SOCIO-ECONOMIC EFFECTS OF SOLAR HOME SYSTEMS IN JORDAN BADIA – A CASE STUDY IN RAWTHAT AL-BANDAN VILLAGE

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ABSTRACT

In light of advancements in energy sources in remote areas of Jordan that occurred at the onset of the 21st century, it is crucial to explore how solar energy has been applied as one of the most vital innovative and renewable sources of energy. A 400 watt-peak solar photovoltaic (PV) stand-alone system with battery storage was created to generate an economical PV energy to supply electricity to remote areas that cannot be served by power grid because of long distances and high cost. This system was applied and assessed in terms of its socio-economic effects between April and May 2016. The system is made up of eight 50 watt-peak 12-volt solar modules mounted on a metal frame. Seven houses and a school were each provided with a 400 Watt-peak system, and these systems are assessed to determine their social and economic practically. A survey regarding the socio-economic effects of the systems was also given to users, the results of which indicated that, on average, the beneficiaries had increased time staying awake and later sleeping in the evening than when they used their old system and spent more time watching TV. Other information provided by participants showed that some users bought TVs, cassette players, washing machines and fans following the implementation of the solar system in their houses. Findings also indicated that they stopped using kerosene for lighting following their obtaining the solar system. With the exception of faults to the isolated battery and lamp manufacturing, no major issues or downsides were seen in using the designed solar system, according to the observations of participants who had used it. Assessment of the new system suggests that it has great effects on the socio-economic situation, is easy to use, can be replicated, plays a huge role in improving living standards, heightens awareness of national issues via mass media exposure, enhances children's educational habits and generally enhances the rural way of life.

Keywords: Badia; Impacts; Jordan; Remote and rural; Socio-economic; Solar home systems

1 INTRODUCTION

The vital role that energy has been playing in accomplishing sustainable development has been evident and developing in the energy policy ever since the 2002 Johannesburg Summit. Unless affordable, trustworthy and clean energy services are available to the public, it would be impossible to achieve sustainable development. Renewable energy sources may be more effective for use in rural areas and regions that are not within the reach of power grids. This is a significant alternative to grid extension, particularly as far as remote communities are concerned, in which grid extension tends to be unpractical and expensive [1–4]. Jordan has many small, remote villages that have no electricity and a little chance of being connected to the high voltage grid any time in the foreseeable future. This is because of the unfortunate financial and geographical circumstances. Per day, the average energy demands in such villages are very low and fall between 1.5 and 3.25 kWh per household. Despite the Jordanian government policy to implement universal access to electricity, grid electricity access remains poor in rural regions of the country. As a result of high transmission and distribution expenses, many remote areas remain unconnected to the national grid.

In these rural areas, the primary electrical loads are for lighting, TV, fans, cassette player and small fridges. Such communities occasionally rely on small diesel generators to meet

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home's power demands. Typically, use of the generators is restricted to night time only. Furthermore, the small generators cause high pollution in the environment, and owing to their frequent faults they are unreliable [5]. The use of these generators is thus not an effective and long-lasting solution. Moreover, the high cost of oil across the world is causing diesel prices to soar in Jordan. Solar home systems are considered effective means for the nation to expand electrification and supply alternate electricity generated from sunlight which is less costly for the rural communities in Jordan Badia. The average solar radiation intensity on a horizontal surface is 5.5 kWh/m^2 per day with a total of 3300 sunshine hours per year [6–14]. These statistics are promising and support the use of photovoltaic generators for heightening electrification of remote villages. It is now widely agreed that access to electricity is crucial for implementing basic services that aim to reduce poverty, especially as far as education and healthcare are concerned [5, 15]. Rural communities have reacted positively to the solar home systems and have witnessed the enhancements that have been made to their lives. However, there are still many questions relating to how the photovoltaic systems have improved life in remote areas and whether it is possible for photovoltaic systems to serve as a tool to make life in rural and remote areas more appealing [16]. There are lots of new projects being implemented in the country, including those being implemented in the eastern Jordanian desert and those occurring in southern Jordan, which will be used by those who need energy for sustaining life. It is thus crucial to develop a model for a family house that is predominantly reliant on solar energy to run the electrical appliances.

Renewable energy is developing quickly as a result of the rapid depletion of fossil-fuel energy, which is limited in supply and is unstable in terms of pricing throughout the world. The ever-growing rates of global energy crisis, environmental awareness and political bindings have led to an urgent need for alternative energy sources. It has also largely heightened interest into renewable energy. There are many possible alternatives, of which photovoltaic energy has been deemed to be suitable in terms of meeting the ever-growing demand. It is particularly appropriate and useful to rural regions, which young and talented individuals often leave as a result of the economical disadvantages of such areas. In these areas, the development of renewable energy is believed to be a new economic branch [1, 17]. Mondal and Klein in [5] asserted that solar electrification can directly and indirectly impact the system users, and can generate various permanent implications. In terms of benefits, it can lower kerosene usage, reduce pollution, provide higher quality light and more hours of light in the evening, generate slightly more income and household work and can allow for studying at night time. If renewable energy is to be used to overcome poverty and support sustainable development, then social acceptance of the new type of energy must be assessed and a socio-technical approach must be used to effectively introduce them in Ethiopia. It will benefit users by positively influencing healthcare through the reduction of air pollution, providing a vital input to setting up various social services, including communication and education. Improvements were also observed in children's autonomy, the flexibility and stability of family life and reduced stress [18]. Furthermore, research conducted in [19] concludes by stressing that geographical and socio-economic data must be gathered prior to installing electrification programs process. This research consisted of a field study and interviews carried out in Laos, Southeast Asia, and its key objective was to gain insight into the design and establishment of the project, its critical success factors and its areas for improvement. Furthermore, Hong and Abe in [20] asserted that understanding of how the economic and technical factors associated with the solar home systems can be matched to social factors in generating sustainability is still poor. The social study into the acceptability of solar home systems in rural areas is regarded to be a key matter for the widespread use of the systems as far as its technologies

and the achievement of energy policy targets are concerned. The level of social acceptance differs between the sources of renewable energy. For instance, research has indicated that 70% of people were familiar with solar, wind and hydropower [1, 2, 15, 21]. Another investigation conducted by Gustavsson in Gambia [22] stated that solar home systems in rural areas have improved studying at home, due to the fact that there is more opportunity to study at night. It also indicated the benefits of exposure to radio and TV. Although there are many solar home systems, the extent to which photovoltaic systems can aid in creating sustainability in rural communities whose void of access to grid electricity [16, 23] must be further explored. In this respect, Bimesdoerfe *et al.* [14] state that the possibilities for green jobs and their social aspects when implementing renewable energy systems into developing countries like Bangladesh must be explored. He explained that about 300,000 households in Kenya and 130,000 in Sri Lanka were using solar home systems by 2010.

2 STUDY AREA AND SOCIO-ECONOMIC DATA

Rawthat Al-Bandan village is one of the most suitable villages to investigate in a socio-economic study into electrification use of solar energy. This research was carried out from April until May 2016 in Rawthat Al-Bandan village, situated in the Northeast Badia of Jordan (Southwest of Ruwashid town) by 22 km at the coordinates 32º 16' 2.9" N; 38º 10' 37.1" E. People living in the village work predominantly in agriculture and herding farm animals. The residents are extremely poor and poorly educated. Furthermore, the residents all belong to the same family (a tribe), namely a father and his sons. There are approximately 50 persons living in 7 houses, all of which are small, typical and built the same way. The houses consist of two rooms (for men and women) and a tiny kitchen. Houses were constructed from concrete with standalone solar system installed in each house (Fig. 1). There is a primary school located in the village. The teachers live in the school and they bring in food on a weekly basis. Drinking water is brought in by tanks from Ruwashid town weekly. No road to the village exists and people must travel to the nearest local town by truck. The economic situation is poor, since residents earn less than $1,500 per year.

Approximately 56% of the solar home system users earn less than 300 US$ per month (Fig. 2), while 28% earn between 300 and 500 US$. More than 16% earned a monthly income that exceeded 500 US$. The income level is correlated with the education level and the jobs of those living at the households. Results indicated that approximately 99% of participants were uneducated. Around 28% worked in some form of agricultural job and 28% were also found to engage with housework or were not employed. Around 16% were employed in other

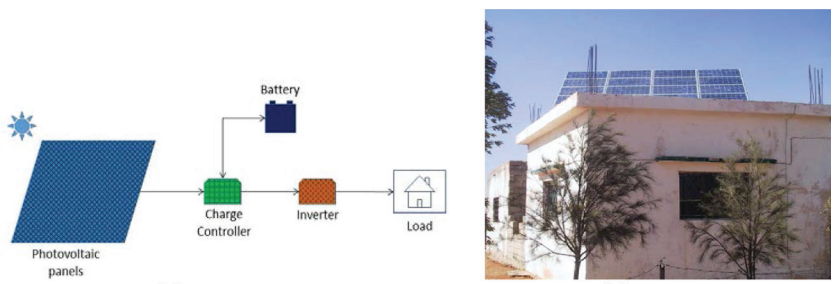

Figure 1: (a) Scheme of the system used and (b) solar panels on one of the houses at Rawthat Al-Bandan village.

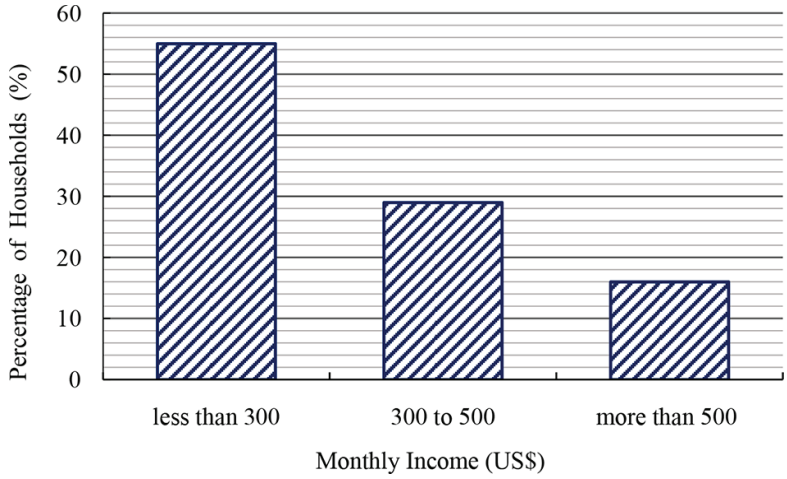

Figure 2: Income distribution of participants.

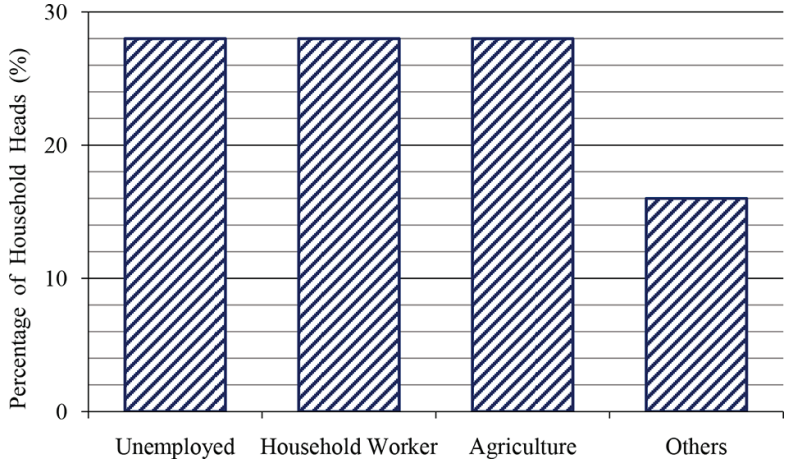

Figure 3: Main occupation of household heads.

roles (Fig. 3). Villages like this have very low demand for daily energy. The household predominantly uses wood and biomass for baking bread.

The village area (Jordan Badia) is renowned for having high solar energy potential and low wind energy potential. On an annual basis, the average wind velocity is around 4.4 m/s, meaning that wind energy converters would be impractical. Contrastingly, solar energy would be practical because the average solar radiation on a horizontal surface was around 5.5 kWh/m^2 per day. In winter, the average temperature hovers between 8 and 10^{o}C and temperatures in the summer months of June, July and August soar above 38^{o}C. This makes the annual average of temperature to be 23^{o}C. The rainy season occurs between November and April, with the average rainfall ranging from below 50 mm to more than 150 mm in some areas [24, 25].

3 RESEARCH METHODOLOGY

Seven households and one school using the solar home system were used in the research. The research used mainly semi-structured interviews with local residents, which were enhanced by

site visits and a literature review. Twelve semi-structured personal (one-to-one) interviews were carried out in April 2016 with village inhabitants. The questions were open and associated with particular questions regarding the rural electrification and social effects that the solar systems had on inhabitants' lives. The interview findings were enhanced by an accompanying literature review of project reports that had been created by the Jordan Badia Research and Development Centre. Also a reference to energy journal articles and reports into rural electrification concerns in developing nations in a general sense was adopted [1, 5, 16, 19, 20, 22]. Additionally, two focus group discussions were held in the village, one of which was with the local community and the other with the school teachers. Many variables were included in the questionnaire, including items pertaining to household information, electricity usage, indicators on socio-economic factors, income, educational background, technology functionality, environmental effects and overall opinions of the project and management [5, 16, 18, 20]. All users of the solar home systems were involved in the survey and it was evident that six of the solar home systems and the school (400 Wp) capacity and one solar home system (800 Wp) capacity had been in operation for over a decade. Furthermore, the electricity had been supplied by two government organizations, which are the Rural Electrification Project in Jordan and Jordan Badia Research and Development Center. The key objective of the survey was to collect information regarding the changes to the users' livelihoods by including questions that explored the period before and after the solar home system was implemented. The questions discussed all dimensions to life in the local communities that used the solar home systems in the village.

This research discusses the living conditions in the rural Jordanian villages and the potential advantage of using the solar home systems to supply basic electrical needs to homes and settlements. It will also explore the potential improvements that may be made to living conditions in the chosen village.

4 RESULTS ANALYSIS AND DISCUSSION

It was revealed that solar home systems (or solar electrification) had many advantages for its users. In such remote and rural areas, the burning of kerosene in traditional lamps can create indoor heat and pollution that largely impact the wellbeing of users, as well as the environment. A decrease in kerosene usage was thus the key benefit associated with using solar systems in these regions. Solar home systems were thus revealed to cause lowered levels of pollution, less trouble of using kerosene lamps and better light. Furthermore, solar home systems in rural regions enabled various electrical appliances to be used, including televisions, small refrigerators, fans, audio players, washing machines and mobile phone charges (which is highly important now in cases of emergency, particularly in remote areas). All participants stated that they used solar electricity for lighting.

The outcomes following analysis of the questionnaires and in-person interviews in the present research were highly fascinating as far as particular issues and individuals' worries about the usage of the solar powered energy in rural areas were concerned. The different figures shown below present the analysis and potential results.

One of the key issues regarding the implementation of any new technology in rural regions ought to be the degree to which the technology can fulfil the needs of the inhabitants. This indicator was applied in order to evaluate the extent to which the solar energy system could meet the immediate needs of residents. To evaluate the suitability of solar home systems in the region, participants were requested to explain why they selected to use solar energy to supply electricity. Many answers were given, and these are presented in Table 1. About 100% of the households stated that they used it because it was the only means of accessing electricity. Some household heads had multiple reasons.

Table 1: Reasons for using solar home systems to supply electricity (Multiple answers were considered).

Reasons	Percentage of respondent (%)
Only way to get electricity	100
Better brighter light	N/A
Children to study	62.5
Security purposes	25
Available energy source	N/A
Comfortable	N/A
No pollution	50
Cheaper	N/A
Needed for lighting	87.5
Easy to use	37.5
Enjoy TV	37.5

No further maintenance is required for the solar home systems; thus, it is a self-contained energy technology. The technical understanding of how to maintain the systems was evaluated as an indicator of the advantages it offers.

All solar home systems investigated in the survey were over 15 years old. The components were functioning well during recent times, in accordance with their predicted lifespan. Furthermore, all systems were highly beneficial as a result of their location in an open area that was not shadowed by any trees or other objects. All users stated that they clean the panel surfaces themselves, thus a thick layer of dust was deposited and caused a drop in the power output of the systems. This is typical of remote and arid areas. A majority of users had experienced the refilling of the distilled water in the battery. Suppliers offered servicing and maintenance of the systems at no cost to the user. Table 2 presents the self-maintenance performance of the users.

To evaluate the impacts of solar energy systems on peoples' options, daily life and income generating activities, Table 3 presents participants' opinions regarding the effects of solar home systems on their health and lifestyle. Around 75% of participants indicated that it had been advantageous to education. Interviewees believed that children gained special benefits in terms of their daily studies.

Table 2: Self Maintenance Performance.

	Percentage (%)	
Item	**Yes**	**No**
Have you cleaned the panel yourself?	100	0
Have you cleaned the battery yourself?	62.5	37.5
Have you re-filled water in battery yourself?	87.5	12.5
Can you replace a lamp on your own?	100	0
Have you received training in system maintenance?	0	100

Table 3: Opinion regarding impacts of solar home systems.

Effects	Percentage (%)				
	Totally disagree	Disagree	Neutral	Agree	Totally agree
Improved wellbeing of women and children	0	0	37.5	62.5	0
Clean indoor air	0	0	25	75	0
Less burning of kerosene lamps and wicks	0	0	50	0	50
Watching TV and listening to broadcasts	0	0	0	12.5	87.5
More opportunity to study at home	0	0	25	0	75
Evident enhancements to students' academic results	0	0	75	25	0
More social gatherings	0	0	37.5	0	62.5
Increased income	0	75	25	0	0
Increased business development	0	100	0	0	0
No pollution	0	0	12.5	87.5	0
Hindrance to studying because of increased TV use	25	12.5	37.5	25	0
Comfortable life	0	0	0	37.5	62.5
More friends visiting	0	0	0	75	25
Safer in the night	0	0	37.5	0	62.5
Can stay up later	0	0	0	12.5	87.5
Increased status in the community	0	0	25	75	0
Less hassle for lighting	0	0	37.5	62.5	0

Furthermore, 62.5% of respondents stated that that the improvement of the health of women and children was a key benefit. This is because houses are healthier, since there is no longer any soot from oil lamps. Furthermore, people stated that they had less pain in their eyes and noses that had previously been caused by the penetrating smell of kerosene lamp smoke.

In the community, 75% of participants reported improvements. They indicated that social interactions had increased due to heightened possibility of meeting neighbours and friends at night, watching television and staying up late. Moreover, children can study collectively during the evenings. 62.5% of participants reported a comfortable life.

Furthermore, night-time security has seen improvements, with 62.5% of participants feeling safer when walking around outside at night. Additionally, 75% said that income-related activities had been improved and all participants said that business had positively developed. However, this is not necessarily due to the solar electricity system, since the area is small and located far from any other communities or persons. Thus, it cannot be assured that quantity and quality of work have been enhanced.

Subsequently, an open question asking participants about changes to their social life following the installation of the solar energy systems in their homes was included. It was revealed that all participants had experienced some sort of change to their social life as a result of the solar energy system. Approximately 87.5% of the respondents believed that their quality of life was better following the installation of the system. All results pertaining to changes on social life following the installation of the systems can be seen in Table 4.

The questionnaire evaluated the knowledge that local residents possessed regarding the price of renewable energy systems in comparison to the cost of energy from the alternative conventional sources. The price of the solar home systems was used as a key tool to evaluate how effectively the users could buy and maintain the systems within the village. None of the family heads had any understanding of the costs of these renewable energy systems relative to the cost of the conventional energy systems. In the village in question, the price of these systems was funded by the Ministry of Energy and Mineral Resources (Rural Electrification Project) in the Hashemite Kingdom of Jordan.

Table 5 presents aspects pertaining to individuals' understanding of environmental issues. It can be seen in Table 5 that 62.5% of participants understood the issue of pollution. Around 12.5% were familiar with global warming, greenhouse effect and acid rain. None of the participants had any understanding of ozone layer depletion, deforestation or biodiversity.

Users' concern regarding how to resolve environmental pollution was found to be correlated with the development of solar home systems (see Fig. 4). It is evident in Fig. 4 that exactly half of the participants thought that the aforementioned environmental issues could be resolved through using renewable energy systems like solar home systems, whilst 25% knew nothing about it. Around 25% of the participants indicated that they did not think renewable energy systems like solar home systems could solve issues relating to environmental pollutions.

All of the above statistics have collaboratively offered a comprehensive insight into the understanding and concerns relating to renewable energy sources, particularly solar home

Table 4: Changes to social aspects following implementation of solar home systems.

Social Impacts	**Percentage of respondents (%)**
Quality of life improved	87.5
Healthy environment	37.5
More entertainment	25
Creates job	0
Advanced communication	25
More TV	75
More chatting time	12.5
Feeling well	37.5
Feeling happy	50
Safe at night	37.5
No eye disease	62.5

Table 5: Understanding of environmental issues.

Environmental issues	Percentage of participants (%)
Pollution	62.5
Global warming	12.5
Greenhouse effect	12.5
Acid rain	12.5
Ozone layer depletion	0
Deforestation	0
Biodiversity	0

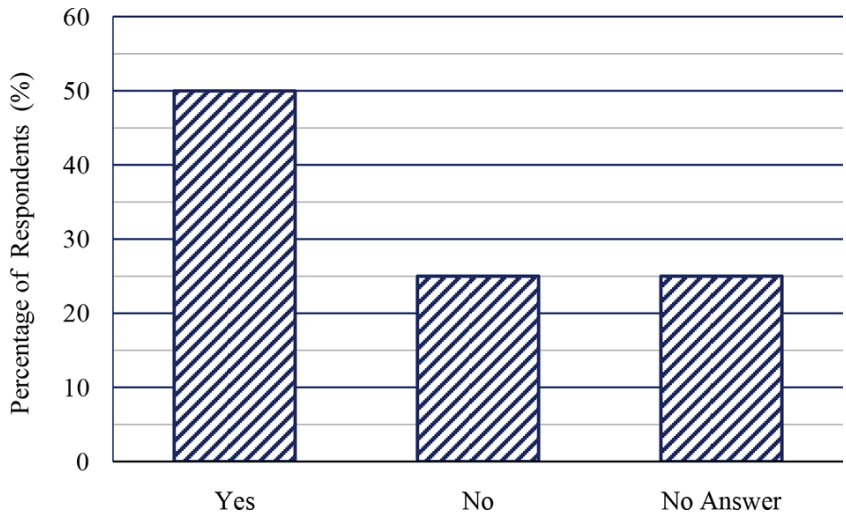

Figure 4: People's perceptions of resolving environmental pollution by using solar home systems.

systems. This information will largely contribute to developing any renewable energy sources in areas that are largely remote or rural. The findings of social research of the same nature may differ between regions and countries due to differing conditions, but the research is still largely beneficial in developing an overall understanding any renewable energy development like solar home systems.

Rawthat Al-Bandan village where the project was implemented is located 22 km away from the national grid. Ministry of Energy and Mineral Resources/Rural Electrification Project estimate that to connect this village with grid, each kilo metre costs 20,000$, this means that the project will cost 440,000$. As the village is very small, the cost per home will be very high and the payback period too will be very long. Therefore, the decision makers at Ministry of Energy and Mineral Resources decided to use an alternative option to feed the village with electricity. As the area is one of the best sites in Jordan regarding solar energy, the only option was to use the photovoltaic solar energy systems. Each house was funded by 5000JD (7000$) to buy and install the solar system. The total cost of these systems including installation and operation was 40,000JD (57,000$).

5 CONCLUSION AND RECOMMENDATIONS

The availability of energy is a fundamental prerequisite for establishing a country's national economy and enhancing living standards for inhabitants. In order to provide energy to off-grid areas out of the reach of conventional electrification, a 400 watt-peak solar photovoltaic system with battery storage was created and implemented in Rawthat Al-Bandan village, Northeast Badia of Jordan. The village has seven houses and one school. The village's rural community consists mainly of users with low income and poor educational backgrounds. Since agriculture is the key source of income, no major improvements to inhabitants' lives were found to result from economically lucrative activities. Furthermore, the system was assessed for socio-economic effects on users.

The findings suggest that solar home systems are more economical alternative in isolated and rural areas. They are also very functional and can meet the fundamental electricity needs of the users. It was revealed that solar home systems offered tangible advantages in term of better lighting, and this ultimately caused improvements in various areas, including children' education. The systems also resulted in less indoor pollution, improved social status, better living standards and ability to use basic appliances like television and radio. On the other hand, no benefits were seen in terms of increased income generating activities or enhanced business development. It was also found that the system increases waking time, decreases kerosene usage, lowers pollution in the environment because of the lowered use of petroleum and various other benefits. Although solar home systems have clear advantages, they must not be applied to replace comprehensive poverty reduction efforts.

It is evident from this research that the typical concerns of those living in the village regarding the development were addressed. It is advised that the use of solar energy systems in rural areas should be promoted by authorities, who should provide political and financial support and develop pilot projects in all remote areas of Jordan. Furthermore, the use of solar home systems in remote regions could improve the quality of life for inhabitants, limit any pressure generated from the unsustainable use of natural resources and minimize rural and remote-urban migration.

REFERENCES

[1] Shamzuzzoha, A., Grant A. & Clarke J., Implementation of renewable energy in Scottish rural area: Asocial study. *Renewable and Sustainable Energy Reviews*, **16(1)**, pp. 185–191, 2012.

[2] Susanto, J. & Smits, M., Towards a locally adapted rural electrification assessment framework: A case study of the Lao PDR. *International Conference for a Sustainable Greater Mekong Sub Region*, Bangkok, Thailand, 26–27 August, 2010.

[3] Reiche, D., Renewable energy policies in the Gulf countries: A case study of the carbon-neutral "Masdar City" in Abu Dhabi. *Energy Policy*, **38(1)**, pp. 378–382, 2010.

[4] Bhattacharyya, S., Energy access programmes and sustainable development: A critical review and analysis. *Energy for Sustainable Development*, **16(3)**, pp. 260–271, 2012.

[5] Mondal, A. and Klein, D., Impacts of solar home systems on social development in rural Bangladesh. *Energy for Sustainable Development*, **15(1)**, pp. 17–20. 2011.

[6] Habali, S.M., Hamdan, M.A., Jubran, B.A. & Zaid, A.I., Wind speed and wind energy potential of Jordan. *Solar Energy*, **38(1)**, pp. 59–70, 1987.

[7] Hammad, M.A., Characteristics of solar water pumping in Jordan. *Energy*, **24(2)**, pp. 85–92, 1999.

[8] Al-Nhoud, O. & Al-Smairan, M., Assessment of Wind Energy Potential as a Power Generation Source in the Azraq South, Northeast Badia, Jordan. *Modern Mechanical Engineering*, **5(3)**, pp. 87–96, 2015.

[9] Kablan, M.M., Techno-economic analysis of the Jordanian solar water heating system, *Energy*, **29(7)**, pp. 1069–1079, 2004.
[10] Mamlook, R., Akash, B.A. & Nijmeh, S., Fuzzy Sets Programming to perform evaluation of solar systems in Jordan. *Energy Conversion and Management*, **42(14)**, pp. 1717–1726, 2001.
[11] Muhaidat, A., Photovoltaic applications in Jordan. In: Utilization of Solar and Wind Energy in Jordan. *Second International Energy Week*, Amman, Jordan, September 15, 2003.
[12] Qashou, M., El-Mulki, H., Jaradat, A. & Taani, R., Compilation and evaluation of solar and wind energy resources in Jordan. *Solar and Wind Technology*, **3(4)**, pp. 293–304, 1986.
[13] Royal Scientific Society (RSS), Assessment and analysis of available energy resources. *Internal Report*, Vol. 3, Amman, Jordan, 1983.
[14] Bimesdoerfer, K., Kantz, C. & Siegel, J., Killing two birds with one stone: Driving green jobs through creating a rural renewable energy systems industry. Paper presented at the UNRISD conference. *Green Economy and Sustainable Development: Bringing Back the Social Dimension*, Geneva, 10–11 October, 2011.
[15] Palit, D. & Sarangi, G., A comparative analysis of the solar energy programs for rural electrification: Experiences and lessons from South Asia. *Third International Conference on Addressing Climate Change for Sustainable Development Through Up—Scaling Renewable Energy Technologies*, 12–14 October 2011, Kathmandu, Nepal.
[16] Retnanestri, M., Outhred, H. & Healy, S., Off-Grid Photovoltaic Applications in Indonesia: An Assessment of Current Experience. In *ANZSES 2005 Conference*, University of Otago, Dunedin, New Zealand, pp. 28–30, November 2005.
[17] Dutton, R. & Shahbaz, M., Jordan's arid Badia: Deeping our understanding, Jordan Badia Research and Development Centre Publications, Amman, Jordan, 2008.
[18] Müggenburg, H., Tillmans, A., Schweizer-Ries, P., Raabe, T. & Adelmann, P., Social acceptance of Pico PV systems as a mean of rural electrification—A socio-technical case study in Ethiopia. *Energy for Sustainable Development*, **16(1)**, pp. 90–97, 2012.
[19] Bambawale, M., D'Agostino, A. & Sovacool, B., Realizing rural electrification in Southeast Asia: Lessons from Laos. *Energy for Sustainable Development*, **15(1)**, pp. 41–48, 2011.
[20] Hong, G. & Abe, N., Sustainability assessment of renewable energy projects for off-grid rural electrification: The Pangan-an Island case in the Philippines. *Renewable and Sustainable Energy Reviews*, **16(1)**, pp. 54–64, 2012.
[21] Abdullah, S. and Markandya, A., Rural electrification programmes in Kenya: Policy conclusions from a valuation study. *Energy for Sustainable Development*, **16(1)**, pp. 103–110, 2012.
[22] Gustavsson, M., Educational benefits from solar technology—Access to Solar Electric Services and Changes in Children's Study Routines, Experiences from Eastern Province Zambia. *Energy Policy*, **35(2)**, pp. 1292–1299, 2007.
[23] Brent, A. & Rogers, D., Renewable rural electrification: Sustainability assessment of mini-hybrid off-grid technological systems in the African context. *Renewable Energy*, **35(1)**, pp. 257–265, 2010.
[24] Abo Sada, A., Abu-Allaban, M. & Al-Malabeh, A., Temporal and Spatial Analysis of Climate Change at Northern Jordanian Badia. *Jordan Journal of Earth and Environmental Sciences*, **7(2)**, pp. 87–93, 2015.
[25] Freiwan, M. & Kadioglu, M., Spatial and temporal analysis of climatological data in Jordan. *International Journal of Climatology*, **28(4)**, pp. 521–535, 2008.