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Water Security in Rural Areas through Solar Energy in Baja California Sur, Mexico

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***Abstract*—**This study aims to assess the potential of solar energy technology for improving access to water and hence the livelihood strategies of rural communities in Baja California Sur, Mexico. It focuses on livestock ranches and photovoltaic water-pump-technology as well as other water extraction methods. The methodology used are the Sustainable Livelihoods and the Appropriate Technology approaches. A household survey was applied in June of 2006 to 32 ranches in the municipality, of which 22 used PV pumps; and semi-structured interviews were conducted. Findings indicate that solar pumps have in fact helped people improve their quality of life by allowing them to pursue a different livelihood strategy and that improved access to water -not necessarily as more water but as less effort to extract and collect it- does not automatically imply overexploitation of the resource; consumption is based on basic needs as well as on storage and pumping capacity. Justification for such systems lies in the avoidance of logistical problems associated to fossil fuels, PV pumps proved to be the most beneficial when substituting gasoline or diesel equipment but of dubious advantage if intended to replace wind or gravity systems. Solar water pumping technology's main obstacle to dissemination are high investment and repairs costs and it is therefore not suitable for all cases even when insolation rates and water availability are adequate. In cases where affordability is not an obstacle it has become an important asset that contributes –by means of reduced expenses, less effort and saved time- to the improvement of livestock, the main livelihood provider for these ranches.

***Keywords*—**Solar Pumps, Water Security, Livestock Ranches, Sustainable Livelihoods.

I. Introduction

FURTHERMORE, it looks into a set of government programmes –which partially finance photovoltaic (PV) water pumps for livestock ranches- that have been operating in Baja California Sur for over six years now and have rendered significant results to date. Since such programmes are also being implemented throughout the rest of the country, this study can serve as a parameter against which other cases can be measured and to evaluate its potential for replication. However, other data suggests that PV pumps have experienced numerous problems for water extraction in various places [9], [11]. Problems with controllers, inverters, pump motors and the matching of components have been repeatedly reported [9]. Nonetheless, a reliable analysis would require a larger sample to truly unearth the causes behind the technical problems; surely the fact that we have only 10 cases where problems were experienced -and where causes greatly differ- makes any explanation very limited.

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II. The Case of Mexico and Baja California Sur

Three quarters of Mexico's territory are arid or semi-arid. There is enormous potential for solar energy and at the same time a constant possibility of facing water scarcity. More than half of the country has an average solar energy density of 5 kWh/m²/ day; if we take into account an efficiency of 10% for solar systems, an area of only 200 million m² –a minor fraction of Mexico's territory- of solar radiation collection could supply every home with electricity. Moreover, because in such ecosystems more solar radiation is inversely related to water availability (regular insolation but very scarce rainfall) this can result in a perfect combination, when the sun is stronger and the need for water more urgent, enough energy can be provided through photovoltaic technology for steady water extraction.

More than five million Mexicans do not have access to grid electricity in over 88,000 villages [4], mainly because of distance and a small consumption level that do not make it economically feasible. Thus, potential justifications for renewable energy systems potentially lie in the avoidance of logistic problems like the economic difficulty of distributing small amounts of fuel and electricity and this makes renewable energy technologies so appropriate in remote areas [5]. However, in some cases forestalling the problems associated to conventional energy sources might not be enough for justifying the introduction of such technology [1] and this study set to find out if this is the case. Baja California Sur has the lowest annual precipitation in the Country, only 175 mm.[2]. There are no major river systems, thus the state depends largely on aquifers for water supply and recharge for these occurs almost exclusively from rain during the very short and limited rainy season in July-September. Substantial recharge also occurs when hurricanes and tropical storms hit the peninsula [8]. In comparison, Average annual groundwater recharge in the Baja California Peninsula is 1,413 hm³, while the Yucatan Peninsula has recharge of 25,149 hm³ [2] BCS extension.

III. Renewable Energy for Agriculture and Sustainable Ranching Programmes In Mexico

Under these programmes solar pumps have been installed in livestock ranches throughout the state with a subsidy-credit scheme (60% and 40% respectively). The Mexican Trust for Shared Risk- FIRCO Fideicomiso de Riesgo Compartido-[1] has been in charge of implementing the program, and it remains so in spite of several changes in the funding scheme.[2]

There are approximately 2500 ranches in Baja California Sur, of which 1200 have the potential for installing PV pumps, 200 already have the technology. To cover the 1000 remaining, 78 million pesos (£4.6 million) would be required (Rochin, personal communication). Total costs for a PV array and pump are in between £1800 and £7000 depending on the depth of the well, size of the array, type of pump, cattle heads (i.e. water demand), etc. and an additional £120 to £180 are needed for the initial study and design [3].

IV. Methodology

This study examines 32 ranches in La Paz Municipality, which are at least 2 km. Away from the grid. It intends to find out whether already installed solar energy technology represents a feasible option for enhancing access to water, for reducing general costs and effort while preserving the natural resource base and hence achieving a sustainable livelihood in remote locations. The Sustainable Livelihoods (SL) and Appropriate Technology (AT) approaches are used here as a methodological framework. This allowed for a flexible research that can accomplish a study that is qualitative in its nature and yet can also make use of quantitative methods to discern general patterns obtained through data gathering. It is important to mention that both of these approaches give priority to people's opinion and knowledge and this is reflected in our findings. Data collection was achieved through a household questionnaire designed based on the SL capital assets framework, by carrying out semi-structured interviews with key informants, making environmental check-lists and through written documents.

The questionnaire was carried out in La Paz municipality over a period of five days, covering 32 ranches (Fig. 1) of which 22 had solar pumps and the rest used other water extraction systems such as gasoline/diesel, wind, or gravity (hoses). Quantitative analysis of the results was done through frequency distributions and cross-tabulations. Qualitative analysis was based on the SL capital assets and the Appropriate Technology criteria. Both analyses were complemented by field observations and information obtained though literature and constitute the groundwork to explain the findings of this study draw conclusions.

[1] Agency of the Mexican the Secretariat of Agriculture (SAGARPA)

[2] Initially Sandia National Laboratories (SNL), based in Albuquerque, New Mexico, USA; and currently with GEF funds. Both complemented by domestic schemes like Alianza para el Campo.

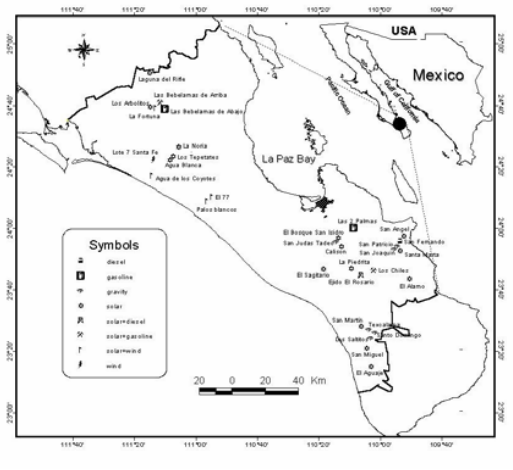

Fig. 1 Location and type of pump of surveyed ranches

V. Results

Ranches in La Paz municipality share similar conditions regarding water availability and main economic activity (livestock). Population Yet very site-specific characteristics partly determine access to water, livestock size, and access to technology. Water is scarce but most people consider that they have enough to meet their needs and are very aware of the importance of rainfall and storage capacity to guarantee water security.

PV pumps have had a positive effect on the livelihoods (Table I) of people but are not suited for every location. It stands out that this might be different according to the technology it is intending to substitute, and cash liquidity of the ranch, especially if we take into account that this technology has experienced operation problems in various places.

When looking at human capital, it stood out that solar water pumping technology has affected livelihoods in two basic ways. Firstly, by way of eliminating the need for physical natural capital and resulting pollution and allowing people more time to look after the livestock, and secondly, having enhanced water management practices by restricting extraction rates to the size of the pump and the daily available sun light.

On the issue of water extraction, two important findings are, firstly, that ranchers only use the water they actually need (and it is mostly for livestock) and secondly, they have a limited storage capacity, even if they could pump out significantly higher amounts of water they have no place to store it. As means of a complementary analysis, a chi-square ($\chi 2$) test was performed to find out if actual values differed significantly from expected values. The null hypothesis –an expected 50-50 answer ratio for yes and no- could not be rejected because of a p value= 0.068 (setting the acceptable level of significance at α= 0.05).

It was found that water extraction with a solar pump is not significantly different from other extraction methods (i.e. a solar pump does not in fact extract an amount significantly

higher); No clear signs of over exploitation due to improved access to the resource can be found from this standpoint. No instrument was used to check the amount of water extracted.

Being a semi-arid environment natural resources are limited but information points to it being enough to satisfy most people's livelihood needs in a sustainable manner. Although water resources are very limited, 65% of the farmers reported they had enough. There is however, a constant need for grazing land and pasture restoration along with sustainable management strategies [3].

Regarding physical assets, an attempt was made to find if people had experienced problems with the solar pumps as well as assessing how much time it took for the problems to be solved. A direct response however, said they experienced problems and 54.5% had not encountered any problems. At first glance it seems that almost half of the people had some sort of problem with the equipment, but further explanations given by the owners reflect a very wide range of possibilities for the technology to have failed. Consequently, a chi-square test was performed with the same criteria as before (α= 0.05). A p value= 0.67 showed that problems experienced by solar pumps were not significantly different from those experienced by other pumps, i.e. that solar pumps were not any more problematic that other types of equipment.

Then again, for at least three ranches the very expensive nature of repairing the [solar] pump resulted in having to use other means for several months. For one of the ranches repairs cost around £265 whereas their monthly income is less than £75.

Now, when looked at from an environmental perspective linked to the AT approach, it is clear that PV pumps are sustainable technology because:

- There are no fuel requirements
- It is easy to maintain
- It has a long life
- There is no heat or noise pollution [6]
- No health risks from hydrocarbon fuels/ well contamination [4]

On financial assets' results, a cross tabulation was done between income and people who have a solar pump; but no generalizations can be drawn from this, as the data is not sufficient to apply a statistical test and obtain its significance. It is interesting to find however, that there is no clear correlation between the two. In fact, the highest proportion of ranches with a solar pump within an income range lies in the lowest -less than £75-, this is, the ones who earn the least have the largest number of solar pumps; the rest is relatively evenly distributed thus showing that income is a very important but perhaps not an altogether limiting factor in the access to the technology.

This is also explained by the distortion caused by subsidies, ranging from 90% when the project started to 60% today, and furthermore, in some cases a 100% subsidy has been granted. Subsidies are indispensable for ranchers to afford the equipment, and the government has recognized that this is one of the weakest points of the programme [3].

Finally, dissemination of the technology has found obstacles both because of incipient networking among communities (mainly due to the scattered nature of ranches) and because of the prohibitive nature of the initial investment to acquire a solar pump. In spite of this, among the ranches surveyed that had a PV pump several income ranges can be found. Implications of this technology can be identified more clearly in livestock -the main livelihood provider.

Scarcity issues must be approached with caution. It is things like quality of the resource, competition between incompatible uses and social economical or institutional barriers which limit access to resources, rather than the absolute availability of water or energy, that affect people's livelihoods [10].

A very clear example of this can be seen in parts of Baja California Sur (Mulege Municipality) where solar pumps were provided but storage basins were not, without them the improved access to water is almost useless and pumping would lead to wastage. Thus, storage basins and small retention dams seem to be far more important than overall water availability for sustaining small livestock ranches, even though water is relatively scarce, increasing supply would not bring about a real solution to the problem.

Another key factor in understanding the relationship between water and livelihoods in these ranches is the fact that many ranchers try to run too many heads of livestock during high rainfall years, with consequent deaths and herd reductions during drought years due to depleted ranges. Through large diesel or gasoline water pumps, the rancher can extract larger amounts of water to artificially maintain a substantial herd size during moderately dry years. However, a solar water pumping system does not allow for this option since water that is pumped daily is limited by the amount of sunlight and system design [7].

VI. Discussion and Conclusions

PV pumps can be considered appropriate technology in that they are reliable, sustainable, adaptable to the local environment and relatively affordable. Therefore, given that the rancher can afford the initial investment without compromising financial security, solar pumps are an ideal alternative for substituting gasoline or diesel ones, but for places where wind and gravity are reliable enough it may be an unnecessary expense and an otherwise asset might become a burden.

On a regional level environmental advantages are clear- reduced emissions, health benefits, sustainable water extraction levels, and reduced risk of overgrazing and soil erosion. Economic gains however are not as evident due to high initial investment and occasional excessive repair costs. Nonetheless, the cost of PV technology has steadily diminished and is expected to be considerably lower by 2010; if the present subsidy-credit schemes can be maintained, it is possible that this technology will become more affordable. In sum, solar pumps make sense in remote locations to overcome the logistical difficulties of fuel. In this case significant savings can be made by renewable energy technologies because there is no need for fuel, and even more so if the

energy and water can be used to grow fodder and food. So far the government has played a key role in making access possible to such technologies. Perhaps the involvement of other sectors of society can make access and dissemination even easier in the future.

The main lessons drawn from this study indicate that they want a reliable non costly water extraction system; enough storage capacity –without which the most efficient extraction method is useless-; more retention dams to increase groundwater recharge and make the most of the diminishing rainfall; and an aid scheme where the ones who need it the most are benefited. People know best and appropriate technology can help in improving conditions for them to do precisely this and in turn achieve a sustainable livelihood. For some this has already happened through solar pumping technology, the possibility of it reaching more people is tangible keeping in mind that it is not the best solution in every case, this is, making sure that it is truly appropriate.

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