to invest in the crop, thus placing huge expectations on the crop as a "miracle" to solve most of their development expectations. Indications including Openshaw's [2] provisions that *Jatropha* could rapidly spearhead economic growth provided a sound ground for the countries to jump into its cultivation. The motivations of countries were manifested through the initiation of biofuel policies with various levels of targets within a specified period. However, as the biofuel policies of the six reviewed countries hinged on specific investment opportunities in favor of green fuel in such countries, the central and common reason for the quick jump to *Jatropha* investment without commensurate and proper empirical research works was due to the quest to become energy autonomous.

The researchers were not totally pessimistic about *Jatropha*, as there were wide expectations for the young crop in a new system with no previous extensive practically scientific proven research. There was no local level research to prove country-specific conditions and the suitability of *Jatropha*, genetic composition, characteristics of *Jatropha*, its soil requirements, suitability, agronomy practices, marketability, and other undisclosed information about the crop. In Ethiopia, Mozambique, and Ghana, where land is the greatest asset for rural livelihoods, there was no critical consideration granted to land issues in terms of how best to incorporate *Jatropha* investments without local land denial and subsequent land alienation. The research, thus, acknowledged that the time for *Jatropha* investment was generally wrong, since it was the period for in-depth studies and knowledge-sharing amongst countries before gradual investments were started. The period was. thus, "research to prove before production" instead of the "wait-and-see approach after production" [106], which was an "easy way out and a short-cut to meet doubtful expectations". The wait-and-see approach, according to Gordon et al. [107], is a deferment approach. The deferment approach is due to the uncertainties associated with the potential allocation of information breaches. This uncertainty is the result of the potential vulnerabilities and threats associated with breaches. Due to these uncertainties, it may be rational to take a wait-and-see approach. In the case of Mexico, it was obvious that the local systems of *Jatropha* investment needed improvement through training and capacity building before the actual *Jatropha* investment, but this never took place. In the Indian case, the government was not financially prepared for *Jatropha* investments, and vague promises were made without fulfilment; as such, no one expected positive outcomes from the *Jatropha* investment in the country. The Chinese case also saw limited support offered by the government to corporate *Jatropha* investors, which led them to pull out from the investments. Perhaps, if the government had positioned itself to substantially support corporate bodies through subsidies during the investment, the development outcomes would have been positive. In Ethiopia, Mozambique, and Ghana, foreign investors rushed to invest without giving recognition to the traditional land rights of the locals. Without this social license from the tradition land-owners and users, instituting a successful business will always be contentious without local support. Figure 2 presents a summary of the global transformation creation trajectory through *Jatropha* investment and its diversity based on the approach to investment.

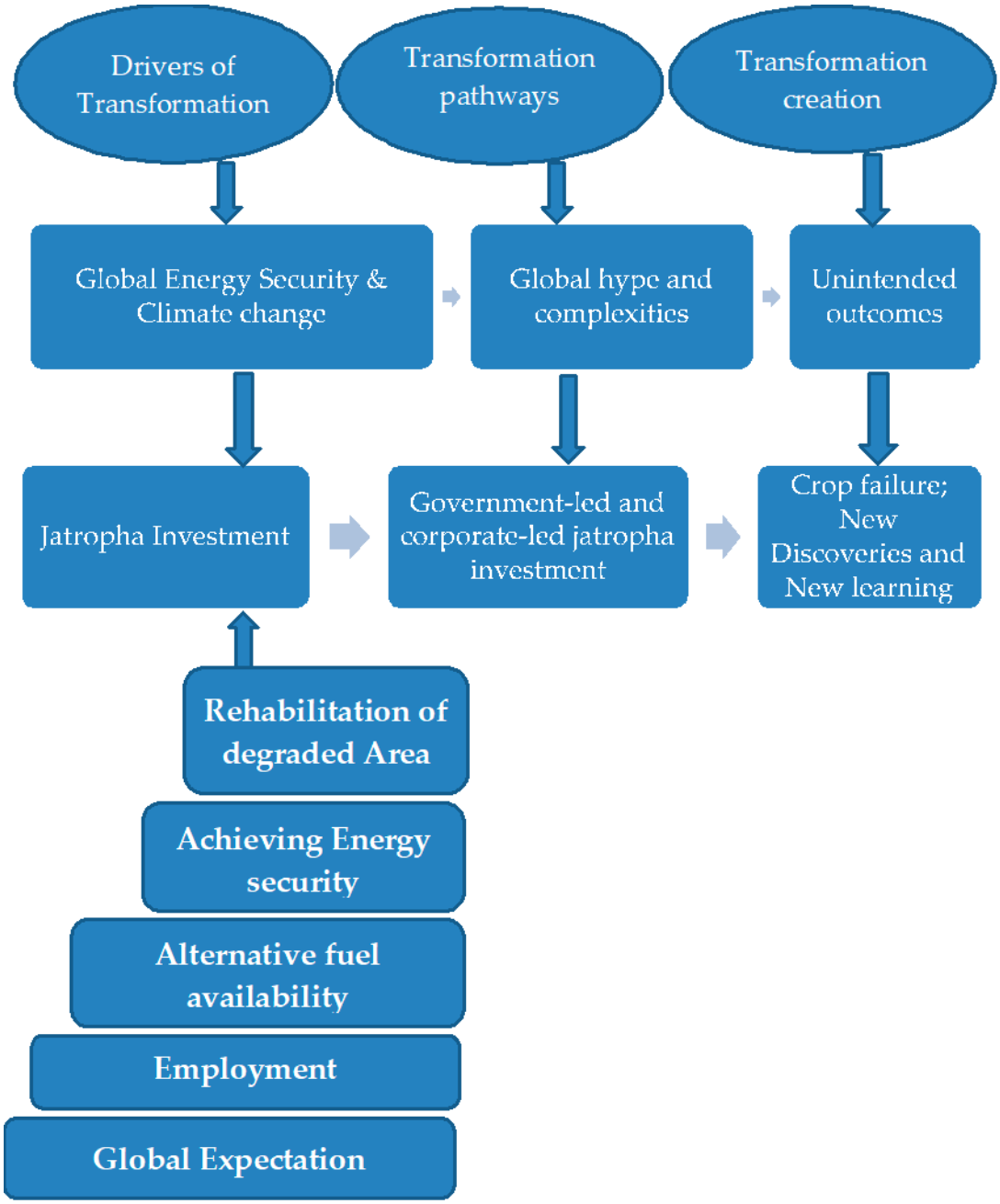


**Figure 2.** Global transformation trajectory through *Jatropha* investment.

*Transformations in Government- versus Corporate-Led* Jatropha *Investment*

Transformations of *Jatropha* investment took two main forms, that is, production initiated by the government and production initiated by corporate or private investors. In all six countries considered in the research, *Jatropha* production failed whether it was led by the government or by corporate investors. In Mexico and India, *Jatropha* investment was a national agenda with the government taking direct involvement in the cultivation process. The Chinese embraced a mix of socialist and capitalist approaches, but the government was somewhat reluctant to inject subsidies into the *Jatropha* initiative. Although Ethiopia and Mozambique have a centralized government control system, the corporate agenda (capitalist approach) was embraced. In Ghana, it was corporate-led in a decentralized democratic system. Based on the corporate production approach adopted by these countries, there were diversities in terms of the environmental, economic, and social transformations after the collapse

of *Jatropha*. From the narrative, government involvement (socialist approach) tried to put "people" at the center of the investment, whilst corporate investors (capitalist approach) placed emphasis on "profit". In relation to the differences in priorities, government-led production focused on "marginal lands", instead of "productive lands" occupied by indigenous and tenant farmers [48,63,69,74,93]. Thus, the rate of environmental destruction for government-led production was lower than that of corporate investors. In fact, government-led production tried putting environmental integrity at the core of its investment. In India, for instance, Zafar [63] reiterated that the government involvement in *Jatropha* production was aimed at reducing soil erosion and the rehabilitation of land for the benefit of communities. The use of marginal lands in Mexico by the government also meant that *Jatropha* cultivation would not consume the green vegetation of communities [57]. In the Yucatan State, Mexico, the government tied *Jatropha* production to afforestation/reforestation with some hectares of land used specifically to expand forest. Chinese government engagement in the investment also led to extensive use of marginal lands, thus safeguarding productive land for the production of food crops.

In relation to corporate investors, the top priority of "profit" meant that lands as livelihood assets for host communities were taken away from them, and forested landscapes were transformed to large-scale *Jatropha* plantations, as in the case in Ethiopia, Mozambique, and Ghana. Flexibility in the use of abandoned lands by both the government and corporate investors varied sharply. In most of the government-led projects, local farmers were advised to use their lands for *Jatropha* production. After the poor outcomes of the initial investment, farmers later transformed their lands back to food crop production with ease. The marginal lands designated by the government for *Jatropha* lay idle, probably due to the fear of low fertility to support farming or the complexities associated with using government lands for personal projects [107]. In Mexico, India, and China, for instance, where there was some active form of government participation, lands used for the investment still lie dormant. With the corporate investors, once they were unable to realize gains from their investment, they left their lands dormant, and some community members ended up using such land for their own farming. In Ethiopia, Mozambique, and Ghana, where investments were predominantly led by private investors, some farmers returned to the *Jatropha* lands for farming purposes [81,86,88]. The subsequent re-transformation of land back to farmland helped advance the livelihood of such farmers, although they can be alienated at any point in time, especially when another investment sets in. There were also instances where corporate lands were re-leased to other private investors for investment; hence, farmers still faced alienation despite the bust of *Jatropha* projects in their communities.

The social implications associated with government- versus private-led investment varied. Whilst land-resource conflict became the hallmark of private investment due to alienation and unfair compensation, government-led investment intensified social capital, helping concretize social cohesion. In Ethiopia, Mozambique, and Ghana, where investment was intensified by private actors, issues on land rights became critical, leading to investor–farmer conflicts in the host communities [73,83,105]. This conflict affected social relations, and somewhat interrupted the operational peace investors needed for sound investment. In the case of government-led investments, government-owned lands were used; hence, issues of eviction were negated [55]. Again, farmers were encouraged to use their own lands for *Jatropha* cultivations. This solidified the unity of work, as farmers had to coordinate efforts and share responsibilities for the cultivation of a common crop, *Jatropha*. As a result, government-led investment did not create social disturbances vis-à-vis private investments.

In countries where *Jatropha* projects were led by the government, particularly in India, the government's intentions and plans were to encourage local farmers through incentive-driven approaches, even though they were not successful. However, the government continually provided the leading role, allowing farmers and agro-business groups to use their own resources for investment. *Jatropha* was planted on a large-, medium-, and small-scale basis, depending on the financial viability of the entities and individuals involved. Ethiopia, Mozambique, Ghana, and China, to a certain extent, saw the direct participation of corporate bodies in *Jatropha* investment. These corporate bodies were both local and foreign-based entities. The greatest proportion of foreign investors (corporate bodies)

featured their investment in these countries due to the government's "open-door policy". Unlike in Mexico and India, *Jatropha* in Ethiopia, Mozambique, and Ghana was basically instigated on a large scale, with investors acquiring large tracts of land for their investments. Although there was land-use change, issues regarding land takeovers and the recognition of local land rights were rare in Mexico, India, and China due to the wide use of marginal lands (especially in Mexico and China) and the farmers' decision to use their own lands for *Jatropha* (India). In contrast, issues of land-use rights and tenure security became a critical development issue in Ethiopia, Mozambique, and China, as many local farmers were evicted from their lands without their approval or commensurate compensation. This affected local agriculture, with direct negative implications on food security. Concerns about food insecurity were also common in Mexico and India, where new pests and diseases were introduced, thus affecting food crops. Particularly in Mexico, the case was further worsened by some of the farmers deciding to vacate crop production for *Jatropha* cultivation. China very rarely had issues concerning the negative outcome of *Jatropha* on food production as marginal lands were predominantly used for *Jatropha* cultivation.

*Jatropha* investment led to the creation of temporal jobs for the local actors involved, but this did not really enhance the livelihood outcomes. In all six cases, *Jatropha* was unprofitable; as such, the target of meeting global energy needs through biofuel was dashed. This led to the *Jatropha* bust, with governments shifting their policy focus from *Jatropha* to make room for evidence-based research, refocusing their attention on a wide range of possible agro-fuel crops. Actors, including governments, local agro-business groups, farmers, and foreign investors, largely withdrew their investment due to the unprofitability of *Jatropha*. In Mexico, India, Ethiopia, Ghana, and Mozambique, some acres of *Jatropha* lands are used for the cultivation of other crops either by farmers or other investors, whilst other portions are yet to be used. Since marginal lands were used for *Jatropha* in China, the lands are still idle after the cessation of investment. Generally, *Jatropha* failed because of the quick leap to its investment without commensurate empirical studies, especially at country-specific levels to prove/disprove the heightened proclamation on the crop. *Jatropha* was just an ordinary crop, instead of the fancy names given to it such as "wonder crop", "miracle crop", etc.

The ongoing discussions imply that interventions based on lessons from both government-led and private-initiated investment need variations to critically address the outcomes associated with large-scale investment projects. There is a need for critical scrutiny and policy-based initiatives to comprehensively address the problems associated with large-scale investments either initiated by the government or by private individuals.

Currently, these countries have come to terms with the uncertain path of *Jatropha* transformation. Transformation patterns ultimately followed policy, investment, and land-use transformations (see Table 1). Thus, biofuel policy attention shifted from *Jatropha* to other feedstocks, investment toward *Jatropha* transformed to other crops or to no investment, and land use for *Jatropha* was transformed to farming grounds by either smallholders/other investors or to total abandonment without any crop production. *Jatropha* transformation led to socio-economic and environmental outcomes, with their diversities widely dependent on the perspective from which such investments were tackled, either led by the government (Mexico and India), corporate investors (Ethiopia, Mozambique, and Ghana), or concurrently by the government and corporate investors (China). As inferred from Deming [30], and Dazko and Sheinberg's [31] theory of transformation creation, the socio-economic and environmental outcomes of *Jatropha* transformation in these six countries as the initial uncertain destinations led to new discoveries and learning, especially toward an effective response to inform future investments. These countries have, therefore, come to terms with the outcomes of investment transformation (system) change through the path of transformation; thus, vast potential lessons exist for them to tap into so as to drive future agro-investment in a positive direction. Table 1 shows a summary of the reviewed literature on transformation creation through global *Jatropha* investment of the six selected previous *Jatropha*-producing countries, and their patterns of transformation vis-à-vis policy, investment, and land use.

**Table 1.** Global perspective of transformation creation in different *Jatropha* centers.

| Country | Support Sources: Government- versus Corporate-Led *Jatropha* Investment | Transformation | | | |
|---|---|---|---|---|---|
| | | Policy Transformation | Environment, Social, and Economic Transformation | Investment Transformation | Land-Use Transformation |
| Mexico | - Government-led<br>- Investors/ agro-industries | National Biofuel Policy attention shifted from *Jatropha*. | - Land: Limited negative outcomes recorded on tenure issues.<br>- Food security: Food production affected especially maize and beans; new pests and diseases.<br>- Employment: Jobs created through agro-industries.<br>- Energy security: Failure to meet biofuel targets. | - Withdrawal of investment by both government and investors. | - Farmers diverted the land to cultivation of food crops.<br>- Marginal lands are idle. |
| India | - Government-led support (but this turned to be limited)<br>- Farmers' own resources<br>- Finance from local enterprises | National Biofuel Policy attention shifted from *Jatropha*. | - Land: Limited land tenure issues.<br>- Food security: Pests and diseases introduced via *Jatropha* which affected food crop production.<br>- Employment: Jobs created via *Jatropha* production at the local level.<br>- Energy security: Failure to meet biofuel targets. | - Withdrawal of investment by both government and investors. | - Community members took over some lands whilst others are yet to be utilized. |
| China | - Corporate-led<br>- Investors in collaboration with the government | National Biofuel Policy attention shifted from *Jatropha*. | - Land: Limited land tenure issues.<br>- Food security: Food production and availability were not affected by *Jatropha*.<br>- Employment: Jobs were created through contract farming.<br>- Energy security: Failure to meet biofuel targets. | - Investment withdrawn by investors and government's interest dwindled. | - Lands lie dormant. |
| Ethiopia | - Corporate-led<br>- Government support Foreign direct investment (FDI) | National Biofuel Policy attention shifted from *Jatropha* toward resilient Policy on Agriculture Modernization | - Land: Issues on land-use rights and tenure security became a critical development concern.<br>- Food security: *Jatropha* somewhat affected food production as grazing areas and farmlands used for rotational farming were alienated.<br>- Employment: Contract jobs were created, but payments were neither fair nor competitive.<br>- Energy security: Failure to meet biofuel targets. | - Investment on halt in some areas.<br>- Investment shifted to other crops in other areas. | - Lands used for other crops by investors.<br>- Farmers took over their lands. |

**Table 1.** *Cont.*

| Country | Support Sources: Government- versus Corporate-Led *Jatropha* Investment | Transformation | | | |
|---|---|---|---|---|---|
| | | Policy Transformation | Environment, Social, and Economic Transformation | Investment Transformation | Land-Use Transformation |
| Mozambique | - Corporate-led<br>- Government support<br>- Corporate funding | National Biofuel Policy attention shifted from *Jatropha*. | - Land: Issues on land-use rights and tenure security became a critical development concern.<br>- Food security: Mixed results. Pests and diseases introduced via *Jatropha* which affected food crop production in some cultivated parts.<br>- Employment: Jobs were created via corporate bodies.<br>- Energy security: Failure to meet biofuel targets. | - Investment diverted to other crops by investors.<br>- Other investors completely withdrew their investments. | - Lands used for other crops by investors.<br>- Farmers took over their lands. |
| Ghana | - Corporate-led<br>- Government support<br>- Foreign direct investment (FDI)<br>- Non-Governmental Organization (NGO) support | National Biofuel Policy attention shifted from *Jatropha* toward resilient Policy on Agriculture Modernization | - Land: Issues on land-use rights and tenure security became a critical development concern.<br>- Food security: *Jatropha* somewhat affected food production as grazing areas and farmlands used for rotational farming were alienated.<br>- Employment: Contract jobs were created, but payments were neither fair nor competitive.<br>- Energy security: Failure to meet biofuel targets. | - Investment diverted to other crops by investors.<br>- Other investors completely withdrew their investments. | - Lands used for other crops by *Jatropha* investors/new investors.<br>- Farmers took over their lands but with no tenure security on land. |

## 5. Conclusions

The global recognition given to *Jatropha* as a "wonder crop" was clearly a bust. The major investment destinations reviewed in this paper failed to achieve their expected results in terms of alleviating local and global energy poverty, reducing the greenhouse gas (GHG) emissions, and enhancing local livelihoods and development. The review established that the intended goal for establishing global *Jatropha* investment, which was to serve as an alternative source of fuel, failed because of the unexpected complexities of the uncertainties and the ubiquitous nature of the hype, which dwelled on the wait-and-see (that is, the deferment option) approach for global *Jatropha* investment. These frustrations caused governments and investors to lose interest in *Jatropha*. It should be accepted that *Jatropha* was over-hyped, in the absence of extensive and convincing scientific research works. *Jatropha* will not gain popular attention any longer, as countries seem reluctant to massively pay credence to its re-investment. Notwithstanding, the current phase of *Jatropha* transformation in the studied countries calls for them to move forward, as countries need to appreciate diversity in policy interventions in relation to key factors that lead to the investment implementation processes. This is premised on the fact that the outcomes of the *Jatropha* transformations in the countries studied are parallel to that which was premised, but not based on the approach and perspective to which *Jatropha* investments were tackled. Differences in socio-economic and environmental outcomes call for these countries to reflect upon the existing potentials and constraints created for responsive policy measures toward their biofuel sectors. Currently, these countries have transformed their biofuel policy attention from *Jatropha* to other feedstocks, and it is expected that these transformed policies will take precautions based on lessons learnt from the previous investments, as well as the current situations that are presented as an outcome through their respective travels on the path of transformation [30,31]. We support the shift in policy attention, since we are not all that pessimistic about the economic and production viability of *Jatropha* (even if treated with adequate responsibility). Perhaps considerable attention granted to other feedstocks, as these countries adopted, might have a future as a better alternative source of energy. It is expected that countries which embrace similar investment approaches, for instance, Mexico and India for government-led investment, and Ethiopia, Mozambique, and Ghana for corporate-led investment, might have some interrelated responses. Policy measures should, however, deeply reflect the peculiar dynamics in each country for effective outcomes.

Our research incites policy lessons that the adoption and promotion of any new crop must be based on incremental measures for sound policy responsiveness and implementation. The "quick jump" to any new crop by countries just because it is widely propagated by the international community as a response to a particular development need is not adequate enough for mere acceptance. Thought-provoking policy measures are needed, premised on wide consultation and a participatory paradigm characterized by in-depth empirical research within a particular country. As suggested by Muys et al. [36], policy measures toward the adoption and promotion of new crops should hinge on viable data from proposed investment communities, as well as a cost–benefit analysis of the outcomes of such investments. Even if this proves satisfactory, initial investment based on experimental trials in selected locations should be embraced as the first step, as this can help to unravel peculiar uncertainties and problems associated with such crops, as suggested by Soto et al. [108]. Another insightful policy implication of these findings is centered on policy interconnectedness, and the need for countries to be aware of and appreciate such connections for effective measures. Lempert [37] revealed that a single policy implementation is usually insufficient to tackle a particular development problem. Therefore, there is a need for national governments, corporate investors, and other important stakeholders to understand that the policy environment is a system made up of a network of several policies that work interrelatedly to address a particular development need [109]. This policy system is also applicable to the emergence and promotion of a new crop, which is likely to present solutions to a development problem. Ultimately, government and private investors must sufficiently reflect on the suitability of endorsing new investment initiatives before accurately appraising the investment viability. Even if

there is such an endorsement, the aftermath of the failures of such initiatives should be appraised to understand the impacts of the failure to transform the system.

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**Notes:** UN-Energy is a collaborative framework for all United Nations (UN) bodies that contributed to energy solutions. It was born out of the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa.

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