Operational management of water reclamation through fertigation

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This study presents key business success factors relating to a water reclamation experiment (fertigation) using minimal technology in rural settings and identifies elements of social entrepreneurship in such endeavors. Various forms of organizational setups are reviewed in their capacity to implement small scale water reclamation projects and derive both economic and environmental returns. A carbon footprint/sequestration calculator and web based simulation models are presented as a way for organizations and entrepreneurs to assess the interplay economic and societal returns.

Keywords: Fertigation, Developing country, Operational management, Rural ecology project, Water reclamation

Introduction

Communities across the world face water supply challenges. Water reclamation, recycling and reuse can address these challenges by creating new sources of quality water1. However such reuse can be problematic as some farmers use untreated water to irrigate edible crops2, creating potential health problems for both farmers and consumers. Treating wastewater to improve conditions of rural inhabitants in developing countries (DCs) is possible even without hi-tech centralized treatment facilities found in developed world3. Unfortunately, effective decentralized treatment facilities are not common in DCs. This study presents an effective framework to reclaim and use wastewater to grow marketable and carbon-sequestering plants, in a manner that has potential to be economically sustainable in rural areas in DCs.

Experimental Section

Tenets and Success Factors

For any social entrepreneurship initiative to be successful, the following three central tenets should be met: i) The project should be sustainable in that it improves the environment, reaches community social goals and increases community financial wealth for the long term4; ii) Project design needs to be appropriate for local conditions5,6, as it is expected to help the local and wider community reach objectives of helping local residents become healthier, and attain skills5,7,8, facilitate local entrepreneurship9, and enhance local infrastructure4; and iii) Initiative needs to be managed and operated by key stakeholders, who have greatest stake in its success1. Those that invest or risk financially should benefit financially and have some say in management of the project. Those stakeholders benefiting environmentally from the project should also be involved in decision making, increasing the likelihood of community buy in. If project raises a new set of social issues, then those affected should have some influence in solving problems. Effective coordination and networking among units is also important for success6. Coordination means that all those involved in the initiative and related commercial endeavors plus those who regulate, should be in consistent, productive, collaborative contact8,10. Important information should be analyzed before long term decisions are made, for example, sources of information pertaining to technology acquisition should be reviewed6 prior to purchase. Often, money has to be raised to fund project endeavors6, markets have to be found and nurtured, and relevant publics should be informed and educated3. Success will be enhanced when new operations and technology are introduced6, and when managers develop motivational schemes so that involved individuals would like to continue to work and improve. Problems will occur if success factors are not pursued and appropriate expertise is not acquired and maintained6.

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if there are not enough technological or financial resources available\textsuperscript{2}, if there is inattention to priorities other than financial\textsuperscript{1}, and if the project existence eliminates the source of some citizen livelihoods\textsuperscript{2}. With regard to networks, problems can occur if contractual agreements do not contain effective assurances, if the network of organizations is too complex, and there are differences in priorities among partners\textsuperscript{8}.

Social Entrepreneurship Initiative

The case under study is a social entrepreneurship initiative involving a test unit, which was established for sustained biomass production by fertigation, utilizing domestic wastewater to grow trees in Surajgarth, Rajasthan in India. A municipality owns water and land in surroundings and is the general manager of test unit. Water flows from community residences to a pond. In the experiment, a project site was chosen at the embankment of the pond, and trees were planted. Wastewater was drawn and routed around the trees so that it wound through the set of trees, irrigating them. Water is untreated, and contains ingredients, which are sources of nitrogen (N), phosphorus (P) and potassium (K) and some micro-nutrients, but does not have commercial value as fertilizer. As a result of water and nutrients in it, trees grew quickly and became big enough to be of commercial value. If and when trees are harvested there will be two value streams (saleable products and carbon-sequestration). This experiment is designed to improves the environment as water will be reclaimed and cleaned into productive purposes. In addition, trees grown will reduce green house gases. Furthermore, the experiment intends to accomplish community social goals, such as empower and employ people and not disrupt community culture\textsuperscript{4}. Fertigation is also likely to be economically sustainable in long run as there are net positive financial returns at an individual and community level.

Based on the initial experiment result, similar types of wastewater treatment system should be propagated. However, specific operations (or processes) can only be determined after discussions among all interested parties. Decisions have to be made by municipality officials with inputs by other interested parties, especially community members and scientists who conducted the experiment. Stakeholders (investors, business owners, suppliers, community members, distributors, and members of local government) will have a stake in business process with interest in different kinds of outcomes (Table 1).

Implementation of a business model will be necessarily complex and include multiple variables (Fig. 1). This model also implies multiple relationships among inputs, processes and outputs, and relationships are multi-directional. For example, one of the outputs is trees, which are marketable, and can be processed into lumber or furniture. Inputs for trees include seedlings, labor, investors, money, land, and water, which might be purified and pumped before it reaches the land. As for processes, trees will be grown, but in addition, there maybe networking between local government, farmers, labor, and marketers, and skills enhancement to grow higher quality trees faster or with less labor. Outcomes will include trees, seedlings for future trees, expertise, a lower carbon footprint and net cash flow, which may be reinvested in more trees, skill enhancement or technology.

<table>
<thead>
<tr>
<th>Important outcomes</th>
<th>Key targeted stakeholder</th>
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<tr>
<td>Adequate margins</td>
<td>Business owners</td>
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<tr>
<td>Sustainable return on investment</td>
<td>Investors</td>
</tr>
<tr>
<td>Enough profits and income to help sustain family</td>
<td>Business owners, local government (taxes), community members, and employees</td>
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<td>livelihood</td>
<td>Community members, society</td>
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<td>Clean water</td>
<td>Pollution reduction advocates, local government</td>
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<tr>
<td>Pollution reduction</td>
<td>Community members (especially the most vulnerable)</td>
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<td>Improved health</td>
<td>Businesses, community members and institutions</td>
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<tr>
<td>Reliable infrastructure</td>
<td>Businesses, distributors and customers</td>
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<tr>
<td>Smooth networking among involved entities,</td>
<td>Investors, community and other governments, community and the society at large, and scientific and scholarly communities</td>
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<td>reliable supplies, parts and resources</td>
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<td>Replicability of technological solution and sustainable operations</td>
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Results and Discussion
Choices for a Business Model

The project involves multiple operations (Fig. 1, Table 1), and there are two extremes for choosing a managerial approach. At one extreme, municipal government can own and manage all operations, and at the other extreme, it can license most operations to local businesses. With licensing, the government influences entity output, but does not control how a business operates. There are advantages and disadvantages for each extreme, although a combination of government control and licensing is the most likely outcome.

Advantages for Direct Government Management

The primary advantage for municipality to manage operations directly is that it will retain control\(^1\), keeps track of, and is able to influence most if not all project processes. Direct management is particularly advantageous because municipality is likely to maintain an environmental enhancement priority\(^2\), while businesses may be neither aware of nor value the benefits of a sound environmental management system. Forsyth\(^3\) found that climate improvement technology projects were more successful when the number of relations in the project networks was low, suggesting that government should either retain control or if it does license or it should do so with very few entities. Forsyth\(^3\) also found that if municipality does license, it must check licensee values before finalizing the contract. Government entities will more likely have the expertise and capacity to obtain funds to setup the project and maintain it. In contrast most local businesses in rural settings are likely to be small with limited economic resources. In addition, government entities may be better in linking with customers, attracting experts and partnering with other governmental units or NGOs.

Advantages for Licensing to Private Sector Entrepreneurs

The primary advantage for licensing is flexibility for all stakeholders. Licensee autonomy make it easier for general managers to oversee at a strategic level while licensees are left to grow and excel on their own terms and interact and coordinate with appropriate partners on the issues important to them\(^4\). According to business theory\(^5\), multiple tasks should be housed under one roof if there is a shortage of entrepreneurs or if the multiple tasks have identical customers. But neither is true in this case. None of the project tasks are so sophisticated that entrepreneurs could not be found to undertake them and buyers for one set of outputs are likely to be different than the buyers for others. For example, buyers of harvested trees would be different than buyers for grown non-edible plants. A second advantage for licensee option is business owners have a
greater stake in the success of their endeavors than government employees. Business owners will also feel more empowered than employees, and when businesses grow, there is an improved employment in the community\textsuperscript{4}. Entrepreneurs as a rule embrace improvement and innovation, which means that both entrepreneurs and their associates learn skills and learn to innovate, improve and grow. Licensed rural businesses are likely to be small, which means that a higher percentage of those involved are near the top of the organizational hierarchy. Networks of entrepreneurs will benefit the project\textsuperscript{15} because networks develop objectives that benefit the collective and greater good and help the individual go beyond a short term particularistic perspective.

Regardless of advantages for each extreme, the ideal is probably a combination of private and public sector involvement. Forsyth\textsuperscript{8} observed best results when public and private sector entities together deliberate to pursue overall development. From a government and regulatory perspective, Rogerson\textsuperscript{16} defines ways, in which government can be constructive, by guiding the involved businesses to build strong relationships and helping the project find markets and funding. By providing support structures, financial assistance when needed, and encouraging relationship building, Toyota as a governing entity, does similar things with its outstanding network of suppliers\textsuperscript{17}.

**Special Problem of Social Entrepreneurship**

Given these goals, tenets, and success factors, entrepreneurial effort will have to be social in that its values will go beyond profitability\textsuperscript{18} while seeking to emphasize social and environmental goals (poverty reduction, skill development, health, and reduction of green house gases). This may complicate matters for profit-focused managers. Hence, the social dimension has to be explicit and part of the organization’s value stream. It can then set an example by articulating goals and standards and choosing the social choice in the face of dilemmas where one path is more social and the other path benefits competing priorities. In addition, the entrepreneurial community is networked, as connected entrepreneurs often develop objectives that benefit the collective and greater good\textsuperscript{15}. Members of such networks are more likely than individual entrepreneurs to share technology and set norms for adherence to social values. Also, such networks are usually large enough to have influence over other key stakeholders, including regulatory bodies to develop sensible and fair rules and regulations for businesses to ensure benefits are accrued for the society at large.

**Analytical Models**

Analytical models help project managers in decision making and give quantitative results, which can provide support for efforts to promote and validate the project, both in and outside the project community. This study presents two analytic models.

**Carbon Footprint Calculator**

Carbon footprint calculations provide a basis for combining an environmental dimension (CO\textsubscript{2}) with traditional cost/benefit business models. The footprint is assessed both at the setup (material, labor, transport, construction) and during the operational stage (transport, energy). Carbon footprint is then coupled with the carbon sequestration in the trees within the stands. Small scale distributed low technology water treatments systems reduce a carbon footprint and its value can be commercialized through carbon credit schemes. Given the uncertainties involved with water reclamation through fertigation, the model allows for a number of scenarios to be inputted in order to conduct sensitive analysis. Variables that can be modified include labor rates, tree growth rates, species, value of fuel wood and lumber, value of carbon credits, number of citizens served by a particular unit and so on. In the long run (10 yrs time horizon), reclamation through fertigation is expected to provide positive environmental and economic returns.

**Micromatic**

A relatively inexpensive, moderately sophisticated, web-based simulation\textsuperscript{19} can provide an effective way of performing a cost-benefit analysis for decisions for this project. This is superior to optimization methods such as linear programming. Simulation allows to study the performance of a business over time and conduct sensitivity analysis for various variables (market prices, yields, input costs etc.). It allows to get a grasp of interactions among variables and to follow dynamics over time. This methodology will help develop guidelines to ensure project success when implemented. By using this simulation, while not all project variables can be included each time, one can vary labor, material and marketing
costs, deterioration due to poor maintenance, inventory (tree stock), and cash flows, and estimate outcomes.

Conclusions

To run water reclamation activity as business, a combination of governing entity control and licensing is recommended. On balance, businesses should run most individual operations. Small businesses are more flexible, will innovate and grow more easily and are less burdened by complexity. Their activity is also more likely to result in both financial and skill gains for more stakeholders, which in turn will benefit the larger community. Also these businesses should be networked as networked businesses innovate with and look out for each other. The governing entity should help seek customers, training opportunities, provide finances, fund technology acquisition, and maintain and guide relationships between the project and other important outside entities including NGOs, investors, scientists and other governmental units. It also needs to ensure that licensees are operating in the interest of the project and provide an infrastructure for the network of businesses. Various analytical tools and decision support systems should be adopted for planning and implementation.

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References