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Carbon Science Technical Advisory Panel

Deliverable for Sub-Activity 1.1.1.1.5
Production of carbon methodologies and approaches synthesis/toolkit necessary for the interventions

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Chapter I - Why Blue Carbon?

This Chapter introduces the concept of Blue Carbon and why it may be an important element to conservation efforts of coastal ecosystems through climate change mitigation strategies.

Why Blue Carbon?

Blue Carbon is a relatively new concept, integrating the fields of marine conservation, coastal management, and climate change. Blue Carbon is used to refer to the biological processes that result in carbon captured by marine living organisms, coastal and marine ecosystems. The term is generally applied to the carbon sequestration by vegetated coastal ecosystems, mainly mangroves, salt marshes and seagrasses (Nellemann et al. 2009). These three coastal ecosystems are the primary pilot projects, globally, focused on exploring blue carbon as an added means for conservation. Blue carbon research and related conservation projects, however, are also beginning to encompass fisheries, marine megafauna, and macroalgae (Chung et al. 2010; Duarte et al. 2013; Smale et al. 2016; Hill et al. 2015; Trevathan-Tackett et al. 2015). This report and toolkit is focused on the climate change mitigation benefits of conserving near shore coastal vegetated ecosystems.

Coastal ecosystems store and sequester carbon in significant proportions. This carbon is stored in the plants' biomass as well as below the surface in sediments. One of the main ecological factors that sets coastal wetlands apart is their high capacity for sequestration compared to terrestrial systems. The soils of healthy coastal ecosystems accrete sediments vertically, reducing the likelihood that belowground C will become saturated (Bianchi et al., 2013). Therefore, the size of the long term carbon sink increases with increasing sediment accumulation over time (Beaumont et al., 2014), suggesting that long standing vegetated coastal ecosystems may release a measurable amount of carbon as a greenhouse gas if degraded or destroyed.

Coastal ecosystems and oceans are the largest long-term carbon sink and form the largest connected system that stores and redistributes an estimated 93% of carbon dioxide (CO_2) on the planet (Nellemann et al., 2009). Five times the amount of carbon per unit area can be stored in marine compared to terrestrial ecosystems (**Figure 1**).

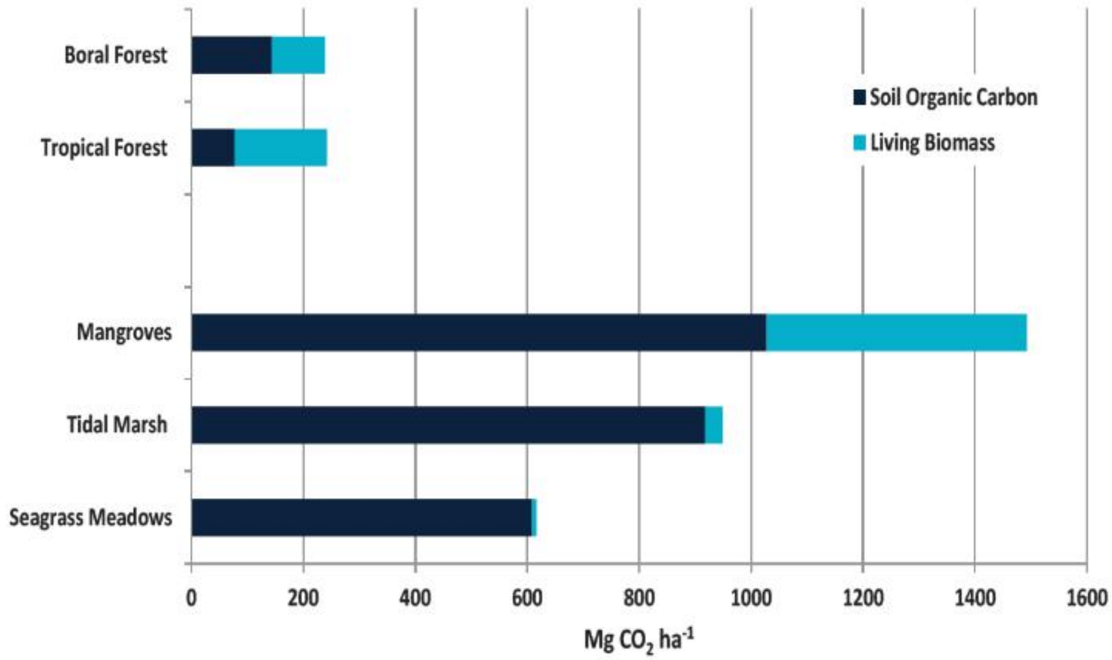

Figure 1: Comparison of the potential for sequestering carbon between coastal and terrestrial forests obtained from the Blue Carbon Initiative

Over half (55%) of the global estimated carbon sequestration is constituted by blue carbon (Nellemann et al. 2009). While individual ecological factors from the length of time that soil is water saturated, to salinity and nutrient load contribute to individual site-specific estimates of carbon dioxide, studies suggest that vegetated coastal ecosystems have a much higher carbon storage capacity per unit area (Nellemann et al., 2009; Mcleod et al., 2011; Pendleton et al., 2012). A study of global data available on carbon estimates in various terrestrial and marine ecosystems suggest that the overall carbon storage capacity varies greatly amongst all ecosystems (**Figure 2**). The long-term storage in vegetated coastal ecosystems ranges from 18 to 1713 g C m^{-2}, with yearly averages estimated to be 138 g C m^{-2} for seagrass ecosystems, 218 g C m^{-2} in salt marsh systems, and 226 g C m^{-2} in mangroves (**Table 1)**. On the other hand, the long-term storage in terrestrial forests ranges from 0.7 to 13.1 g C m^{-2} with yearly averages estimated to be 4.0 g C m^{-2} in tropical forests, 4.6 g C m^{-2}, in boreal forests, and 5.1 g C m^{-2} in temperate forests (**Table 2**) (Mcleod et al., 2011)

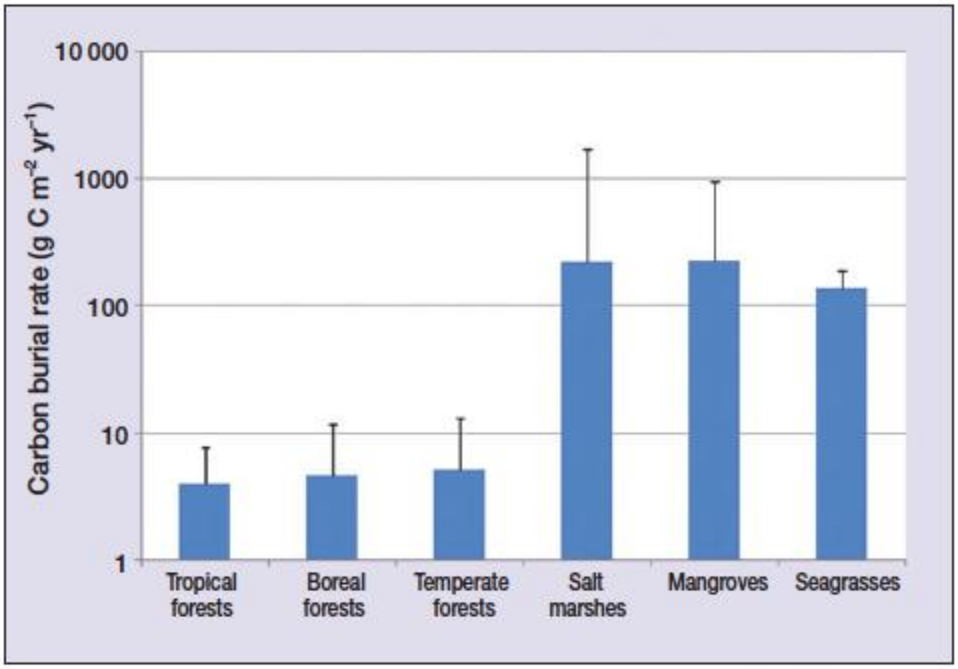

Figure 2. Average belowground carbon sequestration rates over long temporal scales (g C m^{-2} yr^{-1}) of the substrates in tropical, boreal, and temperate terrestrial forests in comparison to salt marshes, mangroves and seagrass beds. Error bars correspond to maximum rates of carbon accumulation. The y-axis scale is logarithmic. (Obtained from Mcleod et al., 2011)

Ecosystem	*Carbon burial rate* (*g C m^{-2} yr^{-1}*) *mean ± SE*	*Global area* (*km^2*)	*Global carbon burial** (*Tg C yr^{-1}*) *mean ± SE*	*Sources: Global area*	*Sources: Carbon burial*
Salt marshes	218 ± 24 (range = 18–1713) *n* = 96 sites	22 000**– 400 000	4.8 ± 0.5 87.2 ± 9.6	Chmura *et al.* (2003); Duarte *et al.* (2005a)	Chmura *et al.* (2003); Duarte *et al.* (2005a)
Mangroves	226 ± 39 (range = 20–949) *n* = 34 sites	137 760– 152 361	31.1 ± 5.4 34.4 ± 5.9	Giri *et al.* (2010); Spalding *et al.* (2010)	Chmura *et al.* (2003); Bird *et al.* (2004); Lovelock *et al.* (2010); Sanders *et al.* (2010)
Seagrasses	138 ± 38 (range = 45–190) *n* = 123 sites	177 000– 600 000	48–112	Charpy-Roubaud and Sournia (1990); Green and Short (2003); Duarte *et al.* (2005b)	Duarte *et al.* (2005a); Duarte *et al.* (2010); Kennedy *et al.* (2010); Duarte (unpublished data)

Notes: *We calculated global carbon burial values using the mean carbon burial rate and the minimum and maximum global area values for salt marshes and mangroves. Global carbon burial values for seagrasses are from Kennedy *et al.* (2010). **No global inventory of salt marshes has been published, so Chmura *et al.* (2003) estimated 22 000 km^2 of salt marshes based on inventories for Canada, Europe, the US, and South Africa. SE = standard error.

Table 1. Carbon burial per unit area per year, estimated global extent, and total carbon sequestration for the global extents of vegetated coastal ecosystems (Mcleod et al., 2011).

Table 2. Carbon burial and global area of terrestrial forest ecosystems					
	Carbon burial ($g\ C\ m^{-2}\ yr^{-1}$) mean ± SE	Global area (km^2)	Global carbon burial ($Tg\ C\ yr^{-1}$)	Sources	
Forest type				Global area	Carbon burial
Temperate	5.1 ± 1.0 (range = 0.7–13.1) *n* = 18	10 400 000	53.0	Schlesinger (1997)	Schlesinger (1997); Zehetner (2010)
Tropical	4.0 ± 0.5 (range = 1.4–7.6) *n* = 15	19 622 846	78.5	Schlesinger (1997); Asner *et al.* (2009)	Schlesinger (1997); Zehetner (2010)
Boreal	4.6 ± 2.1 (range = 0.8–11.7) *n* = 5	13 700 000	49.3	Schlesinger (1997)	Schlesinger (1997); Zehetner (2010)

Table 2. Carbon burial per unit area per year, estimated global extent, and total carbon sequestration for the global extents of terrestrial forest ecosystems (Mcleod et al., 2011).

Globally, coastal ecosystems including mangroves, seagrass beds, and marshes are renown for their ecosystem goods and services, with approximately two billion people relying directly on theses services (Loper et. al 2008). All three of the focal ecosystems that predominate in blue carbon interventions play key roles in providing provisionary services, natural beach armoring, water quality control and climate mitigation and adaptation amongst many other and more specific ecological and economic benefits. All provide supportive functions to other ecosystems as well, such as fish nursery habitats to coral reefs and the open ocean, while seagrass beds stabilize sediment increasing light attenuation, improving water quality and reducing erosion (Donato et. al., 2011; Greiner et al., 2013).

Despite the ecosystem services provided by coastal blue carbon ecosystems, they are some of the most threatened ecosystems in the world. If mangroves are destroyed or degraded, the stored carbon can may be released back into the environment, becoming a carbon source rather than a sink (AGEDI, 2014). Globally, ongoing destruction and degradation could measure up to 19% of emissions from deforestation Approximately 340,000 to 980,000 hectares of coastal blue carbon ecosystems are destroyed annually (Murray et. al, 2011). Annual rates of lost vegetated coastal ecosystems to land use conversion are estimated globally to be 1-2% for salt marshes, 0.7-3% for mangroves, and 0.4-2.6% for seagrasses. If these rates continue, within the next 100 years nearly all unprotected mangroves will be lost as will a further 30-40% of marshes and seagrasses (Pendleton et. al., 2012). It is further estimated that the conversion of these systems to other land use not only has a measurable impact in greenhouse gas emissions, but an economic impact globally ranging from $6-42 billion USD for the related contributions to increases in droughts, extreme weather events, sea level, and reduced inland protection to these events (**Table 3**) (Pendleton et. al., 2012).

	Inputs			Results	
Ecosystem	Global extent (Mha)	Current conversion rate (% yr^{-1})	Near-surface carbon susceptible (top meter sediment+biomass, Mg CO_2 ha^{-1})	Carbon emissions (Pg CO_2 yr^{-1})	Economic cost (Billion US\$ yr^{-1})
Tidal Marsh	2.2–40 (5.1)	1.0–2.0 (1.5)	237–949 (593)	**0.02–0.24 (0.06)**	**0.64–9.7 (2.6)**
Mangroves	13.8–15.2 (14.5)	0.7–3.0 (1.9)	373–1492 (933)	**0.09–0.45 (0.24)**	**3.6–18.5 (9.8)**
Seagrass	17.7–60 (30)	0.4–2.6 (1.5)	131–522 (326)	**0.05–0.33 (0.15)**	**1.9–13.7 (6.1)**
Total	33.7–115.2 (48.9)			**0.15–1.02 (0.45)**	**6.1–41.9 (18.5)**

Notes: 1 Pg = 1 billion metric tons. To obtain values per km^2, multiply by 100. See Methods section for detailed description of inputs and their sources. In brief, data for global extent and conversion rate are recently published ranges (minimum - maximum, and central estimate in parentheses). For near-surface carbon susceptible to land-use conversion (expressed in potential CO_2 emissions [48–50]), uncertainty range is based on assumption of 25–100% loss C upon land-use impact; thus, the high-end estimate is the literature-derived global mean carbon storage in vegetation and the top meter of sediment only (central estimate is thus 63% loss). Results for carbon loss are non-parametric 90% confidence intervals (median in parentheses) from Monte Carlo uncertainty propagation of the three input variables (see Methods). Economic estimates apply a multiplier of US$ 41 per ton of CO_2 to lower, upper, and central emission estimates (see Methods).
doi:10.1371/journal.pone.0043542.t001

Table 3. Estimates of carbon released by land use-change in coastal ecosystems globally and their associated economic impacts (Pendleton et. al., 2012)

Threats through anthropogenic development include engineering of coasts and rivers, agricultural expansion especially along coastal watersheds, and an increase in seal level, which have been shown to decrease the ability of coastal ecosystems to sequester carbon and lead to the degradation or destruction of these communities. There are yet many uncertainties in how climate change will affect carbon sequestration, but there have been suggestions that effects of climate change such as acidification may accelerate carbon sequestration rates through the process of establishing new ecological balances (Bianchi et al, 2013). Various stakeholders have turned towards blue carbon as an additional value that would justify further legal actions for creating coastal spaces for conservation. A universal goal of policymakers is to find an effective, efficient, and politically feasible instrument to curb carbon emissions and/or mitigate the impact. Blue carbon projects utilize the potential of coastal ecosystem's to store and sequester carbon, and the resulting mitigation and adaptation benefits, to promote the conservation, sustainable use, and restoration of blue carbon ecosystems. Since blue carbon initiatives are novel, these projects can lead to convoluted problems for governments, civil society, and the private sector (AGEDI, 2014). Blue carbon programs can be combined with national environmental management programs and support national efforts in ecosystem services valuation by assessing the monetary value of the goods and services provided by blue carbon ecosystems. Blue carbon programs can assist national efforts in climate change, foster national economic stability, and support local communities in income and subsistence resources (AGEDI, 2014).

Global climate change mitigation goals provide opportunities to leverage conservation and restoration of wetlands. Apart from being a key component of the global carbon cycle, coastal vegetation provides services that support societies, economies, livelihoods and food security (Crooks et al. 2011). Blue carbon interventions as an ecosystem based mitigation approach fits within global climate change conventions. The UNFCCC and Kyoto Protocol are beginning to explicitly recognize carbon sinks in coastal and marine ecosystems.

Blue carbon opportunities in developing countries are becoming an extension of the UN's Reducing Emissions from Deforestation and Degradation (REDD+). The REDD+ framework set up after the COP16 negotiations present a set of policy and market approaches for reducing GHG emissions from forest degradation and deforestation through sustainable management and enhancement of carbon stocks. National Appropriate Mitigation Actions (NAMAs) were identified by the COP 18 Bali Action Plan as approaches for developing countries to achieve the GHG emissions reductions goals specified in the Convention. NAMAs are more flexibly defined, as "any action that reduces emissions in developing countries and is prepared under the umbrella of a national government initiative" (UNFCCC). Developing countries can fit policies or cross sectoral actions for conservation of non-forested coastal systems, such as wetlands and seagrasses.

New financial mechanisms designed to support blue carbon interventions may be more appropriately comprehensible for blue carbon sinks. REDD+ financial mechanisms build upon a terrestrial forest methodology, so the below ground soil organic pool of coastal ecosystems do systematically fit well under the purview of the REDD+ framework. (Crooks et al. 2011).

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Chapter II - The Toolkit

This Chapter provides a description of the toolkit creation process, its final structure and an analysis of the literature review performed to create the Toolkit.

Conceptualizing the Toolkit

A toolkit is an assembly of tools that provides the latest information, guidance, and resources to support users. Successful toolkits constructed for coastal purpose include Reef resilience (Reef Resilience, 2016), U.S Climate Resilience Toolkit (U.S Climate Resilience, 2016) and the Mangrove Action Program MAP Toolkit (Mangrove Action Program, 2016).

Toolkits are designed to meet specific users' needs. To realize this goal, a toolkit can take myriad forms. Some toolkits offer online courses or regular webinar series to facilitate capacity building. Some supply users with analyses of the economic, environmental, and social costs and benefits of each tool. Some toolkits prepare a searchable database of literature review and case studies. Others produce feasibility assessment for project implementation. Common features of a toolkit are accessibility, applicability, and being up-to-date. A toolkit should be readily accessible to its audience. Resources provided by the toolkit should be pragmatic and directly related to the audience's project. Furthermore, a toolkit should update its resources and tools in a timely manner.

Who is our audience?

The Global Environment Facility (GEF) is a financial mechanism for several conventions, including the UNFCCC, and the Convention on Biological Diversity. Under their purview, GEF funds several focal areas, including International Waters, under which the Blue Forests project is funded. The International Waters focal area has funded the Blue Forests project, with five country and NGO partners. Their goal is to create the first global scale assessment of ecosystem values, and ecosystem based management through the recognition of the value of blue carbon in coastal ecosystems, aiming to foster cooperation amongst these five initial partners, and likely to expand in the future. Blue Forests was implemented in January 2015 with as a four year project.

The toolkit is primarily designed with the project managers in the GEF Blue Forests project partner countries in mind: Abu Dhabi, Ecuador, Indonesia, Madagascar and Mozambique (Fig.1). The Blue Forest project is a global initiative implemented by the United Nations Environment Programme (UNEP) partnering with NGOs and governmental organizations at each partner country to achieve improved ecosystem management. The initiative focuses on addressing key knowledge gaps in blue carbon to better understand the values associated with coastal marine carbon and ecosystem services (Herr et. al., 2015).

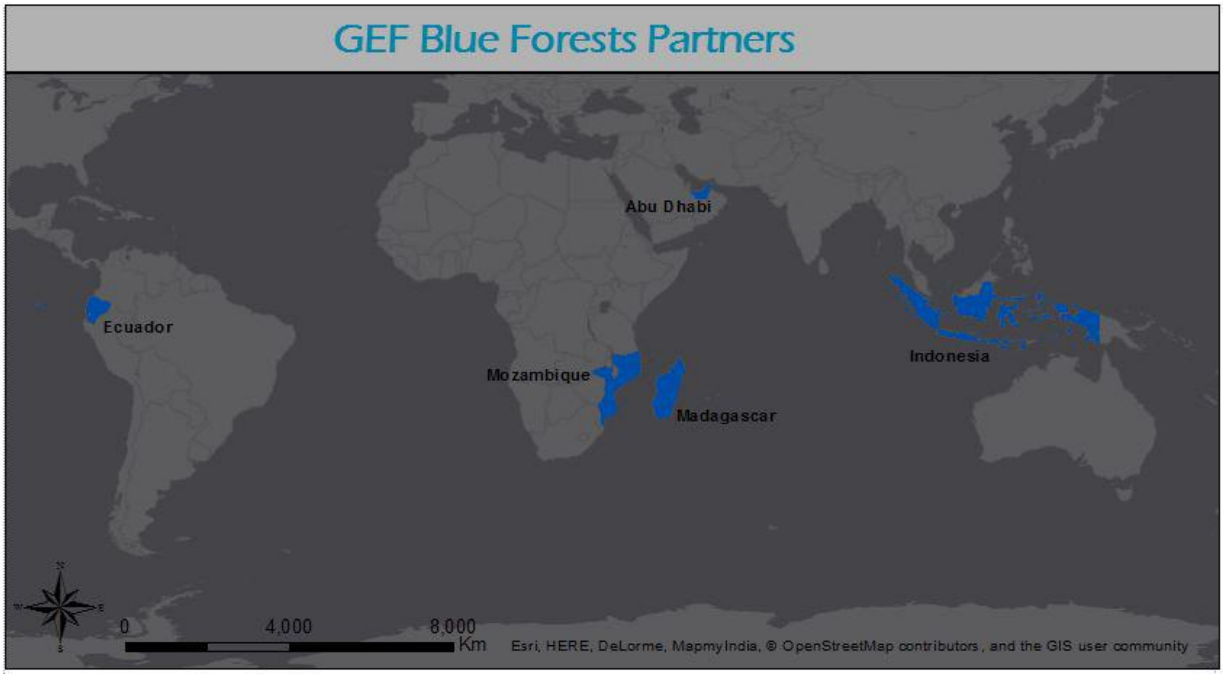

Figure 1. The five GEF Blue Forests country partners in blue. They include Ecuador, Mozambique, Madagascar, Abu Dhabi, and Indonesia.

The five countries each have a project steering committee that is to contribute to the overall goal for improved understanding of blue carbon and fostering international cooperation. Each partner has at least one small scale intervention (SSI) as is spearheaded by a lead partner organization through an NGO or federal government entity, as outlined below.

Blue Forests Country Partner	**Lead Partner Organization**
Abu Dhabi	Abu Dhabi Global Environmental Data Initiative (AGEDI)
Ecuador	Conservation International - Ecuador
Indonesia	Indonesian Government, Indonesian Ministry of Marine Affairs and Fisheries (MMAF) (Research Center for Coastal and Marine Resources, Research Agency for Marine and Fisheries)
Madagascar	Blue Ventures

Mozambique	World Wildlife Fund in Mozambique

Table 1. The five country partners and their respective lead partner organization, funded by the GEF Blue Carbon and contributing to the global collaborative initiative.

The SSIs represent varying governmental and institutional capacity for blue carbon projects, and they are already engaged by the Blue Forest Project - GEF. Potential expansion to other audiences exists after consolidation of information and resources for the pilots in the partner countries is developed. The vision is to have a set of tools and resources that may be applied to a wider audience of project managers, academics and conservationists involved in SSIs for blue carbon at any project stage. By using a simple format, the toolkit aims to help consolidate information and experience sharing for the SSIs in these countries in order to demonstrate results, inspire other countries, and provide proof of concept (The GEF Blue Forest Project, 2016).

What is our toolkit and why have one?

Lack of access to information and resources makes the work of blue carbon project managers difficult in the partner countries. For example, project managers in Ecuador struggled to understand the carbon financing potential for their sites. To meet our partners' demand for support, our toolkit has been conceptualized as a platform with key information in areas such as blue carbon science, financing, and capacity building. The development of this toolkit also allows the analysis of main trends in literature production and identifies gaps. Our toolkit has been inspired by other toolkits such as Reef Resilience and informed by the partners. The toolkit was designed under some limitations such as financial, time and technical capacities. Those have been key factors to outline a platform in a simple format such as Google Drive with the potential to be transferred to a more sophisticated system such as a website.

What should be included?

The content of this toolkit is shaped by both blue carbon experts and SSI partners. Emmer suggested an 11 steps feasibility assessment for all blue carbon projects (Emmer, 2015). After consultation with our local partner, we have decided to streamline these steps to create a 9-step framework for our toolkit. The toolkit is structured to provide resources for each of the steps outlined below.

1. An assessment of the available technologies
2. Whether or not to use approved methodologies
3. An assessment of land suitability/eligibility
4. A description of the potential project boundary
5. An assessment of the baseline scenario
6. An assessment of the with-project scenario
7. An assessment of leakage, additionality, and non-permanence risk
8. A first description of the project structure
9. An assessment of the scope for additional certification schemes involving biodiversity and communities

Table 2: Basic blue carbon project steps identified by Emmer, 2015

Process of Creating the Toolkit

This Master's Project was predicated on Avery Siciliano's 2015 Master's Project – "Developing Guidelines for a Blue Carbon Toolkit." Siciliano's project and our subsequent work were carried out as client-based Master's Projects at at the Nicholas School of the Environment for Linwood Pendleton at LABEX Mer. LABEX Mer is a French non-governmental organization that supports interdisciplinary marine research initiatives, particularly with respect to climate change (LABEX Mer). Our client's needs and the findings from Siciliano's Master's Project were essential in the conceptualization of the toolkit and in our work to date. Siciliano's work identified four key guidelines for a Blue Carbon Toolkit: 1) accessible format, 2) address knowledge gaps, 3) integrate community support and involvement, 4) address project financing mechanisms.[1]

To ensure our toolkit would be an accessible resource we chose an open source web-based platform. The initial vision for the toolkit was to create an interactive website with multiple communication platforms in a format inspired by another conservation toolkit in reef conservation called Reef Resilience[2]. The components of a toolkit identified by Siciliano are organized into categories covering blue carbon related to biophysical carbon accounting, policy, capacity building, financial mechanisms, project lifecycle, and a library of resources (See Appendix). Under Siciliano's guidelines, these

[1] See Appendix for Avery's full report
[2] www.reefresilience.org

tools would be integrated into the interactive schematic of the website design. However, upon evaluating the variability of technology access of the on-site partners, namely the variance of internet access and bandwidth capacity, our client decided upon a platform that would be shareable and usable in settings with limited access to internet. As such, our current working version of the toolkit uses a shared Google Drive as web-based storage for the relevant resources and a formatted Google Sheet as an interactive interface for our SSI partners. This Google Sheet, henceforth referred to as the “Toolkit Interface,” is formatted such that users can browse, sort, and filter the included resources depending on their interests. Further, the Toolkit includes links to access the compiled resources, user guides and original documents generated by our team about Blue Carbon policy and markets.

To address knowledge gaps for the project managers our team carried out an extensive literature review of the available information. We performed Boolean searches using the phrase “Blue Carbon” with additional qualifiers such as “Mangrove”, “Market”, “Estuary”, and “Capacity Building” (See Table 3 for a full list of search terms used). Further, we enriched this literature review with an analysis of blue carbon policy, carbon markets and an in depth case study of the SSI in Ecuador.

Search Terms	AND Qualifiers
Blue Carbon	Mangrove, Salt Marsh, Seagrass, Estuary, Market, Capacity Building, Policy, NAMA, Political Ecology, Participation, Payments for Ecosystem Services

Table 3. Search terms used in the literature review.

While integrating community support and involvement was beyond the scope of our project, we had team members focus their research specifically on local capacity building. Resources focused on capacity building when it was scarce and when it was an area that could benefit significantly from increased information and experience sharing among SSIs.

To address project financing mechanisms we had team members focus their literature review on carbon markets. We created a market analysis that identifies opportunities and hurdles for blue carbon projects hoping to enter carbon markets. While carbon markets are only one financial mechanism, we felt they were the most broadly applicable option as many other financial resources are more country specific.

Our toolkit creation process was guided not only by Siciliano’s work but also by the needs identified by the project managers of the SSIs. Our client communicated the diverse array of challenges faced by the SSIs. The considerations arising and informing the creation of a toolkit included internet access, access to literature in one place, a platform for communication and idea exchange, and primary language used by project managers. Our team has the capacity to create the informational user guide and related videos in English and Spanish. Since other languages may be preferred, future collaborations with partners may co-produce informational material in additional languages.

Once we decided on a Google Drive and Sheet as the best format for our toolkit, we developed the categories by which we wanted to classify resources. As with any compilation of resources we included the resource title, authors, year published, source, abstract and keywords. To make the resources more useable for the SSIs, we classified resources by ecosystem type, audience, whether or not it is open access, the project step for which it would be useful, country and world region, and the type of resource it was. For ecosystem type, audience, project step, world region and type of resource we established a restricted but hopefully comprehensive set of options. Establishing *a priori* the options available for each category allowed us to focus on the functionality of the toolkit as a whole rather than the individual resources. We edited the categories as necessary after receiving feedback from Pendleton and after beginning to populate the spreadsheet. Table 4 provides an overview of the categorizations we chose.

Category	**Options**
Ecosystem Type	Mangrove, Salt Marsh/Estuary, Seagrass, Multiple, Other
World Region	Africa, Asia, South America, Central America & Caribbean, Australia & Indo-Pacific Islands, Europe & Mediterranean, USA & Canada, Middle East, World
Audience	General, Academic, Manager, Policy Maker, Community Leader
Relevant Project Step	Planning, Governance, Methods, Feasibility, Capacity Building, Conservation, Project Assessment, Monitoring, Evaluation, Certification, Implementation
Resource Type	Journal Article, Review, Commentary/Letter, Webinar, Manual, Report, Tutorial, Conference/Symposium Material, Workshop

Table 4: Resource categorizations

When selecting the order in which we wanted to present the columns we created a first draft of what seemed most logical to us. We put the Audience, Ecosystem Type and Relevant Project Step columns first to help project managers easily identify which resources are of interest. We sent a sample of this organizational structure to the SSI project managers and will incorporate their feedback as the toolkit is finalized. When establishing our "Relevant Project Step" categories we drew from the Carbon Project Roadmap created by Igino Emmer.

To maintain organization, we created a Dewey Decimal inspired numbering system. To provide access to the primary resources themselves, we created a set of folders within the Google Drive. The architecture of the folders mirrors the numbering system. Each resources reference number is comprised of three components. The first component indicates whether a resource is open access or not. We wanted to clearly indicate which resources were open access and which were not to ensure that we did not infringe on any copyrights. The second component identifies the type of resource (e.g. journal article, webinar, etc. See Table 5 for full list). Finally, the third component is a unique identification number. Each resource was saved to the Google Drive titled as its respective reference number.

Our toolkit also contains user guides for the users and the toolkit administrator. The administrator guide instructs targeted users on the maintenance and operation of the platform with rules and potential areas of expansion. The user guide helps users to navigate through the toolkit with various tutorials in the folder. The user guide is available as a written document and as simple videos. User guides are available in English and Spanish. Documentation will be available on how to use the toolkit and where to find in-depth analyses and case studies.

Space	**Number**	**Code**
First	0	Open Access
	1	Restricted Access
Second and Third	01	Working Paper
	02	Tutorial
	03	Webinar
	04	Workshop
	05	Journal Article

	06	Review
	07	Commentary/Letter
	08	Report
	09	Conference/Symposia Material
	10	Speaker
Fourth and above	xxx	Unique Id

Table 5: Numbering system description.

Literature Review

There are 269 resources included in the literature review. Of those 269, 136 (50.5%) are open access resources and 133 (49.5%) are restricted access. 55% of the resources are journal articles. 15% are reports. 11% are workshops. 6% are reviews. 4% are manuals. 3% are commentaries or letters. 1% are conferences. Webinars and tutorials each make up less than 1% of the resources.

As expected, the number of resources about blue carbon increased drastically after 2009 when the term was coined (Fig. 4). Further, as of the end of April there were already 21 new resources about blue carbon available in 2016 (Fig. 4). An important caveat when interpreting our literature review results is that we aimed to be comprehensive within pre-defined categories and not to encompass *all* of the available literature related to blue carbon. We specifically focused on biophysical carbon measurement methodologies, carbon market mechanisms and capacity building resources.

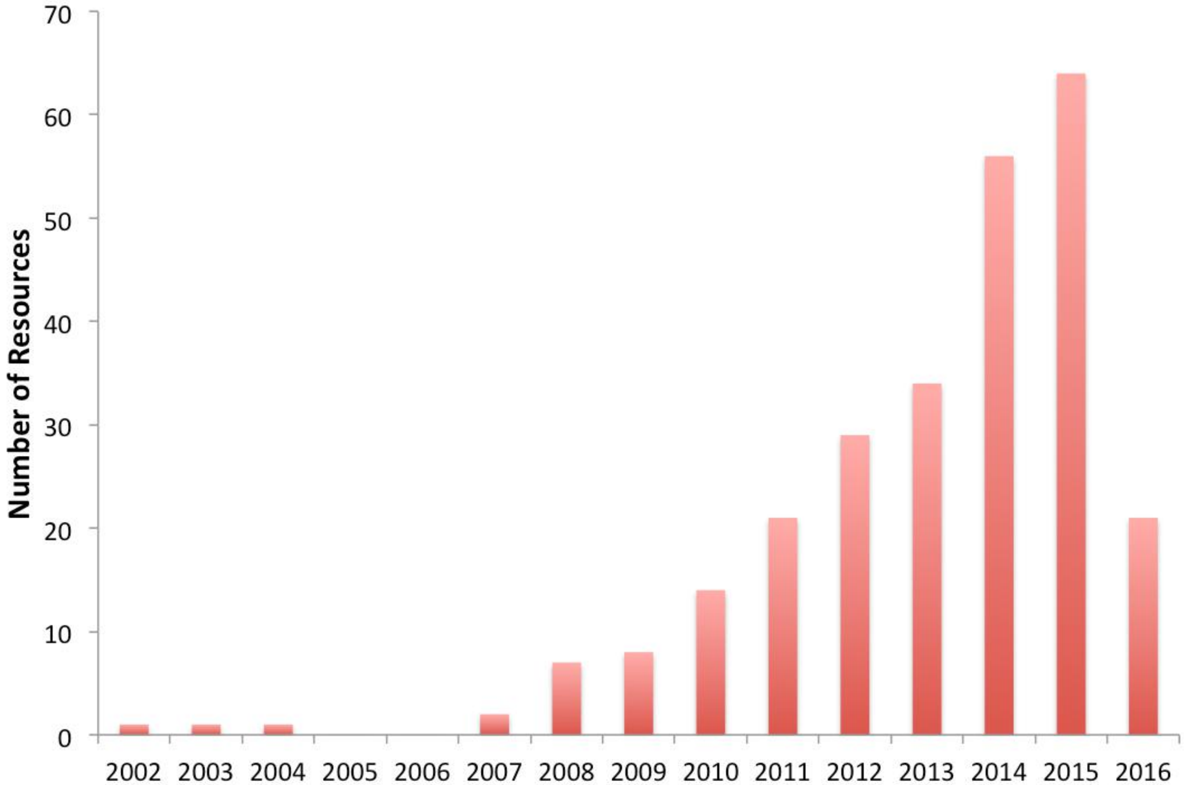

Figure 4: Number of publications in the literature review by year. Note that 2016 publications are as of the end of April 2016.

When considering ecosystem type, the largest portion of our resources pertains to more than one ecosystem. This is likely somewhat driven by the fact that many market-based resources encompassed multiple coastal ecosystems rather than focusing on one specific ecosystem. Of the resources that address only one ecosystem, there are significantly more resources focused on mangroves (28%) than on either seagrass (11%) or salt marsh/estuary systems (3% Fig. 5).

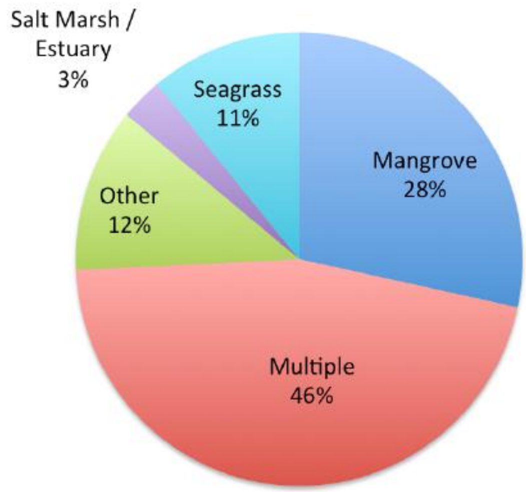

Figure 5: Percent of resources in the literature review by ecosystem type.

In terms of audience, 56% of the resources are targeted towards project managers, 22% towards academics, 10% for a general audience, 10% for policy makers and 1% towards community leaders. Nearly half of the resources we found were global in scope (Fig. 6). The next largest geographic concentration of studies were from the United States and Canada (12%) and Asia (11%, Fig. 6). There was at least some representation from every world region we identified, although studies from the Middle East, Central America & the Caribbean, and Europe & the Mediterranean accounted for less than 5% of the resources each.

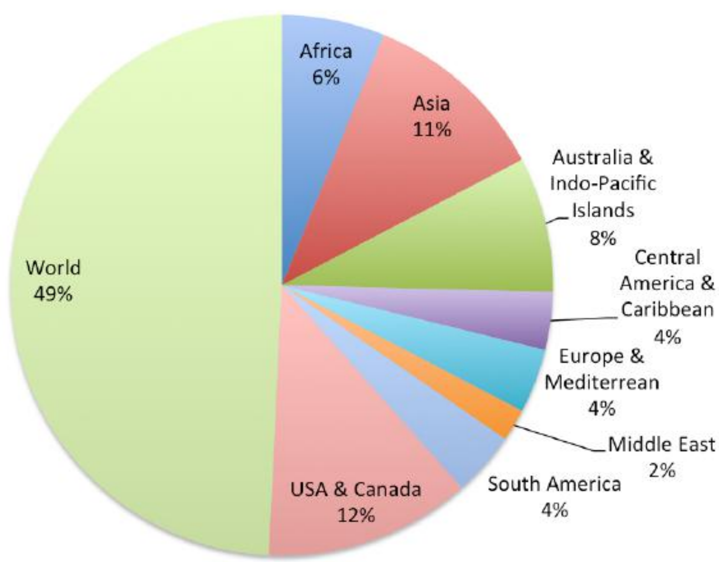

Figure 6: Percent of resources by world region.

While carrying out the literature review we also noticed more qualitative trends. For example, Figure 5 presents a word cloud generated from the keywords identified in all of our resources. Word clouds depict all the words from a given list and the size of the font is proportional to the frequency of occurrence for that word. So a word that was used many times, for example, blue, will appear in large font, whereas a word that only appeared a few times will be very small. The placement of the words is not indicative of any geographic trends, rather the map form of the word cloud aims to emphasize the global nature of Blue Carbon projects. As can be seen in Figure 7, there is significant emphasis on services, markets, the CDM, and policy, to name a few.

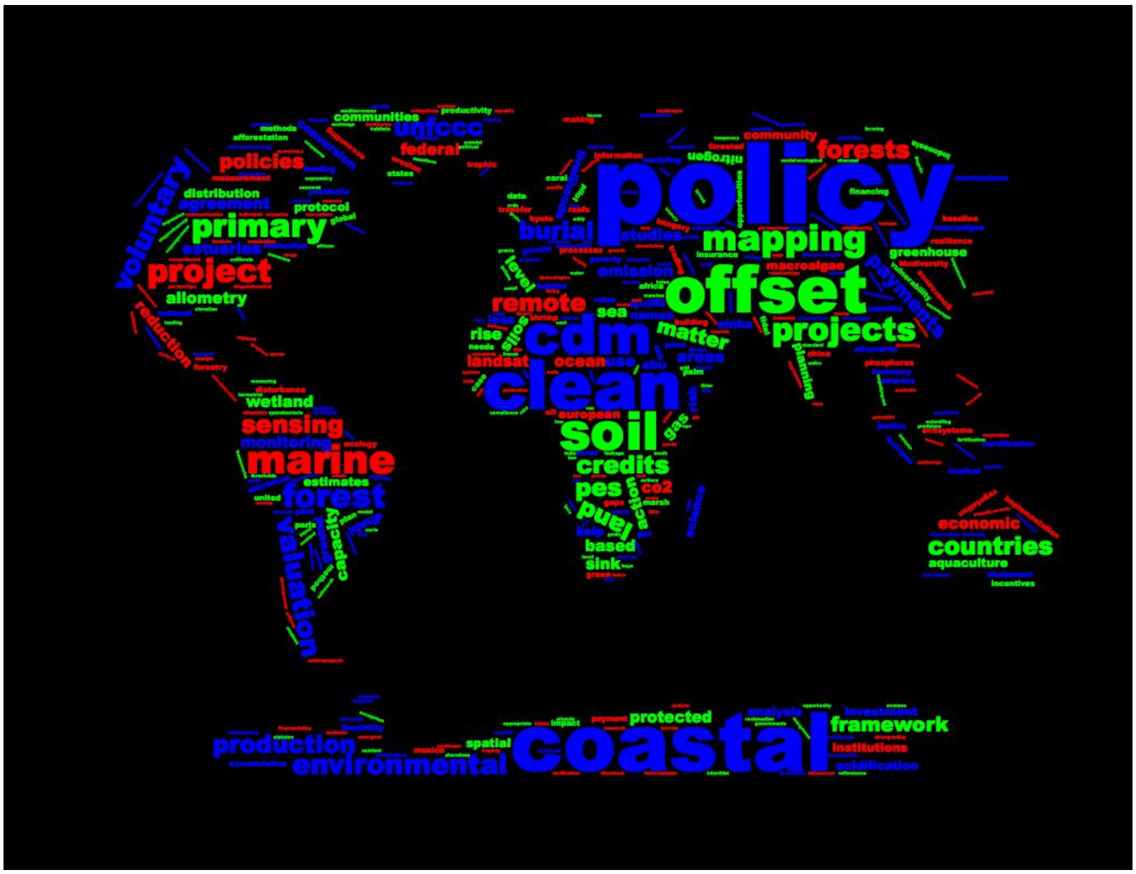

Figure 7: Word cloud based on keywords from literature review.

In the carbon market literature, there is little that specifically focused on blue carbon and even less that describes actual experiences with blue carbon in carbon markets. There is a vast array of market literature centered on experiences from using the Clean Development Mechanism. In terms of capacity building, there is significant literature from a social science perspective that explores the social capital or local institutional capacity to support and manage blue carbon interventions but very little that addresses community governance or stakeholder engagement and inclusion for blue carbon. Many studies provide recommendations but few report on the successes and failures from actual blue carbon interventions.

There were ecosystem-specific studies from all over the world. Many of the seagrass and mangrove studies were targeted towards project managers. For ecosystems other than the typical three (mangroves, salt marshes and seagrasses), such as microalgae and phytoplankton, almost all of the available literature is targeted towards an academic audience.

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Chapter III - Ecuador Case Study

Preface

This project was undertaken to determine how site managers in the field could potentially utilize a blue carbon toolkit. The objective was to identify the major concerns of each group of stakeholders and how they envisioned the toolkit addressing these issues. The following groups of stakeholders were identified: Ministry of the Environment at the national level, Ministry of Environment at the local level, academia, marine reserve managers, association leaders, various NGO and aid organizations, shrimp farmers, and members of the concessions. The goal was to determine the available technologies, current forms of communication, and any information the groups were missing that would be essential for the creation and monitoring of blue carbon projects. The last objective was to discover the reasons why Ecuador's mangrove management has been successful and the incentives behind mangrove conservation for the different groups of stakeholders. This information helped shape the focal areas of our toolkit, the methods for disseminating the information, and the tangible products incorporated.

Why a toolkit?

A toolkit is an assembly of tools that provides the latest information, guidance, and resources to support users. Successful toolkits constructed for coastal purposes include Reef resilience (Reef Resilience, 2016), U.S Climate Resilience Toolkit (U.S Climate Resilience, 2016) and the Mangrove Action Program MAP Toolkit (Mangrove Action Program, 2016). Toolkits are designed to meet specific users' needs. To realize this goal, a toolkit can take myriad forms. Some toolkits offer online courses or regular webinar series to facilitate capacity building. Some supply users with analyses of the economic, environmental, and social costs and benefits of each tool. Some toolkits prepare a searchable database of literature review and case studies. Others produce feasibility assessment for project implementation. Common features of a toolkit are accessibility, applicability, and being up-to-date. A toolkit should be readily accessible to its audience. Resources provided by the toolkit should be pragmatic and directly related to the audience's project. Furthermore, a toolkit should update its resources and tools in a timely manner.

The toolkit is primarily designed with the project managers in the GEF Blue Forest project partner countries in mind: Abu Dhabi, Ecuador, Indonesia, Madagascar and Mozambique. The Blue Forest project is a global initiative implemented by the United Nations Environment Program (UNEP) partnering with NGOs and governmental organizations at each partner country to achieve improved ecosystem management. The initiative focuses on addressing key knowledge gaps in blue carbon to better understand the values associated with coastal marine carbon and ecosystem services (Herr *et. al.,* 2015).

How was the information obtained?

In the summer of 2015, two Duke University students traveled to the field in Ecuador to work with Conservation International, one of the GEF pilot project partner organizations. Conservation International's objective was to not only ensure the conservation of coastal ecosystems, but also to ensure the protection of vital ecosystem services, build local capacity, and to understand the implications of blue carbon policies. Conservation International Ecuador prepared a series of discussions, interviews, field visits, focus groups, and round tables. This offered the chance for representatives of all the different groups of stakeholders involved with blue carbon to express their thoughts and concerns. A series of questions was asked (Appendix 1) to determine what each group of stakeholders envisioned the toolkit to encompass, their major gaps in knowledge, specific tools or functions they wanted the toolkit to include, reasons they do or do not care about protecting mangroves, current forms of communication and available technologies, and finally any general recommendations for the toolkit.

Thirty individuals were interviewed. The participants were selected to represent the different groups of stakeholders as shown in Appendix 2. These groups were created in coordination with Conservation International and based on *a priori* knowledge and an extensive literature review. Conservation International assisted the team with the recruitment process. The interviews were conducted in Spanish and English. The participants represented a broad spectrum of socioeconomic backgrounds, education levels, and interests or lack thereof of conservation of blue carbon ecosystems.

In addition to the interviews, each group of stakeholders was observed in order to better understand the role blue carbon played in their lives and how to best develop a toolkit that would enhance their ability to plan, implement, monitor, and evaluate blue carbon projects. Lastly, potential users of the toolkit were identified, i.e. academics, community leaders, NGOs, project managers etc.

After the fieldwork was completed, two roundtable discussions were conducted with representatives from each group of stakeholders. The preliminary results were presented, allowing an avenue for the representatives to express their opinions and talk amongst themselves (Table 1). Ideas were shared for the toolkit, including the content, distribution, and goals.

Data was collected in the form of transcribed interviews, audio recordings, videos, and photographs. For a full list of meetings, interviews and focus group participants, questions, and presentations see Appendix 1-5.

The data was analyzed qualitatively using the deductive approach and narrative analysis. Each recording (audio and visual) was translated into English and transcribed. The data was coded by hand following traditional methods, instead of using computer software.

Results

Listed below are the five major trends that were brought up and were considered in the creation of the toolkit.

1. Understanding the current political framework and available legal options (nationally and internationally)
2. Finding innovative funding and opportunities for blue carbon in global markets
3. Gaining access to peer reviewed journals and current methodologies
4. Building capacity/infrastructure
5. Communicating between stakeholders within Ecuador and internationally
6. Addressing gaps in technology or gaining access to a technological tool

Blue carbon in Ecuador:

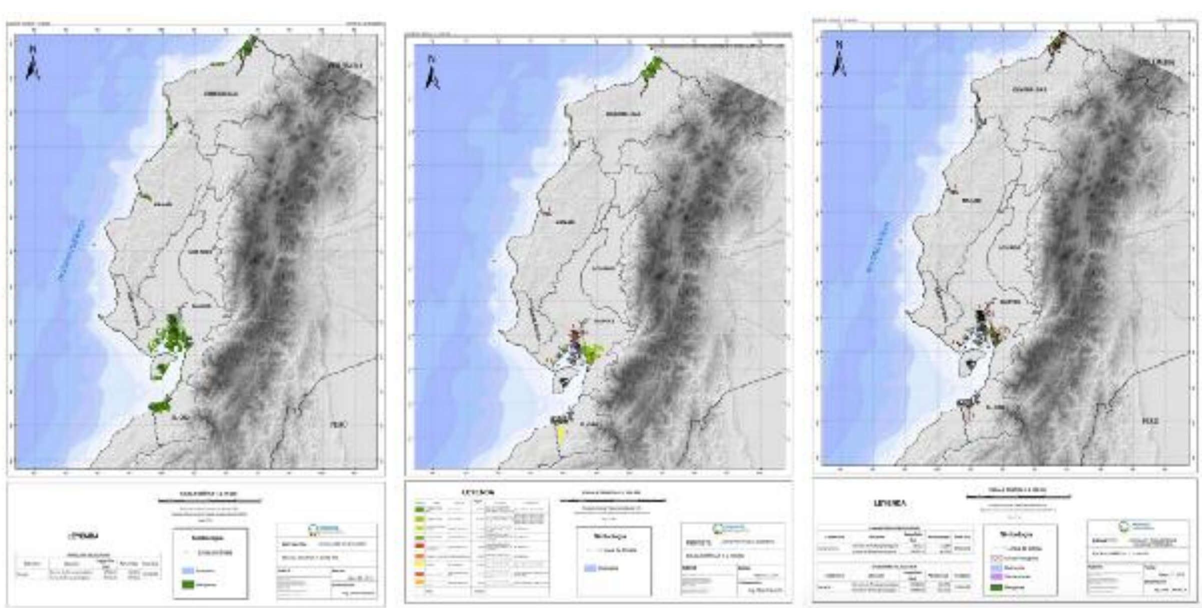

Figure 1. Mangroves distribution in Ecuador

Ecuador's main source of Blue Carbon is its extensive mangrove forests, totaling 113,926.82 hectares (Fernando Jara, 2014). Mangroves are found in all major coastal estuaries of mainland Ecuador (Hamilton and Lovette, 2015). The dominant species of mangroves along the coast of Ecuador include the following: *Rhizophora mangle*, *Laguncularia racemosa*, and *Avicennia germinans* (Hamilton and Lovette, 2015).

Ecuador's Ministry of the Environment started overseeing the protection of mangroves in 1995. By 2013, all of Ecuador's remaining mangrove forests were protected at the federal level (Hamilton and Lovette, 2015). Protected status was given as a result of rapid deforestation by activities such as shrimp farming (Bodero and Robadue, 1995).

Although not all the literature is accessible by all the different stakeholders, Ecuador does have high-resolution spatiotemporal data for each of its estuaries (Hamilton and Lovette, 2015). The far left figure shows the extent of mangrove coverage as of 2014 that has been documented. The middle panel shows protected areas, and the far right panel shows overlap with aquaculture (Fernando Jara, 2014). The current blue carbon stock assessments, methodologies, and other peer reviewed journals (both open and restricted access) have been included in the toolkit, per requested by ALL of the groups of stakeholders.

Mangrove destruction in Ecuador:

Mangrove forests have become one of the world's most endangered ecosystems (Valiela *et. al*, 2001). The past forty years have shown a severe decrease in the amount of mangroves in many countries, especially those of Latin America, Asia, and Africa. 30-70% of the historical mangrove coverage in these countries has been lost (Spalding *et. al*, 2010). Ecuador is the primary shrimp producer in the Western Hemisphere, producing 260,000 tons of shrimp. Shrimp farming is one of the leading causes for mangrove deforestation (FAO, 2013). Land use change, such as the creation of shrimp ponds for aquaculture, has led to the destruction of 1.5 million HA of mangroves in Thailand, China, Indonesia, and Ecuador (Biao and Kaijn, 2007).

Political framework and how Policies differ

In total, there are 28 regulations concerning coastal and marine ecosystems in Ecuador. The legislation covers sustainable use, protection, conservation, recovery, and restoration. About 50% of these policies fall under the control of the Ministry of Environment as the National Environmental Authority based on the 2008 Constitution of the Republic. The remaining half comes from the TULAS (2004), an act that details the management, protection, conservation, and use of mangroves (Fernando Jara, 2014).

Socio bosque: Launched in 2008, Socio bosque is the legal framework for forest conservation. In 2013, the ministry started to give incentives to private landowners (collective or individuals). This monetary compensation incentivized landowners to protect and monitor their forests.

Socio manglar: Launched in 2013, Socio manglar is an extension of Socio bosque for mangrove forests, but differs in landownership rights. Since the Ministry owns mangrove forests, in order to receive the monetary incentive, groups of people living on concessions must form associations providing stewardship of mangrove ecosystems before they can collectively receive the monetary incentive.

Currently only 4 associations are receiving the monetary incentive of $322.97 USD: Association Cangrejeros July 6th, Craft Cooperative Fish Production Nuevo Porvenir, Crabbers and Fishermen Association May 21, Puerto Rome, and the Association of Fishermen and Shellfish. This totals about 7,440.00 HA.

In addition to the associations and concessions, there is a series of national protected areas. The local Ministry of Environment governs these marine reserves.

Available Political Options

NAMAs: Nationally Appropriate Mitigation Actions are mechanisms to assist developing countries in the reduction of greenhouse gases. Under NAMAs there are multiple funding mechanisms: government, international climate and development support, and private sector. Blue Carbon can easily be included in NAMAs (Wylie *et. al*, 2016).

REDD+: Reducing Emissions from Deforestation and Forest Degradation: Mangroves can already be included under REDD+, unlike other blue carbon ecosystems. Under REDD+, each country is able to define what constitutes a “forest” and can choose to include mangroves under their definition. REDD+ provides financial incentives to protect forest carbon reservoirs (Wylie *et. al*, 2016).

CDMs: Clean Development Mechanisms are defined in Article 12 of the Kyoto Protocol and they allow countries emission-reduction commitments within the Protocol to create mitigation projects in developing countries (Wylie *et. al*, 2016).

National and International Blue Carbon Policies are available in the toolkit.

Incentives/Reasons for Success:

The two main reasons for conservation of mangroves in Ecuador were the Socio manglar program and the red crab fishery. Conserving mangroves could lead to a monetary incentive, while deforestation could lead to fines. The Socio manglar program also includes a partnership and access to resources from an NGO or international corporation. There was an understanding that they could build capacity and get access to resources through the Socio manglar program. The second reason for conservation was because their livelihoods and economy relied heavily on the mangroves. The crab fishery is a main source of income and driver of the local economy, and mangroves play an essential role in the life history of crabs. Understanding these incentives helped shape the toolkit, because Conservation International was the only group that spoke about blue carbon or ecosystem services. Understanding that blue carbon is a new concept and targeting additional incentives might be more alluring for project managers should be kept in mind during the compilation of resources for the toolkit.

Major Results and how they were incorporated into the Toolkit:

Understanding the political framework and legal options: The toolkit includes a policy analysis, succinctly summarizing blue carbon legislation and potential opportunities for blue carbon. Legal frameworks and policies regarding blue carbon were focal areas of the literature review. The toolkit includes workshops explaining the divisions between protected areas, concessions, and associations, and includes other case studies of how different regions used policy in their favor. Both national and international information was included in the toolkit.

Finding innovative funding and opportunities for blue carbon in global markets: The toolkit includes a carbon market analysis, with special emphasis on the role of blue carbon in carbon markets. The objective of including an analysis is to help project managers understand the opportunities and challenges associated with using carbon markets to finance blue carbon projects. An overview of carbon finance as well as how blue carbon projects can fit within it is included in the analysis. Carbon markets was a focal area included in the literature review. The toolkit includes resources on available funding opportunities, different aid agencies working with blue carbon, demonstration projects, and supplemental financing options.

Gaining access to peer reviewed journals and current methodologies: This is the fundamental concern that frames the toolkit spreadsheet formatting. The toolkit includes both open access and restricted access resources. Biophysical methodology was another core component of the literature review. The resources include peer-reviewed journals, with articles published as recently as 2016. In addition to articles, the toolkit includes guides, workshops, and manuals on mangrove methodology. Methodology was a key project step included in the toolkit, biophysical information was a focal area of the literature review, and journal articles was a major resource classification. Within the methodology information, the toolkit breaks it down to specific ecosystem type and country; for example Ecuador mainly has mangroves, so they could limit their search to mangrove methodology.

Building capacity/infrastructure: There are several ways to interpret capacity building, but for this case, it will be referred to as providing the project managers with the necessary tools and knowledge to promote their ability to achieve their development goals, specifically those that can be enhanced by blue carbon projects. Reaching Millennium Development Goals was a major concern, so the toolkit tries to provide case studies and other tools to help achieve this goal. Although building capacity was a focal area in the literature review, finding resources on capacity building for the literature review was difficult.

Communicating between stakeholders within Ecuador and internationally: There is a comments section to encourage users to engage in conversation, share success stories, share advice, or demonstrate how the toolkit has helped them. There is also a Google Form so that third parties can submit their own resources. This section needs improvement, and possible improvements will be addressed later in the case study.

Addressing gaps in technology: Google Drive is feasible for areas with minimal Wifi coverage. It is an open source platform that is shareable and usable in settings with limited access to internet. The toolkit can be downloaded onto a zip drive. As such, our current working version of the toolkit uses a shared Google Drive as web-based storage for the relevant resources and a formatted Google Sheet as an interactive interface for our small scale intervention (SSI) partners.

Focus Group and Roundtable Suggestions for Toolkit Improvement:

- Budget Planning Tool `
- Carbon Calculator
- GIS
- More interactive communication between countries and stakeholders
- Impact/risk assessments
- Guides/manuals on how to become an association

Appendix 5. List of interviews and Roundtable interviews

The Final Product

The toolkit is formatted such that users can browse, sort, and filter the included resources depending on their interests. One can filter by ecosystem type, project step, intended audience, keywords, type of resource, region, country and whether it is open access or restricted. The toolkit includes links to access the compiled resources, user guides, tutorials, and market and policy briefs generated by the Blue Carbon Toolkit Team. The case study will also be included. There will be both user guides and a guide for the toolkit administrator. The administrator guide instructs targeted users on the maintenance and operation of the platform with rules and potential areas of expansion. The user guide helps users to navigate through the toolkit with various tutorials in the folder. The user guide is available as a written document and as simple videos. User guides and tutorials are available in English and Spanish. Documentation will be available on how to use the toolkit and where to find in-depth analyses and case studies. If a project manager identifies an area without Wifi, they can request a zip drive of the compiled resources, downloaded videos, etc. Lastly, the toolkit includes a comments section and Google Forms to encourage third party involvement and communication. The administrator will manage the user comments section, but the hope is to have third party members give their opinion on the resources or share success stories, advice, or what not to do. The Blue Carbon team realizes that the list of resources is not exhaustive, and having a Google Form submission will be useful in having resources that the team may have overlooked, especially site specific information or conference material that is not readily available online.

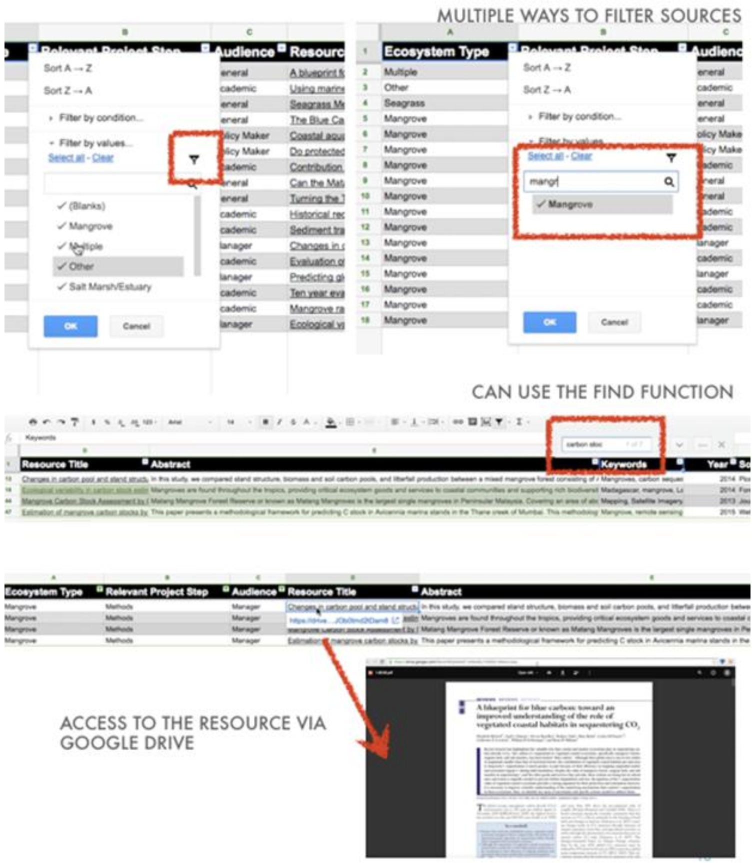

Figure 2. Toolkit tutorial

Possible Questions that could be answered

i. How do I measure carbon in mangroves?
ii. What methodologies are available for carbon accounting?
iii. How much carbon does a salt marsh store?
iv. How much carbon is released when mangroves are destroyed?
v. What are unusual forms of blue carbon?
vi. How does blue carbon fit into climate change policy?
vii. How is blue carbon policy evolving?
viii. Does my country have policies that could include blue carbon?
ix. How does carbon financing work?
x. What are innovative sources of carbon financing?
xi. Can blue carbon projects be used to generate carbon credits?
xii. What kind of carbon credit schemes may finance blue carbon conservation projects?
xiii. Are there examples of community-based blue carbon projects?
xiv. What millennium development goals could be reached through blue carbon projects?

xv. What other countries are utilizing blue carbon projects in a similar capacity?
xvi. What international organizations are working with blue carbon projects?

Assessment of the toolkit

Understanding the current political framework and available legal options (nationally and internationally): Excellent

Finding innovative funding and opportunities for blue carbon in global markets: Good-Mostly focused on carbon markets, could be improved by including more innovative funding schemes.

Gaining access to peer reviewed journals and current methodologies: Excellent

Building capacity/infrastructure: Good-Could be improved by the Google Form Submission and having individual project managers share success stories.

Communicating between stakeholders within Ecuador and internationally: Needs Improvement-Google Drive does not encourage peer-to-peer conversation or promote international dialogue.

Addressing gaps in technology or gaining access to a technological tool: Needs Improvement-Although the zip drive and Google form address issues of limited internet, the specific concerns regarding technology in Ecuador such as GIS, Budget Tool, etc. were not included. This could be addressed in a miniature toolkit specific to Ecuador.

Assessment Frequency	**Excellent**	**Good**	**Moderate**	**Needs Improvement**
All	Access to Peer Review Journals and Methodologies	Supplemental Funding		Communication
Most	Policies	Building Capacity Infrastructure		
Moderate			GIS	Guides/manuals on how to become an

				association
Few			Gaps in Technolog y	Budget Planning Tool Carbon Calculator Impact/risk assessments

Excellent	***Good***	***Moderate***	***Needs Improvement***	

Table 1. Assessment of the Toolkit

Challenges and Next Steps

Challenges were faced when trying to address specific local needs, while keeping the toolkit globally applicable. This problem could be ameliorated by the inclusion of miniature toolkits within the broader toolkit, like how Reef Resilience includes multiple toolkits, for very site specific local needs. The toolkit cannot ameliorate all problems. A toolkit will not be able to change institutional barriers or cultural differences such as the way the information is shared between groups of stakeholders. Future work should be conducted to try and improve the communication function of the toolkit. Having a more interactive comments section, or a platform to improve peer-to-peer communication, and a way to share success stories or advice would be useful. In addition to improving communication, future goals are to create a more developed Google Form for submitting resources. This function could be incredibly helpful, since the toolkit spreadsheet was created with a subset of core focal points and specific keywords. Issues with the Google Form now include quality control and redundancy. Lastly, having a GIS toolkit inside the toolkit would address many of the issues brought up. The toolkit will be taken over by an administrator, who will have the job of quality control and updating the toolkit with resources. Additionally, a social media presence should be a next step. Having SSI leaders promote the toolkit via social media, such as Conservation International, would be useful. To address copyright concerns, reaching out to Duke's copyright experts could help see if deals could be brokered to make some restricted access information open access for this platform. The blue carbon toolkit team is currently in the process of trying to make all the resources open access for the users. The blue carbon team envisions a Beta Test with the SSIs and to continue with iterative toolkit versions.

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Appendix 1. Questions designed for Interview sessions

Questions for Interviews
1.¿Which are the main areas of information that you may consider are more critical and currently are not available for your blue carbon projects?
2. Do you think the toolkit offers enough information to be able to understand the biophysical aspects of blue carbon science (knowing that not everyone will be a blue carbon scientist using the toolkit) to be able to successfully implement a blue carbon project?
3. After looking at the site map, is it clear that the project cycle represents the stages, protocols, and steps to be able to implement a blue carbon project which is different than the demonstration projects which are specific case studies that are currently being implemented or have already occurred. Is there a better format or is it user friendly and easy to distinguish between the two?
4. You were presented the pilot platform for the toolkit. Is there anything you see that should be changed, i.e. deleted, added, reworded, or is there any information you see missing that is necessary for a successful program?
5. Who would be the potential users of the toolkit within your organization?
What is the level of expertise of the intended users?
Do you envision that it would be necessary for these users to have specialized training?
if so, in what area would be most critical to have training?
6. We have offered a definition of what we believe a blue carbon project is, based on this information provided, do you feel that you have any ongoing or planned projects that fall into this category?
if so, what infrastructure (in terms of support, technology, and collaborations/partnerships) do these projects already have?
What gaps, if any, are present in existing infrastructure versus what is needed?
7. What are the main barriers and key challenges of your specific projects and projects at the national level?
8. Do you have any general recommendations or advice for us after looking at our sitemap/pilot platform?

Appendix 2. Groups of Stakeholders and Description

Stakeholder Category	Description
Concessions	Coastal Communities living on concessions or areas with mangroves. The Ministry of Environment owns the mangroves, not the individual people.
Associations	When a group of people living on a concession come together and fulfill all the legal requirements to become an association and to receive the monetary incentive for the protection of mangroves.
Marine Reserves Ministry Officials	Protected areas of mangroves that do not fall in areas populated by coastal communities. These marine reserves have ministry staff that oversee their protection, and they receive funding from the Ministry.
Private Industry	Shrimp Farmers who deforested areas of mangroves to build aquaculture ponds.
Academia	Local universities with professors research coastal mangrove ecosystems.
NGOs Affiliated with a Concession	In order to become an association, an NGO must partner with the community. The level of involvement/interaction differed drastically between the NGOs who had partnered with associations.
Ministry of the Environment	This refers to the Ministry of Environment in Quito as well as the Socio Manglar/Socio Bosque employee in the field.
Conservation International	One of the GEF Blue Forest Project Partners and our in field client. Instead of partnering with one association, they work with all of the concessions and associations.
NGOs not affiliated with an association	NGOs working the area and with the coastal communities who are not affiliated with a specific group of people.

Appendix 3. Designed questions for focus groups

Questions for Focus Groups
1. What are some key areas of local development in Ecuador that may be aligned with blue carbon projects?
2. Which type of structure you believe is needed to strengthen local capacities for the use of information that support local communities' autonomy in the face of joint work with Universities, Government or NGOs?
3. ¿How do you think biophysical information of blue carbon could be shared, access and be used in decision making processes? Example: SIMCE platform, REDD program, Reports on USAID, Communities: management plans, monitoring reports. Sharing information: • From communities to decision makers • From academia to decision makers • From academia to communities

Appendix 4. Agenda of field work in Ecuador

Work plan
Blue Carbon Toolkit Project
Blue Carbon Toolkit General Objective: to develop a user-friendly toolkit aimed at project managers and field ecologists to help them to show various approaches to blue carbon, to determine which protocols best fit the social and political conditions of their site, study cases, and to identify field work that may be required to pursue the chosen protocol (Siciliano, 2015).

Goal for the visit in Ecuador: Stimulate dialogue and capture perceptions around Blue Carbon projects in Ecuador. The team would be able to identify the current state of the information and level of knowledge around Blue carbon projects in Ecuador. The dialogue would help the team to understand availability of information, key stakeholders, flow of information and some gaps in the information that managers/ decision makers need to design, implement and monitoring Blue Carbon projects in the Country (at the National and Local level).

Week	Activity	Description	Subproducts
July 13th to 15th	Interviews in Quito, key government and NGO stakeholders	We would design key questions and conduct individual interviews to key partners such as Socio Bosque, Undersecretary or Climate Change, Instituto Nacional de Biodiversidad, SENPLADES, and the NGO Hivos.	Tool for interviews designed Information gathered on expectations from stakeholders in Quito Identify key persons to interview in Gye Discuss work plan with Javier and Raul
July 16th to 17th	Design interviews and material for field visits in Guayaquil.	Caroline and Tatiana would be flying to Guayaquil. Design specific interview instruments and material for Guayaquil and concession areas visits. Visit local universities to gather information on mangroves and blue carbon	Work plan adjusted in the field Key information identified and gathered (if possible) Gap analysis for blue carbon

			projects in Ecuador, draft 1, structure of the report.
July 20th to 24th	Individual interviews to local organizations in the city of Guayaquil	We would conduct individual interviews to organizations such as Secretaria de Gestion Marino Costera de Guayaquil, ESPOL, Univ. de Guayaquil, Departamento Ambiental de la Ciudad, Autoridad Pesquera, Secretaria Marina, Comision del Pacifico Sur CPPS.	Information gathered. List of people from the concession to be interviewed.
July 27th to 31st	Visit and Interviews in Mangroves Concession areas	Visit and conduct interviews to key stakeholders in the Mangroves Concessions. Visiting CI projects area.	Information of local leaders gathered
August 3rd to 7th	Montse joins field team	Montse, checking in work plan and scorting concessions visits. Revise GAP analysis report.	Gap analysis for Blue Carbon projects in Ecuador draft 2.
August 10th to 14th	Round table with stakeholders in Guayaquil, conclusions, and recommendations.	We would meet Undersecretary of Marine and Coastal resources, ESPOL, Univ. de Guayaquil, Departamento Ambiental del Municipio de Gye, Autoridad Pesquera, Secretaria Técnica Marina, Comision del Pacifico Sur CPPS.	Report from the meeting
August 16th	Returning to Quito GAP analysis for blue carbon projects in Ecuador		Final report Gap analysis for blue carbon projects in Ecuador.
August 17th 9 to 11 am	Round table with stakeholders in Quito, conclusion and recommendations.	We would meet key partners such as Socio Bosque, Sociedad de Cambio Climatico, Instituto Nacional de Biodiversidad, SEMPLADES, and the NGO Hivos.	Report from the meeting
Fall 2015 and Spring 2016	Development of the toolkit in lab	The master project team would develop the toolkit over two semesters, which will integrate the cases of pilots of the Blue Forest project, including Ecuador case.	Toolkit developed

		Students would need to explore the platform that better fits with the objectives of the project (web site, tutorial, among others)	

Appendix 5. Interview and Round Tables

Interviews and Roundtables Participants
1. Conservation International Ecuador
2. Fundación Hivos
3. Wildaid
4. Seajoy Shrimp Farm
5. Asociacion Calisur
6. Centro Internacional para la Investigación del Fenómeno de El Niño CIIFFEN
7. Universidad Catolica, Facultad de Economia
8. Universidad de Guayaquil
9. Sociomanglar Program, Ministerio de Ambiente de Ecuador MAE
10. Independent environmental consultants
11. Ministerio del Ambiente del Ecuador, Sector Areas Protegidas
12. Fundación Jambeli
13. Ministerio del Ambiente del Ecuador MAE, central office Quito
14. Universidad ESPOL
15. Fundación Schutzwald
16. Fundación Cerro Verde
17. Business owner
18. Independent researcher

Chapter IV - Policy and Market Analyses

This Chapter contains first an analysis of international blue carbon policy and second an overview of carbon markets and how blue carbon projects can fit within them.

1. Policy Analysis

The science-based impetus for the conservation of existing mangroves, marshes and seagrasses are that less disturbed, or longer standing ecosystems tend to have more carbon stored due to their existence and corresponding long-term sink capacity. For example, mangrove substrate tends to be anoxic, whereas terrestrial forest soil is aerated, contributing to high potential of carbon stored for longer geologic periods. Thus, the immediate issue is that the capacity of blue carbon sequestration is lower in restored or reforested areas, compared to relatively more non-disturbed coastal ecosystems (Matsui et al. 2012). Another impetus for understanding blue carbon sinks seems to have stemmed from leveraging coastal ecosystems as powerhouses of carbon that can sequester and store up to six times more carbon per unit area than tropical terrestrial forests (Thomas, 2014). As such, global climate change policy has turned to the importance of maintaining or improving the ability of coastal ecosystems to store CO_2 .

In November 2009 the United Nations Environment Programme (UNEP) published a rapid response assessment report on blue carbon. The report played an important role in furthering the process of global carbon accounting that had been started by the Intergovernmental Panel on Climate Change (IPCC) in assessing carbon in the atmosphere and terrestrial systems. Additionally, it brought vital marine and coastal zones to the forefront by emphasizing their significance in global carbon cycling and sequestration, ecosystem services, further exacerbated by the rate of degradation faced by various anthropogenic activities (Nellmann et al., 2009; Thomas, 2014). The assessment resulted in five key policy recommendations, the first of which was to "recommend a global blue carbon fund for protection and management of ecosystems and ocean carbon sequestration" (Nellmann et al. 2009). The other four policy recommendations called for a prioritization of integrated and ecosystem based coastal management towards a goal of protecting at least 80% of the current mangroves, seagrass and marshes while maintaining food and livelihood security.

The United Nations Educational, Scientific and Cultural Organization (UNESCO), Conservation International and the International Union for the Conservation of Nature (IUCN) subsequently established the global Blue Carbon Initiative in 2010, to promote climate change mitigation through restoration and sustainable use of coastal and marine ecosystems. Two operating working groups function within the initiative, one on scientific and technical issues, and the second concerns with investigation of policy issues. The main initial recommendations by the policy-working group were to integrate blue carbon activities into international policy and financing of the United Nations Framework Convention on Climate Change (UNFCCC) as part of climate change mitigation mechanisms (Thomas, 2014). The UNFCCC's Article 4(d) commits parties to cooperate on management and conservation efforts of sinks and reservoirs of greenhouse gasses, including marine biomass, as well as coastal and marine ecosystems (UNFCCC, 1992). Although the science still has ample veins of exploration into understanding the processes and potential of carbon sequestration regarding specific types of canopy, vegetation and sediment (Jones et al. 2014), blue carbon activities are beginning to be integrated into carbon finance mechanisms (Thomas, 2014). There are a number of incentives that support emission reductions and removals through ecosystem management under the UNFCCC, including Reducing Emissions from Deforestation and Forest Degradation (REDD+), National Appropriate Mitigation Actions (NAMAs) and the Clean Development Mechanisms (CDM). Top-down mechanisms such as these can provide strong political and financial incentives for national-level accounting and small-scale interventions in restoration and resource management (Herr et al., 2012).

In June of 2012, at the Rio+20 Conference of the Parties, an inter-agency collaboration between the Intergovernmental Oceanographic Commission (IOC) under UNESCO released the *Blueprint for Ocean Sustainability*, in global efforts towards sustainable ocean and coastal management. The first of the ten proposed measures relates to reducing stress and maintaining or restoring ecosystems, including actions for mitigating and adapting to ocean acidification. The second objective under that first measure advocates for the creation of a global blue carbon market, which would allow for direct economic gain through habitat protection (IOC/UNESCO, 2011).

In 2013, the IPCC accepted and adopted wetlands into their Guidelines for National Greenhouse Gas Inventories, providing a standard for collecting background data for estimation of carbon stock changes in mangroves, living biomass and pools of dead-wood for coastal wetlands. It also provided guidelines for the effects of emissions and carbon removal from soil from various management activities (Herr et al., 2015)

In 2015, the UN released the *2030 Agenda for Sustainable Development* in which goal 14 of 17 is to "conserve and sustainably use the oceans, seas and marine resources for sustainable development." Within goal 14, seven points are made to address ocean issues, of which 14.2 calls for sustainable management of marine and coastal ecosystems to build up resilience and take action for restoration management. While blue carbon is not explicitly one of the sub-goals, interventions for blue carbon may fall under goal 14.3 and 14.5 as well, which target impacts of ocean acidification "through enhanced scientific cooperation" and intends for 10% of global coastal and marine ecosystems to be under conservation management by 2020 (UNSD, 2015).

One of the most successful blue carbon policy measures is often framed within emissions trading. Under the terms of the UNFCCC, nations agree to individual emissions reduction commitments, which can include international emissions trading, joint implementation, and clean development mechanisms. Ullman et al. propose three priorities to streamline blue carbon projects into offset schemes: (1) targeted research about carbon emissions resulting from ecosystem degradation or destruction; (2) establishment of emissions estimates on the global and national scale for this type of emissions; (3) the promotion of blue carbon in relevant policy forums (Ullman et al., 2013).

As nations pledge substantial funds and support toward climate change mitigation efforts, a substantial proportion of those contributions is expected to come from the private sector. Funding flows from committed industrialized countries have jointly pledged $100 billion to publicly and privately finance the needs of developing countries through investments, carbon market payments, and voluntary funds (Stadelmann et al. 2013). In June 2015, several UN branches met with corporate climate leaders at the Global Compact 15 meeting, where over forty private companies committed to facilitating three business strategies for carbon pricing. The first is to include carbon pricing in long-term business strategies and investments. The second is to advocate for importance of carbon pricing, and finally to increase the feasibility and access of communication mediums for dissemination of progress on pricing criteria (UNGC, 2015).

While large top-down commitments like these may drive actions for innovations in finding low carbon solutions and creating clean and efficient technologies, it places pressures to governments for enacting stronger policies supporting markets, for which some governments are less equipped to implement and maintain. For example, Madagascar's blue carbon interventions and research are largely supported by the NGO Blue Ventures, but the infrastructure within the state's government is not fully equipped to fund long-term conservation projects (Aigrette et al., 2015). While research across the first blue carbon intervention sites have led to a better understanding of the historical and current mangrove area, Madagascar still is working to develop the detailed research required to provide a robust analysis for ecosystem characterization and estimation of carbon stocks for distinct species of mangrove flora (Jones et al., 2014).

Theoretical Underpinnings to Ecosystem Services Valuation

Ecosystems services approaches have been regarded as tools that offer opportunities away from a regime of 'conservation *versus* development' to 'conservation *for* development' (Folke, 2006). Yet, commodification of ecosystem services has been contended for issues regarding the ethical reasons of why certain ecosystem resources and functions or wildlife should have a price for sale. Valuation of ecosystems is one of several components toward commodification, but distinct in that commodification is often accepted by traditional economics as the definition of the packaging of a product or object intended to be traded or sold in markets. Furthermore, an economic framing of the environment to conceptualize ecosystem functions as services is not inherently a form of monetary valuation. As such, assigning an economic value to an object or service does not necessarily equate to commodification (Gomez-Baggenthun et al., 2011).

Valuation is one step towards the process of commodification, for which other components necessary to commodification include complementary institutional structures that allow appropriating ecosystem services to be defined by property rights, and their sale or exchange through an existing market (Gomez-Baggenthun et al., 2010). Many blue carbon interventions around the globe are still in their infancy stages, as are the supporting institutions creating payments for ecosystem services (PES) and either regulatory or voluntary markets. Furthermore, many planning and financing decisions run the risk of prioritizing traditional economic considerations over broader environmental or economic concerns; the commoditization of carbon may then be based on data-poor or incomplete analysis of blue carbon valuation lacking informative interdisciplinary analyses (Thomas, 2014). By integrating economic rationality into ecosystem services, the narrative of human-nature relationships is set within the concepts of efficiency, scarcity and profit. Furthermore, the dangers in assigning monetary values to the environment while managing socio-political relations is that the management and outcomes cannot often be completely neutral (Gomez-Baggenthun et al., 2011). Valuation of blue carbon either independently or nested within other ecosystem services is one of the primary challenges in creating policy that adequately encompasses conservation and blue carbon products for market, while being sensitive to local land tenure rules, rights and uses. Integrating blue carbon in natural systems with human economic structures today runs the risk of failing to acknowledge that there may be consequences and costs to human societies by destroying marine systems (Failler and Pan, 2007; Pendleton et al., 2012).

The first markets for ecosystems were not managed without governance and ecosystem failures. The pioneer markets in the USA formed around coastal wetland ecosystems in the 1990s, based on the terms of the Clean Water Act. The US Army Corps of Engineers handled the protection of wetland functions and created a permit system for any development in wetlands. Permits were often granted with provisions that ordered the applicant to create an equitable amount of wetland function as was destroyed by the permitted development. Unfortunately, this system of wetland creation failed to provide the same quantity and quality of functions as were elsewhere degraded or destroyed. The similarities between the Clean Water Act and Clean Air Act became a solid foundation for the creation of a market for air-pollution credits. The market for air pollution credits was partly a response to the many cases where project-by-project creation sites were failing in the wetland mitigation banking system, and from frustrations that developed due to delays and unstreamlined communication between the US Army Corps and land developers. Entrepreneurs were able to benefit by designating large areas of wetlands for conservation, certified for having a certain number of function-based ‘credits’ that could in turn be sold to developers who held permits from the Army Corps, creating the first wetland mitigation market in ecosystem services (Robertson, 2006).

In terms of wetland conservation integrated to payments for ecosystems services in developing countries, mechanisms such as NAMAs are more aptly designed than are REDD+ mechanisms to integrate coastal ecosystems in developing countries into existing UNFCCC supported financing mechanism and approaches (Herr et al., 2012). Any activity aimed at climate change mitigation may fall under the purview of accepted NAMA initiatives. As such, the opportunities conferred under the purview of NAMAs include the ability for countries to tailor NAMAs to their specific capacity, needs and mitigation potential (Herr et al., 2015). Conservation of wetlands in countries with limited research infrastructure could use NAMAs to improve the understanding of carbon sink capacity in coastal ecosystems and of emissions resulting from degradation (Thomas, 2014). In countries where NAMAs are more fitting approaches to wetlands management, they are often seen as tools that are essential to the inclusion of initiatives to account for global emission sources and sinks (Crooks et al., 2011).

2. Carbon Markets for Blue Carbon Applications

Introduction

This chapter provides an overview of carbon markets and how blue carbon projects can take advantage of them. We outline some general concepts essential to understanding carbon markets, discuss their emergence and current status, and review the available certification schemes and current carbon prices. Finally, we address hurdles for blue carbon projects entering carbon markets.

Regulatory versus Voluntary Markets

Regulatory markets, simply put, are markets created by a governing body. In a regulatory market, the policy design determines which economic sectors will participate in the market. Firms within those sectors must then comply the limits, goals or targets of that policy through the market. Voluntary markets, on the other hand, are markets in which firms choose to participate. Voluntary markets can offer more flexibility in terms of the market approaches used, implementation methodologies, and participating sectors.

Offsets, Leakage and Additionality

The idea of a carbon offset is at the core of any carbon market. An offset is essentially the idea that a given actor can pay for someone else to reduce carbon emissions rather than undertaking those emissions reductions themselves. Offsets are typically used in scenarios where it would be extremely costly or infeasible for a firm to reduce their own emissions further so they purchase offsets, or carbon credits, from another actor. To ensure that allowing the purchase of offsets still achieves the policy goal of reducing carbon emissions, policy makers must ensure that they are "real additional offsets." Two key ideas in establishing this are leakage and additionally.

Leakage is a key concept to any emissions reductions policy or project. Simply put, leakage occurs when rather than reducing emissions, a firm, or the production provided by that firm, moves to a different area. Thus, total emissions stay the same even though they may have been reduced in a particular country, sector, jurisdiction or market. Since greenhouse gases are global pollutants, that is to say their effects are not limited geographically to the area in which they are emitted but rather distributed throughout the globe, leakage negates any emissions reductions achieved in a certain area if those emissions just move elsewhere. So for a carbon market to function, it has to prevent leakage.

Finally, additionality is also essential in establishing a "real additional offset." Additionality is the idea that the offset would not have happened without the incentive provided by the purchaser. Since the goal is emissions reductions, a project that would have occurred without the incentive of the carbon market is not a true reduction. While it is a relatively simple concept, additionality can be quite difficult to demonstrate and the lack of additionality has been a key critique of many carbon offset programs, particularly the Clean Development Mechanism (CDM).

Understanding the requirements for real additional offsets is essential for blue carbon initiatives. Blue carbon projects aim to receive carbon credits as a financial incentive for coastal conservation by offering emissions offsets to firms.

History of Carbon Markets

Using financial mechanisms to reduce carbon emissions is a rapidly growing and evolving practice. For example, from 2012 to 2015 the number of carbon pricing instruments grew by 90% (Kossoy et al. 2015). Carbon pricing mechanisms are principally emissions trading schemes (ETS) and carbon taxes. For Blue Carbon projects emissions trading schemes are the most relevant financial mechanism since they offer the largest offset opportunities. Carbon ETSs are an evolution of traditional ETSs.

1. Traditional Emissions Trading Schemes (ETS)

The seminal work of Adam Smith, *The Invisible Hand*, notes that governments should intervene where markets fail. Environmental externalities, such as those caused by air or water pollution, are a prime example of where markets fail. In response to increasing environmental degradation and a more comprehensive understanding of the relationship between sulfur oxide emissions and acid rain, the U.S. Environmental Protection Agency implemented a cap-and-trade regulatory system under the Clean Air Act in 1977. Cap-and-trade systems are a type of ETS where a sector- or economy-wide cap is placed on the emissions of a given pollutant and the regulated firms can trade pollution allowances among themselves. The policy was widely successful and supported by industry and environmentalists alike (Calel 2011). Depending on the policy design, an ETS can chose to set a cap or a more flexible target. Further, they can allow the purchase of offsets. The individual ETS policy will designate any limitations (e.g. geographic area, temporal scope, methodological requirements etc.) on offsets and needs to provide some sort of record-keeping function.

2. Emissions Trading on an International Scale: From Montreal to Kyoto

Given the success of the use of an ETS in the United States and its industry support, the concept was incorporated into the Montreal Protocol in 1987 (Calel 2013). After CFCs were recognized as an international air pollution problem the international community banded together through the United Nations Environment Program (UNEP) to create the Montreal Protocol (UNEP – Ozone Secretariat 2015a). The Montreal Protocol is widely considered an environmental success story. It was the first multilateral environmental agreement with global participation and by 2015 over 98% of the consumption of ozone depleting substances had been phased out in both developed and developing countries (UNEP – Ozone Secretariat 2015b). Further, it is projected that by 2050 the ozone layer will have returned to natural levels (Barrett 2005). The Montreal Protocol has an international emissions trading provision, the first instance of such a provision. However, the provision was rarely used as the majority of emissions reductions were tackled at a national level (Calel 2011).

Once climate change was recognized as a threat, academics began suggesting an international ETS as a solution (i.e. Victor 1991). As an important note, in 1990 Dudek and LeBanc proposed including forestry offsets in an international ETS to combat climate change. In 1992 the UN Framework Convention on Climate Change (UNFCCC) was created at the UN Conference on Environment and Development in Rio de Janiero, Brazil. The use of an ETS in any international climate change agreement was essentially guaranteed when in 1995 a report from the Intergovernmental Panel on Climate Change (IPCC) stated, "for a global treaty, a tradable quota system is the only potentially cost-effective arrangement where an agreed level of emissions is attained with certainty" (IPCC 1995, p 401). Also in 1995, the UNFCCC implemented a pilot program, Activities Implemented Jointly, to test the international ETS mechanisms that would end up incorporated into the Kyoto Protocol (see Schwarze 2001 for a full analysis). In the late 1990's many companies, such as BP, Shell, Alcoa, Motorola and Waste Management, launched internal ETSs to further support the use of an ETS instead of financial mechanisms they found less favorable, such as a carbon taxes (Calel 2013).

The Kyoto protocol was adopted in December 1997 and entered into force in February 2005 with its first emissions reduction target period from 2008 to 2012 (UNFCCC 2014). The UNFCCC states that the intention was for primarily national measures to meet these targets but they implemented three international mechanisms: 1) International Emissions Trading, 2) the Clean Development Mechanism (CDM), and 3) Joint Implementations (JI) (UNFCC 2004). Four types of units are allowed for trade under the international ETS: 1) actual emissions, 2) Removal units (RMU), which are based on changes in land use and forestry activities such as reforestation, 3) Emissions Reduction Units (ERU) which are generated through JI projects, and 4) Certified Emissions Reductions (CER) where are generated through CDM projects (UNFCCC 2004).

3. Issues with the Kyoto Protocol: A Comparison with the Montreal Protocol

Given the widespread success and multilateral adoption of the Montreal Protocol, it is unsurprising that much of the framework of the Kyoto Protocol closely mirrors the Montreal Protocol. Further, the issues of ozone depletion and climate change share many similarities. As Sunstein (2007) points out, both issues were widely recognized by both the scientific community and the public as posing a significant risk, the emissions for both came from diverse, man-made technologies across the globe, both emissions had long atmospheric lifetimes, unilateral action would be insufficient to solve either problem, there were serious international and intergenerational equity issues associated with both, and, finally, the United States was a crucial actor in both negotiations. Given these similarities, why was the Kyoto Protocol nowhere near as successful as the Montreal Protocol at achieving emissions reductions?

First, although the Montreal Protocol had provisions for international emissions trading, they played a small role in actual emissions reductions (Calel 2011). The vast majority of the reductions in consumption of ozone depleting substances were achieved through national programs (Calel 2011). Further, Calel (2013) argues that international ETSs were not actually an apt policy choice to address climate change but were pushed through by interest groups and public popularity. Sunstein (2007) offers and alternative hypothesis; he argues, somewhat troublingly, that the role of the United States in each protocol allowed for or prohibited its success. The United States was a supporter and one of the driving forces behind the Montreal Protocol whereas it firmly opposed ratification of the Kyoto Protocol and eventually withdrew in 2001 (Sunstein 2007). Sunstein (2007) notes that cost-benefit analyses from the United States' perspective about each policy likely drove their vastly different outlook on the two protocols. For the Montreal Protocol, a cost-benefit analysis showed that even for unilateral action (i.e. the United States reducing consumption of ozone depleting substances without international support) the benefits far outweighed the costs (Barrett 2005). On the other hand, a cost-benefit analysis of implementing the Kyoto protocol showed costs far outweighing benefits (Nordhaus and Boyer 2000). Finally, when designing the Kyoto Protocol, the UNFCCC may not have given sufficient consideration to the substantial administrative burden associated with running and international ETS and who would bear that burden (Calel 2011).

4. Domestic and Regional ETSs

None of the countries where Blue Carbon SSI's are located have domestic, regulatory carbon markets. The United Kingdom and Denmark had some of the first ETSs dedicated to carbon (UNFCCC 2014). Since their establishment, many other ETSs have appeared across a variety of sectors. By far the most well known and most studied is the European Union ETS that was adopted in 2003 and launched in 2005. Additional national and regional ETSs continued to emerge throughout the 2000s across the globe (e.g. New Zealand ETS, Western Climate Initiative, China's sub-national ETSs). Case studies on regional ETSs can be developed should they be useful.

Current State of Carbon Markets

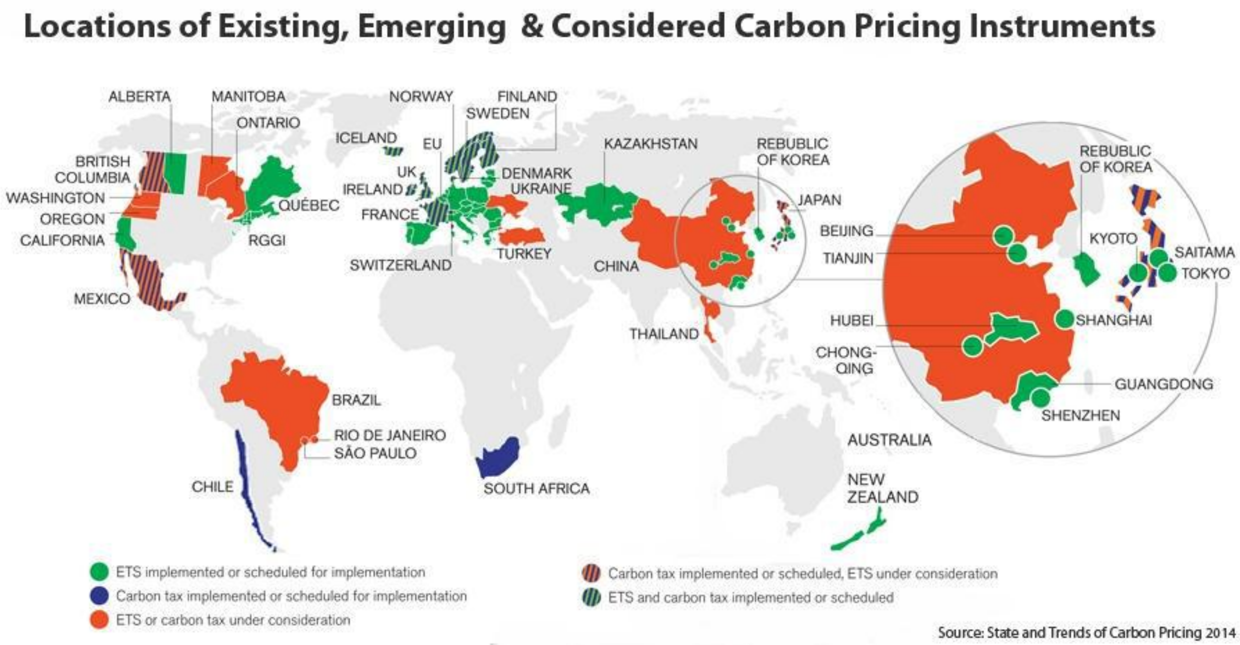

Figure 1. Countries with implemented or planned carbon pricing instruments (ETS and taxes). From *State and Trends of Carbon Pricing* - World Bank, 2015.

The World Bank *State and Trends of Carbon Pricing 2015* provides a detailed look at ETSs, carbon taxes and other new market mechanisms. Below some of their key findings are summarized.

- Market mechanisms have risen from 2 in 1990 to 36 in 2015
- 12% of global greenhouse gas emissions are currently covered under carbon pricing mechanisms. More specifically, 8% are under ETSs.
- ETSs represent US$34 billion as of 2015
- Carbon price varies from US$1 to US$130 per tCO2
- 85% of emissions are priced at less than US$10 per tCO2
- The EU ETS is the largest international carbon pricing mechanism and covers 2 GtCO2
- China has the largest domestic carbon market which is made up of seven pilot regional ETSs, though they are planning on moving to one national ETS
- There is increasing private interest in carbon markets
    - Over 100 companies use internal carbon pricing mechanisms
    - Over 1,000 investors and companies signed a “Put a Price on Carbon Statement”
- None of the countries with Blue Carbon SSIs have domestic markets nor did they submit INDCs prior to the COP in Paris

Carbon project cycle

No matter what type of credit the project decides to pursue, carbon projects largely experience similar certification process, where specific procedures, transparent documentation and close audits are required. The first stages are project identification and documentation. Before project registration, there is a period of over 12 months to properly identify and document the project. After registration with verification bodies and implementation, the project will be monitored the whole time. Subsequently, monitoring reports will be sent to verification bodies. If proved, credits will be issued. These credits can be then sold in the market. In total, it takes about 2 to 3 years for a project to receive its first credit. In terms of transaction costs, most fixed costs occur before project registration. Monitoring is another important source of expense. Overall, fixed costs to pursue carbon finance add up to $90,000, which can be expensive depending on the scale of the project.

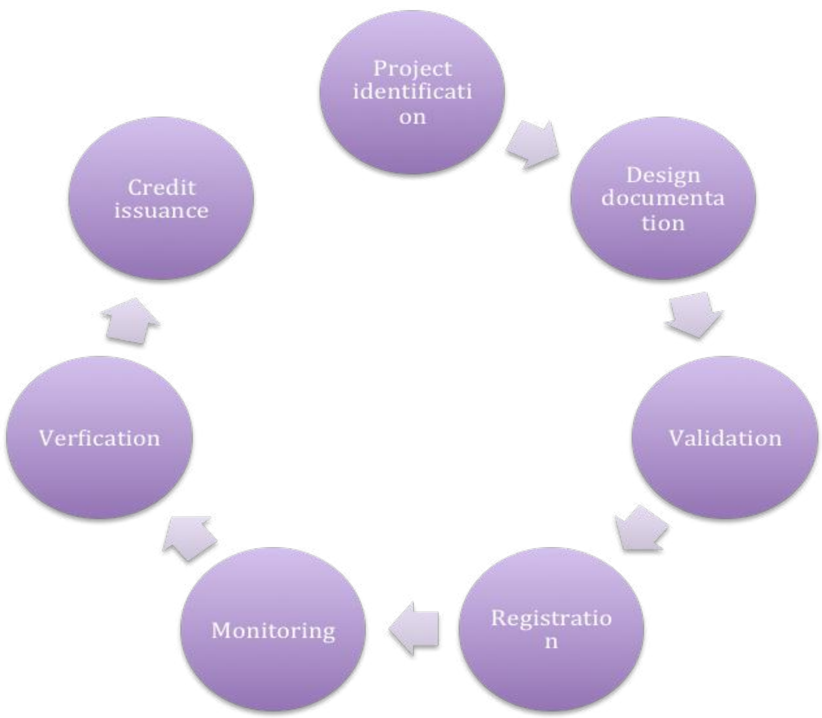

Figure 2. Carbon project cycle

Registration is the step where a project officially enters into a carbon standard. Once a project is in the registry, it becomes eligible for credit trading and crediting. During the entire project lifetime, continuous monitoring is required. The monitoring follows the monitoring plan and tracks the implementation and outcome of the project. After the completion of the monitoring report, it is passed on a third party organization for further verification. The entity will review values of monitored parameter and indicator in the report through site visits. The final step is credit issuance, where the verified amount of carbon credits is approved and issued by the selected standard. Those credits can be sold to brokers in the market, forwards sales contract, or prospective buyers. (GACC)

Certification standard

Certification process is pivotal in carbon finance. The main standards for certifying international carbon credits are:

1. Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM) is a project-based emission reduction and offset system under the Kyoto Protocol. "The scheme aims to assist Annex-I parties (industrialized countries with binding emission reduction targets) to cut global GHG emissions in a more cost-effective manner by allowing them to invest in offset projects in non-Annex I parties (developing countries without binding targets)." (UNFCCC, 2012) Under CDM, projects generate Certified Emission Reduction (CER) units, which can be sold to countries in the schemes.

Under the current CDM, only "the afforestation and reforestation activities of REDD+" are included. This is largely due to concerns over validity and feasibility of other potential activities in the full spectra of REDD+. (O'Sullian et al. 2012) In particular, CDM released its first methodology on "afforestation and reforestation of degraded mangrove habitats" in 2011. (UNFCCC, 2012)

The main criticism about CDM is that there are no "safeguards and performance standards" to help ensure the environmental integrity. The emission trading schemes cannot guarantee that projects would not bring environmental and social harms. Indeed, there is a lack of crucial reforms in procedures such as "technology eligibility assessment" and "sustainable development indicators". (Kollmus and Polycarp 2008) Standards in voluntary markets attempt to solve these issues with stringent requirements for sustainability.

2. Gold Standard (GS)

Gold Standard is a voluntary registry that issues Voluntary Emission Reductions (VER) and Emission Reduction Units (ERU). The Gold Standard has been a leader of innovating methodologies in carbon market, particularly household devices (Hamrick and Goldstein 2015). In order to receive credits issued by GS, projects must display co-benefits generated by activities. These co-benefits include environmental, social and economic benefits, as well as "technological sustainability". (Gold Standard, 2016) The GS provides a sustainability metrics to facilitate project developer in determining their sustainability requirement. The latest version of Gold Standard takes one step further to comprehensively evaluate project impacts in the nexus of climate, energy, and water security.

Gold Standard released its road test version of mangrove afforestation and reforestation guidelines in 2013. However, no mangrove project has received carbon credits from Gold Standard since.

3. Verified Carbon Standard (VCS)

Verified Carbon standard is a voluntary registry that issues Verified Carbon Units (VCU). It focuses on GHG reduction functions only and has no requirement on environmental or social co-benefits. However, it has become increasingly popular for project registered with VCS to pursue additional certifications, such as CCBS and SOCIAL CARBON to receive premium price in the market.

VCS is a leading player in Agriculture, forestry, and Other Land Use (AFOLU) project. It has successfully developed over 10 methodologies for wetland and forestry ecosystems. Two of them are most relevant to blue carbon projects: the “methodology for avoided ecosystem conversion” and the “methodology for tidal wetland and seagrass restoration”. (VCS, 2014) The former outlines a methodology to measure GHG emission reductions from project activities that prevent ecosystem types conversion. (VCS, 2014) While blue carbon is not specified in this methodology, it offers valuable insight into how similar concept can be applicable to our context. The latter provides a means to measure GHG emission reductions from tidal wetland restoration projects. Such projects include “creating or managing the conditions required for healthy, sustainable wetland ecosystems”. (VCS, 2015) This methodology directly addresses benefits generated by blue carbon, such as increase biomass and autochthonous soil organic carbon. And mangrove, salt marsh and seagrass project can all be included under the methodology.

4. Plan Vivo

Plan Vivo is a voluntary registry for land-use projects that work closely with rural smallholders and communities dependent on natural resources for livelihood. Eligible activities include afforestation, forest conservation, restoration and avoided deforestation. The standard aims to serve as an all-inclusive standard incorporating social and biodiversity safeguards along with certified emission reductions. (Plan Vivo)

5. CCBS and Social Carbon

The climate, Community and Biodiversity Standard (CCBS) and Social Carbon are both add-on certificates to projects approved by credit issuance standard. The CCBS identifies land use conservation projects that generate net positive outcomes “for climate change mitigation, for local communities and for biodiversity". Similarly, project developers can establish a baseline using the Social Carbon Standard indicators to point out degrees of sustainability in six resources: "social, human, financial, natural, biodiversity and carbon". (CCBS, 2016) Projects must then demonstrate that there is an improvement along the lifetime of the project in relation to this baseline through Social Carbon monitoring reports, which are independently verified.

According to the results from 2015's voluntary market analysis, projects certified with these additional obtained market price premium. For example, average price of VCS project was sold at $3.3/credit. While projects with CCBS or Social Carbon license traded over 25% more.

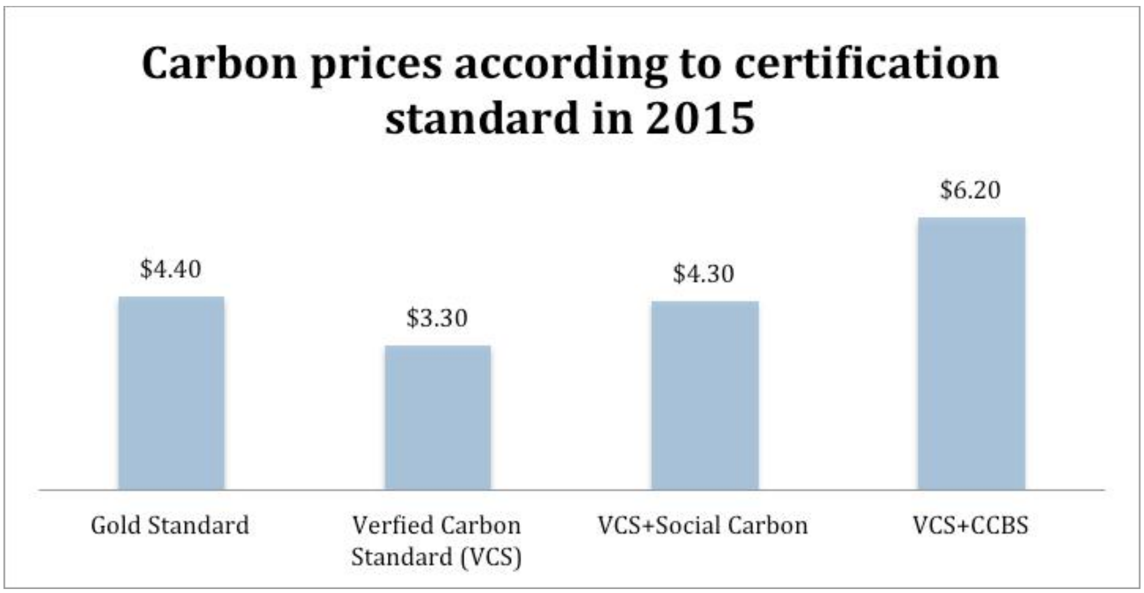

Figure 3: Carbon prices according to certification standard (Hamrick and Goldstein 2015)

Other financing approaches

Apart from standard credit certification process, there are opportunities available in other program and funds. For example, NAMAs are starting to explore ways to incorporating blue carbon projects. Countries are allowed to propose their own mitigation measures and funding mechanisms under NAMAs, which would be promising for blue carbon projects. The pilot mangrove project is planned to implement in Dominican Republic in the coming year. Another option is funding from Green Climate Fund (GCF). This UNFCCC funding mechanism is available for projects with adaptation or mitigation purpose. It can also be viable for certain blue carbon projects to sell offsets to some national or subnational offset program. Additionally, higher mangrove is associated with higher seafood production. Projects can opt to pursue organic certification that raises products to premium price. The shrimp-mangrove farming in

Vietnam is an exemplar case. By conserving mangroves, farmers earned 10% of profit on organic shrimp (Wylie et al. 2016) Last but not the least, to capitalize on the full carbon storage services provided by blue carbon, project should consider bundle three carbon ecosystems together in future project.

Hurdles for carbon financing

The voluntary market is more ideal for small scale projects to leverage carbon financing. However, it is predicted that the voluntary market price will stay low for long (Hamrick and Goldstein 2015). Low carbon price is not likely to make up the increasing costs of project. Additionally, more blue carbon related projects could overflow the market and compete for limited interested buyers. As a result, the price will be driven down further (Wylie et al. 2016).

High transaction costs of certification pose a hurdle for projects, especially for small-scale projects in developing countries. In part, this is because most of fixed costs incur before project registration, while the carbon revenue is can only be obtained after credits are issued and traded in the market (Ellis and Kamel 2007). Figure 8 shows the estimated transaction costs for a carbon project. To cover the transaction costs, a project has to reach a certain scale to generate enough credits. This is particularly challenging for our small-scale intervention partners. Because they tend to have limited fund to initiate the process.

Figure 4: Carbon project cycle cost estimates (GACC)

Carbon certification is likely to take several years. In Vietnam and Madagascar, the length of time and planning required for such process made it difficulty for project developers to continue pursuing carbon credits. The long time framework for carbon certification might stretch the local capacity and turns out to be a less feasible solution to financing. Carbon financing also poses new challenge to capacity building. Projects tended to certify carbon emission reductions without carbon stored within the soil (Wylie et al. 2016), which is "by far the largest carbon pool for all the focal coastal habitats" (Murray et al. 2011). This exclusion prevented those projects from realizing it is full potential. However, in order to account for carbon stored in the soil, it requires more investments in capacity building to conduct measurement and monitoring locally or collaborating with other expertise.

Uncertainty also lies in climate change. 20-foot tidal changes took place during the lifetime of Sundarbans mangrove project (Wylie et al. 2016). It is likely that new blue carbon project may be influenced by future sea level rise. Therefore, it becomes more and more imperative for project developers to take account for climate change impacts. Small-scale interventions lacking of science capacity of interpreting existing data and comprehending projections may not in the best position to secure long-term blue carbon project success.

Conclusion

Blue carbon pilot projects have successfully secured carbon money in the voluntary carbon market. Although the voluntary market only represents a small portion of the carbon market, "the voluntary market is a fertile testing ground" (Hamrick and Goldstein 2015) for new ideas, methods and impacts that could be adopted in the regulatory market. As more countries agree to mitigate and adapt to climate change by reducing carbon emission, the regulatory market is likely to expand and subsequently incorporate more blue carbon projects. Therefore, despite of hurdles and uncertainties, it is still viable for small scale intervention to use carbon finance to fund part of the project.

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