Micro Hydro Power: an effective alternative for climate change mitigation and development of marginalized local communities in the Dominican Republic

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Abstract

This paper presents the experience achieved by the UNDP GEF Small Grants Programme in contributing to climate change mitigation and adaptation, by establishing off-grid community micro hydropower systems, which are managed by local communities in a complete autonomy and provide population in remote areas of the Dominican Republic with the access to electricity, reducing CO_2 emissions and favoring carbon sequestration.

In a country where provision of electricity is a major problem, in a period of 15 years, these actions have achieved the operation of 17 micro hydropower systems, sustainably managed by the same communities, providing a continuous energy service for more than 1500 families, schools, rural health centers, community centers, microenterprises and communication centers.

These initiatives have contributed to improving the wellbeing of families, especially their most vulnerable components; women have considerably reduced the time spent for housework. Similarly, it has facilitated the development of productive activities that require electricity, increasing income generation for sustainable livelihoods. Furthermore, it has positively impacted the children and youth, who can devote more time to study and have access to the communication technology through the use of Internet.

From the economic perspective these initiatives avoid the importation of more 15,700 Barrels of Oils Equivalent (BOP) per year, with a saving for Dominican economic for more than 1.6 millions USD per year. For family economy, now they have more energy for less; before the projects the expense of family to purchase gas kerosene, candle and battery charge was between 12-30 USD per month. Now each family pays 3-6 USD per month and they have access to 4-9 times more electricity, which represent a saving for each family between 100-300 USD/year. Already 35 direct employments generated for people of the communities, especially young and women, whom are responsible for operation and maintenance of the Hydro Power System, as well as the accounting and collection of the payment of electricity service.

Regarding environment benefit, the implementation of these projects have mitigated climate change with more than 24,000 tons of CO_2 per year reduced through the elimination of fossil fuel burning, or absorbed by carbon sinks through the restoration and conservation areas forests that have been recovered by the beneficiary communities themselves in the high watersheds of the basins where the systems are installed. Moreover, the biodiversity into de forest area is protected.

The establishment of community micro hydropower has allowed the Dominican Republic to generate awareness and empowerment inside local communities to address climate change mitigation, by reducing and sequestering GHG, as well as promoting human development alternatives based on self-community effort.

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Introduction

An overview of the Dominican Republic

The Dominican Republic is located on Caribbean region in the Hispaniola Island that share with Haiti, between 17°36' and 19°58' latitude north and between 68°19' and 72°01' longitude west, and, with the Islands of Jamaica, Cuba, and Puerto Rico, belongs to the Greater Antilles. It has an area of 48,400 km^2 and occupies the eastern part of Hispaniola Island, while the western part is occupied by Haiti (Figure 1).

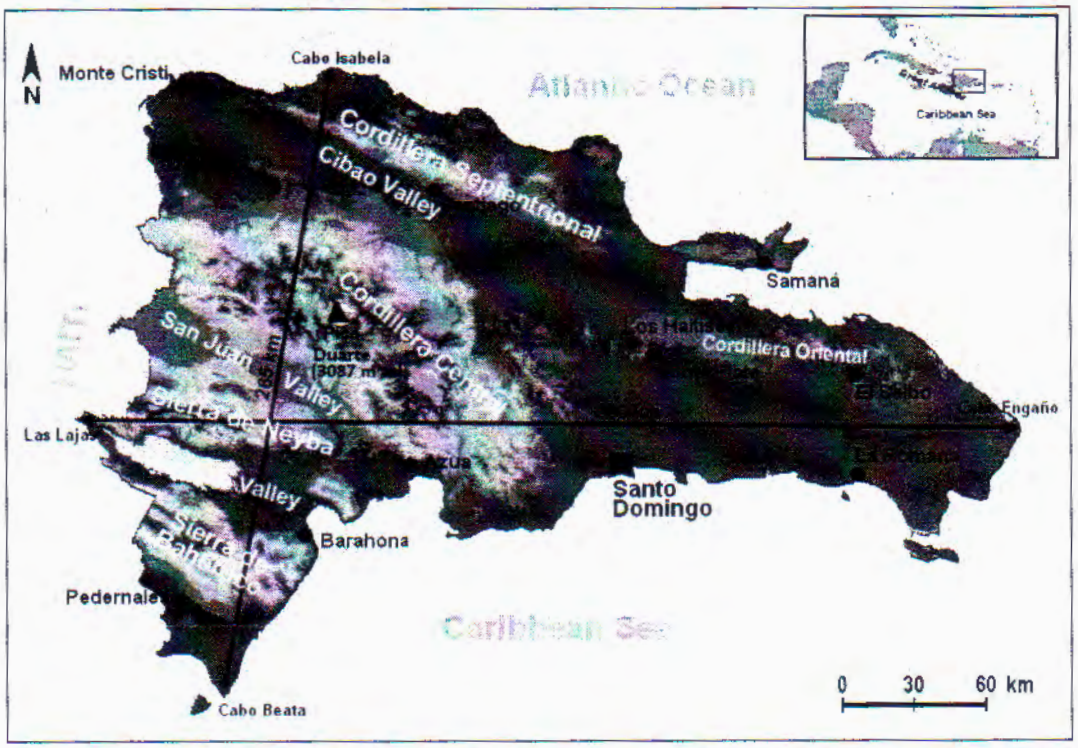

Figure 1. The Dominican Republic, showing the location of the main mountain chains, valley systems, and cities.

Despite a relatively little territorial extension, due to its physiographic setting, where the main mountain chains are aligned perpendicularly to the trade winds, which constitute the main transport mechanism of humid oceanic masses, the Dominican Republic shows a great richness in climate types (Izzo et al., 2010) and, consequently, environments (Bolay, 1997). The country is dominated by young mountainous structures, with steep slopes and narrow valleys, where water resources are abundant in the majority of the national territory. The main rivers from north to south are Yaque del Norte, Yuna, Haina, Ocoa and Yaque del Sur (Figura 1). Each of them are nourished by a great number of tributaries

The above conditions offer a suitable solution for responding to electricity provision needs for many rural communities in the country. The Dominican Republic is a country with evident contrasts between the well-off and wide groups of population who live in conditions of poverty and marginalization. In fact, despite the significant richness in natural resources, the Dominican Republic shows a low human development index of a wide population (Sen, 2001; PNUD, 2008).

One of the priority structural problems of the country is the provision of electricity, since the Dominican electrical system is characterized by low stability, reduced quality, an insufficient supply in comparison with the demand, and one of the most expensive cost structures in the Caribbean and Central America (PNUD, 2008). In this context, rural areas receive the worst impact in terms of deficiency in the provision and often lack of access to electricity, where more than 10% of the population have no access to the electricity services.

Under the impulse of a series of favorable and synergic situations, however, the problem of electrical provision has turned into an opportunity, especially in rural areas, opening the way to

innovative models of development. In the last fifteen years, with the leadership of the UNDP, GEF Small Grants Programme (SGP) started some interventions to promote the renewable energy for climate change mitigation at local level. Far from being experimental and idealistic, they have been demonstrating that sustainability is not just a word, but it can be made real in the daily life of many communities all over the world, expressing a new rurality, and a form of land use which is coherent with the right use of the specific area.

GEF Small Grants Programme in the Dominican Republic

The Small Grants Programme (SGP) is an initiative of the Global Environmental Facility (GEF), implemented by the United Nations Development Programme (UNDP) and managed with a country-driven approach with National Coordination unit and National Steering Committee with representation of the government, UNDP and Civil Society Organizations (CSO) which are mostly in the membership (SGP, 2012).

The SGP was born in the fervent atmosphere of the Rio de Janeiro Earth Summit, with the aim of conciliating social and economic development with global environmental action by local community. The Program works in five focal areas: climate change mitigation, conservation of biodiversity, protection of international waters, persistent organic pollutants (POPs) and prevention of land degradation. The SGP is present in more than 120 economically disadvantaged countries all over the world, providing support to Civil Society Organizations (CBO), Community-based Organizations (CBO), who are implementing initiatives which respond to the SGP mission in the field of environmental protection, sustainable livelihood and local empowerment. Each intervention is characterized by a maximum SGP grant amount of US$50,000 and requires a co-finance 1:1 for each project. The SGP works under values such as democracy, flexibility and transparency, a participatory focus: local organization is strengthened in order to reach the empowerment and autonomy of local communities in land managing according to sustainability.

The SGP has been working in the Dominican Republic since 1993, supporting the implementation of about 375 projects in different areas, among more 100 projects of renewable energy for climate change mitigation. They contribute in a significant way to mitigate climate change. Through their direct effort, local communities use natural resources according to the characteristics of the environment where they live, promoting actions in harmony with natural vocation of land. In terms of the impacts which are produced, both on environment and in socio-economy, the most important area of intervention is micro-hydro power generation at a community level.

Materials and Methods

SGP actions are based on principles such as learning by doing, local group empowerment, self-help, innovation and community accompanying. These principles have a particular key role in the implementation of community micro-hydro power systems.

The SGP focuses on the idea that local development starts from a decision of local communities to improve their living conditions, breaking those barriers which prevent them from achieving their wellbeing. According to this vision, every intervention starts from a precise request from a local group, which is conscious of a specific need in its living environment: directly or through the support of a Non-Governmental Organization (NGO), the community presents its project concept and proposal. Then the SGP National Steering Committee (NSC) evaluates it and finally approves the projects for funding according to the SGP's priority.

Funding is not the final aim of the SGP since its action goes much further. During the whole process of the project implementation, local groups are accompanied and trained in order to strengthen their organizational structure and management skills. In this way, the project itself becomes an experimental field, where alternatives are tested and capacities are built, which eventually will be useful to develop new actions in favor of personal and community improvements.

Promoting synergy among all the actors (governmental and non-governmental institutions, academies, international organizations, etc.) who have a role in the project, the SGP works to improve the social capital on which communities can count in their daily life. Improving reciprocity, mutual interchange and solidarity inside and outside the community, causes an improvement in its capacity of making the dynamics more efficient, by means of a better organization and coordination of the actions which are carried out (Flora et al., 2004). A constructive focus encourages any intervention, so that efforts are made to improve harmonization among the different actors who interact, and intelligent solutions for solving possible problems which might occur.

Participation is promoted at different level: special care is devoted to removing the barriers which reduce human development, and prevent people from expressing in their living environment in a free, democratic and equitable way. Actions are entirely based on community work: the project turns into the ideal space where people can discover and test their attitudes and skills, applying them to reach a common goal. A community-based focus implies a series of variables which guarantee that an initiative is born, develops and remains in a locally managed scheme, as a strong expression of the organized local group.

The methodology of intervention is based on a series of elements, which, as a whole, create the conditions for sustainability:

- **Community commitment.** Any project starts from the collective interest of the community, whose members, as individuals and as a group, give their contributions in terms of labor, financial resources, and materials. Electrical service will be provided to inhabitants on equal terms, for this reason all the potential users must contribute under the same scheme.
- **Human capital.** Academic level does not matter for getting involved in the project: the contribution of any person is important to reach the expected results and sustainability of the actions. Any person has knowledge, experience, and skills which can be very useful for the project. At an initial stage and during the implementation, capacities of people are evaluated and contribution of each person is asked in the field where she or he feels at ease the most. In such a context, people with an academic formation are required to assume a constructive attitude, using their knowledge as a tool to promote common growth.
- **Environmental protection.** Communities who are involved in hydro-power projects assume the protection of the environment as a lifestyle. First of all, they work to improve forest coverage in the basin, in order to preserve the water source which supplies energy for the system. Furthermore, their actions contribute to improving the general quality of the environment where the community is located.
- **Participatory planning.** Monitoring and evaluation is carried out by the community which is implementing the project.
- **Learning by doing.** A continuous training is provided to beneficiaries during their involvement in the actions related to the project. This way the project becomes the ideal environment to test the knowledge which has been learned.
- **Learning from mistakes.** Minimizing risks is a priority in the implementation of a SGP project. Having guaranteed this statement, any initiative is guided by a positive and constructive attitude, where each person participates without worrying about the possibility to make a mistake. Everyone acts with great individual responsibility and engagement, conscious that he or she can count on the support of a social network, constituted of people who will intervene to help him or her to find a solution to the mistakes that have occurred.
- **Solidarity.** Cooperation among individuals and groups is promoted.
- **Knowledge and experience exchange.** Any initiative is a challenge for the specific community who is implementing it. In this way, each local group develops its own experience: sharing the lessons learned by each group is a way for reducing mistakes and continues improvement for whole process. Furthermore, it contributes to create a social network of mutual support, based on common principles.
- **Adaptive management.** Flexibility is a key element in the whole process: any initiative is based on solid but not rigid rules, leaving space for any change that was necessary for the project being successful.

- **High quality standards.** The high quality of the components of the system is a prerequisite.
- **Rational use and energy efficiency.** Local groups are trained to use electricity in the most effective and efficient way, through the application of commonly accepted rules.
- **Local management.** The project is a school where the specific local group learns to self-manage the system in an efficient way.

Results and comments

The first project which was implemented under the above scheme was the installation of a community based 3.5 kW micro-hydro systems in El Limón, a marginalized rural community in the San José de Ocoa province (southeastern portion of the Cordillera Central). The system, which has been in operation since 1998, is providing electricity to 70 families of the village. Despite the smallness of this initiative in terms of it generation, which started as a demonstrative experience to test the possibility of implementation of this kind of systems at local level, the project produced positive impacts for people. The community have access to numerous services linked to electricity, among which one of the most important was Internet (becoming El Limon as the first virtual villages in Dominican Republic in 1998), which was a way to reduce distances and an incredible mean for improving education of both young people and the adults: recollected data have shown that children and young people from El Limón have higher performance than other students attending the same school.

A lot of other projects developed from this first experience: El Limón started a mission of letting other rural communities know that possibilities exist to obtain "light from water". More than 30 studies were carried out to determine the hydroelectric potential in different mountainous areas all over the country for local communities use.

At present, sixteen micro-hydro systems are working, benefiting more than 1000 families in condition of poverty, (Figure 2). The smallest system generates 0.5 kW, while the biggest one 53 kW. Other six systems are under construction, with a capacity between 15-150 kW and more than 600 families will have access to electricity. Other 25 initiatives are finalizing the studies to be developed in the next two years and will give electricity access for more than 2000 family on mountain area of the Dominican Republic.

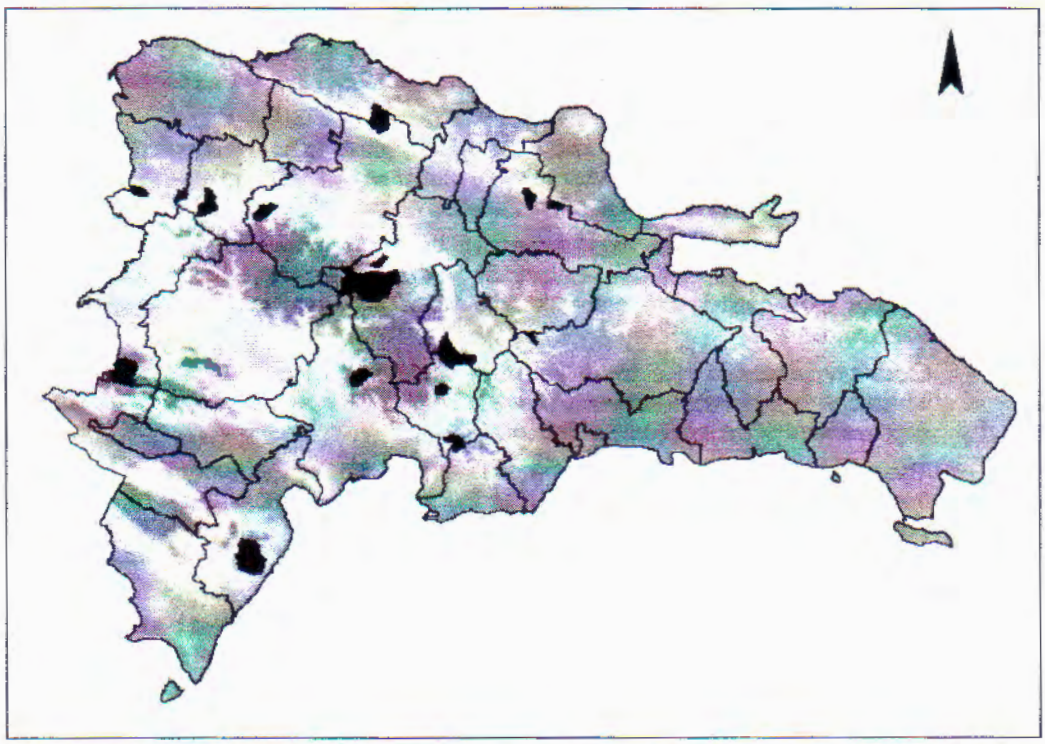

Figure 2. Location of the basins where community managed micro-hydro systems have been established.

From an environmental point of view, this kind of systems affect the environment in a negligible way, since they are designed to be inserted in the most harmonious way in the natural context to minimize the harm on the environment. Water resource is used in a way that a residual flow remains during the whole year, also during the driest periods: in order to reach this objective, in the preliminary phase of study, the beneficiaries themselves carry out periodical measurement of water flow, in order to dimension the system according the hydrological regime of the specific river. No dam is built: waters are canalized through little derivation component: in this way, there is just a little modification of the river channel. During the pipe and electrical network installation, special care is given to minimize any damage for vegetation and soils.

Less measurable environmental impact consists in the diffusion of an environmental consciousness among people involved in the process: communities where these projects are implemented show a better consciousness about the importance of preserving environmental quality: people understand that protecting nature is a way to guarantee that it can continue to offer environmental services which benefit local society and economy as well. An indicator of this care is a better waste management, with a considerable reduction of rubbish in the local environment.

On the other hand these projects contribute in a significant way to environmental protection and climate change mitigation. Adding up the systems which are working and the ones which are under construction, the actions implemented contribute to climate change mitigation avoiding the emission of more than 7,000 ton of CO_2 each year by (444 Kg CO2/BEP, Gallardo Et al. 2008; Sunearth tools.com,2012). Furthermore, communities are working at the application of integral management plans to the basins where these projects have been implemented. Oriented towards sustainability, local communities have reforested and/or established conservation practices in more than 7000 hectares of mountainous areas, many of which are strategic as providers of water resources. Considering a conservative absorption rate of 2.5 CO_2 tons per year (Brown, 1996), these interventions determine an annual absorption of more than 17,000 tons of CO_2.

Even more numerous are the social and economical impacts associated to these projects:

- People involved in these processes develop a new motivation for education, devoting more time to study, especially during night time, when they can use electricity to illuminate domestic environment. In the communities where these systems are working, programs of adult alphabetization have started. Due to the training developed during the project, some young people have discovered important skills that are now giving the opportunity to diversify and improve their incomes. These young people have returned to school that they abandoned before finishing the primary school.
- Communication is made easy and people can access to new technologies, such as computers and Internet. After the installation of the micro-hydro system, communities generally work at the installation of an Internet and computer center.
- Women are among the most benefited by these projects, since due to new technology based on the use of electricity, it takes them less time to do housework, so that they can devote more time to other activities, including diversion and education.
- Electricity produced in a clean and renewable way helps family save expenses, which can be estimated between 12 and 25 US dollars per month. This produces an improvement of the economy of the family.
- There is a significant benefit for the country as a whole: the generation of 2.5 GW from a renewable source implies that the state saves more than 15,794 Barrel Equivalent Of Petroleum gallons (BEP) (1.16 Mw /BEP), which would be necessary to produce the same amount of electricity, with a total annual saving of more than 1.6 millions US dollar.
- In various communities, people are starting new enterprises based on the electricity produced by the micro-hydro system: this allows them to process local raw materials, increasing their value in the market and creating new jobs.
- The experience is spreading to other communities in the country and is crossing the Haitian border as well: an increasing number of local groups is now interested in

developing similar initiatives, with important consequences in terms of the diffusion of more sustainable models of land management, based on sense of ownership among local people, minimizing the diffusion of paternalistic schemes.

Impacts are produced in national policy:

- The SGP experience contributed to the formulation of the 57-2007 national law on renewable energy promotion and incentives, where this kind of project are included to be financed by the Dominican Government.
- The Dominican government has adopted this community based strategy as the typical mechanism for rural electrification, through the establishment of alliances among the SGP and national institutions, like the Energy National Commission (CNE), the Rural and Suburban Electrification Unit (UERS), the Ministry of Environment and Natural Resources to work together for development of this kind of project.
- New national and international agencies have started investing in these projects

Conclusions

Community managed micro-hydro systems are shown to be very effective as models of sustainability, demonstrating that human activities is compatible with environment protection and climate change mitigation through CO2 reduction and sequestration.

When these kinds of interventions are made to empower local communities, they can be motivated to choose their own way to development, according to the best capacity of use of the territory where they live.

The results obtained in more than 15 years work from the SGP of the Dominican Republic show that the Anthropocene (Crutzen, 2000) is a reversible process: when local groups are directly involved in their own development, improvement of living condition is coherent with nature protection, since the dichotomy is cancelled between the extra-territoriality of globalization and local impacts produced at a local scale by natural resources exploitation.

The most important successful factors can be identified in:

- **Skill generation** at a community scale.
- **Improvement of social capital at different scale**, inside communities and among different actors, both horizontally and vertically. A special key role is the establishment of a productive dialogue among local organization and governmental institutions.
- **Implementation of a community based self-support methodology**, where local groups strengthen each other.
- **Local empowerment**, which allows people to be able to decide about their future as individuals and as an organized group.
- **Trust based schemes**, which boost collaboration and synergic behaviors, improving the capacity of people to collaborate for common objectives.
- **Continuous learning**, where each person learns from the other people without mattering the academic level.

As to future perspective, the Dominican Republic has the potential for up-scaling these successful experiences, and thus solving the present problem of electric supply, as well as implementing innovative and sustainable ways of living by strengthening local community groups.

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Annex 1. Acronyms

BEP	Barrel Equivalent petroleum
CBO	Community/based Organization
CNE	Spanish acronym for Energy National Commission
GEF	Global Environmental Facilityt
NGO	Non-Governmental Organization
NSC	National Steering Committee
PNUD	Spanish acronym for UNDP
SGP	Small Grants Programme
UERS	Spanish acronym for Rural and Suburban Electrification Unit
UNDP	United Nations Development Programme

Annex 2. Relation of Micro Hydro Projects granted by UNDP GEF SGP Dominican Republic

Project Name	Organization for Execution	Place of the proyect	Capacity (kWh)	Beneficiary family
Micro Hydro Power El Limón	Consejo Comunitario El Limón	El Limón, San José de Ocoa	3.5	75
Micro Hydro Power Los Dajaos	Asociación Los Dajos	Los Dajaos, Manabao, Jarabacoa	1.5	50
Micro Hydro Power Loma La Sal	Fundación Progresio	El Arroyazos, Tiereo, Constanza	7	2
Micro Hydro Power Los Calabazos	Comité Hidroeléctrico Los Calabazos	Los Calabazos, Manabao, Jarabacoa	11	45
Nano Micro Hydro Power Angostura	Asociación la Milagrosa	Angostura, Manabao, Jarabacoa	0.5	8
Micro Micro Hydro Power de Los Martínez	Comité Hidroeléctrico Los Martínez	Los Martínez, Ocoa	12	65
Micro Micro Hydro Power Fondo Grande	Comité Hidroeléctrico Fondo Grande	Fondo Grande, Capotillo, Dajabón	18	40
Micro Hidro Eléctrica El Recodo	Fundación Sur Futuro	El Recodo, Padre Las Casas	35	130
Micro Micro Hydro Power Piedra de los Veganos	Comité Hudroeléctrico Pierdra de los Veganos-Los Novillos	Piedra de los Veganos y Los Novillos, Bonao	18	74
Micro Micro Hydro Power El Jengibre	Asociación José Gabriel García	El Jengibre y Ceiba de Bonet, Villa Los Almácigo, Santiago Rodríguez	18	65
Micro Micro Hydro Power Paso de la Perra	Junta para el Desarrollo de la Cuenca Alta de Río Yaque del Norte (JUNTAYAQUE)	Hoya de Ramón, La ciénega, La Peñita, Manabao, Jarabacoa	53	200
Micro Micro Hydro Power Angostura	Asociación la Milagrosa	Angostura, Manabao, Jarabacoa	23	100
Micro Hydro Power Los Naranjales	Asociación Máximo Gómez	Los Naranjales, Bani	18	68
Micro Micro Hydro Power La Lomita	Asociación Santa Teresita	La Lomita, Jarabacoa,	12	50
Micro Micro Hydro Power El Dulce	Comité Hidroelectrico El Dulce	El Dulce, Manabao, Jarabacoa	45	75
Micro Micro Hydro Power la Majagua	IDEPAC	La Majagua, Yamasá	23	40

Project Name	Organization for Execution	Place of the proyect	Capacity (kWh)	Beneficiary family
Micro Micro Hydro Power El Limón	Comité Hidroeléctrico El Limón	El Limón, San José de Ocoa	22	85
Micro Micro Hydro Power El Jamo	Fundación Loma Quita Espuela	El Jamo, San Francisco de Macorís	47	70
Micro Micro Hydro Power Villa Nizao	Asociación Arca de Noé	Villa Nizao, Paraíso, Barahona	47	130
Micro Hydro Power El Montazo Vallecito	Federación de Campesinos Unidos (FECAU)	El Montazo-El Vallecito, Santiago Rodríguez	140	150
Micro Hidroelectrica Los Mangos	Comité Hidroeléctrico Los Mangos	Los Mango	18	60