
DEFIANCE
PROGRAMME FOR
FOOTBALL

FROM SUBSISTENCE AGRICULTURE TO SOLAR POWER: HELPING BELIZE ADDRESS A LEGACY OF COLONIALISM THROUGH RESEARCH

Mary Ann Studer, M.S., McMaster Fellow

I have had the privilege of working in Belize since December 2005. With the help of our guide, Ivan Gillett, Programme for Belize (PFB), I have made contact with a number of farmers on the periphery of the Rio Bravo Conservation and Management Area. The research questions that drove the 2007 project were a direct result of agricultural concerns articulated by the farmers with whom I have worked in previous years. Soil analyses information produced by this work has allowed farmers to develop more strategic farming practices, including more effective (and in many cases reduced) fertilizer application and more diverse cropping to supply both local consumption and export markets. The intention was to increase the farmers' profitability and soil health, decrease agricultural debt, and reduce the negative impact on the surrounding conservation preserve.

As the McMaster Belize Learning Community has worked with the farmers of San Carlos to improve the quality of life for the agricultural community, we have learned of the importance of infrastructure and the need for greater access to education for the children of these farmers. But the village of San Carlos has only minimal generator-driven electricity. The potential for solar-driven electricity for San Carlos Government School became evident and resulted in 2007 in a feasibility study to identify the electrical needs of the school and a correlation between those needs and solar photovoltaic (PV) equipment.

Literature Review

The overall conditions that I have observed in Belize over the past three years necessitate a review of this former British colony's historical context to evaluate the rooted concepts of subsistence, foreign priority, and development. Subsistence farmers in small villages on the periphery of the Rio Bravo Conservation and Management Area are isolated by inadequate infrastructure with limited nearly inaccessible roads, only generator driven electricity, only partial access to education, and scarce communication with the outside world. Since the early 1800s foreign logging, citrus, and sugar interests have strategized to constrain agrarian capabilities in Belize in order to reduce competition with imported food products and to diminish the wage earning capacity of indigenous populations. Suppression of earning capacity resulted in a British-controlled low-wage labor pool that was hard to distinguish from the pre-1838 slaves of the British Empire.

It has been noted by political economists that the emergence of capitalism in former colonial societies in the third world, especially those with an agrarian base, cannot be compared with the economic path of the developed Western nations. Moberg (1992) identifies the paradox of "underdevelopment," with its "high rates of economic growth coupled with a deepening impoverishment of the rural majority" (p. 4). This is clearly the case in Belize, with its isolated small villages in the interior of the country. This population is forgotten as the country focuses on ecotourism in the coastal areas.

Moberg (1992) further explains that developed nations achieved their current level of economic development as a result of hundreds of years of exploitation of the human and natural resources of the third world. In Belize in the nineteenth century, forestry employers gave workers wage advances to purchase supplies needed in the timber camps. These wages seldom met the workers' needs even for food costs, and the only supply venues were employers' camp stores, where prices were greatly inflated, thus binding workers to employers through continuous debt (p. 26). In addition, at the time that former slaves became eligible to own property, the secretary of state for the colonies implemented a fee for land acquisition under the rationale that free land would discourage wage labor. According to Moberg, this fee, coupled with the closing of the local Sunday markets, reduced the smallholder farm's ability to compete with the imported-foods market (p. 27–28), further preserving the low wage labor force.

The reliance of industrialized nations on the human and natural resources (raw materials) of third world countries continues today, as does the exploitation. Moberg (1992) states that because third world interests remain secondary to the needs of the developed countries "world systems theorists argue that the Third World will be unable to recreate the consumption levels and autonomous growth of the industrialized nations" (p. 5). Counter to exporting raw materials, the developing countries, that were former colonies, such as Belize, are trained consumers of the processed imports.

According to the 2005 figures from the World Bank, Belize imports nearly 57% more merchandise than it exports based on US dollars (Development Economics, 2006). This deficit is indicative of the fact that Belize is operating at a disadvantage in the world market. This, in turn, severely limits the Belizean government's capacity to promote agricultural investment or industrial self-sufficiency and thus hampers the nation's ability to develop sustainably.

Most Belizean households regularly purchase imported processed foods, ranging from instant coffee and powdered milk to Spam. After the addition of import duties, transportation costs, and markups by village shops, such products are more expensive than in the United States yet remain major elements of the local diet (Moberg, 1992, p. 51). It is important to consider the rationale for Belizean consumption of largely imported food. While it is true that the condition of the roads, the lack of adequate communication, and the relatively recent emergence of co-operative agricultural markets contribute to relatively little produce making its way from rural villages to town dwellers, it is shocking that there is an entrenched cultural legacy of suppressed agriculture. "The corollary of the efforts to prevent cultivation of the soil was a general disparagement of all it produced, an attitude that persists today in the unfavorable comparisons many Belizeans make between food they themselves grow and foodstuffs imported from abroad" (Moberg, 1992, p. 30). Subsistence agriculture was encouraged by slave holders and subsequently by foreign employers (e.g. the timber industry) as a mechanism to reduce their overall costs to feed their labor force. But dependence on exorbitantly priced imported food was the second part of the strategy: it kept the labor force in debt and contributed to the highly evolved consumer base of the developed nations, in this case Britain.

Community Need as the Directive

Sustainable development that empowers our partners in Belize rather than exploits them *is* possible but only with the recognition that support for agrarian populations and the environment must occur in some collective primary sense rather through an outside directive. Thus, my original goal to help farmers increase yield through better soil management missed the extent of their full need. This was evident as early as 2005, during my first trip to Belize, when Johann Bergen, a Mennonite farmer, told an illustrative story. Bergen had encouraged others in his community to plant soybeans based on a promise from the government that they would transport the beans to port. Bergen and his neighbors harvested and literally carted the beans for miles over potholed roads to a central pick-up location only to be refused transport of unprocessed beans. With no access to processing facilities, the farmers suffered as their bountiful crop rotted in the humid climate.

In 2005 I altered my original aim in response to this and other similar experiences of farmers. The reduction of inputs (fertilizer) to lower the farmers' costs and secure some level of profitability became of utmost importance. My emphasis on the strategic application of fertilizer based on soil nutrient analyses also supported natural capital (soil) preservation and minimal environmental impact, thus bringing the 2005 project to a level above short-term profitability.

In 2006 it became clear that the lack of infrastructure was affecting indigenous farmers in northern Belize in the way it had affected them nearly seventy years ago. The farmers I worked with faced two equally negative choices: agricultural production for local consumption with limited market access or literally operate at the mercy of foreign food-export companies. Small-scale indigenous farmers in Belize are forced by limiting infrastructure to remain at a subsistence level or farm for export processors at the risk of their natural capital and the overall health of the environment. Many, like the farmers of San Carlos, are working collectively to pay off mortgages on the agricultural fields that sustain village populations. This is an historical consequence of the timber oligarchy that denied access to small land holdings and controlled the labor pool. Today in Belize the low wage labor pool still exists. At this writing, the unemployment rate is nearly double that of the United States at 9.4% (Belize The World Fact Book, 2006). The effect on Jacob Redecop, a Mennonite papaya farmer I have worked with over the past two years, is to be literally held hostage by the papaya processor that employs his two eldest children. The processor provides the only income for the family beyond agricultural income and is, thus, able to set its price or even refuse to pay for Redecop's papaya.

Critically evaluating how to improve conditions for farmers like Redecop on the periphery of the Rio Bravo Conservation and Management Area has resulted in the projects of 2007. Working to provide soil nutrient-level

analysis for the farmers in and around the periphery of the Rio Bravo Conservation and Management Area is still an integral component of my work.

In addition, I believe strongly that inadequate infrastructure is hampering efforts to sustainably develop this region of Belize. My first step to remedy this has been to conduct a solar power feasibility study for the school at San Carlos. Perhaps if funding and installation is achieved as a result of this study, we can begin to provide increased access to education, including knowledge of outside agricultural and marketing information.

The McMaster Belize Learning Community has become a partner with the communities on the periphery of the Rio Bravo. Along with this is the growing climate of cooperation and respect among the indigenous populations, small villages, and Programme for Belize, the NGO that manages the Rio Bravo Conservation and Management Area. Edilberto Romero, Director of Programme for Belize, met with our McMaster Belize Learning Community at the conclusion of our 2007 visit. He said we were the only research group that had reached out to the periphery communities, specifically the only group working within the agricultural communities, and that for PFB the impact was "huge" (M. E. Romero, personal interview, December 22, 2007).

Project Description

Soil analysis was conducted in the fields throughout the periphery of the Rio Bravo Conservation and Management Area. This analysis was completed using the LaMotte Smart2 Electronic Soil analysis apparatus, which allowed for digital analysis of the soil extract to quantify nutrient levels to hundredths of parts per million or pounds per acre. (See appendix for lab protocols.) I also conducted an onsite physical assessment of soil quality with a modified version of the schema Observational Approach to Soil Health (Romig, Garlynd, Harris, & McSweeney, 1995). Criteria for modification were synthesized using information provided by Assessment of Soil Quality by Mausbach and Seybold (Lal, 1998). A Munsell assessment of soil type based on soil color was made on site. A texture analysis was also completed and plotted for each field sample.

On-site meetings in December 2007 with the teachers and principal of San Carlos Government School, Jose A. Lopez, allowed for the identification of powered equipment that could be used in the school and the estimation of both total wattage and peak-use wattage. Identification of the necessary solar PV equipment was developed through schema referenced in Solar Energy International's *Photovoltaics Design and Installation Manual* (2004), Texas State

Energy Conservation Office's *Feasibility of Photovoltaic Systems* (2006), and subsequent recommendations by area solar PV manufacturers.

Soil Results and Impact Assessment

The results of the soil tests were prepared and distributed through the development of field sheets that are returned to Belize for both farmers and Programme for Belize. These field sheets are compiled with the data resulting from the soil macro- and micro-nutrient analyses and are annotated for crop-specific information. The usability of these field sheets was evident as I spoke with Redecop in December 2007. Based on previous analyses of soil sampled in 2006, I had advised him that fertilizer levels were beyond optimal and were nearing levels that would be detrimental to both the growth of the plants and his yield. Redecop used that information and told me in December 2007 that he had planted another field of papaya following the specifications for nutrient levels that I had provided. The one acre of papaya that he planted in 2006 cost him US$6,312.00, including the seedlings and fertilizer purchased from Maya Papaya. In 2007 he planted another one-acre field of papaya with the same number of seedlings but with reduced fertilizer application. The cost to plant the 2007 field was US$2,616.90, a 59% reduction in input expense. Soil analyses showed a 67% reduction in nitrogen levels, a 24% reduction in potassium levels, and a 75% reduction in phosphorus levels. Yet all macro- and micro-nutrient levels were within the optimal range. The overall average reduction in nutrient levels was 55%, which corroborated the 59% reduction in fertilizer costs.

But the relationship with Maya Papaya—supplier of fertilizer, seedlings, crop transport, and sales—had imploded. Redecop reported that the processor continued to pick up the fruit weekly, but that he had not been paid in 15 weeks. Maya Papaya (Eagle Produce is the U. S. label) said the fruit was too green to pass U. S. import standards. Questioning the rationale of Maya Papaya, I photographed Redecop's crates of papaya. In March 2008 I photographed Eagle Produce papaya in the Defiance, Ohio, Meijer store. The levels of ripeness were similar.

Additional research showed the reason Maya Papaya gave to Redecop for their lack of payment, namely "green fruit," was in direct contradiction with the federal code which declares that "no papaya from Belize require treatment for Medfly"(Mediterranean fruit fly) (USDA, 2002). Therefore Belize is not restricted by papaya import regulations, as are other countries such as Brazil and Costa Rica. In the cases of countries where Medfly is a risk, it is recommended that imported papaya be less than one-half ripe because "fruits less than one-half ripe do not serve as host" (USDA, 1998) for the Medfly. Clearly what Redecop was preparing for pickup by Maya

Papaya would have passed even the tighter regulations for papaya import from which Belize is exempt. Despite Maya Papaya's refusal to pay, Redecop was grateful that he was still able to break even due to decreased input costs at the point that the processor quit paying him. He shared that many of his neighbors, to whom payment had stopped as well, were not as fortunate. Several were currently in debt to the processor for tens of thousands of dollars.

Based on the high phosphate levels recorded while the McMaster Belize Learning Community was testing water in the New River Lagoon and its tributaries and the excessive fertilizer application protocol being used by many papaya farmers, we decided to surreptitiously take soil samples from a commercial Maya Papaya farm within the New River Lagoon watershed. It was not surprising that the macro- and micro-nutrient levels were within the range considered appropriate for papaya. This supports the hypothesis that individual papaya farmers on the periphery are purposely being given information that produces large profits from fertilizer sales rather than optimal crop growth.

The fields of Hernandez and others of San Carlos were being maintained very differently. These farmers had resisted Maya Papaya's scheme and were growing diverse crops to feed their families and sell in the growing local markets. This was due in part because in 2007 Hernandez asked me specifically what I knew about growing papaya. I prepared a comparative that showed nutrient levels of his fields and those of farmers who were growing papaya. I sent the comparative to him early in 2007. In December he told me that analyzing the input expenses based on that comparative kept him from planting papaya.

The agricultural fields of San Carlos are integral to the three-year nutrient-trend analysis that I prepared at the conclusion of this 2007 initiative. The reductions in macro-nutrient levels due to optimal fertilizer application for specific crops in San Carlos over the three years of this project are these: nitrogen – 88%, potassium – 87% , phosphorus – 86% reduction for onion fields; nitrogen – 35%, potassium – 50%, phosphorus – 27% for carrot fields; and nitrogen – 7%, potassium – 24%, phosphorus – 29% for potato fields. The reductions between the first and second years of testing were more dramatic than between the second and third years of testing, since the farmers used the information to strategically apply fertilizer.

It can also be concluded that these farmers are maintaining optimal levels of nutrients, thus lessening the impact of these chemical applications on the environment and preserving their natural capital – the soil. Micro-nutrient levels have been within the range of “non-limiting.” While these nutrient levels are critical to monitor, they have not necessitated a reduction or increase in input. To assess the effectiveness of this project through evidence from the fields tested in San Carlos, one could consider overall average reduction in fertilizer usage of 86% for nitrogen, 37% for potassium, and 20% for phosphorus. Even the lowest of these figures represents a significant reduction in input expenses and an increase in potential profitability that works to move these farmers above a subsistence level.

The above reduction in nutrient levels can be related to a reduction in fertilizer application based on the application protocols that these farmers are now willing to share with me. In addition, all of the information reported above was compared to the soil nutrient-level trends of a farm field directly adjacent to the Rio Bravo Conservation and Management Area that doesn’t receive the field-sheet information. This plot will continue to be tested to allow for the recognition of a fluctuation in nutrient levels that could potentially be based on conditions other than fertilizer application.

Solar Power Feasibility

The solar power feasibility study for the San Carlos Government School was compiled after interviewing the teachers and Jose A. Lopez, the principal of the school, to assess the school’s electrical power needs. Currently the school has no access to power other than that which is occasionally supplied by a diesel generator. Being able to power lights, television and DVD player, fans, a radio, and a copier are top priorities for the school. Given the fact that nearly 50 students, ages 5 through 14 years, are all taught in the same room, powering tape recorders, CD players, and laptops for some individual work is an apparent necessity. Using the equipment lists provided by the teachers of the San Carlos Government School, I determined the PV array size needed and the size of the battery bank in order to formulate an estimated cost of the all materials necessary to install a solar power system.

This feasibility study will serve as a basis to develop the collaborations necessary to acquire the funds and equipment for solar power at San Carlos Government School, with far reaching implications for the community. The community as a whole will no doubt use the facilities. It is realistic to anticipate improved literacy in the community due to lights in the one-room informal library. Powering laptops can potentially provide internet-based agricultural information for farmers.

Conclusion

The most remarkable aspect of this project for me has been the overall impact of the partnerships between the McMaster School for Advancing Humanity and farmers on the periphery of the Rio Bravo over the past three years. The information that we have been able to provide these people is making a difference. We have become expected partners with these communities as they move toward sustainable development. Based on nutrient-data trends of the past three years for sampled fields, farmers have evidence of optimal yields with reduced chemical inputs. I will continue to encourage farmers to maintain diversity in their fields in order to utilize some of the emerging co-operatives for local marketing of food products. This can be accomplished by correlating crop varieties with climate data and soil conditions.

The effectiveness of this project to date can best be summarized through two specific case studies of indigenous farmers with whom I work. In 2005 the fields of Hernandez showed high to very high levels for all macro-nutrients. Utilizing the information that I provided him (annotated soil nutrient levels and suitable crop varieties for the Belizean climate), Hernandez had greatly improved his yield and soil health by 2007. He now grows a variety of crops with optimal levels of fertilizer that reflect an average reduction in nitrogen, potassium, and phosphorus of 50%. His input costs are down, and his yield is up. A second case, Redecop has been growing papaya for the past two years. With adequate information about the nutrient levels in his fields, he was able to reduce the application of fertilizer and, thus, his costs by nearly 60% and still maintain optimal levels of nutrients in his fields. Fertilizer reductions such as these have significant financial impact on the farmers and a positive environmental impact.

The reduction in chemical applications to agricultural areas, the runoff of which affects the water quality of the New River Lagoon, also positively contributes to the efforts of our partner Programme for Belize and their mission in managing the Rio Bravo Conservation and Management Area. That being said, there is much work to be done to reduce deforestation of areas currently being cleared adjacent to fields of soil that have been over-cropped and over-fertilized. It is critical that we continue to work to restore damaged soil so that it will support a diversity of crops and encourage farmers to increase the percentage of crops grown for local markets instead of for export processors. It is also critical to reduce the dependence of these isolated populations on export entities that have a single allegiance to company profitability even if it is achieved through gross exploitation.

Providing solar power to the school in San Carlos will help to improve access to education and reduce the isolation that contributes in a significant way to the subsistence level of these people. The Rio Bravo Conservation and Management Area geographically cradles the New River Lagoon. The small villages that share the banks of the Lagoon are a forgotten population that is struggling daily for survival and anxious for direction on sustainable development

Reflection

I had anticipated that the December 2007 trip to Belize would perhaps have been my last. However, once on the ground working in partnership with farmers, schools, villages, and PFB with Ivan Gillett, I realized that the McMaster School's investment in Belize has grown to have a deeper and broader impact. The community partnerships that have developed, the significant body of research produced, the continued need for agricultural information, and our partners' trust in the McMaster School all inspire me to continue to see this project evolve.

REFERENCES

Belize The World Fact Book. (2006). Retrieved December 1, 2007, from Central Intelligence Agency: https://www.cia.gov/library/publications/the-world-factbook/geos/bh.html *Development Economics, D. D.* (2006, August 12).

Belize at a Glance. Retrieved December 1, 2007, from The World Bank: http://siteresources.worldbank.org/INTBELIZE/Resources/Belize.AAG.2006.pdf

Lal, R. (Ed.). (1998). *Soil quality and agricultural sustainability*. Chelsea, Michigan: Ann Arbor Press.

LaMotte. (2004, 09). Smart 2 Electronic Soil Manual and Test Instructions.

Moberg, M. (1992). *Citrus, strategy, and class*. Iowa City, Iowa: University of Iowa Press.

Romig, D. E., Garlynd, M. J., Harris, R. F., & McSweeney, K. (1995). How farmers assess soil health and quality. *Journal of Soil and Water Conservation, 50*, 229-236.

Solar Energy International. (2004). *Photovoltaics: Design and installation manual*. Gabriola Island, British Columbia, Canada: New Society Publishers.

Texas State Conservation Office. (2006, August). Feasibility of Photovoltaic Systems Fact Sheet No. 19.

USDA. (1998). Proposed rule for importation of papayas from Brazil and Costa Rica: Environmental assessment, February 1998. Animal and Plant Health Inspection Service, United States Department of Agriculture.

USDA. (2002). 7CFR Part 319 [Docket No.00-006-3] Importation of fruits and Vegetables: Technical Amendment. Code of Federal Regulations: Federal Register Vol. 67, No. 36, Animal and Plant Health Inspection Service, United States Department of Agriculture.

Appendix Lab Protocols

Macro-Nutrients (LaMotte, 2004)

Nutrient	**Protocol**
Nitrate-Nitrogen	Cadmium Reduction Method
Nitrite-Nitrogen	Diazotization Method
Phosphorus	Ascorbic Acid Reduction Method
Potassium	Tetraphenylboron Method
Calcium	Schwarzenbach EDTA Method
Magnesium	Schwarzenbach EDTA Method

Micro-Nutrients (LaMotte, 2004)

Nutrient	**Protocol**
Manganese	Periodate Method
Iron	Bipyridyl Method
Chloride	Direct Reading Titrator Method
Copper	Diethyzdithiocarbamate Method
Ammonia-N	Nesslerization Method