Wuppertal Institute
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Julia Terrapon-Pfaff, Carmen Dienst, Julian König, Willington Ortiz

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Results from a post-evaluation on project-level

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How effective are small-scale energy interventions in developing countries? Results from a post-evaluation on project-level.

Julia Terrapon-Pfaff*
Wuppertal Institute for Climate, Environment and Energy GmbH/
P.O. Box 100480, 42004 Wuppertal
e–mail: julia.pfaff@wupperinst.org

Carmen Dienst
Wuppertal Institute for Climate, Environment and Energy GmbH
P.O. Box 100480, 42004 Wuppertal
e–mail: carmen.dienst@wupperinst.org

Julian König
Wuppertal Institute for Climate, Environment and Energy GmbH
P.O. Box 100480, 42004 Wuppertal
e–mail: julian.koenig@wupperinst.org

Willington Ortiz
Wuppertal Institute for Climate, Environment and Energy GmbH
P.O. Box 100480, 42004 Wuppertal
e–mail: willington.ortiz@wupperinst.org

*Corresponding author

ABSTRACT

In many developing countries large parts of the population are negatively affected by the lack of access to clean and affordable energy. Providing sustainable energy services to these people has been acknowledged as a key component to reduce poverty. One form of development assistance to address the needs of the energy-poor at the local level are small-scale renewable energy projects. Like all development interventions, these energy projects are not intended to produce short-term outputs, but to create long-term impacts. Thus, it has become increasingly important to evaluate and accurately assess their sustainability. But despite the widely recognized need to identify successes factors and explain failure only few studies exist that address the sustainability of small-scale of energy development efforts post implementation. Against this background the paper presents the results of a post-evaluation of 23 projects supported via the Sustainable Energy Project Support (SEPS) scheme of the WISIONS initiative run by the Wuppertal Institute. The analysis provides insights on the influence that socio-economic, environmental, geographic and gender factors can have on the sustainability of small-scale renewable energy projects in developing countries.

KEYWORDS

Small-scale renewable energy, developing countries, post-evaluation, sustainability, geography, gender

1. INTRODUCTION

Today about 2.6 billion people still lack access to clean, affordable and reliable energy services to meet their basic energy needs [1]. One of the solutions that are expected to play a vital role in increasing and improving energy access are renewable energy technologies. These technologies offer the possibilities to provide clean electricity, heating, cooking and lighting solutions to people and communities, who so far depend on traditional and often inefficient use of local energy sources and/ or expensive fossil fuels. But despite the technical developments and the price decrease in recent years these technologies are still confronted with a number of social, economic and structural issues. To address theses challenges a deeper understanding of the aspects that influence the effectiveness and sustainability of these technologies within the development context is needed.

But while different efforts exist to model decentralized energy systems in developing countries, so far only a limited number of studies have addressed the question of sustainability with regards to small-scale localized energy systems post-implementation. Others modelled decentralized energy systems for rural electrification in developing countries considering regional disparity like Herran and Nakata [2] or Bekele and Tadesse [3] who modeled small Hydro/ PV/ Wind hybrid system for off-grid rural electrification. Others studies deliver valuable insights on technical and economic aspects, like Dufo-Lópe et al. [4] who analyses off-grid PV-powered community kitchens or Cheng et al. [5] who conducted a technical assessment of small-sized biogas systems in Nepal, The exceptions that have addressed sustainability of small-scale systems post-implementation include for example Ferrer-Martı´ et al. [6] who evaluated three small-scale wind electrification projects, Hong and Abe [7], who assessed the sustainability of off-grid rural electrification projects in the Philippines, Brass et al. [8] who analysed generation projects in the developing world or the study from Ilskog [9] which investigated the sustainability of PV projects. Although these assessments are an important contribution towards the widely acknowledged need to evaluate development efforts with regard to their impacts and sustainability, they are limited to a specific technology and/ or a specific region. Cross-cutting analyses that address impacts and sustainability issues across regions and technologies are however missing.

Hence, this paper aims to address this research gap and increase the knowledge on elements that support or hinder sustainability of small-scale energy development efforts by reviewing 23 sustainable energy projects, which have been supported within the SEPS scheme (Sustainable

Energy Project Support) of the WISIONS initiative[1]. These projects supported innovative approaches and capacity development to respond to energy needs at the local level, focusing on different energy related needs, technologies and implementation concepts within different geographical contexts. The review was carried out 2-8 years after the first introduction of the technologies. While this time period is not sufficient to speak of long-term success the fact that the technology was still functioning and utilized by the users at the time of the review can be used as an indicator on whether or not long-term sustainability is likely to be accomplished. The findings presented in this paper particularly focus on the roles socio-economic, gender and geographical factors play for the technical sustainability.

2. METHODS

The results presented in this paper are based on a) the empirical findings of a post implementation evaluation of 23 small-scale projects, supporting various sustainable energy technologies as well as efficiency measures in developing countries and b) on secondary data like project documentation, field visits to some of the projects and literature. The empirical data was acquired through semi-structured in-depth interviews with the organizations that implemented and monitored the initial project activities. The questions of the survey addressed the following aspects (I) overall project sustainability, (II) technology, (III) social and economic aspects, (IV) environment, (V) replication and dissemination and (VI) policy development. In addition the issues of external effects were addressed in the interviews. While the structure of the interviews was equivalent, some of the questions were only applicable to some of the projects, consequently the questions varied to a certain extent depending on the project design and the implemented technology. The data collected consists of measurable data, such as the number of installations still functioning or increase in the number of beneficiaries over time, as well as qualitative aspects, such as user satisfaction, impacts on society, awareness-raising or network development.

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[1] "WISIONS of sustainability" is an initiative by the Wuppertal Institute supported by the Swiss-based foundation ProEvolution. It was launched in 2004 to promote practical and sustainable energy projects. To ensure the sustainable character of the projects supported by the SEPS scheme their selection is based on the following set of criteria: technical viability, economic feasibility, local and global environmental benefits, replicability and marketability, potential for poverty reduction, social equity and gender issues, local involvement and employment potential, sound implementation strategy and dissemination concept. For more detailed information on the program, please visit the website www.wisions.net.

The main advantages of the chosen survey approach are its time-effectiveness and its suitability to address questions of decision-making and provide information on why some practices work better than others within the communities and households [10]. These advantages outweigh the possible limitations this method entails, which namely are difficulties of quantifying and generalizing the results along with the possibility of biased information provided by the interviewees. The likely shortcomings of the interview approach where furthermore reduced by the fact that all projects were supported under the same funding scheme and therefore, had to meet the same requirements to be eligible for support [11]. Thereby the number of variables is kept constant, providing a sound foundation for identifying common processes and impacts [11]. To furthermore limit the danger of predisposed interpretations the evidence provided was confirmed through the analyses of secondary data in the form of initial project design, progress and final reports, as well as secondary literature and statistics.

3. RESULTS

The circumstances surrounding energy access and energy efficiency projects in developing countries are complex and the factors that can have influence on the sustainability of these development interventions are manifold. Assessments of the sustainability of these projects often focus on the technical, ecological, economic, social and/ or political dimensions. While analysing these dimensions is important, previous findings indicate that it is rarely one dimension that defines the sustainability of a project. Therefore, the following analysis centres on the linkage between technical sustainability and socio-economic factors. Moreover, the cross-sectional nature of the evaluation sample provided the opportunity to further analyse the influence of the geographical and gender dimension on the sustainability of small-scale energy projects in developing countries.

3.1 Assessment of the technical sustainability within the socio-economic context

The evaluated projects supported various sustainable energy technologies, of which applications utilizing biomass for energy generation in the broadest sense represented the largest group with 37%. These are followed by technologies, which transform solar power to other forms of energy, like photovoltaic panels and solar cookers. Whereas wind power and hydro power implementations represent only 7% and 11% respectively of the reviewed projects. Efficiency measures or efficient technologies (e.g. efficient lighting) represent 15%

of the implemented technologies. In Figure 1 improved cook stoves represent a category of its own, but they could also be counted as efficiency improvement technologies. Thereby the share of efficiency technologies would be raised to 26%.

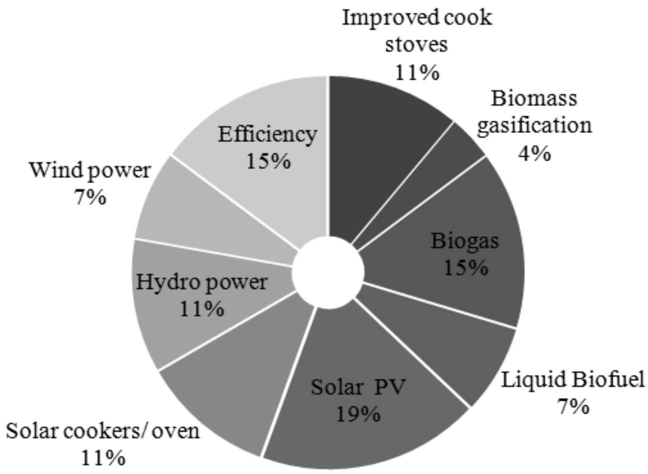

Figure 1: Technology distribution within the evaluation sample

Addressing the issue of technical sustainability the question presenting itself is to what extent did the choice of technology have influence on the continuing success of the former projects. To measure *technical sustainability* the widely applied indicator *operational status of technology* was assessed. Based on the collected data the projects could be grouped in four categories (a) fully operational (b) mostly operational, (c) operational to a limited extent and (d) not operational. The findings from the evaluation show that with 78% of the 23 projects the majority of the implemented small-scale renewable energy interventions were still functioning and utilized by the beneficiaries. Of these projects nearly half (48%) were fully performing and 30% were mostly functioning, with only some systems or structures not being operational. Further 13% of the former projects were only functioning partially, while 9% of the project stopped operating completely.

By taking a closer look at the different technologies it was discovered that in the cluster of projects that were unsuccessful or are only operative to a limited degree, technologies that operate on biomass as energy source (excluding improved cook stoves) represented the largest cluster with 80%. As can be seen in Figure 2, the majority (58%) of the biomass projects was not sustainable from the technical point of view. Whereas all projects that aimed to meet the need of preparing food with less energy inputs, using technologies like improved cook stoves and solar cookers, are still fully or mostly operational. The same can be said for the hydro projects at the time of the review.

While there have been many evaluations focusing on the technical feasibility of renewable energy projects it is widely recognised that the reliability of the technical components does not automatically guarantee sustainable operation of the whole system [8, 12]. Technical infrastructure, like sustainable energy systems, need to be embedded in the local context. This means that the technology supplies the amount of energy that the community or the individual household requires and that the type of energy supply is affordable for the beneficiaries. Either know-how should be available or local technicians should be trained to provide installation, maintenance and repair service. A crucial aspect is as well that the beneficiaries are in need and really want to use the technology and - if necessary - are willing to take on additional tasks to run the technology. To address the role of these factors for the technical sustainability of the reviewed projects, the data on the technical sustainability was linked to the results from the socio-economic assessment. The results provide valuable evidence that the performance of the 23 cases studied was strongly influenced by socio-economic as well as environmental context factors.

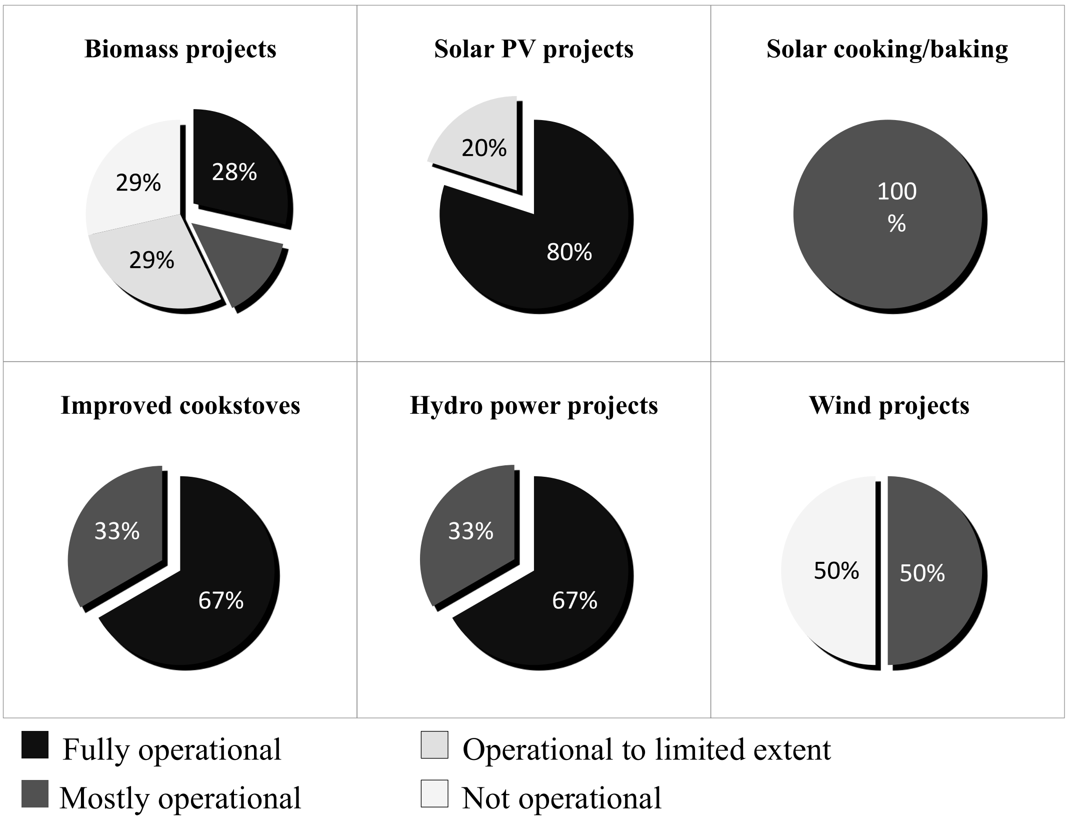

Figure 2: Sustainability of the evaluated projects in accordance to the implemented technology (Biomass projects excluding Improved cookstoves)

The following sections take a closer look at two of the technologies, which provide strong evidence on the link between technical sustainability and the socio-economic system. In the case of projects using biomass as energy resource the missing links between technology and socio-economic systems results in a lower sustainability. Whereas projects utilizing solar photovoltaic (PV) proofed to more sustainable but were still by the socio-economic circumstances.

3.1.1.Energy from biomass

With regards to the biomass projects one major factor that had been identified as responsible for the systems to stop operating partly or fully was the insufficient substrate supply, even though in all cases it was stated before the implementation that enough biomass supply would be available. Thus, the energy systems did not fail due to technical reasons but because the technology was not suitable for the chosen environment. This finding is in line with results from a study on lessons learned from small-scale bioenergy projects in rural China [13], which found that most small bioenergy systems were running under capacity while others stopped operating entirely. Besides the insufficient substrate supply another complaint mentioned in one project was the insufficient and unreliable power supply. This problem again did not have its origin in the technical system but was caused by indistinct responsibilities within the community for managing the system. The sense of responsibility and ownership towards the system was often missing. Comparing community owned projects and individually owned systems it was found that the lacking sense of ownership was more of a problem when a larger group of people was responsible for operating the system, without having one specific employed/ assigned person to manage the system and daily tasks. Likewise a study on community biogas projects in India found that the sense of ownership is one of the main factors that influence the sustainability of community projects [14]. One option to increase responsibility for the energy systems is that the beneficiaries have to invest in the technology themselves, not only in form of labour, time and space but also financially [15]. The problem with financial contributions on the other hand is that people hesitate to invest in technologies that are new and unproven to them. The evaluation results have shown that people are often not used to or not willing to take the risks of long-term investments. Financing models with frequent payments of small amounts instead of large upfront investments could be an alternative. Although these options seem to be favourable in terms of risk reduction they also result in a weaker link between the user and the technology, which again could be counterproductive for the desired sense of ownership within the community. This potential conflict between the creation of a sense of ownership and suitable financing models is representative for many of the aspects that can influence the sustainability of a development intervention. Therefore, these aspects have to be addressed more carefully and precisely before in the project planning phase to ensure sustainability.

3.1.2 Photovoltaic

Looking at the sustainability of the PV projects the reasons for limited functioning of one evaluated project were also not of technical nature. Only half of the beneficiaries continued to use the solar panels because national programs for grid extension reached the project area. The result was that households with new connections to the national grid dropped the commitment to the decentralized energy systems, as the PV installation were not cost competitive with the electricity prices and the service quality (24-hour power supply) of the grid. A sustainability analysis of PV projects by Ilskog [9] also pointed out that grid extensions are a potential threat to solar PV installations, but no empirical evidence on this effect was provided. Still, it was suggested that an indicator *Compatibility with future grid service* should be included in sustainability evaluation. As the experience from the present evaluation show grid extensions are not only an issue in the long-term perspective but can also threaten sustainability within a narrow timeframe. Therefore information on potential grid expansion plans should already be acquired during the project-planning phase. In the future interconnecting PV systems and connecting these systems to the grid could also be an option to avoid the abandonment of the technology when the national grid arrives in these areas. While this option is already viable in developed countries, but unfortunately this option is up to now not feasible in developing countries because of technical as well as regulatory, legislative and administrative barriers. Alongside these general barriers the required infrastructure to connect small PV systems to grid would require additional investments from the users which is one the main obstacles for promoting renewable energy technologies on the local level in developing countries.

3.2 Assessment of the geographic dimension

The 23 reviewed projects were implemented in 17 different developing countries. The geographical distribution presents itself as follows: about a quarter of the evaluated projects were implemented in Sub-Saharan Africa and Latin America, while the other half of the project was implemented across Asia and one project was implemented in the Middle East (Figure 3).

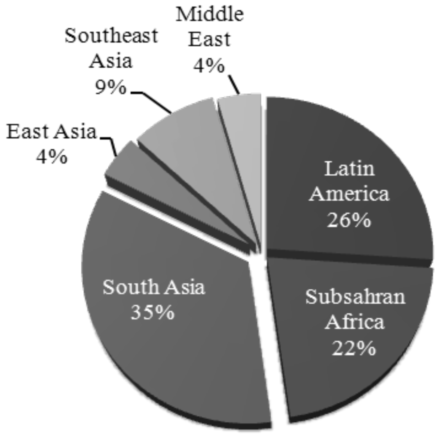

Figure 3: Geographic distribution of projects from the evaluation sample

The geographic location has undeniably influence on the selection of a suitable technology for a project. The renewable energy technology has to be chosen based on the locally available renewable energy potential like solar radiation, biomass supply, water flow etc. The key question of the post-evaluation in this regard is if there are indications that the sustainability of the 23 reviewed cases was also influenced by the geographic context. The answer to this question is that the review gives no indication that the global location had direct influence on the achievement or non-achievement of sustainability in the 23 cases. However, on a smaller scale factors linked to the local geographic context like transport infrastructure as well as the presence of institutional infrastructure in the region had influence on the sustainability. Likewise, as described before in section 3.1, the biomass potential in the chosen locations often proved to be insufficient. Consequently, the geographic aspects need to be addressed more carefully during the planning phase of the implementation. If the focus of a project is a specific technology a location with sufficient renewable energy potential and the necessary infrastructure has to be chosen, but if the project targets a specific location the technology choice and the project design have to be adapted to the local conditions and fulfilment of the local energy-related needs.

3.3 Assessment of the gender dimension

In the past only limited attention was given to the gender dimension in the energy sector. Energy matters were treated as gender neutral based on the assumption that gender equality was more a political issue, unrelated to the technical aspects of energy production and supply.

[16, 17]. Today the gender perspective is increasingly recognized as important element to be considered in planning energy interventions in developing countries (Figure 4). There is a vast amount of literature addressing the potential impacts of access to sustainable energy technologies on the lives of women and girls in comparison to men [18, 19]. A review of academic peer-reviewed literature by the World Bank [20] concludes that multiple relations between gender and energy exist and that energy interventions can have significant gender related benefits for women, including: reduced time spent on supplying fuel wood for household energy needs like cooking, lighting, and heating; decrease of respiratory infections from indoor air pollution; reduced danger of burns and household fires caused by unsaved traditional stoves; improved nutrition and health due to increased availability of cooked food, boiled water and space heating as well as improved safety of women and girls through street lighting at night, allowing them to attend night schools and participate in community activities [16]. Recognizing the potential benefits of sustainable energy access for women, the SEPS supporting scheme considers gender equity in project participation, benefits and opportunities as significant factor for making projects eligible for financial support.

But despite the increase of gender-sensitive energy program designs, the World Bank review [20] also reveals that only a very limited number of evaluations exists that actually measure these impacts with regard to the distinct situation of women and men in relation to energy generation and use patterns. To the best of the author's knowledge even less documentation is available on the influence the gender dimension can have on the sustainability of small-scale energy projects. This lack of literature may be owed to fact that measuring or even quantifying these effects is difficult. To draw causal links between gender and sustainability comparison groups differentiated by gender would be required. The difficulty with this requirement is that even though some households are only female or male-headed, the majority of households compromise female and male members. Furthermore most projects do not target female and male community members separately. In cases where this had been done, there was also the danger of inner-community tension Yet, there are several reasons to expect that gender can have an influence on sustainability of energy projects.

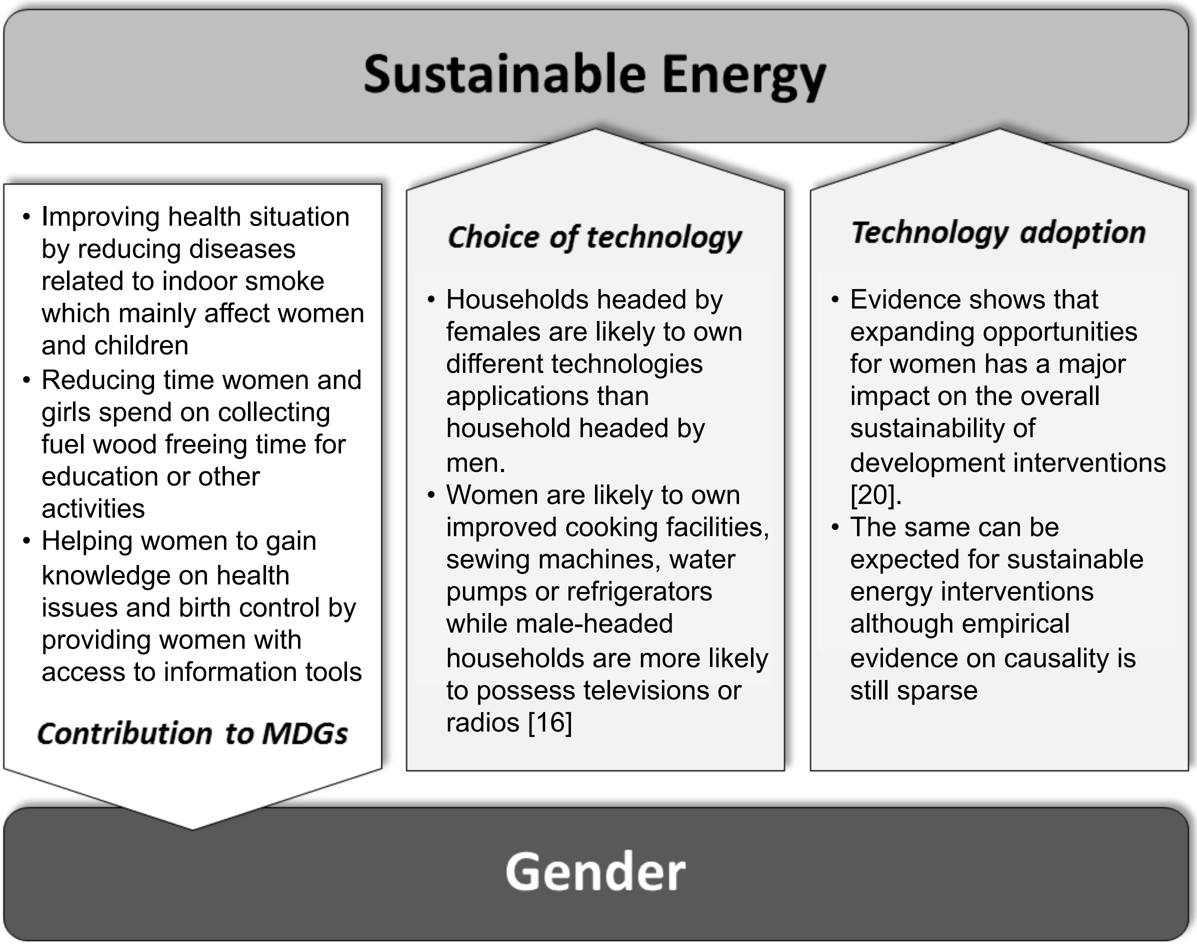

Figure 4: The different gender dimensions of sustainable energy projects

(Source: own compilation based on evaluation results and [16, 24])

The results of our evaluation show that sustainable energy technology addressing the need of food preparation - like improved cook stoves and solar cookers and ovens - were more sustainable than other technologies. All of these implementations were fully or mostly functioning and used by the beneficiaries at the time of the review. In developing countries food preparation is predominantly the task of female household members therefore these technologies are in the majority of cases mainly utilized by women. Although direct causal relationships are hard to establish, it can be anticipated that interrelations exists between the success of these technologies and their primarily utilization by women. This assumption is in line with other case studies that found that women play a crucial role for the adoption of sustainable cooking technologies, like Ditlhale and Wright who analysed the case of Botswana [21], the Food and Agriculture Organisation (FAO) who provided data on the relation between wood, energy and gender [22] or Mohideen R. who studied the implications in communities in South Asia [23].

Beside the gender influence other factors could have contributed to the sustainability of these technologies in the reviewed cases, these factors include the requirement of smaller investments compared to other technologies and that these technologies were mostly individually owned. So to actually prove the influence of the gender dimension on the sustainability of small-scale energy projects pre- and post-implementation evaluations differentiated by gender would be required.

4. CONCLUSION

Despite the large number of small-scale sustainable energy projects that have been implemented in developing countries surprisingly little empirical evidence exists on their achievement or non-achievement of sustainability after the initial project activity was completed. The paper addresses these shortcomings by providing a post-evaluation analysis of the 23 small-scale renewable energy projects.

The results show that technical sustainability did not only depend on the reliability of the technological innovation alone but the embedding of the technology in the socio-cultural, political and ecological context. Factors that had positive influence on the sustainability were the availability of adequate knowledge and skills to provide installation, maintenance and repair services, high levels of user satisfaction, and a sense of ownership among the beneficiaries. To ensure that these requirements are achieved it is vital that the technical implementations meet the energy needs of the target communities or households in terms of amounts of energy supplied, available human capacities, availability of energy resources (especially critical for biomass) and cultural settings. These non-technical soft factors influence the sustainability of energy projects over the entire lifespan of the technology. Beginning with the project ideas and the conceptualization of the project design (e.g. suitability of a technology for the given geographic location, cultural settings and ecological context), during implementation (e.g. ensuring quality of components and installation, training of the local population, establishment of adequate management system) and for the operation after the planned project activities has been completed (e.g. ensuring adequate use and maintenance, assigning responsibilities).

While no evidence for the influence of the geographic location on the sustainability of the reviewed cases was found, the findings of the evaluation support the assumption that gender might have an influence on the sustainability of energy development interventions. Particularly for energy applications that address the need of food preparation, which are mainly used by female household members, the review shows that these technologies have been very sustainable. But it was not possible to provide empirical evidence on the effect of gender on the sustainability of small-scale energy project. To gather data on how gender roles affect project outcomes gender differentiated evaluation would be required. So in addition to the need for further research on the general factors that influence sustainability of small-scale energy projects more detailed research is needed to better comprehend the gender dimension in energy development efforts.

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