Feasibility Study of Solar Irrigation System in Rural Areas of Pirgacha Upazila of Rangpur District, Bangladesh

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ABSTRACT

In this present work, possibility of using solar irrigation system in remote areas of Bangladesh have been studied. In this regard, Itakumari, Pirgacha Upazila of Rangpur District has been selected as the area of study. For primary data, survey among people of Itakumari, two field visits (Ramchandrapur of Kawnia upazila and Jaigir of Mithapukur upazila), underground water-level related information from BADC and market study of solar system are taken into account. Considering three irrigation seasons per year and all necessary costs, installation cost of solar irrigation system is calculated and compared with that of diesel pump system and electric pump system to find the payback period. It has been seen that, whatever is the amount of land, payback period is almost double for solar pump system with battery compared to without battery. Beside this, to water 35 decimal arable land by solar pump with battery, it would take almost five years for full return of installation cost. This study shall help policy makers to choose the best criteria in order to implement solar irrigation system in rural regions of Bangladesh.

Keywords: Irrigation system, renewable energy, rural area, payback period, Solar

1 Introduction

Bangladesh is one of the agro based economic countries in the world and its 80% people are directly or indirectly dependent on agriculture [1]. 59% land of Bangladesh is under irrigation system [2]. The water pumping system used in this country is based on diesel water pump or electric water pump [1][3]. But both these systems have some drawbacks. Our country faces an acute electricity crisis due to load shedding of 1400 MW during dry season [4]. However, 1300MW electricity is needed to be consumed by electric water pump for irrigation [1]. Beside this, diesel water pump has some drawback which are noise, transportation, fume and maintenance [5]. In our country, about 1.3 million diesel water pumps use almost 900000 tons of fossil fuel during peak season [1]. Moreover, there is absence of effective rainfall in Barisal and Magura regions during the irrigation season [6]. These are the great barriers for the farmers of our country in order to get enough water for irrigation. The optimum utilization of water in irrigation is becoming the important issue in the near future. In this regard, we need to find the more available source of electricity energy and use it in a systematic way for the proper watering during irrigation time. Bangladesh is such kind of country where the sunshine is the most available source of energy [7][8]. Using an effective agricultural technology, solar irrigation system can overcome all the resistances of watering during irrigation time. But, it is a matter of regret that still now there is no enough research on this field and our farmers are not aware of the benefit of this system. The aim of this study is to analyze the feasibility of solar water pumping system in order to replace all diesel as well as electric water pumping system. The objectives of this study are to : a) find the percentage of people who are interested in solar water pump system in Itakumari,

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Pirgacha Upazila of Rangpur District and their affordability to invest in this system b) design a small range solar water pump system c) find the payback period in order to find the feasibility of implementing this system.

2 Research Methodology

2.1 Area of the Study

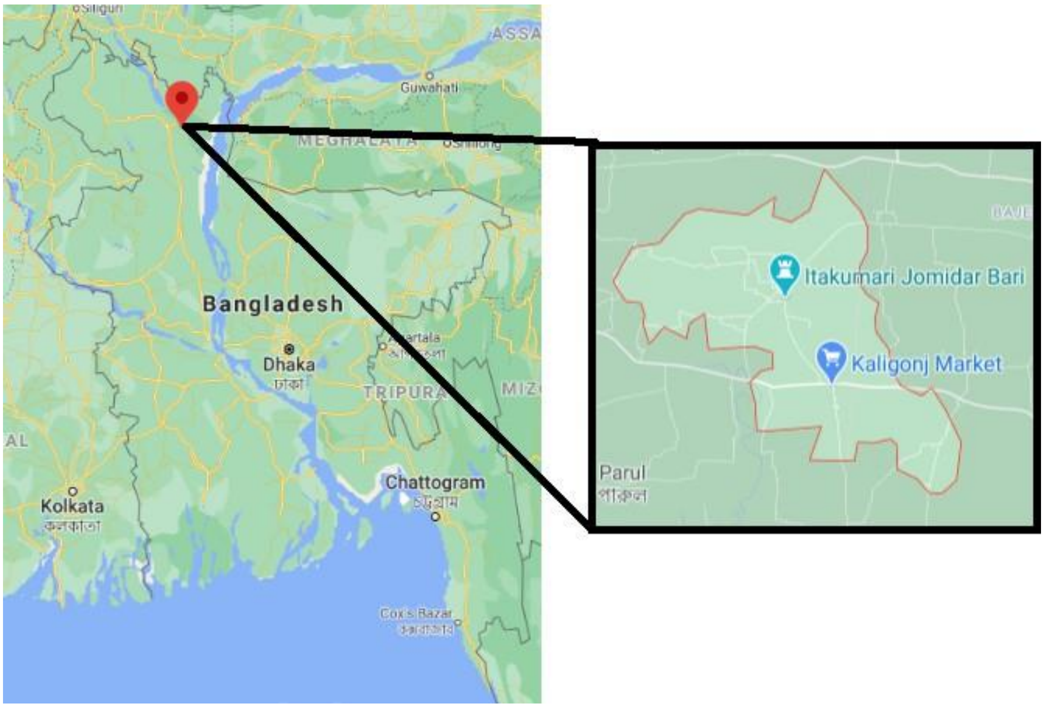

Fig. 1. Village Itakumari

The selected are for this study was village Itakumari of Pirgacha upazila of Rangpur district as shown in Fig.1.

2.2 Technique of the Study

Both qualitative and quantitative methods have been applied in this study to get a breadth and depth of understanding and corroboration in order to offset the weakness inherent to using each method by itself.

2.3 Data Collection

In this study primary data have been used. However, to analyze and explain secondary data also have been used some- what. In this regard, secondary data from various journals, web site and other relevant sites have been collected precisely.

2.4 Field Study

For this study purpose, two field studies were done. The first one is situated at Ramchandrapur village under Kawnia upazila of Rangpur district as shown in fig2. This solar irrigation system was setup by IDCOL in 2016. It was a direct solar system. This solar irrigation system is able to irrigate 70 bigha land. The pump of this system can uplift 1 lackh litre of water per minute. There are inverter, ac pump (18.5 kW) and 100 pieces solar panels (250 Watt each). Total installation cost was 50 lack taka. The second field study was at Jaigir under Mithapukur upazila of Rangpur district as shown in fig.3. This system was also direct solar system. It is used to water supply water for pond. During dry season, water pumped by this pump. It helps in the cultivation of fish. There are 12 pieces solar panels (260 Watt each), ac pump (4 hp), inverter, charge controller, and flow meter. Total installation cost was 1.5 lack taka.

Fig. 2. Solar irrigation pump at Ramchandrapur

Fig. 3. Solar pump at Jaigir

2.5 Survey

Total population of this village is 1500. Most of them are farmers. In this study, the population number was 50 for the survey.

3 Result And Discussion

3.1 Survey Result

As shown in fig.4,5,6 and 7, most of the participants were not familiar with the solar irrigation system. Only 14% people knew about this system. However, 87% of the participants interested to install a solar irrigation system when they heard about it. Among them, 45.45% people were interested to spend 10000-20000 taka and 54.55% people were interested to spend 20000-30000 taka in this system to install. They were not agree to invest large amount of money because the system was totally new for them. Beside the survey among people, it was important to find out the ground water level at Pirgacha. In this regard, Bangladesh Agricultural Development Corporation was visited. From the visiting, it was found out that the highest deep water level was 19.08 feet in 2007 and lowest deep water level was 11.10 feet in 2015 as shown in Fig.8.

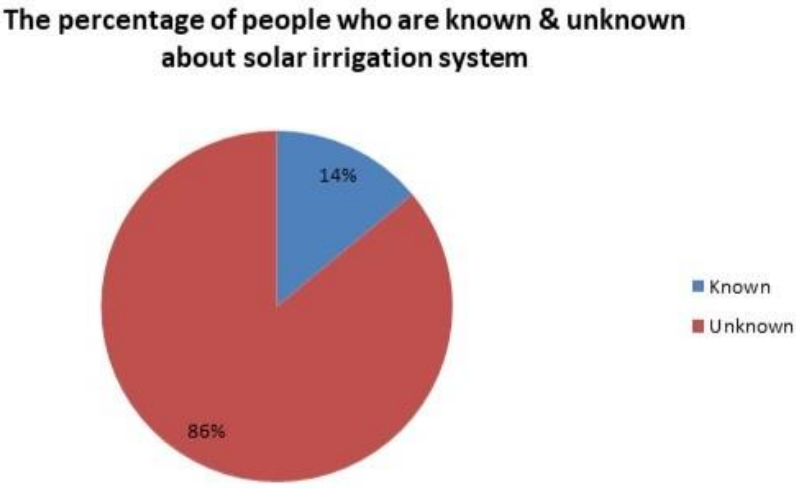

Fig. 4. People's awareness about solar irrigation system

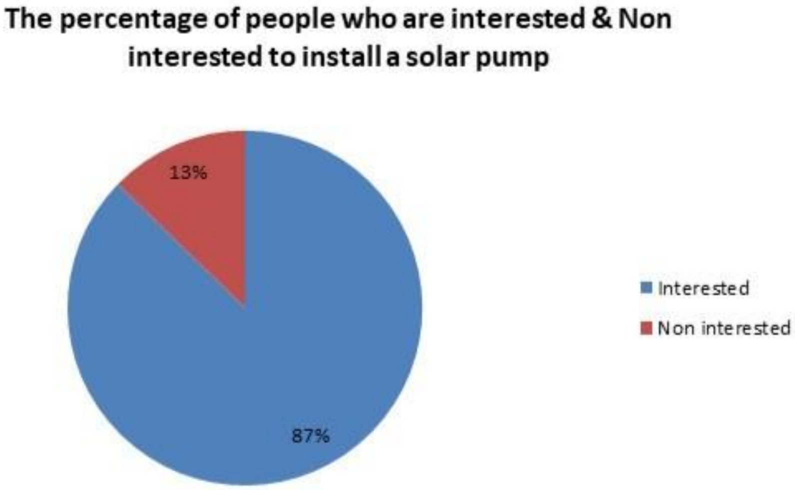

Fig. 5. Interested and non-interested people

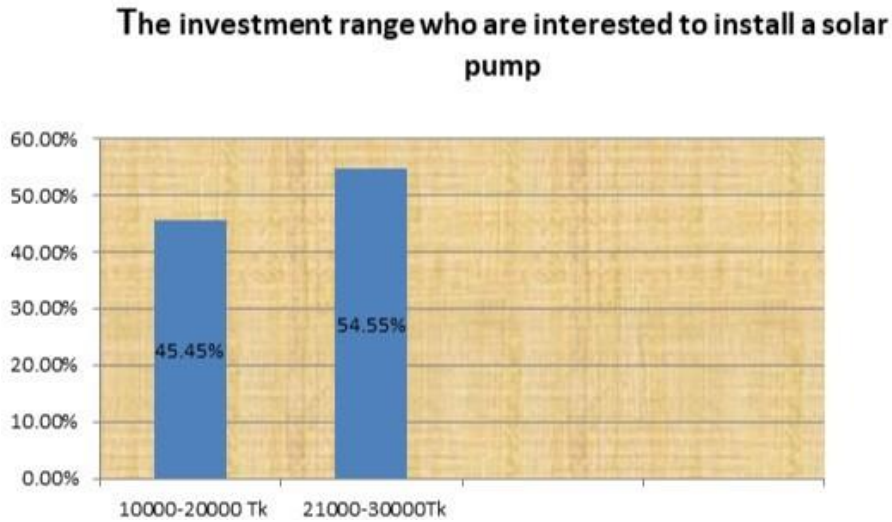

Fig. 6. Interested people's investment ability

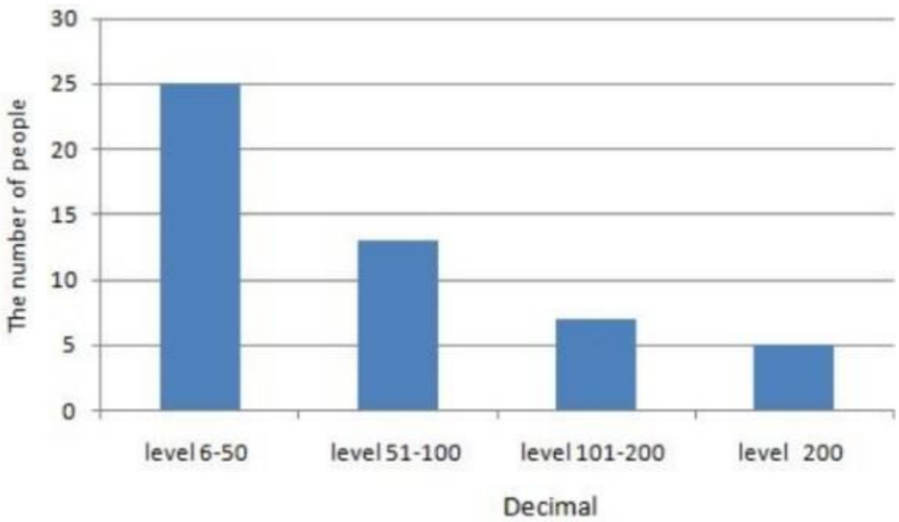

Fig. 7. Interested people's amount of land

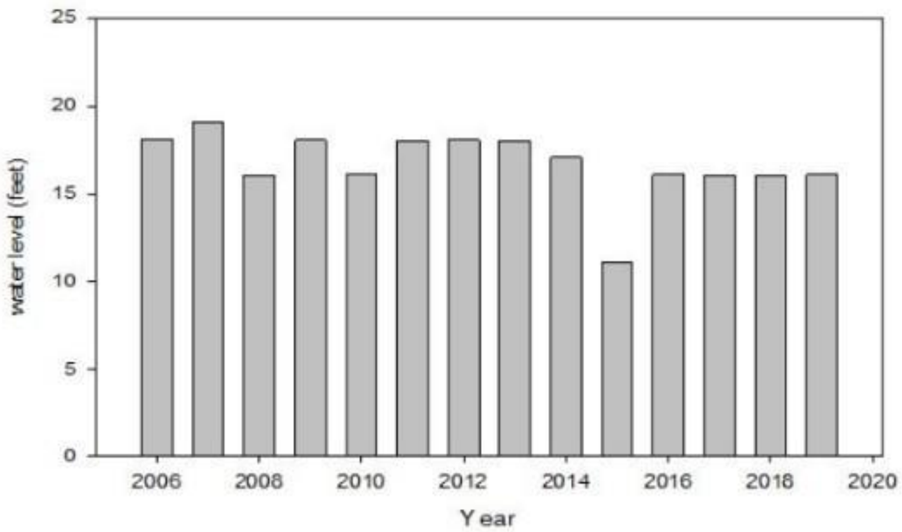

Fig. 8. Underground water level

3.2 Maximum arable land

We know that 1 decimal equals 435.6 square feet 100 square feet land needs approximately 62 gallon or (62 $\times$3.79) = 324.98 liter of water. So, 1 square feet land needs approximately 2.35 liter of water So, 435.6 square feet land needs approximately 1023.66 liter of water

flow rate of the pump = 133.33 liter/min

So, 1 decimal or 435.6 square feet can be watered with about 7.7 min. In our country, average sunlight time /year is 4.5 hrs or 270 min. So, in 270 min the selected pump will deliver 35999.1 liter of water per day. Therefore, within this average day time (4.5hrs), it is possible to water maximum 35.17 decimal or 35 decimal land (approximately) by the selected pump.

3.3 Baterry Calculation of Solar Pump

As shown in Fig.7, 50% people of the selected region have at least 6 to 50 decimal arable land. But, with the selected pump only 35 decimal land can be watered during day time per day. For the remaining (50-35) or 15 decimal land can be watered at night on the same day. In this case, a battery need to be considered.

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15 decimal land will take 115.5 min or 1.9 hrs i.e. approximately 2 hrs to be watered by the selected pump. Now,

$$daily\ demand = selected\ pump\ current \times number\ of\ device \times time$$

In this case, $selected\ pump\ power = 150\ watt, pump\ voltage = 12V, number\ of\ device = 1\ pump, time = 2hrs$

So, the calculation gives 25Ah of of daily demand.

Again, $battery\ power = \frac{daily\ demand \times autonomy}{DOD \times RF \times TR}$

Where, $daily\ demand = 25AH, autonomy = 3\ days, DOD = depth\ of\ discharge = 50\%(solar\ battery), RF = rate\ factor = 1.3(for\ 30\%), TR = temperature\ derating = 1\ (for\ Bangladesh)$

So, after calculation, battery power was 115.39 Ah.

120Ah battery is available in the market. So, the actual size of the battery for this system was $(120 \times 0.95 \times 0.85)$ or 96.9 Ah where columbic efficiency is 95% and voltaic efficiency is 85%. Therefore, the number of parallel battery will be 1.19 i.e. 2 of 120Ah for watering at night when,

$$35\ decimal < arable\ land < more\ than\ 50\ decimal$$

3.4 Charge Controller of Solar Pump

In this system, we did not need any battery for up to 35 decimal arable land but we needed a MPPT charge controller in order to adjust the input as the sunlight changes for both without and with battery situations.

$$\text{charge controller power} = \text{number of parallel panel} \times \mathrm{I_{sc}} \times safety\ factor$$

In this system, we considered 2 solar panels of 100 watt of which Isc = 6.17 A and safety factor = 1.3. So, 16.042 A i.e. we needed one 20 A MPPT charge controller.

3.5 Installation Cost

Since solar panel peak power will be 1.25 times of the power of pump, the required total panel power is 187.5 or around 200 watt.

As shown in fig. 6, 54.55% people are interested to invest maximum 30000BDT for solar pump system. By the calculation, the lowest installation cost was for electric pump system which was 10000BDT. On the other hand, this cost for diesel pump system was somewhat higher than that of electric pump system. These two systems' installation costs are within the people's investment range. However, though the installation cost of solar irrigation system,20950 BDT, within the range without battery ,total installation cost with battery exceeded the range which was 48970 BDT.

3.6 Irrigation Cost

Every year, there are three seasons and during these seasons the selected crops are potato,boro rice and aman rice. The number of times to water one decimal land for potato, boro rice and aman rice are 4, 30 and 3 respectively (from survey). For calculating the irrigation cost we needed to consider each pump system separately. However, we did not need to consider irrigation cost for solar pump system since the electric power will be consumed from solar panel.

a. **Diesel pump system:** After calculation, in diesel pump system, the irrigation cost per decimal land for potato, boro rice and aman rice were 20 BDT, 3BDT and 20BDT accordingly for one time of watering.

b. Electic pump system: After calculation, in electric pump system, the irrigation cost per decimal land were 15BDT,2.5BDT and 15BDT for potato, boro rice and aman rice are 20 BDT, 3BDT and 20BDT respectively for one time of watering.

3.7 Payback Period Calculation

For both diesel and electric system, with increase in land cost increases. But, in solar irrigation system, there is no extra cost except the installation cost which was 20950BDT for up to 35 decimal lands and up to 50 decimal it was 48970BDT. As a result, using this system, a farmer actually can save irrigation cost as net positive cash flow which is either comparable with the cost for using electric pump or the cost of using diesel pump for irrigation. For simplicity, here we considered their average values for calculating payback period of solar pump system.

For electric pump and diesel pump, payback period must be calculated on the basis of the benefit after selling the crops. There was no other way. However, for solar pump system, a farmer has no irrigation cost. In this case, what he virtually saves by using solar pump system instead of other two systems can be used to calculate the payback period. One does not need to consider the after selling benefit to calculate payback period of purchased solar pump system.

If a farmer uses the considered system only for 35 decimal lands then he does not need to buy a battery. But, if he wants to water extra 15 decimal lands by the same system, he has to buy 2 batteries of 120 A which will increase the installation cost almost two times.

As shown in fig.9, for both without and with battery, payback period trends decreased slowly with increase in land. Whatever is the amount of land, payback period was almost double for the solar pump system with battery compared to without battery. For example, the payback period was about 7 years for with battery whereas it was nearly 3 years for without battery to water 35 decimal arable land by solar pump. For with battery , it would take almost 5 years for full return of installation cost. For small amount land, it will be better to use solar pump system without battery and the effective arable lands by this system will be 35 decimal since it will take only 3 years for payback period.

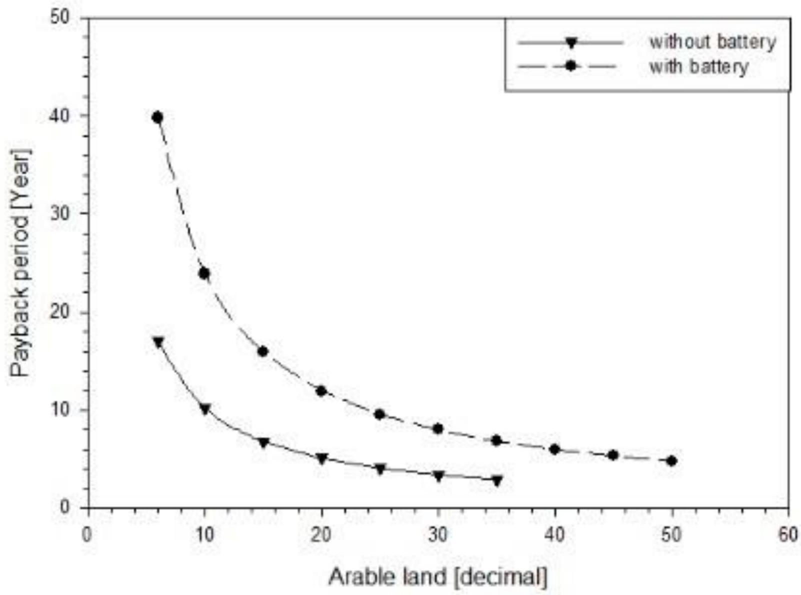

Fig. 9. Payback period

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4 Conclusion

The aim of this study was to find the percentage of people who felt interested in solar irrigation system and their affordability, design a small scale solar irrigation system within the people's affordability and finally the payback period to evaluate the feasibility of the designed solar irrigation system. Important conclusions can be summarized as follows:

1) Though rural areas' people do not know enough about the solar irrigation system, awareness program can be helpful to encourage them to use this system significantly.
2) Pressure head of the small scale solar pump was within the maximum and minimum levels of underground water. So, small scale solar irrigation system is application for water the land.
3) Whatever is the amount of land to be watered, payback period of battery based solar irrigation system will be always greater than that of without battery-based system.
4) For small scale application, almost five years will be needed for full return of installation cost of the solar irrigation system with battery.

5 Acknowledgment

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References

[1] D. Muhammad, M. Mosleh, and S. U. H. Khan, "Assessment and evaluation of solar irrigation system in Bangladesh," *Proc. 2014 3rd Int. Conf. Dev. Renew. Energy Technol. ICDRET 2014*,February, 2014.

[2] M. T. A. I. Khan, S. Sarkar, S. Hossain, A. U. Ahmed, and B. B. Pathik, "The feasibility study of solar irrigation: Economical comparison between diesel and photovoltaic water pumping systems for different crops," *2013 Int. Conf. Electr. Inf. Commun. Technol. EICT 2013*, 2014.

[3] R. Mandal and R. Naskar, "A Comparative Study and Performance Analysis of Two Similar Solar Photovoltaic Irrigation Systems; One with SPV Panel Cleaning Mechanism and another One , without Cleaning Mechanism", *Int. J. Adv. Altern. Ernegy, Environ. Ecol.*, vol. 1, no. 1, pp. 15–35, 2012.

[4] S. Zaman, S. Matin, and A. M. Bin Gholam Kibria, "A Study on the Present Scenario of Solar Irrigation in Bangladesh," *IOSR J. Bus. Manag.*, vol. 16, no. 6, pp. 25–36, 2014.

[5] B. Eker, "solar powered water pumping system," *Trakia J. Sci.*, vol. 3, no. 7, pp. 6–11, 2005.

[6] Y. Yu, J. Liu, Y. Wang, C. Xiang, and J. Zhou, "The feasibility of solar water pumping system for Cassava irrigation in Guangxi Autonomous Region, China," *Energy Procedia*, vol. 142, pp. 447–454, 2017.

[7] M. M. Rahman and N. Shafiq, "Optimization of a Solar Powered Water Pump for Crop Irrigation," August, 1322.

[8] R. Mandal and R. Naskar, "A Study of Solar Photovoltaic Application in Irrigation System and Its Performance Analysis in Laboratory Scale," *Int. J. Adv. Altern. Energy, Environ. Ecol.*, vol. 1, no. 1, pp. 1–14, 2012.