Assessing Sustainable Development of Isolated Communities: The Role of Electricity Supply

Summary

The term "rural development" refers to initiatives undertaken aiming to improve the quality of life of non-urban communities. Sustainable development (SD) of rural communities is directly linked to the communities' skills for adapting themselves to changing conditions in constructive ways. Different studies have shown that one important factor contributing to the development and growth of rural communities is power supply (Berglund & Soderholm, 2006; B. Borroto, Borroto, & Vázquez, 1998; DFID, 1997). However, assessments on the influence of power supply over rural development have fallen short of expectation as they have been too technical, mainly using econometric approaches or coefficients based on misery line. This paper seeks to contribute from a holistic approach to identify economic and social development in which energy is a crucial factor that contributes to human, social, and economic development, all supported on information technologies and mechanization processes, thus enabling sustainable development.

Keywords: Off-grid communities, sustainable development, rural electrification, sustainable livelihoods (SL) framework, system dynamics.

Introduction

Energy supply contributes to the economic and social development of isolated communities (Ozturk, 2010; Painuly & Fennhann, 2002; Rozakis, 1997; Siemons, 2001; Utlu & Hepbasli, 2007). However, there are other elements are required for sustainability, including the application of electricity to processes that add value to a community (J. A. Cherni et al., 2007; J. a. Cherni & Hill, 2009; Henao, Cherni, Jaramillo, & Dyner, 2012; Singh & Hiremath, 2010). The literature has shown the

need to evaluate the evolution of energy technology over time (BID, 1998; Goldemberg, 2000), but this does has not addressed the need of engaging with sustainable development. Rather, this emphasizes the development of particular elements of the community by neglecting a systemic approach, which limits the broad approach required to address development issues.

SL is primarily and specially about people. SL also contributes to better define institutional agreements that may promote strategies to overcome poverty and to improve communities' quality of life. Its aim is to achieve a realistic understanding of the strengths of communities (capital endowments) and their possibilities to use these for better livelihood (DFID, 2002). The SL framework below (see Figure 1) can be useful to the identify goals, opportunities, and development priorities in order to accelerate progress and to eventually eradicate poverty.

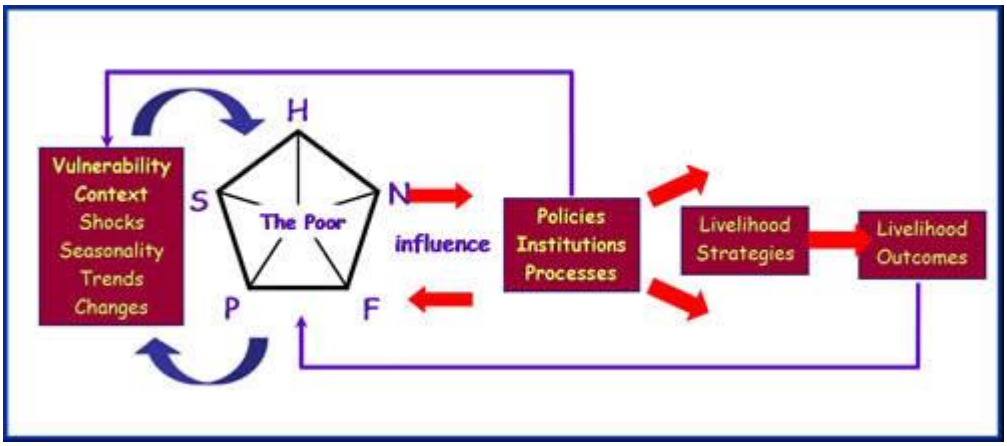

Figure 1 Sustainable Livelihoods framework (DFID, 2002)

On the side of communities and their needs, development in rural areas is a holistic problem that integrates relevant factors such as education, health, social capital, economic means, and environment. In this paper, we focus on how energy supply may contribute to rural development. This is done by demonstrating how different elements contribute to the development and how these evolve over time in a simulated environment. This simulation through an SD model incorporates the ways in which behaviors may contribute to reinforce the build-up of the

communities' endowments – i.e. capitals (human, social, financial, natural, and physical (see DFID, 2002)). To this end, different approaches and methodologies are discussed in the next sections regarding the problematic situation analysis of the community's SL.

Problem Situation

Maslow (2000) has established that human needs are prioritized according to some categories. These categories range from the most basic ones (physiological), through the ones that determine safety, shelter, and love, up to those related to self-esteem and those related to achieving the potential of individuals in society (see Figure 2). In these sense, and according to Sen (1999), *freedom* ultimately promotes the emergence of development as most actions carried out by people seek for a level of sustained welfare (Pg. 3, Sen, 1999). The actions of individuals are motivated by the satisfaction of needs, and eventually targeted by providing safety and means for survival. Particularly, individuals within off-grid and poor communities look for solutions (social, economic, natural and others), so they are able to move upwards in Maslow's pyramid.

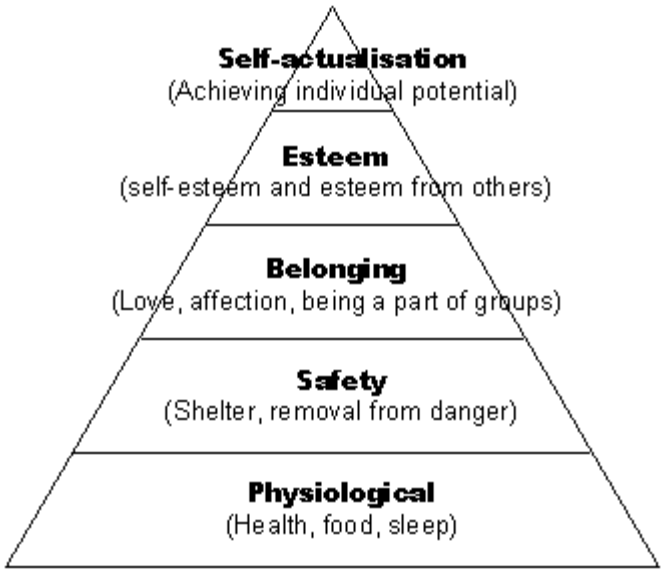

Figure 2: Pyramid of Maslow (Maslow, 1943)

Under this theoretical framework, the role of energy technology is understood as means for sustainable development wherein communities may freely progress upwards in the pyramid of needs, and may assess the impact as well as the boundaries that limit the development of the respective communities (Abualkhair, 2007; Singh & Hiremath, 2010). In this sense, rural communities are not only determined by their physical or geographical endowments, but they may also take responsibility for the ways in which technology is managed. This can be measured in terms of technical and technological capabilities, which might be learned and developed, and by the level of freedom that might be attained by individuals (Robledo & Ceballos, 2008). However, as long as energy technology provides means to attain freedom (welfare), it also entails responsibilities regarding its maintenance and sustainability.

This leads us to our model-based approach framed within the systems-thinking methodology (Berglund & Soderholm, 2006; Hjorth & Bagheri, 2006). This approach adds conceptually some problematic situations, uncertainty, and numerous interactions between system components – in terms of a theoretical model – that address isolated rural communities.

Methodology

Our dynamic hypothesis is proposed in Figure 3. As shown, energy is necessary for satisfying basic needs (physiological and safety needs), which in turn contribute to the development of social and economic activities, thus attaining freedom for individuals and developing social welfare. The eventual satisfaction of needs and the use of energy lead to further energy needs, which justifies additional power capacity. This capacity can be affordable by increasing communities' income generated by the growth of their economic activities. By meeting needs, it also becomes evident the emergence of some freedom that supports possibilities towards technology learning and efficient satisfaction of needs at all levels of the Maslow's pyramid (Maslow, 1943).

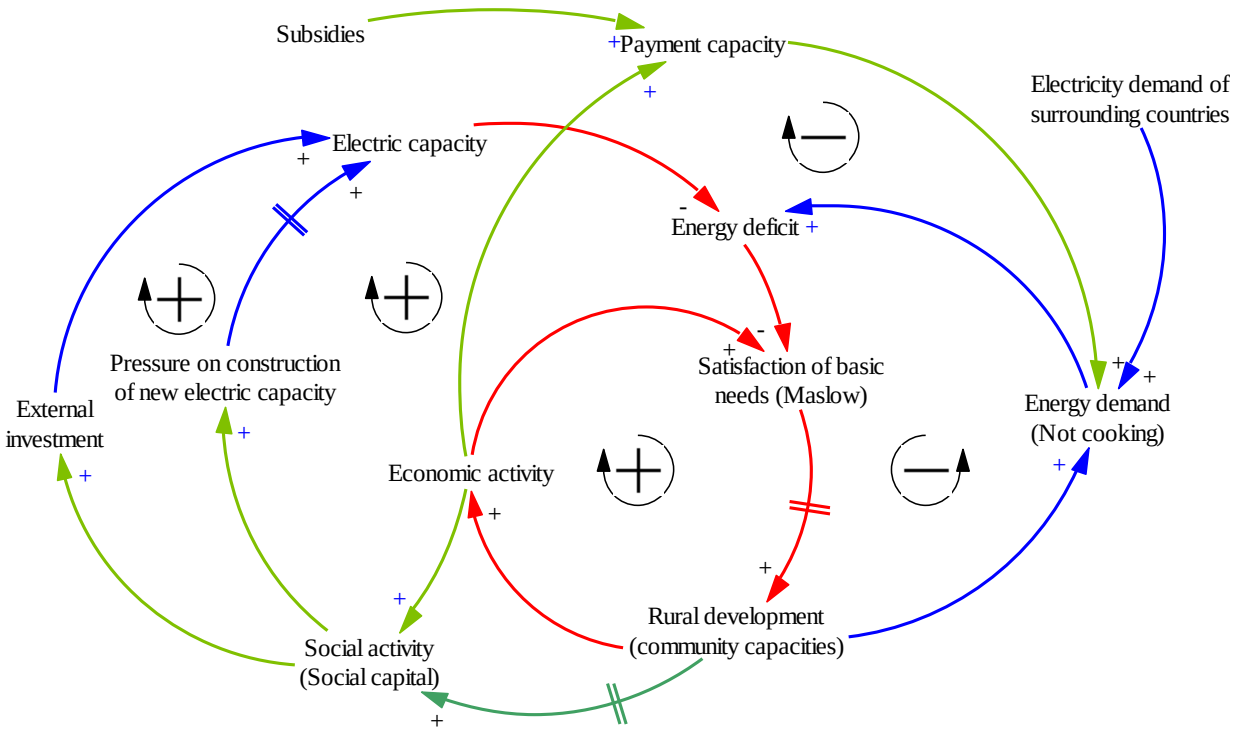

Figure 3. Development supported by energy technology.

The diagram shows a set of cycles in which the most important are the central ones, which involve elements of Maslow's pyramid. These include the satisfaction of physiological, security, and belonging needs. When these needs are satisfied, rural development is boosted and freedom of individuals is more likely to be achieved.

When the community makes progress towards development, income improves as the product of more diversified economic activities. This increases the communities' abilities to afford electric energy enabling the exchange of goods and services. It is important to note that subsidies from the State also facilitate the communities' access to energy technologies, fostering energy demand for subsistence as a consequence. Furthermore, social activities are embodied into groups or associations. These strive for the consecution of more energy-related infrastructure and for the acquisition of external investment, which increases, at long term, greater investment in energy capacity. By taking into account such

energy demand, in conjunction with electricity supply, the community's energy deficit is determined, which exacerbates Maslow's pyramid of needs.

Simulation model

Social development and basic satisfactions are mapped as levels depend on the energy technology in place. Income level is a result of the community's economic activity. Electricity capacity is expanded depending on the community's demand and its payment capacity. In this way, Maslow's pyramid is incorporated as part of the SL framework (Maslow 1943).

Social capital is influenced by a number of factors, including support groups (technical and technological knowledge about energy), which meet sustainability needs. Human capital depends on information technologies that contribute to learning processes. Surrounding communities are exogenous to the system.

Social, human, and financial capitals – as part of the Sustainable Livelihoods (DFID, 2002) framework – are central in the model as they represent the variables that directly influence development in accordance to the aforementioned hypothesis.

Results

For the analysis of results, it has been necessary to identify the impact of the availability and consumption of energy in rural communities.

Considering Maslow's perspective, Figure 4 shows that, with the impact, there is a long-term satisfaction starting with physiological needs. Needs satisfaction is more compelling as the community focuses its efforts on improving the quality of food when adopting different ways of cooking, preserving, and marketizing aliments.

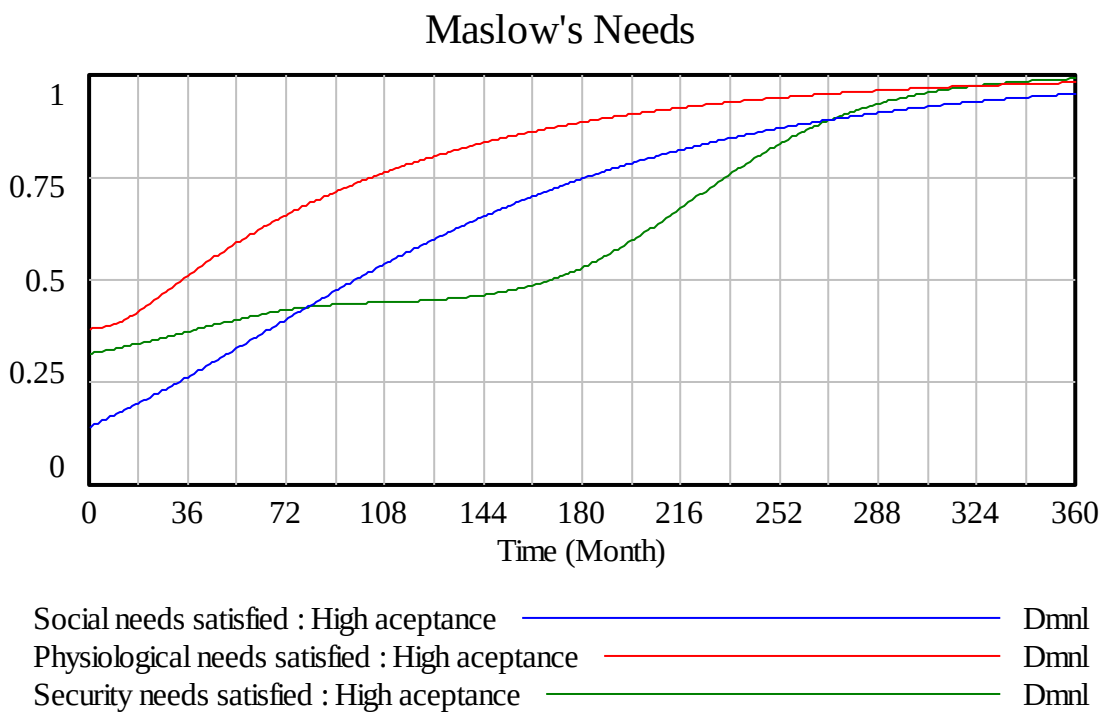

Figure 4. Maslow's needs satisfaction.

This improvement has a direct impact on security needs. This can be explained by the fact that when physiological needs are satisfied, the community actions focus more on improving housing and night illumination, and meeting different needs that could not be supplied before due the basic need of purchasing food for subsistence. Later, with the satisfaction of social needs (group membership), resources availability that permit the creation of new operation partnerships, maintenance, and improvement of human relations within the community is identified. This set of changes improves communication dynamics of the community, potentiates its income from available resources, and makes the very community a development focus within the region. This makes this grow to change, because after energy adoption this level can overcome surpassing previous limits. Energy helps community to grow in this needs, in use of energy, related to acceptance and use.

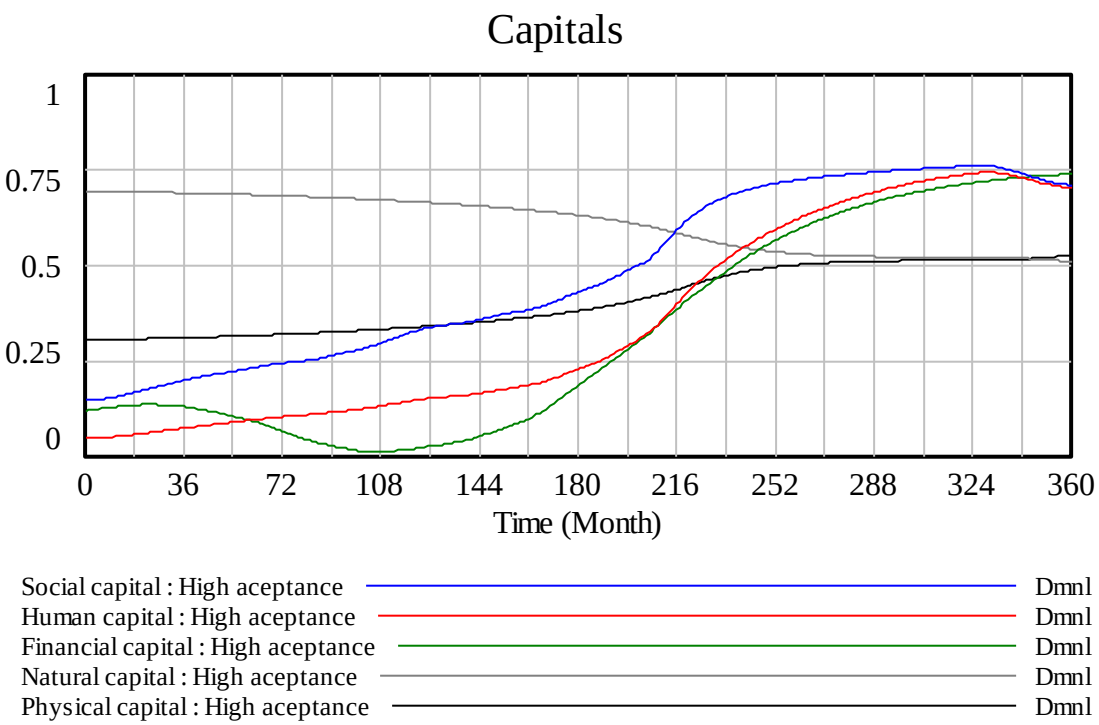

Figure 5. Capitals.

The measure using capitals allow to make an analysis in a wide approach, reviewing aspects not shown in the dynamic hypothesis. Social capital are related directly to belonging needs and the rest of capitals are related to rural development. In addition, the model shows that, due to a greater amount of energy available, long-term income increases. This may be because the accessibility to different means of generating income is possible, creating a new culture of exploitation around electric power. As shown in Figure 5, after a small foreign investment in maintenance and energy, operation training is accomplished leading to a steady income increase related also to commercial exchange with neighboring communities, the exploitation of resources and better use of them. All this takes place with various forms of energy exploitation, either by creating nightly meeting points and or by establishing partnerships aimed at better managing new revenues. For the natural capital the use of resources like water or even gas in energy generation slowly decreases the natural resources of the region, but at the same time this allows to the community to grow in physical capital and financial

capital, related to the use of energy and the increase in generation in all the time of this simulation.

However, the demand for energy increases as time passes by since the attraction of foreign population leads these energy requirements to grow steadily. This generates a cycle of reinforcement, which makes the external investment necessary. However, at long term, this can be replaced by a transfer of income from the community to training processes and teaching technology management. Moreover, given that the ownership rate of energy technology is superior due to human capital accumulation (represented by the newly acquired technical skills of the community), it can be seen that there is a decrease in energy deficit combined with strong pressure for the construction and improvement of existing energy technology (see Figure 6). At the same time is shown that income per capita goes down, because this energy deficit affect negatively the income, related directly to the new uses of energy that cannot be achieved.

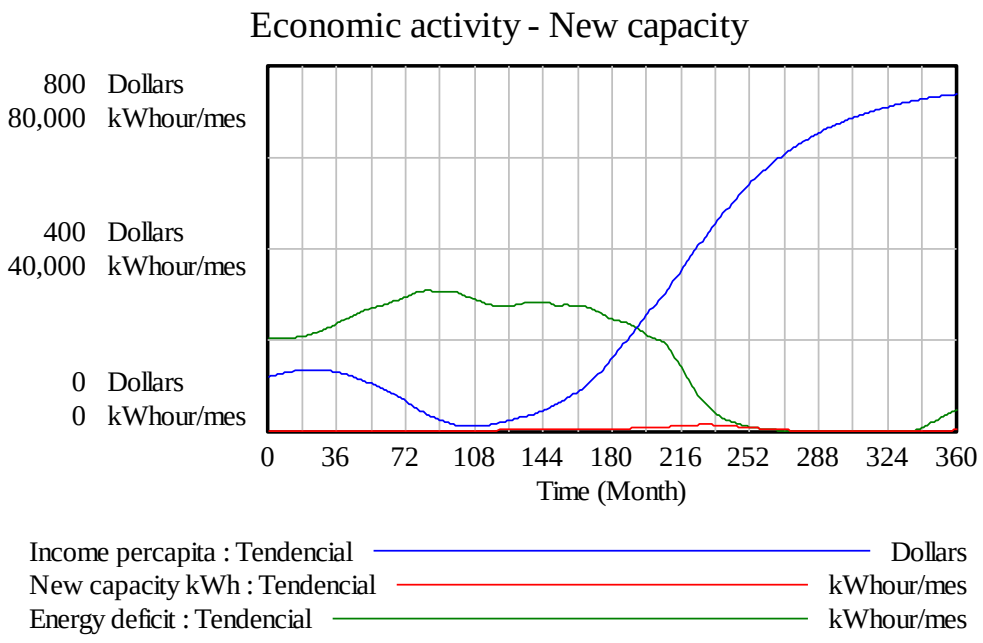

Figure 6. Energy changes

With respect to capitals, these emerge from the satisfaction of needs proposed by Maslow. This occurs possibly because when individuals have a good satisfaction level satisfaction of physiological needs, they switch to training people in the community in technology management, which is ultimately the human capital. Besides, this capital enables the creation of partnerships, which are based on the need to belong to groups (Belonging needs) of people, generating automatically an improvement in social capital.

The creation of support groups is present at the beginning of the simulation, but as time goes on, given the capabilities of the community, these groups are turned into collective knowledge, allowing easy maintenance and operation of energy technology, which reduces the need for conducting on-going support programs.

Finally, the expected behaviour from the inclusion of energy technology in a rural community is to be accompanied by comprehensive support programs, pending knowledge appropriation, and further emergent needs in communities. In these ways, maintenance by local authorities interested in developing and meeting the needs of the community and other surrounding communities.

Conclusions

Poverty, which has been discussed by various authorities from scholar and social viewpoints, is directly linked to quality of life. Solving poverty certainly allows full development in terms of basic needs and proper social relationships. In the model presented here, poverty is classified as a cluster of factors that are discussed from a global perspective linked to the evolution of capital. Since they all have a growing tendency, they can demonstrate that energy, based on the previous model, contributes to better development.

The conceptualization of the problem, from external and internal components, necessarily imply that communities need to develop knowledge by their own means, in the case there are complex technological capabilities as a source of resources to sustainable development.

Management of technological capabilities is supposed to accumulate knowledge through learning, which entails sharing internal and external sources for synergy between the parties. Hence, building complex technological capacity can be positively related to technological success.

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