Carbon2Markets

Greening the Globe through Carbon Sequestration

Next Generation Technologies in Carbon Market Development

A Prospectus of the Global Observatory for Ecosystem Services

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INTRODUCTION

Global climate change is increasingly recognized as the greatest global threat facing humanity. In a recent report (Feb. '07),[1] the United Nations Scientific Experts Group on Climate Change and Sustainable Development concluded that "the human race…has never faced a greater challenge." As is often the case, the authors of the report observe that the world's poor will bear the heaviest burden of a changing climate, leading to the designation of a new type of refugee – environmental refugees – that will potentially number in the tens of millions. For the majority of the world's population, the persistent problems of food insecurity, rural poverty, and the struggle to develop and sustain new sources of economic growth must now be considered against a backdrop of uncertainty and change in historical climatic patterns. Separately and together, governments, and both international and domestic organizations not only need to continue responding to the immediate concerns of extreme poverty, environmental degradation and social unrest, but in addition must now begin to prepare communities and entire regions to adapt to uncertain future climatic regimes, as well as to make tangible contributions in first slowing, and ultimately re-establishing a balance in greenhouse gas exchanges at a planetary scale. Under mounting time pressures, there is an urgent need to evolve win-win solutions that address both these immediate local and long-term global threats.

Carbon sequestration in agricultural soils, grasslands and woody perennials, and the transfer of carbon credits through market structures, represent one such win-win opportunity. Among the alternatives, tree planting offers perhaps the greatest potential. Trees grow in all but the most extreme conditions (e.g., deserts and arctic). Their physiology enables them to tolerate intra-annual climatic fluctuations of greater magnitude and duration than annual species, thus allowing them to mitigate risks to which annual crops are most vulnerable, and which with increased climatic change, will become increasingly common. Many tree species also yield additional high-value products – edible fruits and leaves, fodder for livestock, gums and oil-bearing nuts for human and industrial uses, including feedstock used in the manufacture of biofuels – that offer a perfect opportunity for creating a win-win situation through removing carbon from the atmosphere and providing new sources of income for farmers worldwide. In fact, the approach developed at Michigan State University – Carbon2Markets™ – focuses on the co-development of market value-chains for sequestered carbon and secondary products. This approach, we believe, is pivotal to enlisting the managerial skills and lands of tens of millions of farmers around the world in the struggle to slow and abate climate change.

Carbon as a Commodity. Sequestered carbon is now a globally traded commodity. As a commodity with the ability to provide economic returns to land managers, carbon sequestration can serve as a new catalyst for improved forest management practices such as forest preservation, lengthening fallow periods and reduced impact forestry. Unlike traditional development models based on deferred and diffused benefit streams, the new carbon-market model offers an opportunity to directly link land management and natural resource conservation with specific and immediate market incentives. This market-driven approach will stimulate growth and development of local social and technical infrastructure that is self-sustaining and

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[1] United Nations – Sigma XI Scientific Expert Group Report on Climate Change and Sustainable Development (2007). "Confronting Climate Change: Avoiding the unmanageable and managing the unavoidable." Prepared for the 15th Commission on Sustainable Development.

can be maintained over the long term, with highly valued additional benefits such as enhanced land tenure and environmental quality.

Carbon Financial Markets: a Biobased Economic Opportunity. In recent years opportunities for participation in carbon credit trading markets have been growing. The Chicago Climate Exchange (CCX) now boasts more than six million trades per month. A recent summary of the *State and Trends of the Carbon Market 2006* prepared for the World Bank's BioCarbon Fund reports a rapid increase in corporate participation in the carbon market. One opportunity lies in the Michigan landscape where forestry projects or rural conservation tillage practices can link Michigan farmers into carbon financial markets where they can sell their carbon offsets to industries wishing to reduce their carbon risk and carbon footprint. An additional exciting opportunity lies in prospects for leveraging this growing carbon financial market in the US and Europe to assist poor farmers in developing countries who could participate in tree planting or vegetation regeneration projects and earn revenues that can, in turn, catalyze economic development within their communities, increase rural incomes, enhance land tenure security, and stimulate natural resource conservation.

Forestry and Agroforestry. Most of the carbon market trade involves emission reduction credits but there is also growing interest in the use of trees and forests for absorbing carbon dioxide from the atmosphere. The Clean Development Mechanism (CDM) of the Kyoto Protocol and some voluntary carbon markets, such as the Chicago Climate Exchange, allow countries and companies to offset their carbon emissions by carrying out tree planting projects. There is also considerable evidence that forests and agroforestry (the planting of trees on farms) in developing countries provide substantial benefits to rural dwellers, national economies, and the environment. Trees provide a range of products for home use such as food, timber, firewood, medicines, and fodder as well as products for sale, boosting farm incomes, rural economies, and national exports. Trees on farms and in forests can also provide a range of environmental services, such as conserving biodiversity, reduced soil erosion and sedimentation in rivers and lakes, and increased soil fertility. Moreover, what is often unrecognized is that while forested area is declining in developing countries, tree cover on farms is rapidly increasing, as farmers substitute for the tree products they formerly accessed from forests and seize market opportunities for selling tree products. Agricultural land now accounts for over double the area of forested land in Africa, giving justification to the slogan that, "the future of trees is on farms.

Sustainable development links natural resource management with tangible ecnomic improvements in rural livelihoods. Approximately 3 billion people, half of the world's population, live below the ethical poverty level (EPL). The ethical poverty level is defined as the point at which life expectancy falls as rapidly as income, and above which life expectancy rises only slightly compared to income increases (Edwards, 2006). Currently, the global EPL is around $2.70/day. A vast majority of these individuals depend for their survival on the 400 million small-farms that are found throughout the developing world (Gates Foundation, 2006). If the appropriate markets can be created the cumulative human and natural resources that can be marshaled in reducing atmosphere carbon, and raising rural incomes are vast. Traditional approaches to reforestation and agro-forestry, often fail because farmers are asked to make immediate investments of scarce land and labor to plant and protect trees with the uncertain hope that the trees will begin to produce benefits 5-15 years later. The ability to link tree planting with near-term payments through the emerging carbon markets, with additional payments from other tree products coming on-line in subsequent years, has the potential to positively impact millions of lives. Furthermore, once productive, the continued generation of high-value tree products (fruits, oil-bearing nuts) serves to protect the stored carbon from being harvested as fuel wood, burned and the re-released into the atmosphere. The fact that some oil-bearing nuts (e.g., jatropha) can be used in the manufacture of bio-diesel, thus reducing the use of fossil fuels and release of additional stored carbon, constitutes yet another positive gain of our approach to carbon sequestration.

ENGAGING THE TECHNOLOGICAL FRONTIER

This proposal builds on advances in geo-spatial and other related technologies that create a transformative opportunity to create cost-effective, pro-poor measurement and monitoring systems for A/R, LULUCF projects. It is our intent to bring these emerging technologies to the measurement and monitoring of carbon sequestration, other GHG and related co-benefits using a growing base of innovative earth observation and location-based technologies. Trends impacting the ability to utilize these technologies include:

- Satellites are now offering global, near real-time data with high spatial resolution which allow for accurate land use, land use change and forestry tracking anywhere in the world.
- Satellite imaging is decreasing in cost as more extremely high-resolution imaging systems are launched into orbit – and internet-enabled GIS mapping is now available for integration of multiple types of geospatial data layers, including land cover, land ownership, population, infrastructure, and other features; and geospatial content management software is increasingly available.
- GPS enabling, location-based services are built and available on distributed internet GIS.
- Telecommunications, wireless hand-held devices and increasing internet connectivity enable information flow from the field to centralized databases;
- Increasing computing power is lowering the cost of managing large and complex data sets such as remote sensing images.

Earth Observing Technologies (EO). Similar to the internet, there has been significant government and public investment in EO technologies. Companies are entering this market with interest in leveraging this public investment for consumer applications. Examples include Google with its launch of *GoogleEarth* and Microsoft with its acquisition of *Vexcel*. The project team will leverage this public investment into emerging environmental applications, focusing specifically on the carbon and environmental markets. MSU has experience in developing and deploying these technologies, coupling them together and managing the complex datasets required to apply them to environmental markets. By applying emerging technologies to environmental markets, the project will be able to provide more accurate and rigorous measuring and monitoring technologies to better understand land use, natural resource management and climate change.

New Mapping Technologies. In addition to classification, new methods that focus on continuous fields, such as fractional cover analysis, are providing techniques for developing percent tree cover maps and continuous fields of forest density at scales ranging from 30 to 1000 meters. New techniques, such as the *K Nearest Neighbour* (kNN) technique are being developed which link point measurements, such as forest stand inventories with remote sensing data for spatial extrapolation. These types of mapping techniques allow measures of changes within classes and can account for natural resource degradation, where classification usually only captures outright transformation or loss. These methods are also more closely tied to the kinds of natural resource inventory and status techniques typically performed by ground-based sampling. It is now possible to develop measures of natural resource conditions to supplement ground based programs, and thus greatly reduce human resource requirements and costs.

Based on the discussion of emerging methods and technologies above, it is clear there are opportunities to develop spatialized and mapped measurements of: a) land use and land cover change which provide a mechanism to define a community/landscape map that could be used in a carbon credit system; b) changes in tree density and cover density to evaluate changes in carbon density above-ground over time using fractional cover techniques; and c) area-wide extrapolation of point measurements on the ground, using kNN and similar techniques for comparing point measurements to satellite measurements for verification.

Geographic Information Systems (GIS). These remote sensing tools, when integrated into a GIS framework, can provide a means to map carbon changes, making it possible to provide measures of carbon sequestration for entire landscapes or projects that include several communities in a region. The ground-breaking use of EO technologies and web-based GIS tools will enable the international development community to overcome barriers presented by the overly complex and expensive protocols currently being promoted that keep local communities and project developers from entering these new ecosystem service markets.

THE APPROACH

As the pioneer land grant university with a broad, respected and growing base of international engagement, Michigan State University (MSU) is perfectly positioned to help develop the next generation of advanced ‘green’ technologies and apply these in support of global natural resource management. The primary aims of this initiative are twofold: 1) establish the standards, protocols and computation systems for the next generation of carbon accounting; and 2) create the internet-enabled carbon management system that will support individuals and communities in managing their carbon resources and to aggregate and link these accounts with the CCX market floor. To accomplish these aims, we will demonstrate the field use of these new tools and systems in a select number of international settings with our partner organizations. The technologies deployed are, and will continue to be, incubated at the facilities of MSU’s Global Observatory for Ecosystem Services (GOES). Ultimately, for these new technical capacities to realize their full potential, they must migrate to the private sector. Thus, while we continue to develop and refine the technologies within the GOES environment, we will work in parallel with the CCX and ready private entities to support and accelerate their broader application. In carrying out this work, we will engage our international network of collaborators and partner with credible organizations capable of implementing and managing exacting research and financially viable field projects.

Overall Objectives. The project will be focused on three objectives that bring land-grant university R and D into practical application and use for carbon measurement and trading, using MSU science and technology assets.

Specific Applications Objectives
1. To develop a unified protocol to account for carbon sequestration at the community level using remote sensing measurements, carbon models and geographic information systems;
2. To develop a suite of simple, but precise, bookkeeping models for above and below ground carbon sequestration accounting that can be readily used by rural communities and local support organizations;
3. Develop the needed technologies to support carbon sequestration and carbon off set measurement, monitoring and trading using earth observation satellites, internet-based GIS and databases, and ground based sensors and sensor webs.

The Next Generation Technologies. Our overall goal for this initiative is to assemble, demonstrate and refine the tools needed to reduce costs and expand the opportunities for bringing carbon sequestered through reforestation and agro-forestry to market. By replacing the need for high-cost, time-consuming *in situ* measurements with the use of advanced technology systems, we are able to centralize common carbon measurement, monitoring and reporting tasks and thereby greatly reduce the overall expense of accounting. The reduction in intermediary costs will enable a greater share of benefits to flow to the individuals and communities installing and managing the sequestration systems, stimulating a virtuous cycle of additional sequestration efforts. The advanced technologies that we will bring to bear include the use of satellite imagery and remote sensing analysis in conducting plot-level to landscape-wide carbon stock assessments and monitoring, the use of bookkeeping carbon flow models to quantify above and below ground carbon storage, and web-enabled Geographic Information Systems (GIS) to provide a secure registration and account management web-portal. The GIS tools, needed carbon models, library of remote sensing imagery and analytic capabilities are already in place. The task that remains is to integrate these components into a seamless, end-to-end operational system that can be deployed to track and quantify carbon sequestration anywhere on the globe.

To take this next step, we propose the following specific activities:

- Assemble and integrate a suite of accurate bookkeeping models for above and below ground carbon sequestration, and develop a data input template for local calibration that can be readily used by landowners anywhere in the world;
- Integrate these models with an array of geospatial information technologies, including GIS, remote sensing, GPS and others, that allow for highly accurate, low-cost, landscape-wide measurement and monitoring of carbon sequestration on an annual basis over the long term;
- Develop a secure, web-based portal for carbon account management that links individuals and communities to the CCX market floor;

- Write the protocol for the appropriate use of very high resolution satellite imagery (30m, 15m, <1 m), carbon models, geographic information systems and remote sensing analysis in carbon sequestration accounting.

These four objectives (see Figure 1) create the means by which land managers around the world, including many of the most impoverished, can be supported with rigorous accounting methods, market accepted standards, and practical guidelines that will allow them to participate in the growing carbon marketplace. As shown in Figures 2 and 3, a clear implementation pathway can be forged in bringing these activities to life. Ultimately, the successful creation of market-driven, win-win opportunities will be critical if humanity is to tackle the growing challenge of global climate change.

<u>Challenge Proof Protocol.</u> Emission reductions and removals must be real, measurable and permanent. Definitions of standards and practices for measuring, accounting, verifying, and monitoring that will be accepted in the market is required. We will develop an improved carbon accounting protocol that can be used in creating highly accurate carbon cadastral maps and monitoring diverse land management practices, at low costs, through the use of advanced technologies that are field calibrated and verified. The new protocol will enable the use of satellite imagery, remote sensing and integrated carbon sequestration models capable of covering very large areas with high levels of accuracy and will be demonstrated across a wide range of conditions at selected international pilot sites.

<u>Remote Sensing for Measurement and Monitoring</u>. The backbone of the new accounting system is the use of high resolution satellite imagery and remote sensing analysis. The initiative will utilize a large archive of current and historical satellite imagery to provide the spatial database for locating participating land areas, conducting baseline carbon assessments, and measuring and monitoring changes in land use and carbon stocks over time. Remote sensing data will also be used to set parameters in the carbon models. Recent advances in the use of remote sensing to directly parameterize models for carbon accounting enable detection of: a) area changes, rates and extent of tree plantings, b) changes in stand density and percent cover, c) leaf area index, d) vegetation strata, and e) other important parameters related to total carbon assessment. Data on land use and forestry measurements will be obtained from a combination of NASA assets (Aster, Landsat and MODIS sensors) and commercial satellites providing very high resolution imagery (Quickbird <1m data).

<u>Numerical Accounting Models</u>**.** In addition to using remote sensing analysis, the other core element of the protocol will be the use of bookkeeping carbon models that can project and track carbon storage in vegetation and across a range of physical conditions and land management regimes (e.g., temperate to humid zones, mono-culture plantations to multi-species agro-forestry systems). The use of proven bookkeeping models will greatly reduce the need and costs of conducting *in-situ* measurements, and when coupled to remote sensing measurement, can cover whole landscapes. In this way, a centralized accounting system can be established, capable of providing services to many farmers, each managing potentially very different systems, in order to aggregate marketable volumes of sequestered carbon. The centralization of routine tasks relieves individual landowners of the burden of undertaking their own accounting and reporting.

Developing a Web-GIS Registry Portal**.** We will construct a web-enabled GIS management system to integrate the satellite imagery and other data layers in: a) a registry for potential participants/sellers to sign up and enter important data, such as location of land area, description of management techniques, edaphic characteristics etc.; b) an accounting system that provides both buyers and sellers with current credit value as a function of market price per metric ton of carbon dioxide, carbon sequestration accounts, and other factors considered in an accounting model; c) a monitoring mechanism to ensure that participants are in compliance, based on remote sensing observations; and d) a reporting function that produces quarterly and annual reports for investors, land owners, and the market (i.e., CCX) in the required formats. In developing the needed web portal features, we will make full use of our unique experiences in creating and operating data management tools for large data sets (>terabytes) and commercial, web-based GIS platforms developed through prior funding.

Secondary Products and Renewable Energy. Using agroforestry for carbon sequestration also has some secondary benefits beyond carbon sequestration per se. Trees grown to store carbon can also produce a number of economically useful secondary products, such as Shea Butter which now commands an extremely high price as a lotion sold in Europe and the US, purchased in the consumer market as fair trade items from small rural producers in Africa and Asia. These secondary products produce added income streams to rural farmers in addition to their carbon credits. Also, there are opportunities to "close the loop" on the carbon cycle through agroforestry projects that grow renewable energy products. One such product is Japtropha. Grown throughout Africa and Asia, Jatropha produces a nut that can be rendered with extremely high efficiency into a bio-diesel. This bio diesel-can be used by local farmers or exported (ie to Michigan to run in Lansing built cars!).

Carbon2Markets Approach and Carbon Market Linkages. This project will develop rigorous, yet cost-effective, standards and protocols for carbon sequestration and field-test these in several pilot projects on MSU properties, on Michigan farms, and in developing countries. Using recent advances in the deployment and use of remote sensing earth observing technologies, numerical carbon accounting models and geographic information systems, MSU will deliver a verifiable accounting mechanism with a high degree of spatial accuracy. A key output from this accounting system will be a carbon cadastral map that identifies all parcels of land within a community and links these to carbon sequestration parameters, as well as ownership information for each parcel needed for market integration.

Carbon2Markets™ A positive synergism exists in developing the value-chains for carbon in conjunction with other tree products. Analysis shows that carbon markets can serve a catalytic function in stimulating increased tree planting and improved forest management, thus helping to realize the multiple benefits of forestry and agro-forestry systems that advocates have long promoted. Throughout the developing world, the ability to incorporate higher tree densities into farming systems and local landscapes offers particular promise. Not only is some form of agro-forestry association a traditional practice in most areas, but the potential of coupling payments for carbon sequestration with the development of new natural product value-chains responds to one of the perennial challenges that have thwarted agro-forestry initiatives in the past, namely the time gap between farmers' investments of land and labor in establishing tree plantings and the delayed onset of benefits, measured in years before trees begin to produce harvestable products. The temporal profile of income streams of different tree products, including carbon, from an example Carbon2Market™ project in West Africa is shown in Figure 4. The potential of incorporating different tree species in different locations, when linked to associated value-chains, offers individual and communal land managers a wide range of flexibility in generating new, locally targeted, sources of income. Depending on the products involved, market-linked enhanced agroforestry systems have the potential of more than doubling the incomes of even the poorest of the poor, or those living on less than a dollar a day.

PLACES AND PARTNERS

We currently have cooperative agreements with partner organizations in five countries: two in Africa – Senegal and Mali – and three in Asia – India, Thailand and Vietnam. The pilot sites are listed below in order of readiness. The fieldwork for the Senegal, Thailand and Vietnam activities is supported through a combination of external research grants, university resources and GOES own budget. In India, we are linking with the field programs of Community Forestry International. The fieldwork proposed for Mali is currently under review by the United States Agency for International Development (USAID) as part of a major development initiative in that country. We also have on-going discussions with partners in Kenya, Uganda, Morocco, Laos and Cambodia. In addition, with MSU's recent membership to the CCX, GOES has been asked to develop an accounting framework to assist management of the university's carbon footprint. This effort, and collaboration with the research being undertaken at the Long-Term Ecological Research (LTER), led by Dr. Phil Robertson at MSU's Kellogg Biological Station, will serve as our reference research site for carrying out detailed studies on gas exchange and *beta* testing our technology systems.

Senegal. MSU's College of Agriculture and Natural Resources recently expanded its commitment of resources in partnering with the *Université de Cheikh Anta Diop* in Dakar, Senegal. The revised focus of this joint program, now in its fourth year, is the development of the Carbon2Markets™ model involving carbon sequestration research and tree-based natural products, e.g., Gum Arabic, Neem and Jatropha.[2] A Senegalese PhD candidate in MSU's Department of Forestry is currently in Senegal (Summer 2007), working with colleagues at UCAD's geospatial research laboratory (*Laboratoire d'Enseignement et de Recherche en Géomatique*) to select research sites, begin calibration of the carbon models, hold

[2] MSU's Institute of International Agriculture is currently carrying out a market study on Gum Arabic for USAID. In addition, MSU GOES is engaged in discussions with two companies, GANTECH and EcoNeem, with interests in importing Neem oil from Senegal.

discussions with participating communities, and formalize the network of local implementation organizations. This student's degree program is supported by the GOES laboratory, and will focus on carbon sequestration research in Senegal.

Thailand. Using its own resources, GOES has initiated a partnership with the Inpaeng Community Network, in collaboration with the Walai Rukhavej Botanical Institute and the National Research Council of Thailand, to develop and field test our carbon sequestration measurement and monitoring technologies. This effort targets the agro-forestry and reforestation efforts undertaken by members of the Inpaeng network, a self-created community membership organization established in 1980. Located in communities in Kudbak District, Sakon Nakhon Province, Inpaeng members have transformed all or part of their farms from mono-culture crop cultivation to multi-purpose, multi-species, agroforestry systems. In March-April, GOES Researcher, Jay Samek, visited with the partners collaborating on the project and began collecting field data, including: GPS mapping of agro-forestry parcels, tree locations, digital pictures used in ground truthing, forest biometrics, and information on tree ownership and land use history. Over the Summer of 2007, remaining satellite imagery will be acquired and analyzed.

Vietnam. Funded through a grant from the Asia Pacific Forum for Environment and Development (APFED), and GOES own resources, GOES has initiated a joint project with the Forest Inventory and Planning Institute, part of the Vietnamese Ministry of Agriculture and Rural Development. The project objectives are to contribute to the development of policies, technological applications and management practices necessary to sequester carbon and bring this carbon to the market. Participating families in the project area, located in the Kien Lao Commune, Luc Ngan District, Bac Giang Province, 120 km northeast of Hanoi, have already planted trees on

465 ha as part of a national reforestation initiative. Between March – May 2007, GOES researcher Jay Samek has visited with project collaborators twice. Work has already begun on acquiring and analyzing satellite imagery and collecting field data necessary to construction of the base carbon cadastral maps.

<u>Mali</u>. MSU has relationships with the college of agriculture (*Institut Polytechique Rural*/*Institut de Formation et de Recherche Appliqueé*)(IPR/IFRA) and major research institutions (*Institut d'Economie Rurale*) in Mali, dating back in some cases to the 1970s. The U.S. Agency for International Development (USAID) has recently issued a request for proposals, under the title of the Mali Economic Growth Activity (MEGA), to implement a major program targeting the tripartite of agricultural productivity enhancement, financial support services, and market development. MSU's GOES has entered into a partnership with the Associates in Rural Development to work with the Agricultural College, IPR/IFRA, in Mali and other organizations in developing Carbon2Markets™ pilot projects involving carbon sequestration agreement with Community Forestry International (CFI), a well-respected research and development non-and production of a range of natural products -- Shea butter, Gum Arabic, and Jatropha (used in the manufacture of biodiesel).[3] Under this initiative, we anticipate working in upwards of a dozen communities across a range of biophysical conditions.

<u>India</u>. In India, GOES has a working governmental organization with nearly 20 years of field experience in India. Under their current projects, CFI has targets of working with 8,000 communities, involving an estimated1.2 million households in the state of Andhra Pradesh, as well as communities in northeastern India in the Senapti District, Manipu and the East Khasi Hills of Meghalaya. The dominant activity across all locations is conservation reforestation, improved community forest management, and the sustainable harvest and marketing of non-timber forest products (e.g., Pongamia pinnata which, similar to Jatropha, produces a high yielding oil suitable for use

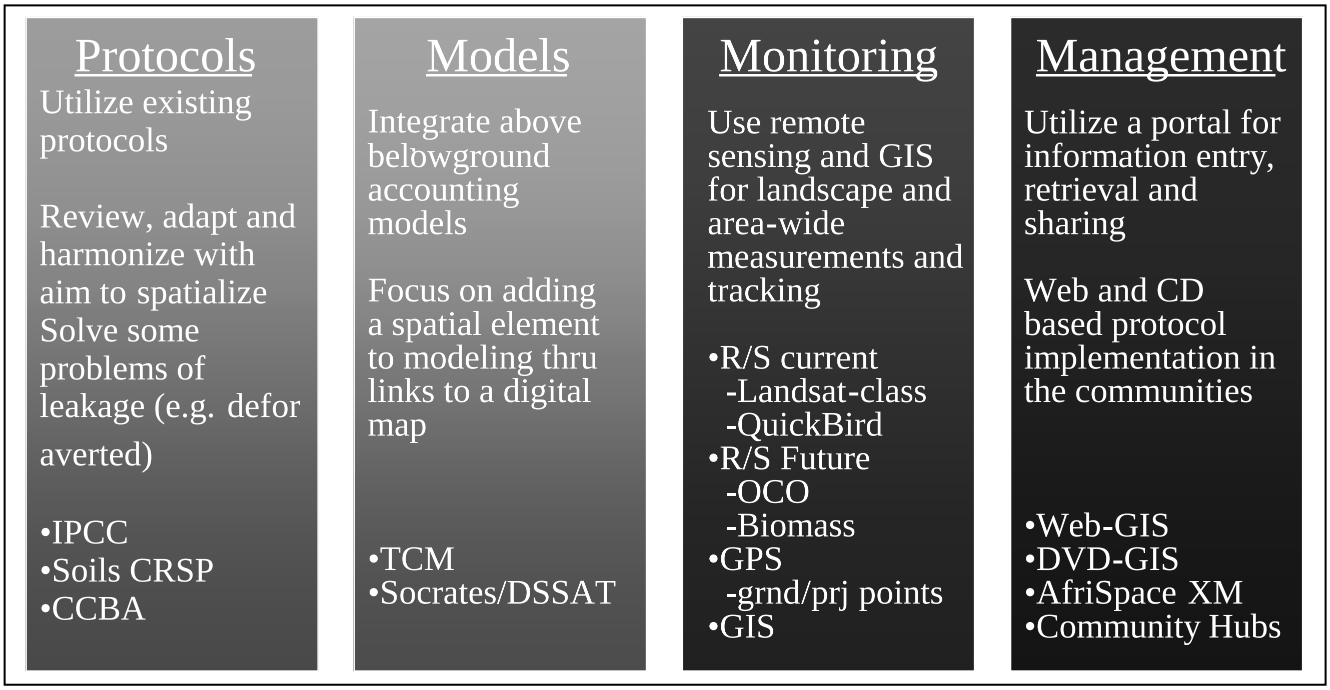
[3] IPR/IFRA's Director General, Dr. Fafre Samake, conducted his PhD research on Jatropha systems, and recently planted 1 ha of Jatropha on the campus farm to produce oil to run the Institute's buses.

in the manufacture of bio-diesel). CFI also provides assistance to communities in establishing community management committees, a number of which have in turn drafted and signed community management contracts for carbon sequestration. In several sites, CFI has established GPS coordinates for reforestation plots that will be monitored under this initiative.

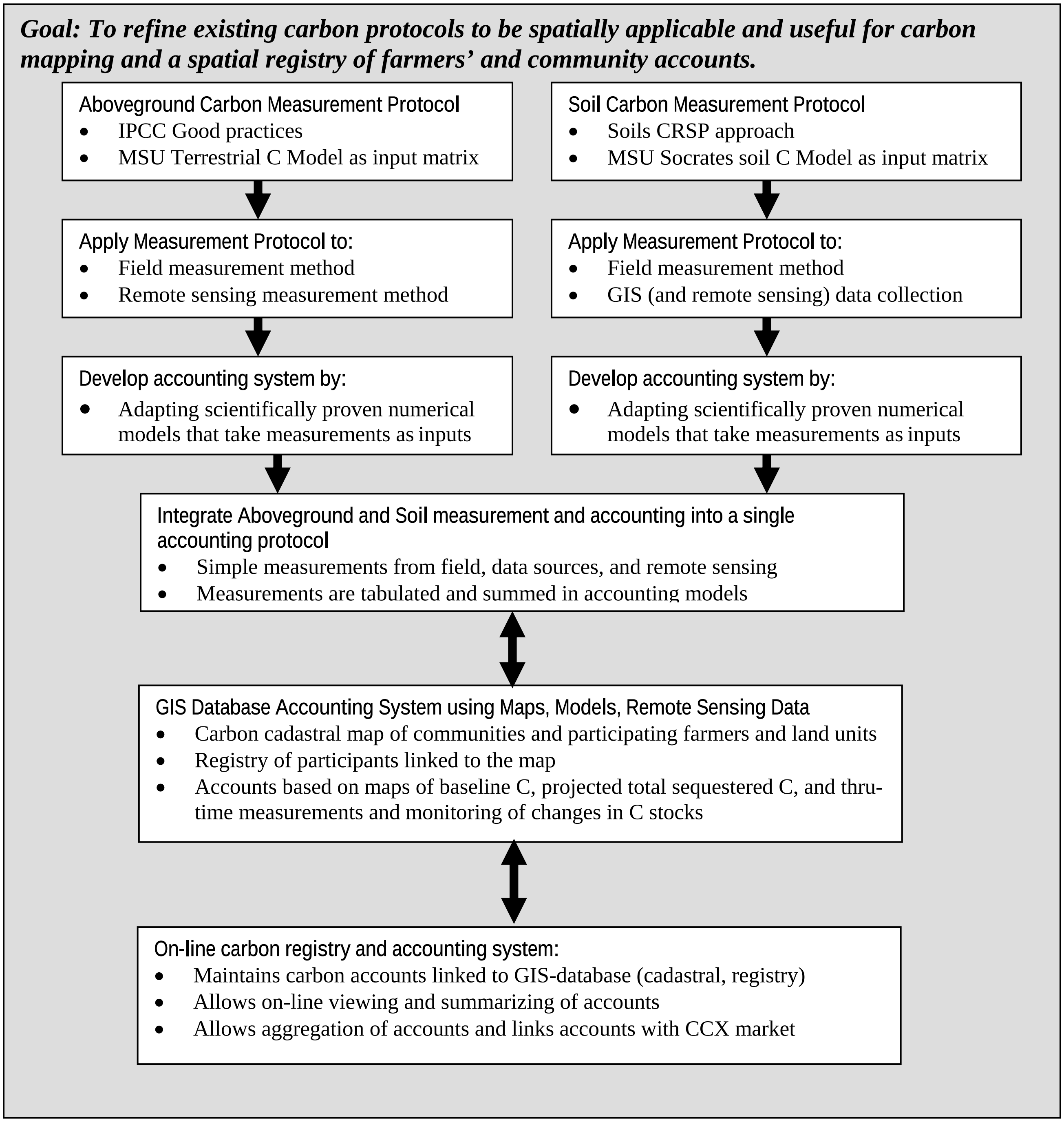
Sub-Regional Networking. In addition to the specific field projects listed above GOES is playing a leadership role in a number of sub-regional networking and capacity-building efforts related to carbon market development. Two important events are slated for this Fall (2007). In October, the second sub-regional meeting of the West Africa Network for Environmental Research will be held at the University of Ghana, Legon campus, in Ghana. As with the network-launching meeting held in Dakar, Senegal, in 2005, GOES has helped secure funding for this year's meeting, this time from the international GOFC-GOLD program. GOES will play a key role in helping to develop the workshop agenda, which will include sessions on carbon measurement and monitoring. This meeting will bring together researchers from across West Africa, as well as support programs from Europe, and will provide an excellent opportunity for expanding the network of collaborating institutions developing carbon market projects.

Also in October, GOES is organizing a training and project site identification workshop in SE Asia for collaborators from Cambodia, Laos, and Vietnam. The primary outcomes of this event, which is funded by the Asia Pacific Network, are the development of a carbon accounting training manual (and training sessions using the manual), selection of pilot projects (at least one per country), and creation of baseline landcover and carbon assessments for each pilot site at two time periods – 1999/2000 and 2005/2006. The next step in moving to a market-ready project will be the focus of partnership activities in early 2008. The cumulative impact of these efforts is the ability of going to scale, rapidly – a much needed outcome, given the pressing threats of global climate change.

Figure 1. Schematic diagram of the components of the MSU P3M Approach



<u>Figure 2.</u> ***<u>Part 1 of the Implementation Pathway</u>*<u>:</u>** Development of the measurement and monitoring infrastructure for a carbon accounting system. This part requires the development of the software, databases, models, supporting geospatial data, and standards and practices that comprise new protocol.



<u>Figure 3.</u> *<u>Part 2 of the Implementation Pathway</u>*: Initiation of the protocol and technical infrastructure for a particular community, involving development of a Baseline Registry and Carbon Accounts. Carbon Accounts change over time and these changes are monitored using remote sensing, models, and field measurement.

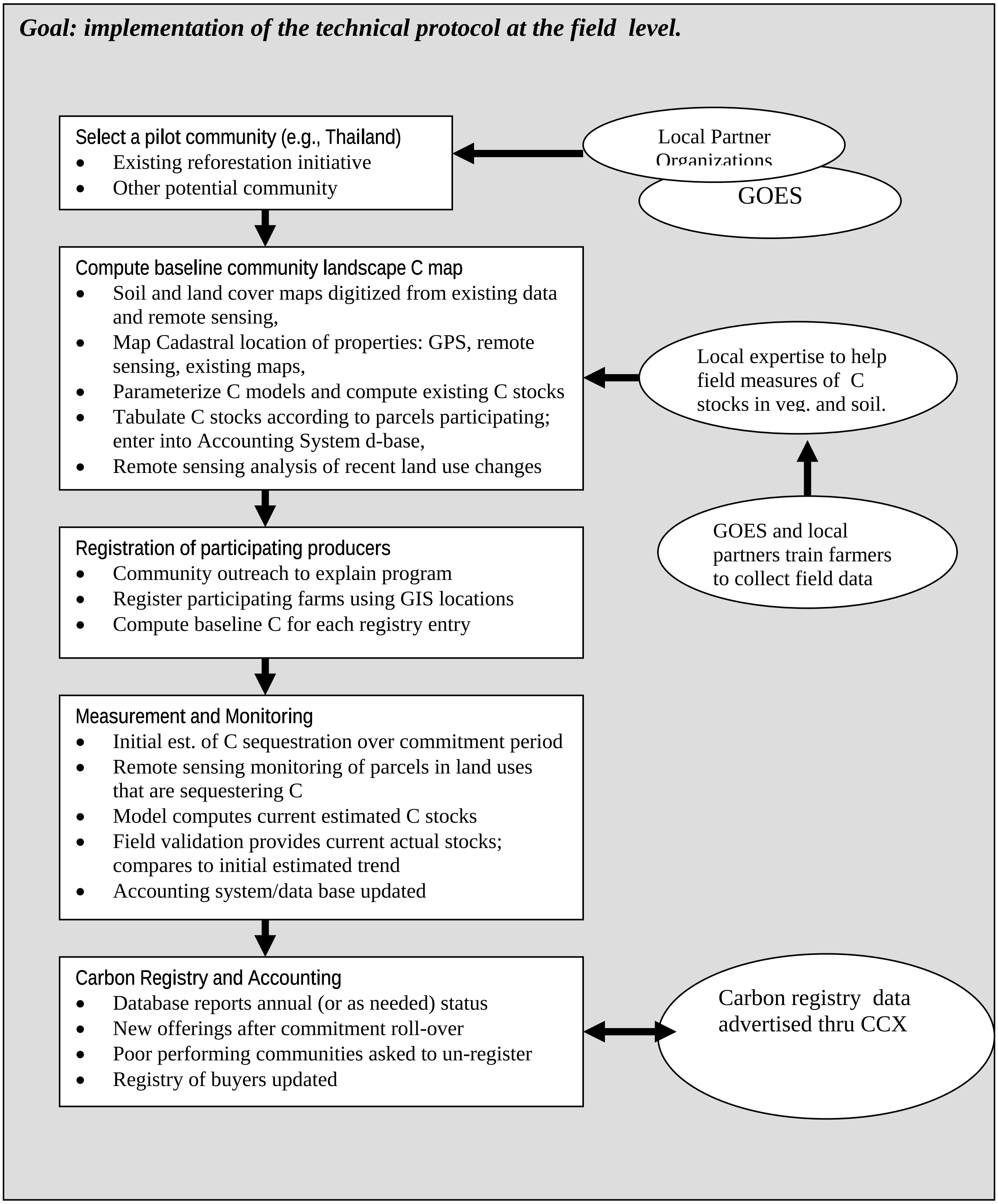


Figure 4. Carbon2Markets™ Income Streams of a Typical West African Agroforestry System

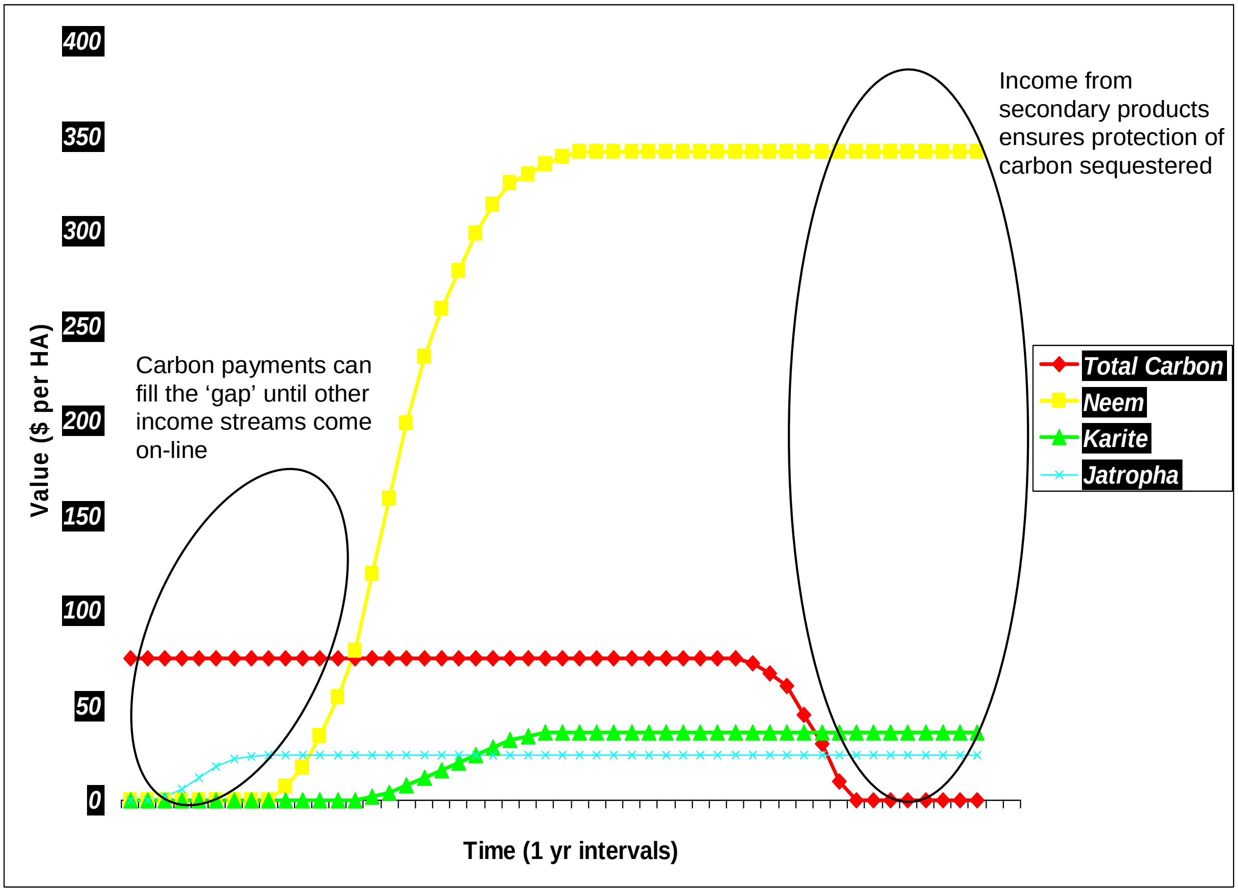


Table 1. Roles and Responsibilities Partner Organizations

MSU/GOES	***Primary role is to develop the protocols, standards and practices for a spatial Carbon Accounting System and implement it on a web-based portal.***
	Core Activities include: • Review and refinement of existing protocols; develop a spatialized protocol • Integrate carbon models, remote sensing analysis and GIS data layers • Development of a secure access web-based carbon account management portal • Construct community carbon cadastral map; maintain and update map • Development of a data collection template for model inputs • Development of data template for field validation • Development of baseline carbon stock assessment for pilot sites • Collection of basic measurement and monitoring data (land use, cover, soil type, etc) • Acquisition of satellite data for carbon assessment and map preparation • Maintain routine (annual) monitoring and verify compliance with registered land uses • Development of an on-line Carbon Accounting System • Development, maintain an account registry; input sellers' data into registry
National Partner Organizations	***Primary role is to assist in protocol development, design and implementation of projects, work closely with communities to establish the projects, perform training and coordinate input data collection.***
	Core Support Activities include: • Identifying community participants • Managing project design and implementation plans • Training programs in communities • Implementation of projects; field data collection • Communications and outreach
CCX	***Primary role is to provide institutional support in the development of the new protocols and their demonstration at international pilot sites***
	Core Linkage Activities • Provide guidance on the needed content and level of specificity for protocols • Working with the MSU/GOES team to refine protocols • Participate in the review of protocol field performance • Provide input on the portal design and participate in testing access and functionality of the portals