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Socio-economic Assessment and Implementation of Small-scale Biochar Projects

Stephen Joseph

Introduction

Chapter 19 evaluates the financial and environmental costs and benefits of operating large-scale pyrolysis plant at purpose-built central locations and at industrial or waste management sites. This chapter, which should be read in conjunction with Chapter 19, also explores the financial and environmental costs and benefits of pyrolysis technology, but at the household, farm and village level. It discusses the social costs and benefits and local use of the biochar and syngas produced.

In this context, and particularly for small-scale projects in rural areas or in developing countries, the methods used for designing, analysing and evaluating programmes and projects are very different from those used for industrial-scale plants. This chapter takes this into account by including outline descriptions of project design and analysis methodologies as essential precursors to the final evaluation of project costs and benefits.

Perhaps the most important feature of this treatment is that it emphasizes the need to develop programmes that are people centred, responsive and participatory (Schneider, 1999), that are economically, institutionally and environmentally sustainable, and that involve partnership between all stakeholders, including users of the biochar, producers, researchers, extension personnel, government at all levels and donor organizations (Chambers and Blackburn, 1996; Carney, 2002).

At present, there are few such analyses of biochar projects. However, socio-economic studies in related areas can assist the development of suitable methodologies for biochar technology transfer programmes (Smith et al, 1993). They include the introduction of improved biomass cook stoves (Natarajan, 1999), kilns and furnaces, and improved charcoal production techniques (Limmeechokchai and Chawana, 2003). Socio-economic assessments of renewable energy projects, and of improved agricultural and forestry techniques (Upton, 1996), also provide specific insights.

The chapter is divided into two main parts. The first introduces relevant concepts and presents a framework for project design and socio-economic analysis; the second provides a brief case study on the introduction of improved charcoal kilns and low-emissions cooking stoves that also produce biochar as a soil amendment.

Developing a methodology

Developing a framework

Socio-economic analysis at the household, farm or community level involves not just the quantification of the financial impact of biochar technology, but also the broader social, cultural, political and environmental impacts (Hanmer et al, 1997). International efforts have focused on developing a common project framework for aid agencies, and international development agencies have been supporting the development of a common methodological framework whose aim is to ensure projects increase the sustainability of local livelihoods and the security of food, energy and soil health (Davies, 1996). An appropriate methodological framework has been developed by the Sustainable Livelihoods Group (Carney, 1999), as shown in Figure 20.1 below.

This framework is designed to improve our understanding of the livelihoods of lower-income groups who lack the access to resources that is common to middle- and

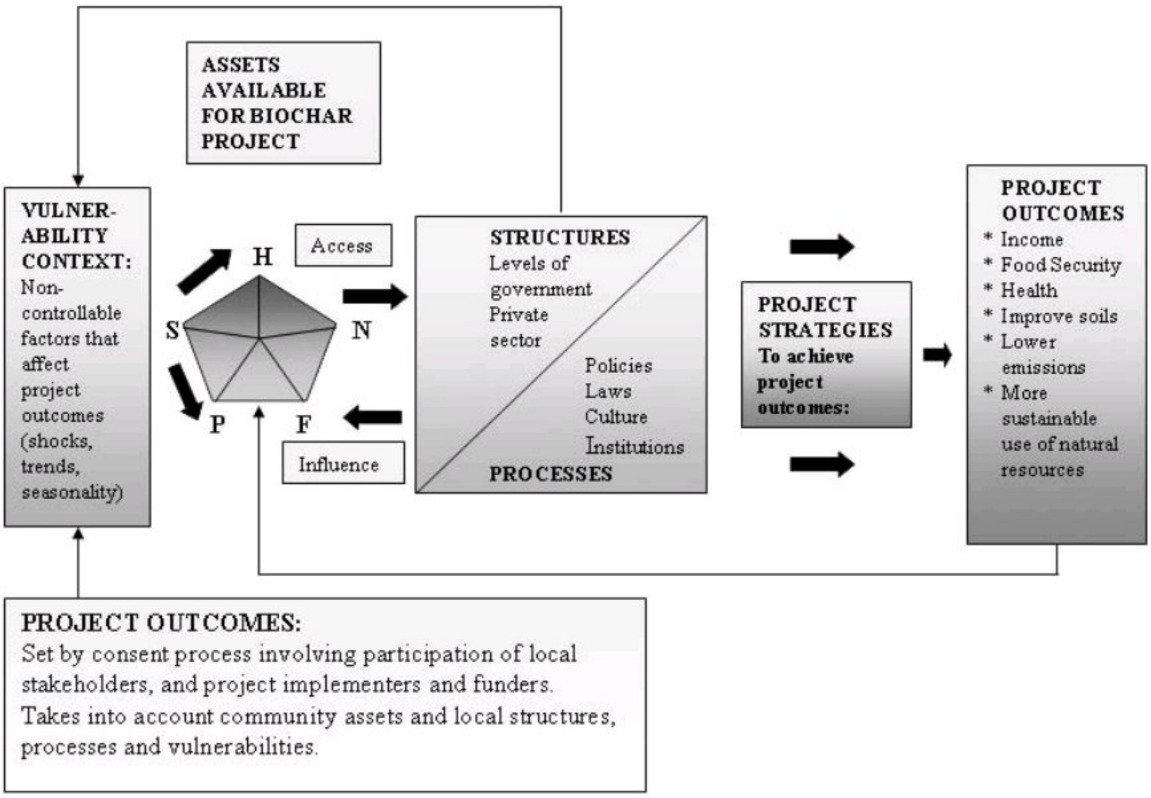

Figure 20.1 *Framework for socio-economic assessment of biochar projects*

Note: H= human capital; S = social capital; N= natural capital; P = physical capital; F = financial capital.

Source: Stephen Joseph

upper-income groups (DFID, 2001). It is now widely used, in part or as a whole, by non-governmental organizations (NGOs), the World Bank and governments (Robb, 1999) for assessing and formulating projects that target rural households and industries.

DFID (2001) notes two important characteristics of this type of framework: it is non-linear and it is people centred. In particular, it:

- provides a checklist of important issues and sketches out the ways in which these link to each other;
- draws attention to core influences and processes; and
- emphasizes the multiple interactions between the various factors that affect livelihoods.

The arrows within the framework indicate different types of relationships, all of which are highly dynamic. None of the arrows implies direct causality, although all imply a certain level of influence.

Figure 20.1 is an adaptation of the DFID framework. The pentagon at the centre of the framework represents the local assets that may be utilized to introduce biochar technology (Moser, 1998). In developing the framework, it is acknowledged that there are many factors that may affect the successful introduction of a technology (Hanmer, 1998). Some, such as droughts and wars, are not easy to predict. Others, such as government regulations, are either stated explicitly (laws) or are implicitly understood by the local community (Davies, 1996). Understanding these factors can assist in both designing a project and in assessing its viability. Project objectives, and strategies to meet these objectives, should be derived from a consensus of all participants as to what is achievable with the given resource base, community needs, potential vulnerabilities, and external and internal structures and processes (Holland and Blackburn, 1998).

The framework can then be used to assist in determining what data should be collected, how it should be collected and how the inevitable complexities can be understood.

Using the framework to collect the data needed for a socio-economic assessment

Ideally, baseline data collection is carried out before the introduction of a new technology and agricultural practice (Ashley et al, 1999). Impact assessment is then based on comparing the system at the end of project implementation with the baseline data gathered before project commencement (Jenkins, 1999). However, if a programme is already under way, socio-economic evaluation should start with an assessment of the existing physical, economic, political, social, cultural and environmental systems.

Assessment of vulnerability context

Many factors affect the lives of village people, farmers and small-scale businesses. When developing a biochar industry, data must be collected in the three categories summarized in Table 20.1. It should be noted that not all shocks will have negative impacts. For example, a sudden increase in the price of fertilizer may provide an incentive for farmers to experiment with biochar.

Assessment of different types of capital: Human, social, natural, physical and financial

Human capital assessment quantifies the skills, knowledge, ability to labour and health of people and enterprises that may directly or indirectly participate in a development project. Data is collected on the amount and quality of labour available, which will vary according to household, farm, enterprise size, skill levels, leadership potential, and health status.

Social capital includes networks and connectedness, membership of more formal-

Table 20.1 *Classes of data to determine vulnerability context*

Trends	*Shocks*	*Seasonality*
Population Resource (including conflict) National and international economy Governance (including politics) Technological	Human health Natural (e.g. floods, droughts and severe storms) Economic (increases in fuel and fertilizer prices) Conflicts Crop/livestock health	Prices Production Health Employment opportunities

Source: Stephen Joseph

ized groups (often entailing adherence to mutually agreed or commonly accepted rules, norms and sanctions); and relationships of trust, reciprocity and exchange that facilitate cooperation, reduce transaction costs and may provide the basis for informal safety nets amongst the poor (DFID, 2001). While an understanding of social capital is important for good project design, collecting and analysing data on social capital is difficult and requires considerable time and interpersonal skills.

Natural capital covers the stocks and flows of natural resources (forests, fields, marine life/wildlife, water quality, air quality) that may be required for livelihoods, and from which services such as nutrient cycling, erosion protection and waste assimilation are derived (DFID, 2007). Data will be needed on how, in combination with other assets, natural capital is used to sustain a biochar project and create value for the participants.

Physical capital comprises the basic infrastructure (e.g. transport, secure shelters and buildings, water and sanitation, clean affordable energy and access to communications) and producer goods (tools and equipment used in productive activities) needed to support a particular productive activity (DFID, 2007). It is important to determine if the infrastructure available can actually support the introduction and utilization of biochar technology.

Financial capital includes available stocks such as cash, bank deposits or liquid assets such as livestock and jewellery, and regular inflows of money from sources such as pensions or other transfers from the state, as well as remittances. This information is essential when trying to determine what level of credit or other financial support is required to ensure that local businesses or households can afford the biochar technology (Ledgerwood, 1999).

Assessment of structures and processes

The potential impact of local and national (and, in some cases, international) institutions, organizations, policies and legislation on biochar programmes needs to be ascertained. These may determine the ease with which the biochar programme can gain access to capital and to extension services. It is important to ascertain the different rights and responsibilities between the project participants and institutions and organizations that are directly or indirectly involved (e.g. departments of agriculture, energy or industry, and environmental protection agencies).

The framework (see Figure 20.1) includes feedback loops. There is direct feedback from processes and structures to the *vulnerability context*. Processes (policies), established and implemented through structures, affect trends both directly (e.g. fiscal policy and economic trends) and indirectly (e.g. health policy and population trends) (Carney, 1999). They can also help to cushion the impact of external shocks (e.g. policy on drought relief). Other types of processes are also important, such as well-functioning markets that help to reduce the effects of seasonality by facilitating inter-area trade (DFID, 2001).

Institutions can restrict people's ability to adopt biochar innovations – for example in rigid caste systems (Barry, 1998). More common are policies and regulations that affect the attractiveness of particular livelihood choices through their impact upon expected returns (Ashley et al, 1999). Responsive political structures that implement pro-poor policies, including extending social services into areas in which the poor live, can significantly increase people's sense of well-being. They can promote awareness of rights and a sense of self-control. They can also help to reduce vulnerability through the provision of social safety nets (DFID, 2007).

Tools for collecting and analysing data

Small-scale projects are assessed using both quantitative and qualitative methods (Marsland et al, 1998). These are mentioned briefly with references for further reading. Different tools (Rennie and Singh, 1995) are available to collect and analyse baseline data; but participation of all stakeholders (e.g. households, farmers and charcoal-makers) is essential for effective data collection (Booth et al, 1998).

Macro-economic analysis is important in setting the overall economic context within which a biochar project operates (Agenor and Montiel, 1999). It includes appraisal of how monetary, fiscal, trade and exchange rate conditions affect the price of the goods needed to produce biochar (Ellis, 1992). Similarly, movements in interest rates that can affect the ability of a project to repay loans should be studied. Review of secondary published macro-economic data is, thus, an essential component of the analysis.

In contrast, micro-economic analysis is used to assess decision-making processes within households, farms and small businesses (Bebbington, 1999). Many micro-economic techniques are available for assessing the costs and benefits of new technologies to farmers (Gittinger, 1982) and small industry (Brent, 1990). Relevant examples of their applications include stove programmes (Natarajan, 1999) and renewable energy projects (IT Consultants, 2002). Amongst these techniques, cost-benefit

Table 20.2 *Summary of all impact indicators for the biochar technologies considered*

Environmental impact indicators	*Social impact indicators*	*Economic costs (with assumptions)*
Emissions (air, climate change and water)	Community benefits	Resource extraction
Noise	Energy diversification and security of supply	Resource and biochar transportation
Visual	Employment	Materials processing
Effect of biodiversity, soil health, wildlife, erosion, local hydrology	Health	Establishment of crops
	Political and governance	Cultivation of crops
Landscape	Institutional	Processing of crops
Planning and costs	Tourism	Biochar manufacture
Recreation, loss of agricultural land		Plant construction, decommissioning
Energy payback		

Source: based on IT Consultants (2002) analysis (CBA) is perhaps the most powerful tool for deciding between alternate strategies; recently, it has included impact indicators of renewable energy technologies (IT Consultants, 2002). Table 20.2 is an example of how these are applied to biochar technology.

To gain a better understanding of the relationship between the livelihoods of the potential project participants and their environment, the above indicators can be expanded by using an environmental checklist procedure (Donnelly et al, 1998). Examples of checklist questions include the following:

- Are forests and fields being degraded, and if so, why? Could biochar help to prevent this? What role do policies and institutions play in that degradation (Hughes and Dalal-Clayton, 1998)?
- What is the contribution of pollution (such as smoke inhalation from stoves) to the ability of women to participate in the introduction of the biochar technology?
- What is the risk that severe floods or droughts could have on the cost of implementing a biochar programme? How much biochar may be removed by floods or strong winds?

Where possible, costs associated with the current environmental issues are determined before ecological economics can be used to analyse the data (Therivel and Partidario, 1996; Daly and Farley, 2004). Similarly, analysis can be undertaken at various scales with different institutions and stakeholder groups to determine their roles in the biochar programmes (Harriss et al, 1995). It is usually built around checklists (DFID, 2001) and seeks to understand the nature of the external environment and the impact of different factors within it, including:

- whether responsibilities (e.g. for service delivery or environmental management) are sensibly allocated within government and between government and the private sector (including local people) (Mehta et al, 1999);
- roles and strategies: whether organizational structures match functions, and the nature of interaction between organizations and their clients at different levels (North, 1991);
- leadership, management style, incentives (financial and otherwise), organizational culture and their implications for change;
- management systems and their impact upon performance (using key baseline indicators) (Rew and Brustinov, 1998);
- human resource requirements and constraints (DFID, 2001); and
- financial performance and prospects for viability.

Gender analysis can be used to determine the dynamics of gender differences in relation to social relations, division of labour, access to resources, decision-making, networks and specific needs. These are particularly important for assessing the likelihood of conflict between women and men. For example, women may use the biochar stove, but men have the financial means to buy it.

Checklists can also be used to analyse the impact of local governance on biochar projects (Beckhart and Harris, 1987). Suitable questions may include:

- Is political power exercised fairly? If not, how could it affect the project (Hyden, 1998)?
- How efficient, effective and accessible are agricultural, forestry and industry extension workers and are they willing to learn new skills and participate in the project (Hobley and Shields, 2000)?
- Are government organizations that must interface with biochar projects honest, efficient, effective and accessible?
- Could issues of enforcement of basic human, legal and property rights result in

barriers to successful implementation of the project?

The challenge in governance analysis is to differentiate between those factors 'controlled' by the structures closest to communities (e.g. local governments) and those variables determined by higher, and usually more remote, tiers of government (DFID, 2001; Moser, 2001).

Developing objectives, strategies and projects

Participatory project development involves members of the community, researchers and the project implementers jointly analysing data, identifying local needs and resources that can be utilized sustainably, determining barriers to implementation, and assessing the social and cultural strengths of the community. It also involves evaluating the costs and benefits associated with different strategies and technologies. From such analysis, specific project objectives, strategies, organizational structures, budgets and time lines are developed that incorporate principles of sustainability. A detailed monitoring and evaluation methodology is developed to ensure that impacts can be measured both during and at the end of the project, and that project objectives and strategies can be changed if necessary.

Model scenario of a hypothetical village-level biochar project

This model scenario shows how a socio-economic assessment of a biochar programme could be undertaken at village level in a developing country. In the absence of such studies, in practice, it draws on real data from similar studies carried out for improved stove and charcoal kiln projects in a tropical Asian country (Joseph et al, 1990; Edwards et al, 2003; Limmeechokchai and Chawana, 2003).

The approach taken mirrors the hypothetical plant approach of Chapter 19, and adapts data on changes in efficiency and emissions from Feldmann (2007), Limmeechokchai and Chawana (2003) and Edwards et al (2003).

Background

This hypothetical case study is based on a community of 950 people (200 households) that has created a local organization to re-forest common land and to improve water quality. The community has asked a local NGO to help improve land-use practices and soil health and to reduce fuelwood consumption for cooking and charcoal production. The NGO wants to assess if the community's needs can be met by introducing new low-emissions biochar stoves and charcoal kilns. The NGO also wants to determine if this intervention will reduce the burden of women, improve the village income, reduce the incidence of eye and lung disease, and reduce greenhouse gas emissions (Wang and Smith, 1999) while producing both clean heat and biochar. This hypothetical study goes further to examine the feasibility of using trimmings from the forests (when they are better established) to manufacture biochar for agricultural and fuel use.

Before implementing the project, the local NGO undertook a baseline study with a representative group of villagers. The following socio-economic assessment is a summary of the data collected and of the results of the analysis, based on the sustainable livelihood concepts introduced in the previous sections.

Socio-economic assessment

Table 20.3 outlines data (hypothetical) on the vulnerability of the community. Clearly, the community has felt the effects of increases in global temperatures, from changes in local weather conditions, decreases in fuel availability and increases in fuel prices. In particular, women and children now spend three hours per day collecting fuelwood instead of two, resulting in a loss of income from handicraft production and the sale of processed food of about US\$20 yr^{-1} in each household. In addition, the use of poorer-quality fuels has increased the frequency of eye and lung infections by 20 per cent in the last two years. The local health authority economist estimates costs to the nation from loss of production and increase in medical costs for each person as US\$20 person yr^{-1}.

Drought has affected the availability of disposable household income, credit from local lending institutions and labour. These factors have slowed many development programmes, although it has, in part, been cushioned by income remittances from urban areas.

Table 20.4 summarizes community capital assets. It shows that although the community has suffered from the impact of climate change, it still has assets that could be used in the project. Community members have embraced modern forms of communication, have internet access and the governance environment is positive. There is a pool of skilled labour and literacy rates are high. An effective community organization is starting a community forest programme, and there are strong micro-enterprise credit systems and effective local agricultural extension services. Within the community there are skilled manufacturers of charcoal and lime who could assist in training women to manufacture biochar in their homes efficiently.

At present, in order to purchase goods and services such as health and education, the community relies on remittances from males who work seasonally or who have moved to local or international urban centres. But the movement of seasonal workers is a major issue in terms of labour availability and inter- and intra-household conflict. Wealth is not distributed evenly: this causes conflict and results in the poorer sections of the community having insufficient time to participate in new development activities.

Table 20.3 *Vulnerability context (assumptions for model scenario)*

Trends	*Shocks*	*Seasonality*
Population increasing at 1.5% per year.	Severe drought last year led to low crop and livestock stocks.	Crop prices decrease during harvest (options to preserve crops do not exist).
Average temperature is increasing every year.	Household income decreasing and time taken to collect water and fuel increasing.	Two crops per year when sufficient rain is available.
Inflation of 3% per year.	30% increases in fuel and fertilizer prices.	Onset of wet season sees increase in vector-borne diseases.
Adoption of improved governance practices to ensure continuation of aid and international loans.	Dramatic increase in eye and lung disease caused by shortage of fossil and wood fuels and increased use of dung.	Men are in urban areas when harvesting is finished. Women bear most of the tasks of planting.
Mobile phones and internet increasingly used.		

Source: Stephen Joseph

Table 20.4 *Summary of the assumptions of community assets*

Human	*Social*	*Natural*	*Physical*	*Financial*
70% literacy 1% higher education 10% high-school educated 4% trade certification 60% traditional skills (e.g. pottery, metal work) Traditional medicine still practised Wide range of agricultural skills Leaders come from specific families, although mechanism to replace these if community perceives lack of skill and honesty	Complex social structure that is used to overcome shock, but also results in conflict, especially regarding distribution of assets on death Strong inter- and intra-village ties Some conflict over land Support mechanism for poor has been weakened with drought Conflict arises when men return from seasonal work	20ha of community forest 200ha of degraded forest 10km from village Home gardens for each household; dung and ash used in garden Stream flows in wet season High winds in dry season High household stove emissions High brick and charcoal kiln emissions	School with internet access Dispensary One deep well Dirt road to highway Blacksmithing shop Pottery Bakery Lime kiln Little wood available near village (mainly from thinnings from community forest); the poor use residues and dung; kerosene for lighting and some cooking	Average savings US$50 per person Inflow from remittance US$100 yr^{-1} per person Main agricultural stock: forest, cattle, tea trees Gold jewellery is associated with household wealth Three 4-wheel drive vehicles One minivan as a taxi

Source: Stephen Joseph

Cost-benefit analysis

Avoided emissions from stoves and kilns

A sample survey of households, businesses, local government and NGOs determined the possible costs and benefits of introducing biochar stoves and improved charcoal kilns. Fuel consumption and emissions were measured on 20 stoves. Households were selected at random and one stove was selected from each. Emissions measurements by gas and particle analysis (Zhang et al, 2000) allowed calculation of greenhouse warming commitment (GWC) in g CO_2e (carbon dioxide equivalents) MJ^{-1} heat released based on the following formula:

$$GWC = \sum_i GHG_i \times GWP_i \qquad [1]$$

where GHG_i is the quantity of the *i*th GHG in question, and GWP_i is the 20-year global warming potential per molecule of that particular GHG relative to CO_2 (Edwards et al, 2003). Fuelwood consumption was measured to be about 5kg per household per day at 12 per cent moisture content (Joseph et al, 1990). CO_2e emissions for the entire household were 2t to 4t CO_2e yr^{-1} (400t to 800t CO_2e yr^{-1} for the entire village) (Zhang et al, 2000) and stove heat transfer efficiency was approximately 19 per cent.

Two families operate two charcoal pit kilns and employ three individuals to help build and load the kilns, which takes about four days. The kilns are fired every month. Each kiln uses about 800kg of wood. The charcoal yield is about 22 per cent, with a total C content of 75 to 85 per cent. Fine charcoal materials without commercial value ('fines'), at about 50kg per kiln firing, can be used without payment. Charcoal sells for about US$150 and US$250 t^{-1} in the dry and wet seasons, respectively, giving a weighted average of US$175 t^{-1}. Greenhouse gas emissions from traditional kilns are 0.77kg to 1.63kg CO_2e kg^{-1} of charcoal produced (Pennise et al, 2001). Thus, total GWC emissions from the two pre-existing kilns are 3.2t to 6.7t CO_2e yr^{-1}.

Women working with local artisans and a combustion engineer designed a biochar metal stove with a secondary combustion chamber to convert 98 per cent of the volatiles to CO_2 and water. Local artisans built them for US$36 each (price ex-factory). Tests showed heat transfer efficiency increases to 29 per cent and fuel consumption fell from 5kg to 3.5kg day^{-1} for each household (Joseph et al, 1990; Limmeechokchai and Chawana, 2003). Biochar production per stove was about 0.75kg day^{-1}. Greenhouse gas emissions (GWC) were reduced by 90 per cent from 0.2t to 0.04t CO_2e yr^{-1} per household (20t to 40t CO_2e yr^{-1} per village), and household air quality improved significantly (reaching levels common with the use of kerosene stoves; Edwards et al, 2003). Women testers found the stove easier and faster to use and estimated that they would have an extra hour each day to tend the gardens, and an extra 30 minutes for cultural, community or family activities.

An improved kiln (with a forced-draught after-burner that will eliminate most products of incomplete combustion) was produced in collaboration with the local bricklayers and charcoal producers and was priced at US$3000 (wholesale price). Data from secondary sources (FAO, 1987; see Chapter 8) used to analyse its costs and benefits showed that the yield of these brick kilns is 30 to 33 per cent, and that the time between firings can be reduced from four weeks to three, increasing annual yields by about 1t or a 50 per cent increase in annual yield. Three per cent of the output of these kilns is fines that can be directly used as a biochar. Another benefit is that the kiln is permanent and the labour associated with rebuilding pit kilns is saved. Therefore, labour requirements can be reduced by four person days per firing (at US$5 per person day). The after-burner would reduce greenhouse gas emissions by more than 95 per cent. If two kilns were built, the reduction in greenhouse gases (GWC) of the entire village would amount to 0.16t to 0.34t yr^{-1}.

Increased agricultural production

In agronomic trials, samples of biochar fines from pits (from a recent firing) and from the biochar stove were incorporated to grow maize at 6t ha^{-1} (similar to Kimetu et al, 2008). Maize yields are assumed to increase from 3t to 5t ha^{-1}. There appeared to be no significant difference in yields between the biochar produced from the pits and that from the stove. Table 20.5 summarizes the anticipated costs and benefits, based on the following assumptions:

- In year one, 110 households have stoves, increasing to 200 households in year two.
- In year one, the new kiln starts operation in the second half of the year and full output is reached in the second year.
- Kiln and stove lifetime is five years.
- The discount rate set by the government is 12 per cent.
- The benefit of not replacing trees used for firewood is US$10 t^{-1} (Feldmann, 2007) as a community and national benefit.
- Avoided emissions in year one are 50 per cent of those in year two.
- Carbon credits from reduction in emissions from the stoves and kilns are valued at US$23t CO_2e (negotiated by the NGO).
- Carbon credits from burial of biochar and reduction of standing forest is assumed to be zero.
- It is assumed that once biochar is added to soil, its effect on improvement in yields

Table 20.5 Cost-benefit analysis of the project

	Units	*Years*				
		1	*2*	*3*	*4*	*5*
Input data						
Biochar from stove	(t yr^{-1})	30.00	54.60	54.60	54.60	54.60
Biochar from kiln	(t yr^{-1})	0.50	0.83	0.83	0.83	0.83
Charcoal from kiln	(t yr^{-1})	6.00	8.32	8.32	8.32	8.32
GHG traditional kilns (GWC)	(t CO_2e yr^{-1})	4.90	4.90	4.90	4.90	4.90
GHG new kiln (GWC)	(t CO_2e yr^{-1})	0.25	0.25	0.25	0.25	0.25
GHG traditional stoves (GWC)	(t CO_2e yr^{-1})	600.00	600.00	600.00	600.00	600.00
GHG new stoves (GWC)	(t CO_2e yr^{-1})	30.00	30.00	30.00	30.00	30.00
Reduction in GHG (GWC)	(t CO_2e yr^{-1})	287.33	574.65	574.65	574.65	574.65
Increase in wood stock	(t yr^{-1})	109.20	109.20	109.20	109.20	109.20
Increase in maize	(t yr^{-1})	10.17	28.64	47.12	65.60	84.08
Labour rate	(US$ day^{-1})	5.00	5.00	5.00	5.00	5.00
Price maize	(US$ t^{-1})	200.00	200.00	200.00	200.00	200.00
Costs						
Stove	(US$)	7200				
Charcoal kiln	(US$)	6000				
Depreciation (straight line)	(US$)	2640	2640	2640	2640	2640
Maintenance	(US$)	100	660	660	660	660
Kiln labour	(US$)	780	780	780	780	780
Extension + external consultants	(US$)	30,000	20,000	5000	5000	5000
Compliance monitoring and evaluation	(US$)	5000	5000	5000	5000	5000
Total costs	(US$)	51,720	29,080	14,080	14,080	14,080
Income						
Carbon credits stove, kiln	(US$)	6608	13,217	13,217	13,217	13,217
Charcoal sales	(US$)	1050	1456	1456	1456	1456
Savings from increase in trees	(US$)	1092	1092	1092	1092	1092
Increased maize sales	(US$)	2033	5729	9424	13,120	16,815
Reduced medical expenses	(US$)		14250	20,000	28,500	28,500
Income increases labour available	(US$)		4000	4000	4000	4000
Total yearly income	(US$)	10,784	39,744	49,189	61,385	65,080
Total yearly income – costs	(US$)	−40,936	10,664	35,109	47,305	5,1000
Total income – costs	(US$)	103,142				
Internal rate of return	(%)	58				
Net present value calculation	(US$)	−36,550	8501	24,990	30,063	28,939
Discount rate		0.12				
Net present value	(US$)	55,943				

Source: Stephen Joseph

Table 20.6 *Summary of community perception of non-quantifiable costs and benefits of improved stoves, biochar application and improved charcoal kilns*

Environmental benefits and costs	*Social benefits and costs*	*Economic benefits and costs*
Benefits: • improved air quality in households; • soil easier to till; • reduced smoke from charcoal kiln; • soil retains more water.	**Benefits:** • more conducive environment for family interaction; • more time to spend with family and community; • successful project enhances community's self-respect and motivation to undertake similar projects; • successful project brings other agencies to area to impart new skills.	**Benefits:** • more food for households; • increase in time and income raises possibility of other economic ventures; • possibility of profitable charcoal business if community forestry programme succeeds.
Costs: • possible increase in extraction of wood from forest for charcoal production as household has the ability to make charcoal an alternative income; • if biochar is not produced correctly. it could have a negative effect on soil.	**Costs:** • possible conflict over distribution of C credits, especially from charcoal kilns; • if the project does not produce financial gains, other environmental projects may not proceed; • time required to learn new skills (biochar production and use); • loss of income if biochar has negative effect on plant growth.	**Costs:** • time required to learn new skills (biochar production and use) • loss of income if biochar has negative effect on plant growth

Source: Stephen Joseph

remains the same over five years. Increase in yields is then calculated on the basis of 6t biochar ha^{-1} and increase from 3t to 5t ha^{-1}. Since biochar is either collected free from the kiln or is produced during cooking, its value is assumed to be US$0.

- Costs to the nation from loss of production and increase in medical costs from eye and lung disease from wood stove smoke are assumed to be US$20 yr^{-1} per person.

The cash flow shows a payback period of less than three years, an internal rate of return greater than 50 per cent and net present value (NPV) of greater than US$50,000. Under these assumptions, the project is financially as well as economically viable. The principal national economic benefits are reduced incidence of eye and lung disease, on the one hand, and increased maize production, on the other, thus reducing the need for medical services and food imports. Table 20.6 summarizes the non-quantifiable costs and benefits.

The NGO, village leaders, opinion-makers and representatives of households and charcoal-makers discussed the feasibility of the project within the constraints imposed by the drought conditions. They reviewed the survey data, the stove and kiln tests and the agronomic trials, together with the results of the cost-benefit analysis (see Tables 20.5 and 20.6).

All parties concluded that the new technologies and the resultant production of biochar would help them to overcome the burden of drought. Women and children would be healthier from using the new stoves, and would have to spend less time in collecting fuel and cooking food, with more time spent in family and community activities. The improved kilns would result in more income created within the community, less pollution in the surrounding area, and in freeing up labour for other activities.

The community's main concern was their lack of knowledge about how to operate the new stoves and kilns. They were also concerned that the biochar may not be produced to the correct specification. This could then jeopardize the yields of maize. The community thus emphasized the need for considerable assistance from the department of agriculture and for extensive trials at the beginning of the project.

Other concerns included the following: metal workers may not produce a stove with the required quality; kiln operators may not adapt to the new charcoal-producing techniques; the biochar might not be applied to maximum benefit; the biochar produced in the household might be sold as charcoal, which would reduce the income derived from C credits and increased maize production; new kilns could increase the rate of forest depletion; the owners of the charcoal kilns might not allow the fines to be distributed freely and equitably. People expressed uncertainty about how the C credits would be distributed to the villagers and how reliable the income from this source would be. To take these factors into account in the design of the biochar programme, it was agreed that the income from the C credits would be used to employ more young men to plant trees. This, in itself, could generate more C credits. A contract between the charcoal producers and the community would be drawn up and would be administered by the local agricultural extension officer.

Conclusions

A framework and methodology for assessing small-scale biochar projects from a socio-economic point of view are outlined in this chapter. The case study introduces how assessment and planning may be conducted for implementing a biochar project in a developing country. The approach emphasizes the involvement of stakeholders both in the assessment process and in the project design. However, this framework and methodology may be used for introducing biochar within any community. For example, a project to reduce waste on dairy farms in industrialized regions can be undertaken in partnership with all local farmers, the population within a local town and with the local government body. This framework and methodology requires further refinement as experience is gained in biochar project design and implementation.

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