C-Scape: The political economy of ecosystem-based offsets in the global carbon market

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Abstract
Carbon offset projects are intended to provide cost-effective emission reductions for carbon intensive businesses in industrialized nations, promote sustainable economic growth in developing countries, and facilitate the uptake of clean technologies and environmentally positive behaviours globally. However, international carbon markets are skewed, with ecosystem-based offset activities significantly under-represented. This lack of representation can be considered a market failure, as the development and commercialization of ecosystem-based carbon offset initiatives offer considerable benefits in terms of climate change mitigation and adaptation, and ecosystem services.

This paper takes a systems approach to analyse the anomalous participation of ecosystem-based offsets in the global carbon market. The manuscript is developed in five sections. First, we introduce the value chain perspective and outline the methods used in this study. Second, we present an analysis of global carbon offset markets using data on 8075 offset projects from the Clean Development Mechanism (CDM), Joint Implementation mechanism (JI) and major voluntary carbon offset schemes. Third, we review the range of factors commonly identified as constraining ecosystem-based offset project development, and consider traditional explanations for the paucity of ecosystem-based offset activities in the market. Fourth, we argue that these commonly cited factors are indicative of a neoclassical interpretation of carbon economics, and that the limited participation of ecosystem-based offset activities in carbon markets is better understood through the theoretical lens of a revisionist or evolutionary economic perspective. Finally, we summarize our findings and outline a research agenda that will facilitate improved implementation of ecosystem-based offset projects.

1. Introduction

Carbon offset activities are crucial components of international climate mitigation strategy in that they are the principal incentive mechanisms of the global carbon market, and thus represent the means by which businesses are given flexibility and financial motivation to participate in the necessary economic transition to a low carbon industrial base (Grubb et al., 2010; Lewis, 2010). Offset projects are intended to provide cost-effective emission reductions for carbon intensive businesses in industrialized nations, promote sustainable economic growth in developing countries, and facilitate the uptake of clean technologies and environmentally positive behaviours globally (Schneider, 2009; UNFCCC, 2011). However, international carbon markets are skewed, with ecosystem-based offset activities significantly under-represented. This lack of representation can be considered a market failure, as the development and commercialization of ecosystem-based carbon offset initiatives offer considerable benefits in terms of climate change mitigation and adaptation. These benefits include the sequestration of carbon dioxide in biomass and soils, the provision of habitat, production of food, regulation of local climate and disease vectors, nutrient cycling and pollination (Donato et al., 2011; Mooney et al., 2009; Power, 2010; Sanchirico and Mumby, 2009)

This paper applies a systems approach in order to evaluate the potential for the development of ecosystem-based carbon offset projects. A systems view allows for the application of a range of analytical tools while considering the carbon offset market from a value chain perspective. Following this Introduction, the paper is developed in five principal sections. In Section 2 we introduce the value chain perspective and outline the methods used in this study, which include an array of systems approaches. In Section 3, we present an analysis of global carbon offset markets using data on 8075 offset projects from the Clean Development Mechanism (CDM), Joint Implementation mechanism (JI) and major voluntary carbon offset schemes. We apply a dynamic stock and flow model to project outputs of the offset value chain to 2050, demonstrating the probable outcomes of these emerging 'business as usual' trends in global carbon markets to date. The analysis provides a comprehensive overview of market characteristics and trends, and highlights the limited role of ecosystem-based carbon offset activities, which can be considered a market anomaly. In Section 4, the paper reviews the range of factors commonly identified as constraining ecosystem-based offset project development. These constraints include issues relating to finance, technical capacity, regulatory provisions, physical issues and governance. We consider the traditional explanations for the paucity of ecosystem-based offset activities in the market. The assessment reveals that standard interpretations of the carbon offset supply chain do not adequately explain the anomalous participation of ecosystem-based offset activities in carbon markets, and suggests additional and alternative drivers. In Section 5, the paper argues that these commonly cited factors are indicative of a neoclassical interpretation of carbon economics, and that the limited participation of ecosystem-based offset activities in carbon markets is better understood through the theoretical lens of a revisionist or evolutionary economic perspective. This approach recognizes the influence of transaction costs, institutional dynamics, social-historical factors and path dependencies, and suggests an agenda for research and policy reform that is grounded in this evolutionary theoretical perspective. Section 6 summarizes our findings and outlines a research agenda that will facilitate improved implementation of ecosystem-based offset projects.

2. Methods: The value chain perspective

In simplified terms, offset project methodologies can be described as achieving reductions through reduction, avoidance, destruction or sequestration of emissions (Thomas et al., 2010). The Clean Development Mechanism (CDM), which is considered the benchmark standard for carbon offsetting, recognizes almost 200 methodologies across 15 sectoral scopes (UNFCCC 2011). These sectoral scopes include renewable energy generation, energy distribution, waste management, chemical industries, forestry and agriculture, amongst others.

Reducing emissions against a ‘business as usual’ scenario depends on methodologies that represent improvements or efficiency in existing methods rather than innovation; these can include decomposition and burial of captured emissions of industrial gases, energy efficiency, landfill gas capture, recovery of fugitive emissions, fuel switching, cement production and CO_2 capture. Methodologies that avoid emissions involve alternative development pathways including renewable energy provision from sources such as wind, solar and geothermal power, as well as transport and energy distribution systems. Industrial gases and by-products, particularly hydrofluorocarbons (HFCs), have significant global warming potential (relative to natural greenhouse gases); these products can generate offsets by being destroyed through combustion and burial in landfill. A few methodological approaches directly sequester carbon in soils or in vegetation by accreting new biomass. Very few offset activities involve sequestration in aquatic environments; vegetated coastal and aquatic ecosystems may have been excluded from calculations of the total global carbon ‘budget’, which is an unfortunate omission as these environments represent substantial carbon stocks and sequestration potential (McLeod et al., 2011).

The development and production of carbon offsets can be understood as a value chain that extends from 'producers' to 'consumers' (or end users). Figure 1 describes this value chain in five phases: Design, Registration, Production, Market and End Use. Within each phase there are several distinct steps. The diagram also shows (in grey outlines) the boundaries of governance frameworks. The steps within these outlines are governed by particular regulatory structures. The largest area, crossing the Design, Registration and Production phases, represents the rules and mechanisms established by the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to the Convention. The smaller boundary within this identifies activities that are governed by the domestic regulation and systems of host countries for offset projects. These countries are in most cases developing nations, or non-Annex 1 countries (using the terminology of the UNFCCC). The final boundary area represents the regulatory pale of countries with domestic legislation requiring emission reductions from corporate polluters. These countries (or in some cases states or provinces) have committed to reducing their carbon emissions and have implemented domestic legislation that requires corporate entities and facilities to achieve specified emission reductions, which can be met (in part) with the use of offsets from the international market.

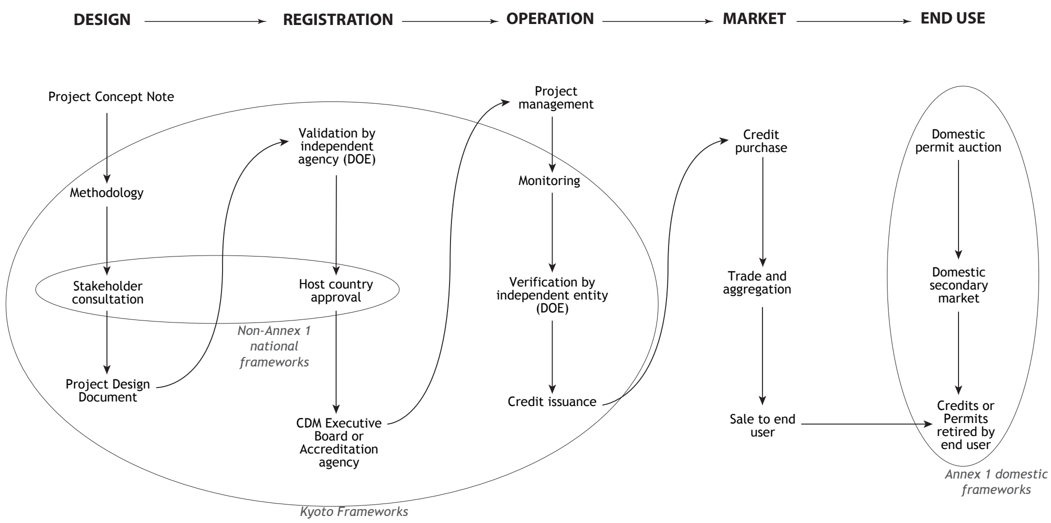

Figure 1: A schematic representation of the carbon offset value chain

The European Union Emissions Trading Scheme (EU ETS) is the largest regulated carbon market, and considered to be succeeding, in that the EU-27 is on track to achieve its joint (and individual) Kyoto commitments (Graichen et al., 2010). While compliance is being achieved in part through actual reductions in emissions (derived in the main from energy efficiency and technical improvements), the substantial majority of reductions are in fact offsets purchased through the CDM. In 2009, 10 CDM projects accounted for 66% of offset credits surrendered in the EU ETS, and more than 84% of credits surrendered in that year were HFC and N_2O destruction projects derived from a few chemical factories in China and India (Elsworth and Worthington, 2010).

The analysis presented here is based on data from the CDM, JI and major voluntary carbon offset schemes. These voluntary schemes include: Brasil Mata Viva; Carbon

Fix; the Chicago Climate Exchange (CCX); the Climate, Community and Biodiversity Standards (CCBS); the Gold Standard; ISO 14064-2; Plan Vivo; Social Carbon; and the Verified Carbon Standard, previously the Voluntary Carbon Standard (VCS). Data were sourced from various online registries between December 2010 and March 2011. CDM and JI data were obtained from the UNEP Risoe CDM/JI Pipeline Analysis and Database (UNEP 2011). Data for Brasil Mata Viva, Carbon Fix, ISO 14064-2, Plan Vivo, Social Carbon and the VCS were sourced from the Market Environmental Registry (Public View) (Markit, 2010). Chicago Climate Exchange (CCX) data were extracted from the CCX Registry (CCX, 2010), and Gold Standard data from the Gold Standard Registry (2010). The data were compiled into a single database using Microsoft Excel 2008. The voluntary scheme data, having been sourced from several different registries, were substantially different in layout and level of detail. As a result, individual Project Design Documents (PDDs) for each voluntary project were examined, with details (including credit start dates, methodologies, project types, credit buyers and developers) extracted and inserted into the database.

The database contains up-to-date information (as of 1 March 2011) about each of 8075 projects currently “in the pipeline”. This includes registered, retired and withdrawn projects as well as those awaiting validation or approval. Where available, data regarding emission reduction volumes and financial investments to date have been included. The database therefore allows for extensive, detailed analyses of the current carbon market.

3. Results: State, trends and future of the global carbon offset market

The full range of offset project methodologies was consolidated into 14 categories, as shown in Table 1. For the purposes of this analysis, ecosystem-based project types were defined as including 5 project scopes: afforestation and reforestation (A/R), agriculture, biogas, biomass and avoided deforestation (REDD).

Table 1: Project types (Ecosystem-based project categories in italics)

Category	Components
A/R	*Afforestation and Reforestation*
Agriculture	*Agriculture*
Biogas	*Biogas*
Biomass	*Biomass energy; Biomass or liquid biofuel*
Energy efficiency	Energy efficiency (households; industry; own generation; service; supply side)
Energy distribution	Energy distribution
Fuel switching	Fuel switching
Fugitive emissions	Fugitive emissions from fuels; HFCs; SF_6; N_2O
Manufacturing	Manufacturing industries; Cement
Mining	Mining/ Mineral production; coal mine methane
REDD	*Reducing Emissions from Deforestation and forest Degradation (REDD)*
Renewable energy	Renewable energy (hydro; solar; wind; geothermal)
Transport	Transport
Waste handling & disposal	Waste handling & disposal; landfill gas; methane

Biogas projects mostly involve the capture and use of methane from wastewater treatment or animal effluent. Biomass projects generally provide electricity, replacing fossil-derived power from the national grid. Biomass projects can therefore be considered as renewable energy, but are here included with other ecosystem-based activities as the use of plant material as fuel stock is a qualitatively different energy source than wind, water or sunshine.

To highlight the participation of different project types in the market, we have consolidated different scopes into 6 ‘colours’: brown representing industrial efficiency projects (energy efficiency and distribution, fuel switching, fugitive emissions, manufacturing, mining, transport and waste management); yellow representing renewable energy provision (wind, hydro, solar, geothermal); and the ecosystem- or natural-resource-based project types distinguished as purple (biomass and biogas), orange (agriculture), green (afforestation and reforestation, and REDD), and blue (for ecosystem-based activities conducted in marine and coastal environments). The representation of different project types (colours) is shown in Figure 2.

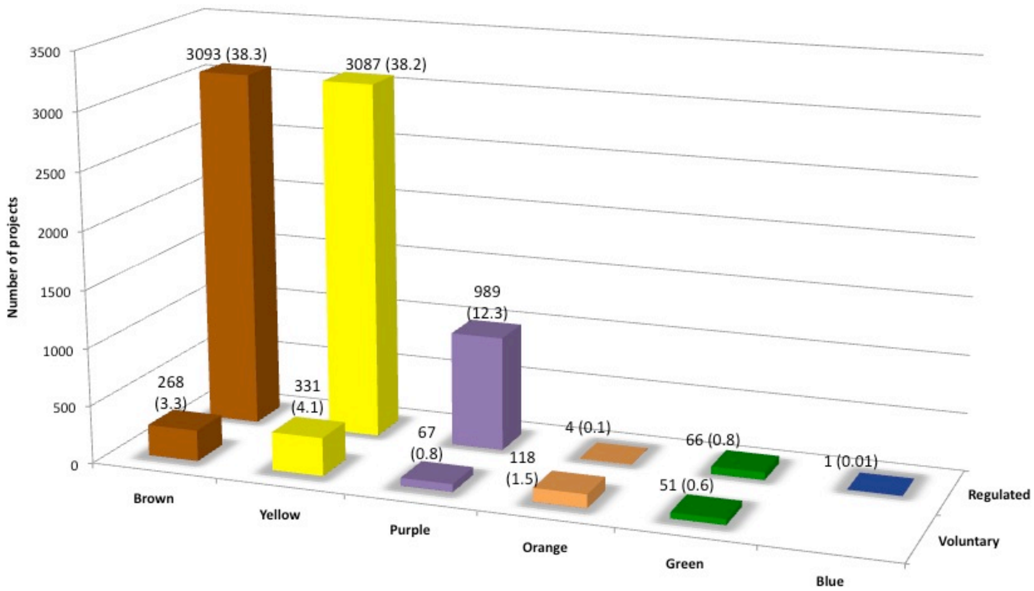

Figure 2: Number of projects by project type in regulated and voluntary markets

There were a total of 8075 projects on record as of 1 March 2011. This figure includes projects in both the regulated and voluntary markets, in various stages of registration or approval. Of these, more than 89% were CDM/JI (regulated) projects. Voluntary market projects represent less than 11% of the total. There were 1060 ecosystem-based projects in the regulated markets, making up 14.65% of the total number of regulated projects. In the voluntary market, 236 projects (28.26% of all voluntary projects) were ecosystem-based, of which half were agriculture projects. These proportions are shown in Figure 3.

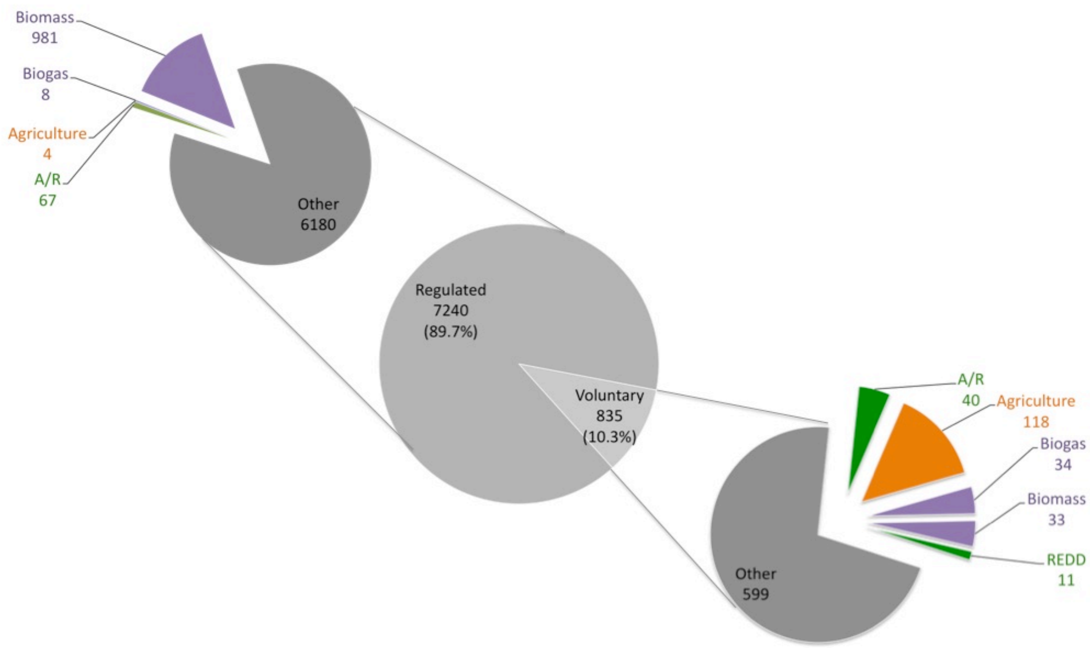

Figure 3: Proportion of projects by type in regulated and voluntary markets

These figures are anomalous considering that 30% of project methodologies (meaning rules of project implementation) relate to ecosystem-based project activities, but only 16% of projects do so. A/R methodologies comprise 7.4% of the total, whereas only 1.3% of projects were A/R projects. Similarly, while agriculture methodologies comprised 5.4% of total methodologies, only 1.5% of projects were agricultural. In contrast, 70% of the total methodologies were applied to 84% of total projects, all of which were not ecosystem-based.

The lack of representation of ecosystem-based projects is not uniform. Within this subset of all projects, it is also the case that some activities are much more common than others. In particular, there is a preponderance of biomass projects, the number of which began increasing gradually after 2000, and saw a steep rise in 2007 (Figure 4). The number of agricultural projects steadily increased from 2002 to 2005 before hitting a plateau.

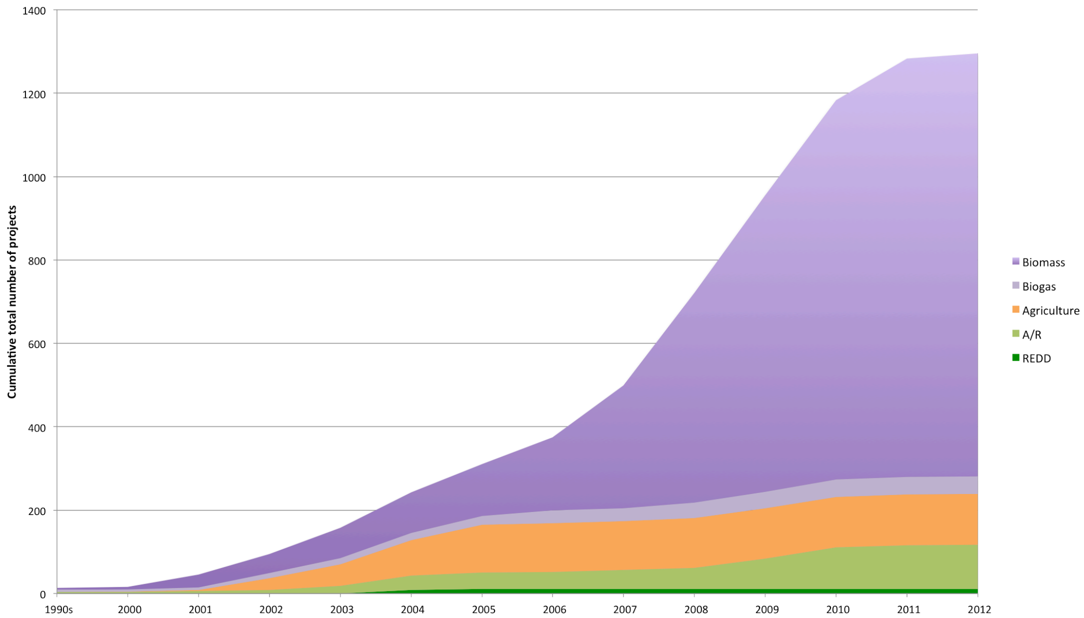

Figure 4: Cumulative total number of natural resource-based projects over time

Of the 1060 ecosystem-based projects in the regulated markets, 341 are registered, and 248 have been rejected, with the remaining 481 in various other stages of the pipeline. In other words, 32.2% of regulated ecosystem-based projects are registered, and 23.4% have been rejected. In comparison, 37.5% of non-ecosystem-based projects are registered, while 15% have been rejected.

In the regulated markets, the biomass sector has the largest proportion of registered projects compared to the other ecosystem-based project types. There are no registered agricultural projects, where 75% are at validation and 25% have been rejected. There are no REDD (avoided deforestation) projects in the regulated market. In the voluntary markets, 206 of the 236 ecosystem-based projects are registered (87.29%), 1 project is retired and none of the projects have been rejected. The remaining 29 projects have either been validated or had credits issued. Of the Brown and Yellow projects, 70.3% are registered, 24.4% have been issued and the remainder has either been validated or retired. Of the voluntary ecosystem-based projects, 100% of A/R, agricultural and REDD projects are registered. More than half of biogas and biomass projects are also registered, with a large percentage of the remaining projects having been issued.

Of the 8075 projects in the database, 107 are A/R projects, 122 agricultural, 42 biogas, 1014 biomass and 11 REDD bringing the number of ecosystem-based projects to a total of 1296. More than 80% of these are implemented in 10 out of a total of 116 countries (Table 2).

Table 2: Distribution of ecosystem-based offset projects by country

			Regulated				Voluntary			
	Total no. of natural resource-based projects	% of total natural resource-based projects (1296)	A/R	Agriculture	Biogas	Biomass	A/R	Agriculture	Biogas	Biomass
India	472	36.42	10	2	0	438	0	0	10	12
Brazil	162	12.50	2	0	0	145	2	0	0	2
United States	143	11.03	0	0	0	0	24	113	2	4
China	132	10.19	6	2	0	111	0	1	9	3
Malaysia	48	3.70	0	0	0	48	0	0	0	0

Thailand	34	2.62	0	0	0	25	0	0	6	3
Indonesia	27	2.08	1	0	0	25	0	0	1	0
Chile	18	1.39	3	0	0	14	1	0	0	0
Russian Federation	17	1.31	0	0	1	15	0	0	0	1
Philippines	15	1.16	2	0	0	13	0	0	0	0
TOTAL	1057	82.41	24	4	1	834	27	114	28	25

We used pipeline data to generate a conservative determination of the likelihood that projects would succeed (meaning be registered), be revised (have revisions requested), or fail (be rejected). Based on the proportion of all projects that have requested registration under the CDM, probabilities of success, failure, or requests for revision were applied to an analysis of all projects in the database that have passed the validation stage under the CDM or voluntary mechanisms. Probabilities were based on CDM projects only, due to lack of data on voluntary projects prior to registration. The probabilities are therefore conservative, as CDM projects involve more stringent regulations and substantial transaction costs. The analysis was carried out using a stock and flow model built with STELLA™ (version 9.1.4). The proportions of successful and failed projects by scope are shown in Table 3.

Table 3: Percentages (%) of project types that have been registered, had revisions requested, or been rejected (failed)

	Brown	Yellow	Purple	Orange	Green	Blue
Registered	87.24	90.59	86.47	0	91.30	0
Revise	3.82	4.10	3.51	0	8.70	0
Failed	8.94	5.31	10.02	0	0	0

A stock and flow model depicts the manner in which changes take place by identifying stocks, accumulations that change over time, and flows, which are responsible for the changes by filling and draining accumulations. In addition to stocks and flow pipes, a stock and flow diagram typically has converters, which define inputs to the model and convert an input to an output, and connectors, which connect model elements. The stock and flow model was therefore populated with the probabilities of successful registration for projects in each scope between the years 2000 and 2010. The model was then run forward to 2050. To demonstrate how the model works, the stock and flow diagram for Brown projects is used as an example (Figure 5).

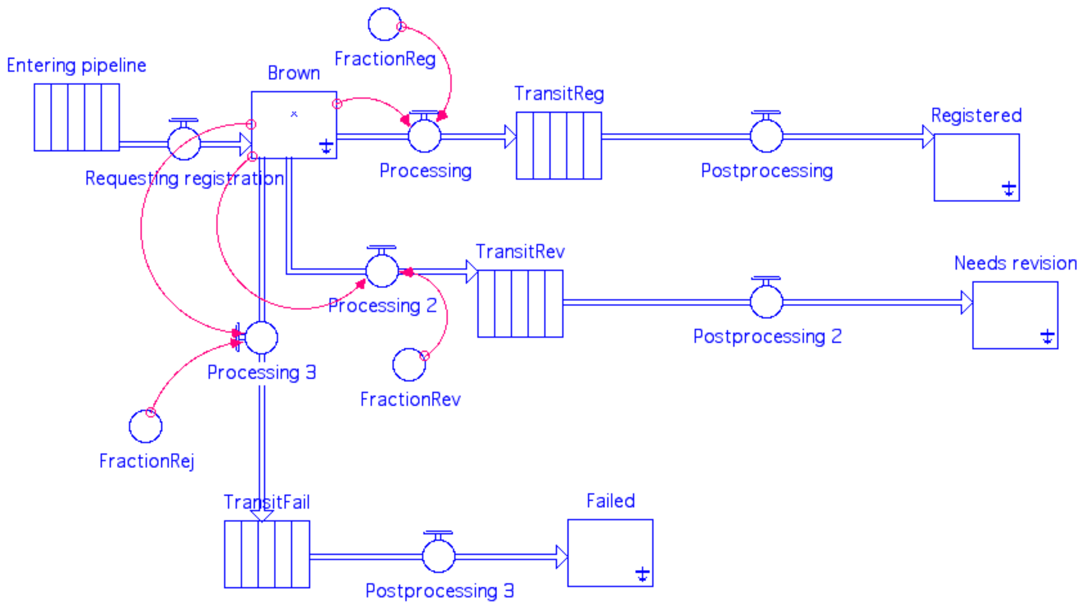

Figure 5: Business as usual stock and flow model for 'Brown' projects. The stocks of 'FractionReg', 'FractionRev' and 'FractionRej' have input values corresponding to the proportion of registration, revision requests and failure of Brown projects (Table X). Similarly, input values for 'TransitReg', 'TransitRev' and 'TransitFail' stocks are transition times from Table Y.)

As Brown projects enter the pipeline ('Entrance'), they begin by requesting registration, flowing into a reservoir of Brown projects. The projects in this stock undergo processing and a proportion of these projects get rejected, as defined by the converter 'FractionRej' with an input value calculated from the analysis of CDM pipeline data (Table 3). Similarly, another proportion of the projects obtain revision requests (defined by 'FractionRev'), while the rest become registered projects (defined by 'FractionReg'). Next, each group of projects flows into a conveyor with different transition times. After a specific processing time has passed, these projects then flow into the final stage, where they become either registered, rejected, or have revisions requested.

Project numbers for each project scope type between 2000 and 2010 were used to calculate future values, using the equation $a + bx$, where:

$$a = \bar{y} - b\bar{x}$$

and:

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2}$$

and where x is the sample mean of known x values (years 2000 to 2010) and y is the sample mean of known y values (project numbers for years 2000 to 2010).

The data for this analysis being current up to March 2011, project numbers for 2011 and onward were forecast. The projected numbers for the years 2020 and 2050 were then run in the model for run-times of 365 days to obtain a snapshot of the state of the market in the future, under current transition times and rates of registration or rejection (Table 4).

Table 4: 2020 and 2050 projected project numbers under a BAU scenario. Data for 2010 are actual values.

	Year	**Registered**	**Requesting review**	**Failed**	**Total**
Brown	**2010**	121	41	7	169
	2020	513	22	53	588
	2050	1269	56	130	1455
Yellow	**2010**	416	60	4	480
	2020	802	36	47	885
	2050	2087	95	122	2304
Purple	**2010**	39	13	0	52
	2020	147	6	17	170
	2050	355	14	41	410
Green	**2010**	6	2	0	8
	2020	11	1	0	12
	2050	22	2	0	24

4. Review of constraints on ecosystem-based offset projects

The limitations and failures of offsetting have been extensively critiqued (Alexeew et al., 2010; Boyd et al., 2009; Wara, 2007), and the imbalances in the global market have been well documented (Hamilton et al., 2010; Newell, 2009; Thomas et al., 2011). This study provides a new perspective on these imbalances, interpreting the array of limiting factors through the lenses of institutional and evolutionary economics.

Existing commitments to 2020 are judged insufficient to ensure an emissions reduction trajectory that would be consistent with a “likely” chance of limiting global warming to 2° Centigrade (den Elzen, 2010; IPCC, 2007). The nature of financial benefit-cost analysis has resulted in domination of the carbon markets by energy efficiency and industrial waste destruction projects. The carbon market architecture is encouraging investment in renewable energy technologies, but is doing little to direct capital toward carbon-oriented environmental management and ecosystem-based project activities (Helm, 2008; Kossoy and Ambrosi, 2010).

Ecosystem-based project activities and enterprises can be constrained in terms of physical issues, capacity, finance, governance and regulation. The predominant constraints, barriers and enabling factors comprising these broader concerns are identified in Table 5. All of these issues are connected; social-ecological systems are complex matrices of relationships and processes (Andersson et al., 2011; Chapin et al., 2010). For the sake of clarity and utility, these issues are discussed separately in further detail below. The following text has been adapted from Thomas (2011).

Table 5: Constraints, barriers and enabling factors in marine and coastal ecosystem-based enterprise

Physical issues	Access, logistics
Capacity	Knowledge, networks, infrastructure
Finance	Capital, transaction costs, delayed returns
Governance	Legitimacy, effectiveness
Regulation	Tenure, additionality, permanence, monitoring and verification

4.1 Physical issues

As discussed previously, most offsets are generated as reductions against a projected business as usual scenario. Carbon offsets are not physical commodities, but conceptual ones. Ecosystem-based offsets, however, are developed in physical contexts, including forests, farms and other natural environments. This characteristic implies two principal potential constraints: access, and logistics. Access relates to the ability of project developers, managers and validators to be physically present in project sites. In areas of primary or secondary forest, road infrastructure may be limited, thus constraining opportunities to conduct carbon stock assessments. Ecosystem-based projects may be implemented at some distance from population centres, or over large areas, necessitating particular, and difficult, transport arrangements. A related issue is that of logistics, which involves the equipment, materials and infrastructure that is required to conduct project management operations.

To illustrate, we can consider the case of marine and coastal ecosystem management – or 'blue carbon' offsets – which presents particular challenges. The nature of these environments can pose difficulties in terms of both access and logistics, yet marine habitat mapping is a crucial component of ecosystem-based project management (Cogan et al. 2009). Coral reefs, seagrass meadows and mangrove forests are all difficult to access by virtue of their physical environmental characteristics. While remote sensing technologies are developing rapidly, it remains the case that understanding marine environments requires direct scientific presence. In coastal habitats, it may often be the case that physical infrastructure (such as roads) is unavailable. The logistical requirements of working in these areas are also unusual. Rehabilitating or monitoring underwater ecosystems requires specific skills and equipment, including boats, and SCUBA and other technical gear (Eyre and Maher, 2011; Neckles et al., 2011).

4.2 Capacity

The capacity of individuals and organizations to develop and implement carbon offset projects can be constrained by knowledge (or more accurately, knowledge deficiency) in a range of ways: lack of awareness of policy instruments, technologies and market opportunities (Qi et al., 2008; Rosendal and Andresen, 2011; van der Gaast, 2009); lack of data or the inability to collate necessary information (Pelletier et al., 2010; Ramachandran Nair et al., 2009); and inadequate levels of technical or operational skills (Thomas and Dargusch, 2010).

Networks (or partnerships, or linkages) allow for flows of information and knowledge, materials and services, and provide a range of facilitative opportunities for project developers and managers (Suneetha et al., 2011). Networks are an integral component of social capital, which contributes to resilience to climate impacts and the adaptive capacity of communities (Smit and Wandel, 2006; Tol et al., 2008). Networks can operate between individuals, professional associations, regional groups, communities, governments, businesses, environmental groups, and other types of collectives. Networks have the potential to not only open new opportunities based on synergies between the goals of different organisations (O'Connor, 2008), but also to facilitate advances in other areas discussed here, particularly infrastructure, transaction costs, legitimacy and effectiveness.

A third aspect of capacity relates not to social capacity but the capability of physical and technological infrastructure to facilitate the positive outcomes of offset projects. For the 57% of rural households in India that lack connection to grid electricity, for example, there is little likelihood that biomass-based renewable energy projects will make any difference unless funds are first provided to support the development of connectivity (Sirohi, 2007). Similarly, the ability of farmers in developing tropical countries to implement conservation agriculture practices including controlled traffic farming may require particular types of machinery (Rochecouste and Dargusch, 2011). Rehabilitation of coral reefs using artificial substrates, for example, might require access to particular materials, vehicles, and technologies (Spieler et al., 2001).

4.3 Finance

Project development cannot occur without finance; funding is necessary for any novel economic activity. In the case of public forestry and land use policy, governments are unlikely to consider alternative activities unless these offer a revenue stream at least comparable to returns from current practices (Osborne and Kiker, 2005). Investment in commercially oriented carbon offset projects will not occur unless there is a likelihood of positive financial return (Hultman et al., 2010). While approaches to economic valuation and benefit-cost analysis are evolving, it remains the case that financial considerations remain significant in ecosystem-based project activities, including conservation programs. Examples of these considerations are the availability and provision of investment capital, transaction costs incurred in project development, implementation and management, and the disincentive of delayed returns.

Capital is necessary for investment in most new project activities. In the case of ecosystem-based projects, it is usually the case that investment is required to cover the costs of new technology (such as biogas digesters, or SCUBA equipment to be used in underwater work), materials (including seedlings), vehicles and machinery, infrastructure (grid connections, field preparation) or training (Boyd et al., 2007; Gilau et al., 2007; Gong et al., 2010).

Transaction costs are an inevitable component of any economic activity, and are one of the principal constraints in the development of carbon offset projects (Chadwick, 2006; Thomas et al., 2010). In terms of ecosystem-based offset project development, transaction costs can be defined as those expenses that can not be attributed to the physical process of providing the environmental service or goods, nor the level of demand for those ecosystem products. For example, if a mangrove reforestation carbon offset project were undertaken without the expense (the transaction cost), it would not result in additional greenhouse gas emissions, but would also not qualify for the issuance of offset credits (Chadwick, 2006). Project transaction costs are therefore those associated with project development (gathering baseline data, employing technical expertise), independent validation of project design details, annual verification and administrative costs (e.g. Gong et al., 2010).

Delayed returns are a characteristic of ecosystem-based projects. While it is relatively simple to identify emission reductions through the avoidance of emissions (as in the case of building a wind farm as an alternative to a coal-fired power station), actual sequestration of greenhouse gases through forestry takes time, and the issuance of carbon credits in these cases will be delayed until the trees (for instance) have grown. Similarly, enterprises based on habitat restoration or biodiversity protection take time to achieve their goals. In addition, where ecosystem-based offset projects require substantial initial investment with the expectation of future return, but no guarantee (as forests and reefs for instance are vulnerable to weather impacts and natural disasters), small-scale project operators are unlikely to participate (Gong et al., 2010).

4.4 Governance

Governance systems are critical in terms of both project development potential and host-country investment attractiveness, and are likely to influence offset project effectiveness at all levels. Ecosystem governance can be understood in terms of its legitimacy and effectiveness (e.g. Lederer, 2011).

Legitimacy is the notion that regulations should be obeyed because of their merits and innate virtue rather than because of coercion or self-interest (Hurd, 1999). While regulated carbon offset projects can be considered to have a steadily increasing degree of procedural legitimacy (Lederer, 2011), the sustainability outcomes of these activities are less clear. Voluntary project mechanisms, by virtue of their social and environmental agendas, are likely to be considered more legitimate offset instruments than their market-oriented counterparts. Legitimacy, however, must be considered not only in terms of horizontal comparisons but also in its vertical integration and impacts, meaning the extent to which policies and actions are proposed, developed and accepted by stakeholders at different levels, from national government to regional agencies to local communities and individuals. Legitimacy will be an absolutely critical consideration in the development of REDD+ programs in tropical forest countries, as these different stakeholders will need to not only accept policy approaches but also collaborate effectively in their implementation to achieve successful REDD+ outcomes.

One aspect of legitimacy that must be considered in the implementation of ecosystem-based project activities, particularly in the case of public instruments such as REDD+, is the fact that stakeholders who provide or control funding streams are likely to be those responsible for establishing operational processes and accountability criteria (Rosendal and Andresen, 2011). Thus, it may often be the case that mechanisms will be designed to suit the priorities of investors rather than operators, local communities or the environment. Arguably, the ideal approach (ideal meaning the most effective, equitable and efficient) to project design and implementation involves ecosystem-based management in the context of a social-ecological systems perspective.

Legitimacy also operates vertically. Multi-level, multi-actor governance is critical to achieving successful outcomes in circumstances where the range of stakeholders includes multiple government agencies at local, regional and national scales, communities and commercial organisations, as well as NGOs, indigenous peoples and illegal or unrecognized actors. In the case of projects involving coral reefs and associated ecosystems, these concerns are critical (Villanoy et al., 2012). In economic activities involving multiple parties and business between international partners, governance systems serve to shape the investment landscape, and are therefore vital to producing effective outcomes (Jung, 2006; Thomas et al., 2011).

The effectiveness of projects can be gauged not only by the achievement of stated goals, but also by the success of technology transfer and capacity building, and the replacement of unsustainable industrial and land use practices with socially and environmentally positive alternatives. A critical consideration in the development of REDD+ activities, for instance, is finding ways to decrease the demand for the forest products that drives deforestation (Skutsch and McCall, 2010). It is not simply a question of providing alternative income streams for loggers in tropical forest countries; as long as there is demand, substitutes will need to be found for the goods and services that logging and forest degradation provide. Similarly, in the context of fisheries, the use of poison and explosives to secure food is difficult to prevent without the provision of alternative sources of sustenance.

4.5 Regulation

Land tenure is a crucial consideration in ecosystem-based carbon offset activities, and can be understood as the statutory or customary right of an individual or group to hold and use an area of land and its associated resources, for a period of time and under particular conditions (e.g. Sunderlin et al., 2009). Tenure is an issue that exemplifies the complex nature of the subjects explored in this special issue. For instance, most forests in tropical countries, including coastal mangrove areas, are inhabited and exploited by local communities, for fuel and building materials, food sources, medicines, and other economic and cultural activities. Similarly, many coastal communities have traditional relationships with their local marine territories. While some national governments might consider moving inhabitants from their customary land as a simple means of ensuring forest integrity and avoiding deforestation, research suggests that community-based forest management is in fact more likely to preserve and enhance carbon stocks and biodiversity than direct forest protection, because the latter tends to foster illegal activities and unmonitored degradation (Porter-Bolland et al., 2011).

The concept of additionality is fundamental to the development of offset projects, but has been criticized as inherently paradoxical, and often likely to encourage perverse outcomes (Bode and Michaelowa, 2003). The principal meaning of additionality is that changes (against a ‘business as usual’ baseline scenario) resulting from the project activity would not have occurred in the absence of the project (e.g. UNFCCC, 2011). Additionality is also used to mean that projects could not occur without revenue or finance derived from the sale of offset credits. Yet these stipulations can be considered disincentives to countries to implement regulatory reform requiring improved environmental practices (Bode and Michaelowa, 2003).

In addition to the potentially perverse nature of the concept, the independent assessment of additionality (as required under the CDM, VCS and other voluntary carbon schemes, for example) is highly subjective. Many project applications cite additionality criteria that lack credibility or rigour; at the same time the agencies evaluating project design documents frequently fail to provide clear statements explaining how barriers (including the requirement of additionality) were assessed as valid or realistic (Schneider, 2009). Analysis of project design documents and validation reports suggests that more ambitious benchmarks and rigorous standards are necessary to address these issues (Bushnell, 2010; Olsen, 2007; Sutter and Parreño, 2007).

Permanence is a critical issue in ecosystem and natural resource management activities. Permanence can be understood as the longevity of a project outcome. Carbon sequestered in natural systems including forests is considered to be at risk (from fire, logging or other hazards) and is treated as non-permanent in the global carbon market. This is considered to be a disincentive for investment in ecosystem-based project activities (IETA, 2009; Thomas et al., 2010). Similar risks apply to coral reefs and other marine habitats, in that weather events and projected changes to ocean chemistry threaten the long-term viability of coral ecosystems, making ‘farming’ of coral reefs a high-risk proposition (Hoegh-Guldberg et al., 2007).

Finally, monitoring and verification are critical issues in the implementation of offset project activities. Also known as MRV (monitoring, reporting and verification), these components of project operations are intended to provide accountability, thereby contributing to project legitimacy and effectiveness. Monitoring and verification will be key aspects of ecosystem-based carbon offset projects, to ensure the integrity of issued carbon credits.

4.6 A systems view of constraints on ecosystem-based offset projects

This range of factors can be described in terms of influence, as shown in Figure 6, which is a causal loop diagram (or influence diagram). The diagram was constructed by the authors through an iterative workshop process, beginning with a structure derived from the preceding literature review, and developed in consultation with a range of academic and industry experts over several months. The arrows in the figure indicate the flow of influence from one variable to another, with ‘S’ and ‘O’ meaning that dynamic change in the variables will occur in the same or opposite direction, respectively. For example, the influence of the degree of physical constraints on the potential to demonstrate ecosystem-based offset projects is opposite. As the degree of physical constraints increases, the potential to develop projects decreases. Conversely, the same potential increases as enabling regulatory conditions also increase.

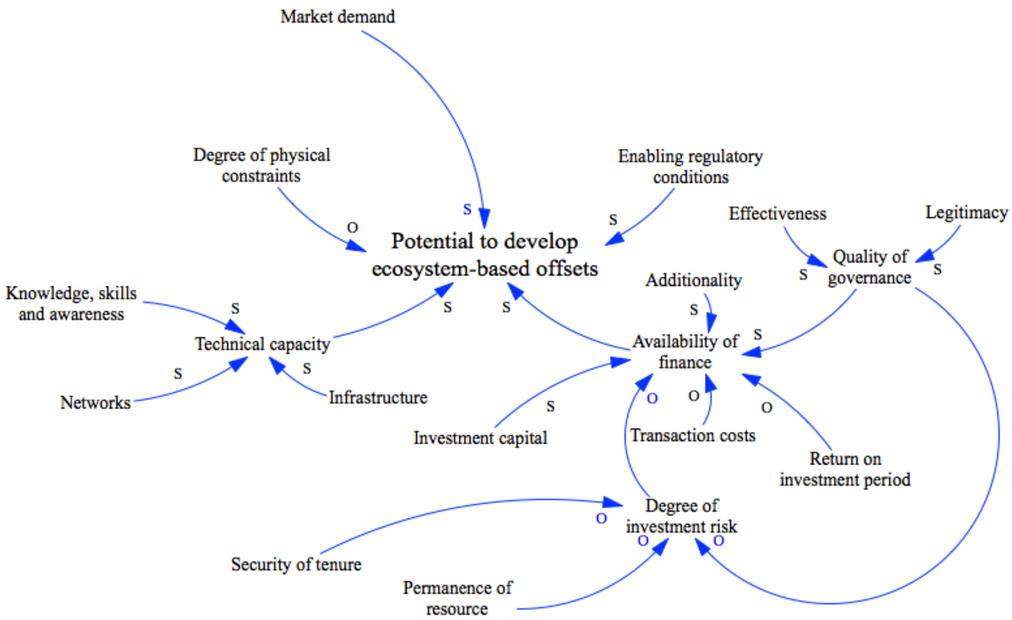

Figure 6: Constraints and enabling factors affecting the potential for the development of ecosystem-based offset projects

Within the context of the value network introduced earlier, the relationships and influences depicted in Figure 6 suggest novel interpretations of the restricted participation of ecosystem-based offset activities in the global carbon markets, as we discuss in the next section.

5. Discussion

The detailed analysis of the global offset markets presented above provides a clear picture of the prominent features of the carbon landscape, or ‘c-scape’. Some of the findings are to be expected; there are also, however, a few surprises. These results help identify priority areas for research and policy reform.

Renewable energy projects made up the largest percentage of carbon offset projects globally, while avoided deforestation projects made up the smallest. This is a well-recognized feature of the carbon market, and indeed one of the principal goals of the climate policy architecture is to facilitate the uptake of renewable energy activities as alternatives to greenhouse-intensive fossil fuel-based power generation. The importance of ecosystems as both drivers and casualties of climate change, and their importance to human communities is, however, both recognized and often underestimated. (Cannon and Müller-Mahn, 2010; Duarte et al., 2008; McAlpine et al., 2010). It is clear that ecosystem-based project activities are significantly under-represented in global carbon markets.

Ecosystem-based projects represent less than 15% of the regulated markets, whereas in voluntary schemes this figure nearly doubles to 28%. This is partly explained by the fact that this analysis includes avoided deforestation projects as voluntary projects, since REDD activities do not form part of the regulated (CDM) sector. (It is important to note that REDD+ activities are moving closer to implementation, and this could be considered in the future as part of the regulated market, although at this time (as discussed previously in this paper) REDD+ projects are not market-based.) Yet while 30% of all offset methodologies were ecosystem-based, only 16% of projects were ecosystem-based. This indicates that while a wide range of approaches to ecosystem-based offsetting have been developed, the implementation of projects using these methodologies is constrained or less attractive than other options.

The greater representation of ecosystem-based projects in voluntary schemes demonstrates that while these projects may be less financially competitive than other offset activities, they are more likely to result in broader social and environmental benefits, and are therefore supported by community-based and non-government organizations. The commoditisation of carbon offsets within traditional market frameworks does not naturally encourage investment in project activities with benefits beyond financial returns. The fact that 15% of CDM projects are ecosystem-based but generate only 7.6% of credits suggests that research is needed to establish how to make these project types more cost-effective. One option would be to include the valuation of ecosystem services in carbon offset project methodologies.

In the regulated market, 32.2% of ecosystem-based projects are registered, 23.4% rejected. This figure contrasts with the 37.5% of non-ecosystem-based projects registered and 15% rejected. Rejection rates of ecosystem-based projects are higher than for other project types. In regulated schemes, the largest percentage of registered projects is biomass-based power generation activities, and there are no registered agricultural projects. In voluntary markets there have been no projects rejected, perhaps as a result of the project development process in voluntary schemes, and not because of lax standards.

Early explanations of the limited participation of ecosystem-based projects in carbon markets focused largely on issues of supply and demand (Jotzo and Michaelowa, 2002; Olschewski et al., 2005). While there has been some consideration of specific policy features that influenced market outcomes, it was generally the case that the success or failure of ecosystem-based offsets were understood as being related to their availability and costs (supply side considerations) or their utility and price (demand side considerations) (Convery et al., 2008; Isenberg, 2010; Sheeran, 2006; Wara, 2007). There has been extensive consideration of the issues affecting end users in the carbon market value chain, including cost reduction, regulatory compliance, risk minimization, influence, and reputation (Hoffmann, 2005). This focus has continued through to the present, with some studies noting changes in the drivers of investment decision making, but remaining preoccupied with the importance of end user preferences (Hultman et al., 2010; Kim, 2010)

Increasingly, there has been greater recognition that factors beyond traditional notions of business logics play important roles in the dynamics of carbon markets. There is growing consideration of the importance of several key factors. The first of these is project specific transaction costs – (Chadwick, 2006; Pfaff et al., 2007, Thomas et al., 2010). The second is institutional dynamics – the role of government subsidies to industries; the impact of civil society in driving project development; how social, political and economic relationships affect environmental impacts and outcomes (Ostrom, 2009; Thomas et al., 2011). Finally, there is growing attention being paid to the role of the 'producers' of carbon offsets, and the importance of social-ecological systems to understanding the barriers and enabling factors that affect the development of ecosystem-based carbon offset projects (Andersson et al., 2011; Corbera et al., 2009)

These perspectives – transaction costs, institutional dynamics, social-ecological systems theory – fit comfortably within an evolutionary interpretation of carbon market dynamics. This approach recognizes path dependencies as drivers of development; societies are likely to develop according to pre-existing physical and cultural infrastructures. If roads exist for vehicle transport, it is likely that a society will evolve its fuel (from diesel to biodiesel) rather than abruptly transition to electric ultralight aircraft (Kosoy and Corbera, 2010; Maréchal, 2009; Unruh and Carrillo-Hermosilla, 2006; van den Bergh, 2007). In terms of carbon markets, path dependencies are likely to result in 'lock-in' of carbon-oriented infrastructure, and there is a danger that this could extend to new markets in developing countries (Unruh, 2000; 2006).

6. Conclusion

This paper presents a snapshot of the global carbon markets as the first commitment period of the Kyoto Protocol draws to a close. The analysis presented in this paper is the first inclusive statistical review of the global 'c-scape' in that it includes offset projects from the regulated and major voluntary market schemes. The analysis highlights the limited role of ecosystem-based offset activities in the wider marketplace, and demonstrates that under current market and policy frameworks this lack of representation will continue. We argue that this anomaly is best understood not in terms of supply and demand (as has been the case in most early and traditional analyses of carbon market dynamics), but from an evolutionary perspective, recognizing not only the importance of transaction costs but also the role of institutional dynamics and the full range of social-ecological constraints.

The results presented in this paper strongly suggest that traditional interpretations of the factors affecting ecosystem-based offset project development fail to capture the full range of relevant issues. Here, we have used a value chain perspective to accommodate an array of theoretical and analytical approaches in order to arrive at an integrative understanding of this important question.

The value chain perspective taken here has identified several areas where new research is critically needed. We propose that, in order to address this important topic, three key research priorities should be investigated. These are:

1. Understanding what institutional policies and reforms can contribute to improving the participation of ecosystem-based project activities in global markets (Rosendal, 2011; Westley et al., 2011);
2. Investigating how to enable the integration of ecosystem services other than carbon storage and sequestration in offset project methodologies involving agriculture, forestry, and marine and coastal zone management (orange, green and blue projects) (Ribaudo et al., 2010); and,
3. Identifying policy tools and economic instruments that will enhance carbon value chain connectivity and integration (Komarek and Lupi, 2011; Sumaila et al., 2011).

In summary, this paper provides a comprehensive analysis of a critical market failure in an important contemporary economic arena. The paper offers useful market data and economic analysis of value to investors and policy makers, and a novel analytical approach in a rapidly developing field. Most importantly, the paper applies an original theoretical perspective that highlights flaws in previous analyses, and identifies a research and policy reform agenda that should contribute to improvements in existing development strategies and market-based climate policy instruments.

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