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Implementation of Bioenergy Systems towards Achieving United Nations' Sustainable Development Goals in Rural Bangladesh

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Abstract: This research presents a conceptual model to illustrate how people living in rural areas can harness bioenergy to create beneficial 'community-driven' income-generating activities. The research is contextualised within the rural developing areas of Bangladesh where people live in abject poverty and energy deficiency. The research methodology applied in this study aims to determine the basic requirements for implementing community-based anaerobic digestion (AD) facilities and illustrate how an AD facility positively impacts upon the lives of rural communities directly after its installation. The survey results demonstrate that implementing a biogas plant can save 1 h and 43 min of worktime per day for a rural family where women are generally expected to for cook (by the long-term tradition). In addition to the positive impacts on health and climate change through adoption of clean energy generation, this time saving could be utilised to improve women's and children's education. The research concludes that, by providing easy access to clean bioenergy, AD can change people's quality of life, yielding major social, economic and environmental transformations; key benefits include: extending the working day; empowering women; reducing indoor air pollution; and improving people's health and welfare. Each of these tangible benefits can positively contribute towards achievement of the UN's Sustainable Development Goals. This work demonstrates the potential to increase the implementation of AD systems in other developing world countries that have similar geographic and socioeconomic conditions.

Keywords: Bangladesh; anaerobic digestion; biogas; bioenergy; Sustainable Development Goals

1. Introduction

The Millennium Development Goals (MDGs), which sought to eradicate global poverty, and augment education, health and environmental initiatives, expired [1] in 2015 and UN member states are finalising the new Sustainable Development Goals (SDGs) which supersede them [1]. The SDGs have gathered momentum alongside the need to secure global sustainable development [2]. Sustainable development includes aspects that seek to balance technical innovation, financial affordability, ethical approval and cultural sensitivity [3]. Developing countries, such as Bangladesh, have a long history of experiencing human suffering, environmental change and natural disaster, but their people have demonstrated resilience in the face of abject poverty [4]. Circa 160 million people live in Bangladesh and the country exhibits diverse human-environmental interactions that are typical of many low-lying coastal areas of South Asia [5]. Around 66% of the country's people live in rural areas and lack access to modern forms of energy [6]. Indeed, the energy market in many developing countries is inefficient, particularly in rural areas, where nearly 2 billion people cannot access electricity, oil or gas [7]. The rural population who live below the national poverty line rely primarily on traditional biomass fuels such as wood and dung cake (dried cattle dung) [8]. Reasons for this reliance on traditional biomass are myriad but include: geographic location; limited or no access to alternatives; and deficiency of finance [9]. Dependency upon traditional (and environmentally damaging) biomass and solid fuels incurs substantial labour costs and causes both social and environmental impact. Hence, the requirement to reduce people's reliance upon these fuels and provide more sustainable solutions through the use of clean fuel options is glaringly apparent.

A viable alternative option is the use of anaerobic digestion (AD) to convert biodegradable organic matter (such as manure or vegetation) into clean biogas fuel [10]. Anaerobic Digestion facilitates the biodegradation of (complex) biomass matter under anaerobic conditions and is made possible by interacting groups of anaerobic microbial consortia available in cattle dung [11]. Biogas comprises a mixture of methane (CH_4) and carbon dioxide (CO_2) together with small amounts of other gases, such as hydrogen sulphide (H_2S) and ammonia (NH_3). Utilising AD has many benefits, for example it can provide a supply of energy which improves both indoor air quality and sanitation by removing pathogens [12]. The end product of AD is nutrient rich, fibrous compost that can be utilised to replace chemical fertilisers, providing incidental financial benefits for subsistence farmers [13]. Labour saving benefits accrued from using AD in South Asia have been publicised by the Netherlands Development Organization (SNV) and suggest that women can save up to 900 h per year by not collecting and splitting firewood [14]. A typical biogas plant can save 1800 kg of firewood a year and 45 L of kerosene, thus reducing CO_2 emissions by 4.5 ton per annum [15]. The installation of a community AD facility can therefore improve the rural community socially, economically and environmentally.

Against this prevailing backdrop, this research work aims to develop a conceptual model to illustrate how rural communities can adopt AD and create financial returns on their initial investment of renewable technology. Concomitant objectives are to:

- Enhance the process and operation of AD;
- Report upon the potential impact that AD and biogas have in the context of replacing fossil derived fuels; and
- Report upon the community impact of rural AD and SDGs in relation to energy, public health, environmental impact and sustainable economic growth.

2. Environmental Ecology and Rural Development

2.1. Converting Waste into Energy

Traditional biomass fuels (e.g., wood, animal manure and leaves) are used mostly for cooking in rural Bangladesh [16]. The utilisation of wood has several drawbacks including low energy efficiency, human exposure to respiratory disease and environmental degradation (such as deforestation, depletion of organic matter in soil and air pollution). Similarly, using dung cake as a fuel means that it cannot be used as fertiliser and excessive use of woody biomass from local trees and bushes can lead to deforestation [16], which in turn increases the propensity for environmental disasters such as floods and river bank collapse, thus compromising agricultural productivity and economic development [17]. These socio-economic and cultural issues within the rural community can hinder the progress towards achieving sustainable development goals.

Waste represents another source of biomass and each day 3500 ton is deposited in Bangladesh's capital city Dhaka–refer to Figure 1 [18]. This includes municipal solid waste (MSW) and agricultural and animal waste [19]. Annually in Dhaka, 511,000 ton of waste is disposed of in controlled landfill and another 509,248 ton is lost or illegally dumped [20]. Dumping waste has created major environmental problems such as the transmission of diseases, greenhouse gas emissions (GHGs) and ground water pollution through pipe leakages [21]. In addition to dumping waste, open storage of cow dung on farmers' properties causes water pollution and provides a breeding ground for mosquitoes and bacteria, resulting in diseases such as malaria [22].

Figure 1. Dumping of Waste at the Roadside (**Left**) and Dumping of Poultry Litter near the Poultry Farm (**Right**) [18].

Using AD to process biomass from waste has become an important option for vulnerable people living in rural developing countries [23]. Biogas and the solid digestate, which can be used as a bio-fertiliser, are both valuable products of the process [24]. When sustainably harvested, biomass fuels are GHG emission neutral because biomass is combusted into CO_2, which was derived from the vegetations [25]. However, biomass fuel must be burnt efficiently and completely for this process to be emission neutral [26]. Burning of solid biomass fuels in stoves typically achieves only about 10-25% in overall efficiency [18] and also emits a significant portion of pollution via the products of incomplete combustion, for example methane (CH_4) and polycyclic aromatic hydrocarbons (PAHs). These chemicals have a greater impact upon global warming when compared to CO_2. Thus, inefficiently burned biomass fuels have a global warming contribution even if renewably harvested [27]. When used in cooking stoves, biogas derived from AD is much cleaner. The combustion efficiency in a gas stove is 57% which is more than for woody biomass (22%) and much higher than the direct burning of dung cake (10%) [28–30]. The amount of animal manure used in AD plants as a feedstock is increasing, as larger numbers of biogas plants are being built [31–33]. AD is therefore an appropriate technology for rural communities because it is relatively easy to implement and operate, does not require complex infrastructure, utilises local resources and produces clean fuel.

2.2. Energy, Poverty and Gender

Evidence suggests that women are important contributors to SDGs because they are primarily responsible for overseeing the provision of energy, the removal of waste and the collection of wood fuel [34]. Various projects have demonstrated that supporting women through a range of initiatives (e.g., improving cooking facilities), increases the successful sustainability of the project [35,36] by engendering changes in social custom and religious belief [37,38]. Accordingly, technologies used to generate income can empower the poor by investment in their education, acquisition of manual skills, competency and available naturally occurring resources to meet their own demand. The high levels of gender bias in poverty suggest that 70% of the 1.3 billion people living in poverty are women [39,40]. Women living in poor rural areas of developing countries tend to assume child care and domestic responsibilities, and as a consequence, work longer hours than men [41,42]. Because of this imposed socio-cultural circumstance, women secure less income, are more prone to ill health and are susceptible to higher rates of mortality. Typical work activities include collecting wood for stoves and carrying it back home to store. Often, several kilometres are covered in a single day; the time and labour expended on these work activities is physically exhausting and effectively eliminates the women's available time or ability to engage in other more productive and income-generating activities [43,44]. Women's muscular skeletal health also suffers from this exhausting manual labour (such as carrying heavy loads over long distances) and their respiratory health suffers from cooking on, or near to, smoky fires [45]. In culmination, educational opportunities and income generation are limited and consequently, women remain trapped in the poverty cycle [46].

2.3. Benefits of Biogas for Rural Households

Programmes for the extension of AD technology to rural areas have been highly effective in South Asian countries such as India (4 million units), Nepal (250,000 units) and Bangladesh (20,000 units) [24]. Biogas produced from these plants is mainly used for cooking food and gas lighting. Numerous surveys have been conducted by biogas extension organisations on the plants they have built [47,48] and numerous benefits for users have been revealed, which include:

- Cooking using a clean gaseous fuel that does not produce smoke, is instantaneously available and does not need constant attention [48];
- Removing the need to clean soot from pots [49];
- Creating habitats where occupants can live in a smoke free atmosphere and where the danger of getting burnt is significantly reduced [49];
- Eliminating the need to collect wood because the AD feed materials (i.e., animal dung and food wastes) are available locally [50];
- Reducing the need to store wood, so houses are free from insects that live in wood stores [51] also due to rapid urbanization and industrialization, the country is significantly losing its cultivable land as well as woody biomass [51,52];
- Enabling mothers and children to eat a cooked breakfast before they leave for school (because they no longer have to collect fuel), which improves their education [53]; and
- Creating an effective fertiliser from the biogas plant's effluent, thus saving a farming family's income money by reducing their reliance upon the fossil fuels used to make artificial fertilisers [54]. The total saving of fossil carbon is estimated as 4.9 tonnes a year.

Van Ness et al., [14] proffer that a typical domestic biogas plant saves 2000 kg of wood fuel a year and that 1000 biogas plants can save the felling of 33.8 ha of forest each year—refer to Figure 2. for a typical example of a biogas plant [49]. Biogas can be used to replace kerosene for lighting and/or cooking [24], with a typical saving of about 32 L per year. This reduction in usage of flammable liquids has an incidental benefit of mitigating house fires that occur when lamps are inadvertently knocked over.

Figure 2. A Domestic Fixed Dome Biogas Plant Constructed from Brick, Sand and Cement (**Left**) and a Simulated Side View of an AD Plant (**Right**) [24].

The financial benefit of replacing cooking over wood fuel with the use of biogas has been determined to be worth between £213 to £342 per tonne per year of carbon saved [55,56]. The main health benefits derive from the reduction of indoor air pollution which causes irritation to the eyes, nose and airways of occupants who do the cooking or are in the near vicinity [57]. Such irritation results in greater susceptibility to infections and lung disease, such as bronchitis, chronic obstructive pulmonary disease and/or asthma [45]. These health benefits encouraged the establishment of the Biogas Support Programme (BSP) in Nepal in 1992 by SNV based upon a previous programme set up by the Development and Consulting Services (DCS) of the United Mission to Nepal (UMN) [58]. The BSP programme proved very successful [33] because it emphasised the establishment of biogas plant construction companies with trained staff and a high level of quality control, leading to longer term reliability [24].

2.4. Rural AD and Sustainable Development Goals

The SDGs defined by the United Nations in 2015 offer greater specificity and scope for improvement when compared to the MDGs defined in 2000 [59]. In particular, the SDG framework addresses the systemic barriers that hinder progression towards meeting sustainable development targets, which include: inequality, unsustainable consumption patterns, weak institutional capacity and environmental degradation [59]. Six essential elements for delivering the SDGs are: (i) planet; (ii) people; (iii) partnership; (iv) prosperity; (v) dignity; and (vi) justice–refer to Figure 3 [34]. By providing a low cost, clean and affordable fuel, rural AD could play an important role in achieving these SDGs through improvement to all six elements.

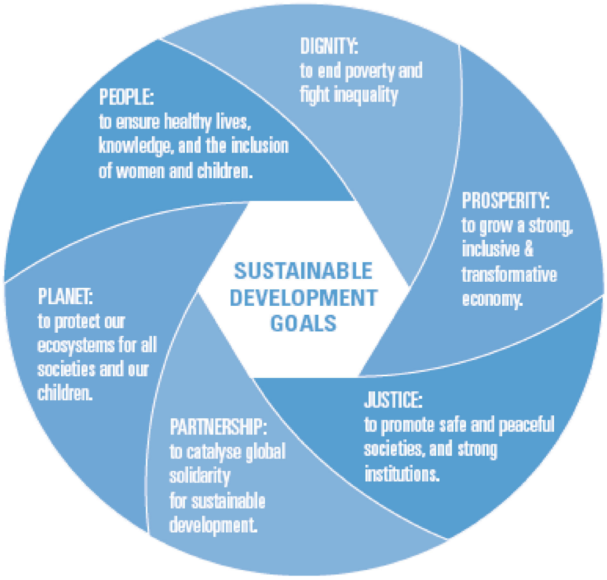

Figure 3. Essential Elements for Delivering the Sustainable Development Goals [34,60].

According to the United Nations Development Programme (UNDP) [61], quintessentially important issues for development include reducing poverty, ensuring gender equity and securing environment sustainability. Successful projects that have alleviated poverty tend to invest in, and efficiently utilise, human resources [38]. However, the prevailing customary system in developing countries means that women are often economically dependent upon men even though they are the domineering household matriarch (completing most of the chores and rearing children) and source of income generation activities [62]. Projects that empower women and free their time to become more independent enable them to be happier and healthier. With more free time, they can find quality work rather than being restricted to household work only [62]. Within this context, development of community based rural AD represents a viable option for improving the rural lifestyle of women and in so doing, generating sustainable development (Table 1).

Table 1. Possible Impact of Having an AD System (Based on Action) to Meet Sustainable Development Goals (SDGs) (Developed from [15,60–63].

SDGs	Action	Possible Impact of Having AD System
3	To ensure the health and wellbeing for people living within rural communities.	Support for the maintenance of good health and well-being.
4	To ensure a high quality and socially inclusive education and promote lifelong learning opportunities for all.	Contribution towards educating women and children.
5	To achieve gender equality and empower all women.	Empowerment of women by freeing their time to make more efficient contributions to their local community.
7	To ensure access to clean, affordable, reliable and sustainable energy for all people living in rural communities.	Biogas is a clean and affordable fuel.

3. Methodology

For this research a post-positivist and inductive methodological approach was adopted (with elements of an interpretivist epistemological lens) to assess whether the use of AD could enable rural people to meet SDGs (Table 1). A semi-structured survey of Bangladesh was undertaken (covering five districts and twenty plants built by three Bangladeshi extension agencies) to determine the impact of using AD on the lifestyles of plant owners. These districts were: (i) Dhaka; (ii) Manikgong; (iii) Narshindhi; (iv) Mymensingh; and (v) Barisal. Dhaka, Manikgong and Narshindhi are in the Dhaka division which is in the centre of Bangladesh, Mymensigh is in the northern part and Barisal is in the southern part (Figure 4). The three construction agencies were: (i) the Bangladesh Council of Scientific and Industrial Research (BCSIR); (ii) the Local Government Engineering Department (LGED); and (iii) the Grameen Shakti (GS). The districts were selected randomly but samples were chosen so that certain aspects were representative of a broader area such as: the transport system, biomass resources and biogas plant access. BCSIR, LGED and Grameen Shakti are three pioneering organisations within Bangladesh who deal with anaerobic digestion and biogas.

Figure 4. Map of Bangladesh Showing Dhaka (including Manikgong and Narshindhi), Mymensingh and Barisal [64].

AD Plants and Households Visited

A total of 20 biogas plants and the households that these supplied were visited (refer to Table 2). The survey investigated the overall performance of each biogas plant and its impact upon the rural lifestyle of the owners. A questionnaire was used as the main data collection instrument and sought to assess the socio-cultural impact (social, economic, environmental and health) of AD implemented within the community. Data collected consisted of both qualitative and quantitative data. Qualitative data sought to obtain the views, opinions and perceptions of the respondents in terms of reasons for AD usage and what the benefits to their families were. Quantitative data collected sought to delineate the numbers of plants visited, identify who installed these plants and report upon the time saved (or lost) as a result of using AD.

Table 2. Number of Biogas Plants and Households Visited in Different Districts of Bangladesh.

District	Number of Plants	Installed by		
		BCSIR	LGED	GS
Dhaka	4	1		3
Manikgong	7	2	2	3
Narshindhi	2			2
Mymensingh	3			3
Barisal	4	2		2
Total	20	5	2	13

During the survey and collection of primary data, the similar experiences of SNV, GIZ (German Development Organisation), Grameen Shakti (Gofran) and BCSIR (as secondary data sources) were reflected upon. Therefore, the primary data analysis was augmented by the analysis of secondary data to validate this current survey. Justification for this approach is founded upon a body of knowledge that suggests that quantitative data from each secondary source is unreliable [65]. Furthermore, the questionnaire allowed more than one response from each respondent and more than one respondent from each plant owning family. Therefore, there were 83 completed questionnaire surveys from 20 AD plant owning families. The response rate was 100% because the research team held one-to-one meetings with respondents before the survey commenced.

4. Results and Discussions

The research findings provide a comparison between the factors that motivated the purchase of biogas plants and the actual socio-economic impacts upon the daily life of owners.

4.1. Motivation Factors and Impacts

Respondents were asked to provide the most important reasons or motivating factors for the installation of biogas plants (refer to Table 3).

The most popular motivating factors were: economic benefits, including saving of time and energy (frequency (f) = 22); environmental benefits (f = 17); availability of subsidy (f = 8); and health benefits, including the reduction in smoke-borne diseases (f = 7). Given these attractive benefits, the installation of modern domestic biogas plants (as an alternative source of energy) has increasingly gained popularity within Bangladesh's rural communities [63]. However, commercialization of larger scale biogas plants are also increasingly popular and have positively contributed to upskilling the local populous [66]. A proportion of these biogas plants generate sufficient electricity to sell to the grid and generate surplus biogas that can be sold directly to neighbours [67]. Consequently, the installation of AD is already making a palpable contribution towards wider social and community development, particularly in terms of generating new industry and commerce (refer to Table 4).

Table 3. Motivating Factors to Install Biogas Plants and the Number of Responses.

	Motivating Factors	Frequency of Responses
1	Economic benefits (saving time and energy)	22
2	Environmental benefits (saving forest)	17
3	Subsidies	8
4	Health benefits	7
5	Motivation from service provider	7
6	Motivation from other plant owners	6
7	Non-availability of other fuel sources	5
8	Social benefits/Prestige	5
9	Fertilizer of higher nutrient value	4
10	Others	2

Table 4. Some Socioeconomic Characteristics and the Impact of Biogas Plants (Survey and Further Peer-Reviewed Analysis).

	Socioeconomic Characteristics	Impact
1	Demography (population pattern)	Reduction of the workload of women and improvement in child health.
2	Economic status (occupation, income)	Active participation of women in farming and development projects.
3	Educational status	Increase of the literacy percentile and levels of higher or further education.

4.2. Community Impact of Rural AD

To assess the impact of rural AD upon the community, a number of aspects were considered within the survey, namely: impact of time saving and workload reduction; impact upon saving of conventional fuel sources; economic impact/community development; environmental impact; impact of bio-slurry; and the wider impact of rural AD and SDGs.

4.2.1. Impact of Time Saving and Workload Reduction

The respondents, especially women, reported a significant time saving by using biogas for cooking rather than wood fuel. The survey revealed that, on average, people saved 50 min per day by cooking meals using biogas instead of solid fuels. In addition, and because biogas burns cleanly, a significantly reduced need to clean equipment was also observed with an average of 28 min being saved per household per day. 14 households collected fuel wood from a nearby jungle and their own land. The total time saved per household per day from not collecting fuel wood ranged from 25 min to 1 h, with an average of 42 min. Collection of water and the time required to feed a plant was only 6 and 9 min respectively. Extra time required for animal husbandry was minimal when dung was collected for digester feeding. Only two respondents answered that more time was needed for cattle husbandry because they now feed their cattle in their stalls to allow them to collect more dung to feed into the digester. However, the average time required for cattle husbandry was only 2 min per household per day. In total, the research revealed that AD can reduce the time required to undertake domestic activities by up to 1 h and 43 min per day per household (refer to Table 5). This surplus time could be used for: livestock management; technology development; and extra education for both women and children. Some additional time is required to operate the AD plant but such maintenance time is minimal in comparison. Therefore, AD can significantly contribute to poverty alleviation, improved gender equality and women's empowerment.

Table 5. Average Time Saved After the Installation of Biogas Plant.

Activity	Average Time Saved/Added Per Minute Per Day	Remarks
Cooking of meal	50	Time saved
Cleaning of cooking vessels	28	Time saved
Collection of fuel	42	Time saved
Collection of water	−6	Time added
Feeding of plant	−9	Time added
Caring of cattle	−2	Time added
Average time savings	103 min (1 h 43 min)	

4.2.2. Impact on Saving of Conventional Fuel Sources

A direct benefit of a biogas plant to rural households is accrued from the financial savings made by replacing conventional fuel sources for cooking and lighting [68,69]. For example, Rahman [63] reveals that a 3.2 m^3 AD plant would replace annually approximately 1.9 ton of fuel wood for cooking and 55 L of kerosene used for lighting. Biogas therefore has a proven ability to reduce fossil fuel dependency, where the latter: has limited supply; consumes finance both from the family and government (via subsidy); and contributes towards global climatic change. Replacing fuel wood with biogas for cooking ensures a more comfortable, smoke-free environment, reduces expenditure and saves time. Replacing kerosene lamps with biogas lights ensures a safer study environment for rural children. Cumulatively, these palpable benefits have a positive impact upon rural education and daily life in the community.

4.2.3. Economic Impact/Community Development

Domestic biogas programmes are often justified on the basis of the private benefits and costs savings for individual households [70]. However, there are also benefits to the wider environment. Gofran [18] estimates that one 2.4 m^3 biogas plant can save circa 2.4 ton of biomass per year if operated efficiently [71]. A survey of 66 biogas plants (undertaken by SNV) revealed that an average of 156 kg of wood fuel can be saved per household per month [47]. In addition, the World Wildlife Fund claims that the establishment of 1000 biogas plants saves 33.8 hector of forest being clear-felled [44]. Talukder's survey of 30 biogas plants [67] serves to identify the different types of biogas plants operated within Bangladesh. The results reveal that approximately 78% of the 30 plants surveyed were between 2 and 10m^3 in size. Commercial biogas plants can be used to generate income. Interestingly, some of the larger poultry farmers in Bangladesh were seen to be actively generating, selling and distributing biogas to their neighbours. Typical charges range between 300–500 taka (£3–£5 UK sterling) per month per family. This supplementary source of income (in addition to the money saved by the owner by cooking with biogas in their own home) helps the owner pay back the total cost of biogas installation in a shorter period of time [72].

The financial benefits are likely greater when people switch from liquid petroleum gas (LPG) to biogas, as opposed to changing from collected wood to biogas. Moreover, it is likely to be more difficult for a group of population to invest in biogas due to a lack of financial savings following installation, therefore alternative methods of financing are necessary in order for many people of developing countries with zero-grazing livestock to gain access to biogas technology [73]. The availability of affordable finance is critical to promoting the use and development of biogas technology. Even where generous government subsidies are available, affordable finance is a prerequisite requirement for poor rural households who need to invest in AD plant which often has a payback over several years. Aside traditional sources of funding (such as government, banks and other financial institutions), a growing trend is to use 'micro-finance' or 'crowd funding' to generate the necessary income and avoid high interest charges [74,75]. The development of a Carbon Credit Market can be an important way to increase the economic convenience of rural biogas technology.

4.2.4. Environmental Impact

If dried animal manure (such as cow dung) is used directly for cooking, the CO_2 emissions from 1 tonne of animal manure is 0.648 ton; yet conversely, if animal manure fuels an AD plant and the gas produced is used for cooking, then the CO_2 emissions per ton of animal manure is equal to 0.0677 ton [76]. Using these values, CO_2 emission mitigation through biogas plants from one ton of animal manure is 0.5803 ton CO_2 equivalent. The total possible CO_2 emission mitigation is 46.58 million tonnes per year if 3.67 million family biogas plants can be built in Bangladesh. Biogas use is also expected to have longer term benefits related to environmental preservation for biodiversity. An average rural household of five members burns about three metric tons of biomass per annum [72].

Biomass can be used as raw material to generate liquid, gaseous and solid fuels to play a sustainable role in a more diverse and sustainable energy mix. Biomass is potentially the most attractive renewable energy resource available because it is widely dispersed and could contribute zero net carbon dioxide emission to the atmosphere [77]. SNV/IDCOL states that one 'properly functioning' homestead biogas plant prevents the release of 2.5 ton of CO_2 over a period of one year compared to burning biomass. There is no way (other than taking bioenergy and solar energy) for reducing environmental degradation for a developing country [78].

4.2.5. Impact of Bio-Slurry

Bio-slurry (a by-product of AD) is also beneficial as a viable replacement for expensive chemical fertilizers [24,79]. Bio-slurry does need to be properly treated but has no global warming potential (GWP) impact. In addition, nutrient rich bio-slurry also acts as a soil conditioner by building up the soil structure, especially when the land is intensively farmed over several years, thus safeguarding soil fertility [80].

4.2.6. Rural AD and SDGs—Development of the Conceptual Model

Proper utilization of the benefits from AD (e.g., energy and fertilizer production) can contribute to the further development of the rural community. Acquiring these benefits involves management of the technology through community ownership, capacity building and training/competence development [81]. In turn, this will ensure livelihood improvement and simultaneously engage rural women in development activities. Concomitant benefits include improved maternal health and reduction in child mortality because women have less arduous work to do and can devote more time to their families and/or fund childcare support. This eventually helps to reduce poverty and therefore works towards satisfying the UN's MDGs and SDGs. Enhancing rural biogas programmes saves labour time and provides children and women with opportunities to pursue education, thus improving social equity within a community (refer to the conceptual model represented in Figure 5). Integration of an external agency, bank and/or micro-finance organisation can help to facilitate the implementation of a community-based AD program (as an iterative chain of events)–further increasing women's empowerment (Figure 6). First and foremost, education provides a gateway for rural communities to seek training in areas such as microcredit to encourage the development of small AD projects. Various rural development programmes in Bangladesh (administered by groups such as Grameen Shakti) have already recognised these benefits [82]. Continuation of this trend is essential for developing further the implementation of a biomass and bioenergy program within rural communities.

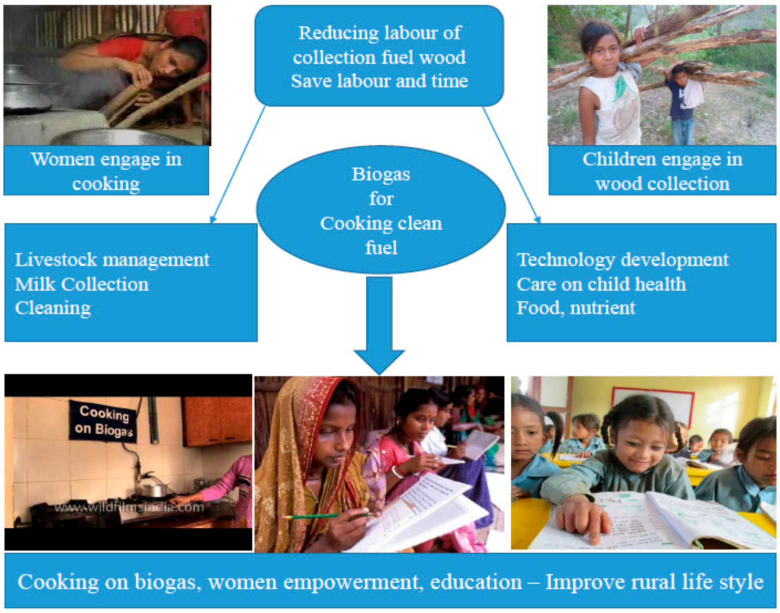

Figure 5. Cooking on Biogas Changes the Lifestyle of Women and Children and Ensures an Emission-Free, Healthy Life.

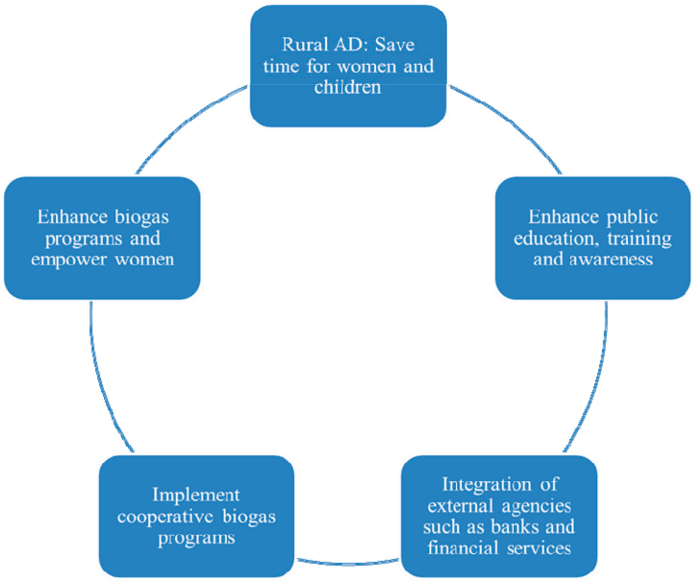

Figure 6. A Circular Model to Implement Community Based Cooperative AD and Ensure Rural Empowerment.

Biomass, which is an important source of bioenergy, play an essential role in creating options for affordable and clean energy, particularly in developing countries. The Sustainable Development Goal 7 (SDG7) seeks to address four themes in the goal statement: "Ensure access to affordable, reliable, sustainable and modern energy for all [83]." Biogas production and upgrading techniques could be used for energy production as a means of realizing the SDG goal 7 within the next 15 years [84]. The formulation of SDG7 produces a circular definition of sustainability, a difficulty that is currently resolved at the level of the targets and indicators in a way that regards energy technologies primarily as artefacts [85].

The economic growth and sustainable progression of developing countries is dependent upon a reliable source of energy. Deficient coverage and the poor quality of energy supply are key barriers to development of both the industrial and agricultural sectors. Therefore, a bold and innovative strategy for sustainable development of the energy sector needs to be emphasized. Demand for biofuels has been growing as fossil fuels are becoming increasingly a more expensive and rarer commodity. The opportunity to 'mass deploy' domestic and community based medium AD plants is extremely encouraging. Public sector bodies and private finance enterprises are actively involved in supporting biofuel production schemes. Using AD vis-à-vis wood fuel can provide sufficient energy for domestic consumption and generate enough bio-fertiliser to enrich the farm land to increase harvest production.

Any initiative to promote and support sustainable development must be based upon the premise that it resolves prevailing social, economic and environmental issues [24]. The proper management of biogas plants could be ensured through the introduction of bespoke training of rural people in their operation and maintenance [44]. The overwhelming evidence within academic literature indicates that the use of AD can significantly improve the social welfare of vulnerable people living in rural communities. In addition, AD has the potential to mitigate climate change by reducing GHG emissions (SDG13) and enhance the energy self-reliance of energy deficit countries. Thus, the effective use of AD has the potential to contribute to poverty reduction (SDG1) and ensure clean and affordable fuel to the rural community (SDG7). Integrating all the benefits from AD could be a vital scheme for community development. The implementation of a community based cooperative AD model would be beneficial for many rural areas or districts in fuel poverty globally.

5. Conclusions

Rural biogas extension programmes have a number of beneficial impacts related to positive motivation through work time saved. This provides major benefits to rural families, bringing them closer to meeting the UN's SDGs in terms of economic, environmental, health, social and cultural aspects of national development. These benefits are recognised by rural people in Bangladesh and this has motivated them to purchase biogas plants. The survey results presented demonstrate an average time saving of 1 h 43 min a day for women using a biogas plant. A community-based biogas plant has a significant impact upon rural community development through increasing child education and women empowerment. The time saved (through reduced time for cooking meals, reduced collection of firewood and less cleaning of cooking vessels) can be used to improve the education of women and children. There are also significant health benefits to be accrued if biogas replaces cooking using wood fuel, such as irritation to eyes, nose and the respiratory system. Furthermore, the benefits extend to the wider environment: by reducing the need to collect wood fuel the rate of deforestation also reduces, thus giving an opportunity for biodiversity to recover. Biogas stoves are more efficient than wood fires, so the amount of CO_2 released is also reduced. Therefore, the implementation of rural bioenergy could help in realising a number of SDGs (such as SDG 3, 4, 5 and 7).

6. Limitation and Recommendation for Further Research

The existing socioeconomic conditions of many rural areas of developing countries make them still unsuitable for a sustainable development project, where the largest challenges are always faced at the beginning of a project. A programme could be hindered due to many reasons such as: severe poverty, lack of awareness, limited access of expertise, indifference to accepting new technology and social, cultural and religious issues. These limitations could be overcome through the active participation of people in a rural bioenergy system. Positive initiatives to support the development of more widespread 'national' bioenergy schemes for Bangladesh could include: introducing a bioenergy training centre; increasing public awareness; and offering an easier and longer duration repayment loan to rural farmers. Future investigation and research are needed to explore these limitations and determine how to best overcome them, and also to implement some of these aforementioned positive initiatives and measure their success or otherwise. It would also be prudent to compare the efficiencies of biogas production to determine how such could be improved further.

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References

1. The Guardian. Sustainable Development Goals: Changing the World in 17 Steps—Interactive. 2015. Available online: https://www.theguardian.com/global-developmentsustainable-development-goals-changing-world-17-stepsinteractive (accessed on 10 May 2018).
2. Sachs, J.D. From millennium development goals to sustainable development goals. *Lancet* **2012**, *379*, 2206–2211. [CrossRef]
3. Selinger, E. Technology transfer: What can philosophers contribute? *Philos. Public Policy Q.* **2007**, *27*, 12–17.
4. Mahmood, S.A.I. Impact of climate change in bangladesh: The role of public administration and government's integrity. *J. Ecol. Nat. Environ.* **2012**, *4*, 223–240. [CrossRef]
5. Foster-Turley, P.; Das, R.; Hasan, M.K.; Hossain, P.R. USAID Bangladesh: Bangladesh Tropical Forests and Biodiversity Assessment. 2016. Available online: https://www.usaid.gov/documents/1865/bangladesh-tropical-forests-and-biodiversity-assessment (accessed on 10 May 2018).
6. World Bank. World Bank Data on Rural Population (% of Total Population). 2015. Available online: data.worldbank.org/indicator/SP.RUR.TOTL.ZS (accessed on 2 April 2019).
7. Douglas, F.B.; Robert, V.D.P.; Floor, W. Tackling the rural energy problem in developing countries. The world economic outlook. A survey by the staff of the international monetary fund. *Financ. Dev.* **1997**, *34*, 11–15.
8. World Bank. Forecasts Global Poverty to Fall Below 10% for First Time; Major Hurdles Remain in Goal to End Poverty by 2030. 2015. Available online: www.worldbank.org (accessed on 6 October 2015).
9. Negash, D.; Abegaz, A.; Smith, J.U.; Araya, H.; Gelana, B. Household energy and recycling of nutrients and carbon to the soil in integrated crop-livestock farming systems: A case study in Kumbursa Village, central highlands of ethiopia. *GCB Bioenergy* **2017**, *9*, 1588–1601. [CrossRef]
10. Muthu, D.; Venkatasubramanian, C.; Ramakrishnan, K.; Sasidhar, J. Production of biogas from wastes blended with cow dung for Electricity generation—A Case study. *Earth Environ. Sci.* **2017**, *80*, 012055.
11. Cantrell, K.B.; Ducey, T.; Ro, K.S.; Hunt, P.G. Livestock waste-to-bioenergy generation opportunities. *Bioresour. Technol.* **2008**, *99*, 7941–7953. [CrossRef]
12. Manyi-Loh, C.E.; Mamphweli, S.N.; Meyer, E.L.; Okoh, A.I.; Makaka, G.; Simon, M. Microbial anaerobic digestion as an aapproach to the decontamination of animal wastes in pollution control and the generation of renewable energy. *Int. J. Environ. Res. Public Health* **2013**, *10*, 4390–4417. [CrossRef]
13. Litmanen, S.; Kirchmeyr, F. *The Use of Digestate as an Organic Fertiliser*; Environmental Laboratory, EBA—European Biogas Assocation: Hertfordshire, UK, 2014.
14. Van Nes, W.; Lam, J.; ter Heegde, F.; Marree, F. *Building Viable Domestic. Biogas Programmes: Success Factors in Sector Development*; SNV Netherlands Development Organisation: The Hague, The Netherlands, 2009.
15. Rahman, K.M.; Melville, L.; Fulford, D.; Huq, S.M.I. Green-house gas mitigation capacity of a small scale rural biogas plant calculations for bangladesh through a general life cycle assessment. *Waste Manag. Res.* **2017**, *35*, 1023–1033. [CrossRef]
16. Nath, T.K.; Baul, T.K.; Rahman, M.; Islam, M.T.; Rashid, M.H. Traditional biomass fuel consumption by rural households in degraded sal (Shorea Robusta) forest areas of bangladesh. *Int. J. Emerg. Technol. Adv. Eng.* **2013**, *3*, 537–544.
17. Van Nes, W.J. *Feasibility of a National Programme on Domestic Biogas in Bangladesh*; Technical Report; Biogas Practice Team Ed.; Netherlands Development Organisation: The Hague, The Netherlands, 2005.
18. Gofran, M.A. *Biogas Projukti (Biogas Technology—Translated by Author)*; Report; Bangladesh Biogas Development Foundation: Dhaka, Bangladesh, 2009.
19. Sinha, A.H.M.M.; Enayetullah, I. Study waste concern and worldwide recycling: Financing Dhaka market composting with public-private partnerships and carbon credits. In *Solid Waste Management in the World's Cities*; UN-Habitat: London, UK; Washington, DC, USA, 2010; ISBN 978-1-84971170-8.

20. Choudhury, R.C.M. Draft report of the inaugural meeting on the regional 3R forum in Asia, 11-12 November, 2009. In *Solid Waste Management in the World's Cities*; UN-Habitat: London, UK; Washington, DC, USA, 2009; ISBN 978-1-84971170-8.
21. Dhaka City Corporation. *Dhaka City State of Environment Report*; Dhaka City Corporation: Dhaka, Bangladesh, 2004.
22. Biswas, W.K.; Lucas, N.J.D. Economic vability of biogas technology in a Bangladesh village. *Energy* **1997**, *22*, 763–770. [CrossRef]
23. Stuart, E.; Bird, K.; Bhatkal, T.; Greenhill, R.; Lally, S.; Rabinowitz, G.; Samman, E.; Binat, M.S.; Lynch, A. Development Progress, Overseas Development Institute, Leaving No One Behind, A critical path for the First 1000 Days of the Sustainable Development Goals, Flagship Report. 2016. Available online: https://www.odi.org/publications/10489-leaving-no-one-behind-critical-path-first-1000-days-sustainable-development-goals: (accessed on 22 June 2018).
24. Fulford, D.J. *Small-Scale Rural Biogas Programmes*; Practical Action Publisher: Rugby, UK, 2015.
25. Smith, K.R.; Uma, R.; Kishore, V.V.N.; Zhang, J.; Joshi, V.; Khalil, M.A.K. Greenhouse implications of household stoves: An analysis for India. *Annu. Rev. Energy Environ.* **2000**, *25*, 741–763. [CrossRef]
26. UNEP. Indoor Air Pollution from Solid Fuels. *GEO Year Book 2006.* 2006. Available online: http://www.unep.org/geo/yearbook/yb2006/056.asp (accessed on 6 March 2019).
27. Edwards, R.; Kirk, R.; Smith, U.C. Households Stoves: Energy, Health, and Global Warming. 2002. Available online: http://www.giss.nasa.gov/meetings/pollution2002/present/3_Edwards (accessed on 6 March 2019).
28. Smith, P.; Martino, D.; Cai, Z.; Gwary, D.; Janzen, H.; Kumar, P.; McCarl, B.; Ogle, S.; Mara, F.O.; Rice, C.; et al. Agriculture. In *Climate Change 2007: Mitigation*; Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK; New York, NY, USA, USA. 2007.
29. BBS. *Statistical Yearbook at Bangladesh*; Bangladesh Bureau of Statistics, Ministry of Planning, Planning Division, Government of the Peoples Republic of Bangladesh: Dhaka, Bangladesh, 2006.
30. Foell, W.; Pachauri, S.; Spreng, D.; Zerriffi, H. Household cooking fuels and technologies in developing economies. *Energy Policy* **2011**, *39*, 7487–7496. [CrossRef]
31. Lim, S.S.; Vos, T.; Flaxman, A.D.; Danaei, G.; Shibuya, K.; Adair-Rohani, H.; AlMazroa, M.A.; Amann, M.; Anderson, H.R.; Andrews, K.G. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the global burden of disease study 2010. *Lancet* **2012**, *380*, 2224–2260. [CrossRef]
32. Rosenthal, J. The real challenge for cook stoves and health: More evidence. *EcoHealth* **2015**, *12*, 8–11. [CrossRef] [PubMed]
33. Gautam, R.; Baral, S.; Herat, S. Biogas as a sustainable energy source in nepal: Present status and future challenges. *Renew. Sustain. Energy Rev.* **2009**, *13*, 248–252. [CrossRef]
34. UN. The road to dignity by 2030: Ending poverty, transforming all lives and protecting the planet. In *Synthesis Report of the Secretary-General on the Post-2015 Agenda*; UN: New York, NY, USA, 2015.
35. Cecelski, E.; Dutta, S. Mainstreaming Gender in Energy Projects: A Practical Handbook, ENERGIA International Network on Gender and Sustainable Energy, Practical Action. 2011. Available online: http://www.energia.org/cm2/wp-content/uploads/2016/02/01.-Mainstreaming_gender_in_energy_projects_A_practical_Hand_book1.pdf (accessed on 17 May 2018).
36. Danielsen, K. *Gender Equality, Women's Rights and Access to Energy Services*; An inspiration paper in the run-up to Rio+20; Ministry of Foreign Affairs of Denmark: Copenhagen, Denmark, 2012.
37. Chen, M. Action for Equality, Women and Poverty Development and Peace. In Proceedings of the United Nations Conference, Beijing, China, 4–15 September 1995.
38. Siddique, M.A.B. *Gender Issues in Poverty Alleviation: A Case Study of Bangladesh*; Discussion Paper 96.20; The University of Western Australia: Perth, Australia, 1996.
39. Chant, S. *Revisiting the "Feminisation of Poverty" and the UNDP Gender Indices: What Case for a Gendered Poverty Index*; Gender Institute: London, UK, 2006.
40. Marcoux, A. *The Feminization of Poverty: Facts, Hypotheses and the Art of Advocacy*; FAO: Budapest, Hungary, 1997.

41. Wheldon, A.; Sharma, C.; Haves, E.; Dobbs, E.; Wheldon-Bayes, S. Women and Sustainable Energy—How the work of Ashden Award Winners Impacts the Lives of Women and Girls. Ashden Report. 2015. Available online: http://www.energia.org/cm2/wp-content/uploads/2016/02/DFID-Energia-Ashden-Report-Public-Summary-Feb-2015-1.pdf (accessed on 17 May 2018).
42. Fontana, M.; Natali, L. Gendered patterns of time use in Tanzania: Public investment in infrastructure can help? In *IFPRI Project on Evaluating the Long-Term Impact of Gender-Focused Policy Interventions*; IFPRI: New York, NY, USA, 2008.
43. Islam, S.M.; Mainuddin, A. Relationship between income generating activities of rural women and their reproductive health behaviour in Bangladesh. *Rural Remote Health* **2015**, *15*, 3216.
44. Fulford, D.; Devkota, G.P.; Afful, K. *Evaluation of Capacity Building in Nepal and Asia Biogas Programme*; Report by Kingdom Bioenergy; Kingdom Bioenergy Ltd for SNV: Hanoi, Vietnam, 2012.
45. WHO. Burden of Disease from Household Air Pollution for 2012. World Health Organisation Report. 2014. Available online: go.nature.com/smuctx (accessed on 16 May 2018).
46. UNDP. Generating Opportunities: Case Studies on Energy and Women. 2001. Available online: https://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/generating_opportunitiescasestudiesonenergyandwomen.html (accessed on 4 September 2017).
47. Bajgain, S.; Shakya, I. *The Nepal Biogas Support Programme—Successful Model of Public Private Partnership*; Report for SNV (Netherlands Development Organisation) by BSP (Biogas Support Programme) Kathmandu; SUV: The Hague, Netherlands, 2005.
48. Ashden Awards. Biogas Sector Partnership Nepal: Domestic Biogas for Cooking and Sanitation. Case study for Ashden Awards for Sustainable Energy. 2005. Available online: www.ashden.org/winners/biogas-sector-partnership-bsp (accessed on 5 May 2018).
49. Fulford, D.J. Energy Technologies. In *Women's Issues and Reflection*; Manohar, C., Ed.; ISPCK Delhi: Delhi, India, 2012; ISBN 978-81-8465-255-0.
50. Ashden, A. Grameen Shakti/Rapidly Growing Solar Installer also Provides Clean Cooking Case Study for Ashden Awards for Sustainable Energy. 2008. Available online: www.ashden.org/winners/grameen-shakti (accessed on 5 May 2018).
51. Ashden, A. The Appropriate Rural Technology Institute (ARTI)/Biogas from Food Waste for Urban Homes. Case Study for Ashden Awards for Sustainable Energy. 2006. Available online: www.ashden.org/winners/the-appropriate-rural-technology-institute-arti (accessed on 5 May 2018).
52. Islam, M.; Chandra Sarker, P.; Kumar Ghosh, S. Prospect and advancement of solar irrigation in Bangladesh: A review. *Renew. Sustain. Energy Rev.* **2017**, *77*, 406–422. [CrossRef]
53. Ashden, A. BIOTECH/Turning Food Waste into Cooking Gas; Case Study for Ashden Awards for Sustainable Energy. 2007. Available online: www.ashden.org/winners/biotech (accessed on 5 May 2018).
54. Ashden, A. SKG Sangha/Biogas Plants Provide Cooking and Fertiliser. Case Study for Ashden Awards for Sustainable Energy. 2007. Available online: www.ashden.org/winners/skg-snagha (accessed on 5 May 2018).
55. Kountouris, Y.; Makuch, Z.; Tan Loh, E.F. *Quantification and Evaluation of the Voluntary Carbon Market's Co-Benefits (Parts I and II)*; Report for ICROA; Imperial College London University: London, UK, 2014.
56. Bagepalli Coolie Sangha, BP. Biodigesters, India (Biogas CDM Project of Bagepalli Coolie Sangha). 2017. Available online: https://www.bptargetneutral.com/us/how-we-work/our-projects/cookstoves-india/ (accessed on 1 September 2017).
57. Langbein, J. Firewood, smoke and respiratory diseases in developing countries-The neglected role of outdoor cooking. *PLoS ONE* **2017**, *12*, e0178631. [CrossRef] [PubMed]
58. Karki, A.B.; Shakya, I.; Dawadi, K.D.; Sharma, I. *Biogas Sector in Nepal*; Highlighting Historical Heights and Present Status; Nepal Biogas Promotion Group (NBPG): Kathmandu, Nepal, 2007.
59. United Nations Development Programme. From the MDGs to Sustainable Development for All—Lesson from 15 years of Practice. 2016. Available online: http://www.globalamalen.se/wp-content/uploads/2016/05/From-MDGs-to-SDGs-Lessons-of-15-years-of-practice.pdf (accessed on 18 May 2018).
60. UN. The Road to Dignity by 2030: Ending Poverty, Transforming All Lives and Protecting the Planet. Synthesis Report of the Secretary-General on the Post-2015 Agenda. 2014. Available online: http://www.un.org/ga/search/view_doc.asp?symbol=A/69/700&Lang=E (accessed on 2 March 2019).
61. UNDP. *Human Development Report*; Oxford University Press: Oxford, UK, 1995.

62. Lee, Y.S.; Waite, L.J. Husbands' and wives' time spent on housework: A comparison of measures. *J. Marriage Fam.* **2005**, *67*, 328–336. [CrossRef]
63. Rahman, K.M. Determination of the Potential Energy Contribution and Green House Gas Mitigation of Small and Medium Anaerobic Digester Systems in Bangladesh. Ph.D. Thesis, University of Brighton, Eastbourne, UK, 2012.
64. Free World Map. Bangladesh Political Map. 2018. Available online: http://www.freeworldmaps.net/asia/bangladesh/political.html (accessed on 5 May 2018).
65. Wilson, D.C.; Adebisi, O.A.; Kaine, C. Building recycling rates through the informal sector. *Waste Manag.* **2009**, *29*, 629–635. [CrossRef] [PubMed]
66. Gofran, M.A.; (Biogas consultant, Grameen Shakti, Dhaka, Bangladesh). Personal communication, 2009.
67. Talukder, S.I. Impact Assessment of Biogas Plants: A Case Study in Bangladesh. Master's Thesis, University of Flensburg, Flensburg, Germany, 2010.
68. Rao, D.N. Kerosene subsidies in India: When energy policy fails as social policy. *Energy Sustain. Dev.* **2012**, *16*, 35–43. [CrossRef]
69. Rehman, I.; Kar, A.; Banerjee, M.; Kumar, P.; Shardul, M.; Mohanty, J.; Hossain, I. Understanding the political economy and key drivers of energy access in addressing national energy access priorities and policies. *Energy Policy* **2012**, *47*, 7–37. [CrossRef]
70. Srinivasan, S. Positive externalities of domestic Biogas initiatives: Implications for financing, renewable and sustainable energy reviews. *Renew. Sustain. Energy Rev.* **2008**, *12*, 1476–1484. [CrossRef]
71. UNEP. *United Nations Environment Program Bangladesh: State of the Environment*; United Nations Environment Program Bangladesh: Dhaka, Bangladesh, 2000.
72. IDCOL; SNV. Implemented Plan on National Domestic Biogas and Manure Program (NDBMP) in Bangladesh Islam, M.S. 2006, Presentation–Biogas Programs in Bangladesh: A Solution to Growing Fuel Crisis in Rural Households. Dhaka, Bangladesh, March 2006. Available online: http://www.reein.org/biomass/presentation/biogas.htm (accessed on 6 April 2019).
73. Hamlin, Alison. *Assessment of Social and Economic Impacts of Biogas Digesters in Rural Kenya*; Independent Study Project (ISP) Collection: Nairobi, Kenya, 2012; p. 1247.
74. Biswas, W.K.; Bryce, P.; Diesendorf, M. Model for empowering rural poor through renewable energy technologies in Bangladesh. *Environ. Sci. Policy* **2001**, *4*, 333–344. [CrossRef]
75. Nancy, B.; Elaine, C. Learning about women. Economic development, entrepreneurship and the environment in India: A Case Study. *J. Dev. Entrep.* **2007**, *12*, 4.
76. Bahauddin, K.M.; Salahuddin, T.M. Prospect and trend of renewable energy and its technology towards climate change mitigation and sustainable development in Bangladesh. *Int. J. Adv. Renew. Energy Res.* **2012**, *1*, 156–166.
77. Islam, M.R.; Parveen, M.; Islam, M.R.; Haniu, H. Technology development for bio-crude oil from pyrolysis of renewable biomass resource. In Proceedings of the 2009 1st International Conference on the Developements in Renewable Energy Technology (ICDRET), Dhaka, Bangladesh, 17–19 December 2009.
78. Islam, M.R.; Islam, M.R.; Beg MR, A. Renewable energy resources and technologies practice in Bangladesh. *Renew. Sustain. Energy Rev.* **2008**, *12*, 299–343. [CrossRef]
79. Gutser, R.; Ebertseder, T.; Weber, A.; Schraml, M.; Schmidhalter, U. Short-term and residual availability of nitrogen after long-term application of organic fertilizers on arable land. *J. Plant Nutr. Soil Sci.* **2005**, *168*, 439–446. [CrossRef]
80. Warnars, L. Bioslurry: A Supreme Fertiliser Positive Effects of Bioslurry on Crops. In Proceedings of the IFOAM Organic World Congress 2014, "Building Organic Bridges", Istanbul, Turkey, 13–15 October 2014.
81. Rowse, L.E. Design of Small Scale Anaerobic Digesters for Application in Rural Developing Countries. Graduate Thesis, University of South Florida, Tampa, FL, USA, 2011.
82. Grameen Shakti. A Report on Biogas Plant Bangladesh. 2005. Available online: http://www.gshakti.org/index.php?option=com_content&view=article&id=61&Itemidter (accessed on 17 July 2018).
83. Bull, G. Background study prepared for the thirteenth session of the United Nations Forum on Forests, United Nation Forum on Forest. In Proceedings of the United Nations Forum on Forests Secretariat, New York, NY, USA, 7–11 May 2018.

84. Dada, O.; Mbohwa, C. Energy from waste: A possible way of meeting goal 7 of the sustainable development goals. *Mater. Today Proc.* **2018**, *5*, 10577–10584. [CrossRef]
85. Hillerbrand, R. Why affordable clean energy is not enough. A capability perspective on the sustainable development goals. *Sustainability* **2018**, *10*, 2485. [CrossRef]