Project Idea Note (PIN)

Project Title:

Restoration of mangroves removed for shrimp farms and firewood in the Gulf of Fonseca, Honduras

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Summary Information

Project Title	Restoration of mangroves removed for shrimp farms and firewood in the Gulf of Fonseca, Honduras
Project Location – Country/Region/District	Departments of Valle and Choluteca, Honduras
Project Coordinator & Contact Details	Dr Tim Coles, rePLANET, Wallace House, Old Bolingbroke, Spilsby, Lincolnshire PE23 4EX
Summary of Proposed Activities (Max 30 words)	To provide financial incentives to local communities to restore and maintain mangroves that have been damaged for firewood collection and smallholder shrimp farming
Summary of Proposed Target Groups (Max 30 words)	Subsistence fishermen and farmers in the SAPZsurH protected area buffer zone and surrounding areas in the Gulf of Fonseca in Southern Honduras

Part A: Project Aims & Objectives

A1) Describe the project's aims and objectives

This Project aims to sequester carbon dioxide while restoring mangrove ecosystems that have been damaged through firewood collection and the development of unproductive smallholder shrimp farms along the Gulf of Fonseca in Southern Honduras. The majority of the land that will be used for this project is a part of the Natural Protected Areas Subsystem of the Southern Zone of Honduras (SAPZsurH), a national park that combines 10 protected areas under a single management plan run by the Honduran Forestry, Protected Areas, and Wildlife Ministry (ICF) and local nonprofit, Comité para la Defensa y Desarrollo de la Flora y Fauna del Golfo de Fonseca (CODDEFFAGOLF). A small portion of the proposed area is in the outskirts of the park, but still on national land and considered to be an important area for maintaining the park's borders. There is significant interest from the government of Honduras in restoring and protecting mangroves along the coast to improve conservation outcomes in the Gulf of Fonseca, bolster fisheries, and protect communities from tropical storms (Fig.1).

The project intends to drive improvements in livelihoods in the region both directly through the reforestation program, as well as with a community development program focused on entrepreneurship and job creation in forestry, ecotourism, and conservation. Some of the polygons selected for this project were previously unproductive "usufructo" land, where communities had the rights to develop land but no resources to do so effectively. The project aims to provide use for this land by engaging the owners in the restoration process, who are eager to see their community land restored to its previous beauty. This process will be overseen by CODDEFFAGOLF and a local laboratory to ensure the reforestation methodology is followed and communities receive sufficient support to replace income lost from firewood sales or shrimp farming.

Figure 1. Unharmed mangrove in the Gulf of Fonseca, Source: CODDEFFAGOLF (2021).

Part B: Proposed Project Area

B1) Description of Project Location

Project Location

This project will be implemented in deforested mangrove locations across five federal protected areas (national land) along the Gulf of Fonseca in Southern Honduras within the Natural Protected Areas Subsystem of the Southern Zone of Honduras (SAPZsurH), specifically in AMHE Bahia de Chismuyo, AMHE Bahia de San Lorenzo, AMHE Los Delgaditos, and AMHE Las Iguanas y Punta Condega, AMHE El Jicarito (Table 1). It also includes a few areas of deforested mangroves within 5 km of each protected area, outside of the park boundaries but still on national land.

As Table 1 shows, the proposed areas comprise a total of 1548 ha, of which we will select 1400 ha for the entire project. The first 700 ha proposed are areas where mangroves were deforested for firewood and abandoned shrimp farms where owners are willing to cede their land in exchange for financial incentives from the project. The following 700 ha, to be selected from the best of the remaining area, will be on land where farmers have 30-year, renewable “usufructo” contracts (see below), some of whom are ready to cede land for project benefits and some whom have been hoping to sell their “usufructo” rights to shrimp farms. However, it is very likely that these waiting farmers will be willing to participate in the project once they see the financial benefits arriving at neighboring communities while the possibility of selling their rights remains uncertain. We will prioritize land within SAPZsurH during the first phase of the project and include some border areas in the second phase.

No	Protected area/Influence zone	No Polygons	Ha	Communities
1	AMHE Bahía de Chismuyo	20	42	Valle Nuevo, Calicanto, El Relleno
2	AMHE Bahía de San Lorenzo	38	123.86	San José de las Conchas, Punta Ratón, Carretales y Botadero.
3	AMHE Iguanas Punta Condega	77	762.69	El Guapinol I , El Guapinol II, Boca de Río Viejo.
4	AMHE Los Delgaditos	28	99.79	Boca de Río Viejo, 3 de febrero, Carretales, Botaderos
5	AMHE El Jicarito	81	519.93	Prados 1, Prado 2, San Jerónimo, El Fantasioso, El Tulito, Teonostal
	Total	**244**	**1548.27**	**20**

Table 1: This table shows the polygons corresponding to 20 communities in the Gulf of Fonseca, Honduras.

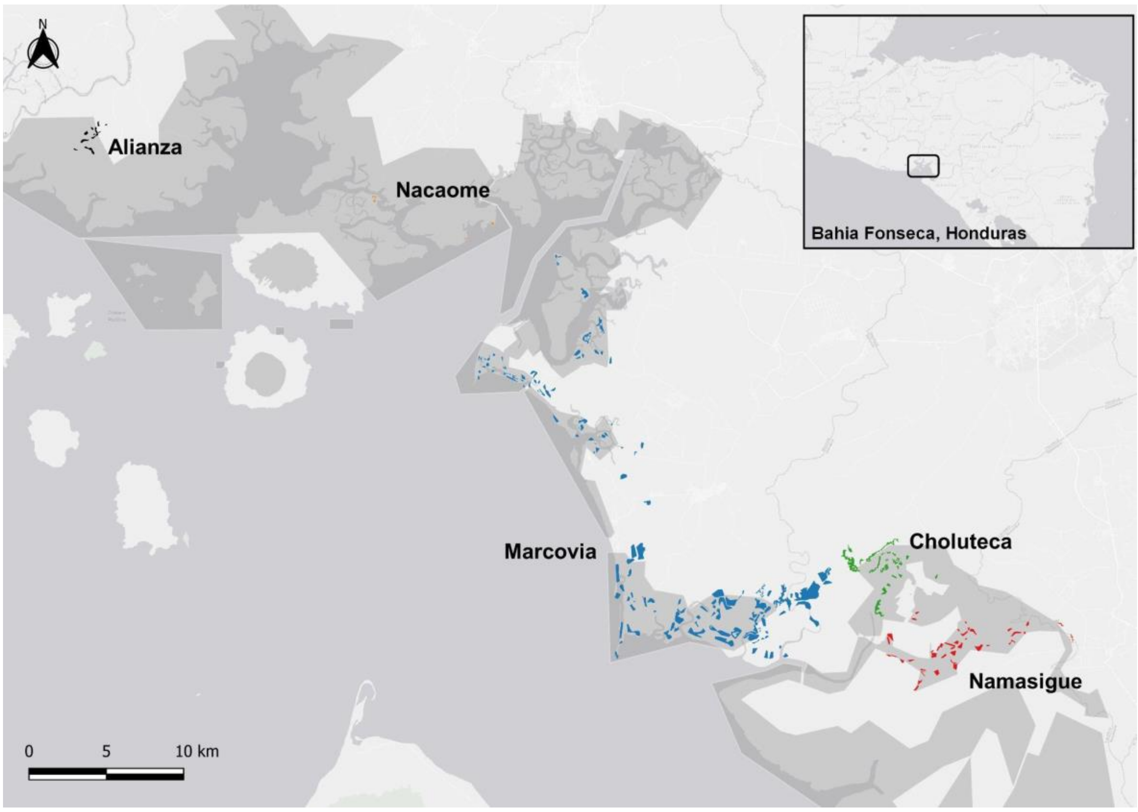

Figure 2: Project sites in the Gulf of Fonseca in Southern Honduras. The gray zones indicate the SAPZsurH protected area, which overlaps with most of the proposed polygons. Black indicates project sites in Alianza municipality, orange indicates project sites in Nacaome municipality, blue indicates projects in Marcovia municipality, green indicates projects in Choluteca municipality, and red indicates projects in Namasigue municipality. Alianza and Nacaome are located in the Valle Department while Marcovia, Choluteca, and Namasigue are within the Choluteca Department.

To visualize the exact locations of our proposed sites within each municipality, please download the map files through this link: Mangrove PIN Honduras.

Identification of legally designated/protected conservation areas adjacent to the project areas

SAPZsurH is co-managed by the National Institute of Forest Conservation and Development, Protected Areas and Wildlife (ICF) and CODDEFFAGOLF, a Honduran NGO created in 1988, who will implement this project (Table 2). Over two-thirds of areas in this proposed project are within SAPZsurH, with a small portion in the outskirts but still on national land that falls under similar regulations. The land outside SAPZsurH has slightly laxer resource use policies but otherwise has the same in ecosystem and legal status.

SAPZsurH is broken into two major areas, the nucleus and buffer zone, which is further divided into several use zones. The nucleus makes up 2.34% of the park and is a strict conservation area, where the only permitted activities are scientific monitoring, species rehabilitation, and maintaining existing infrastructure. The buffer zone makes up 97.66% of the area where local communities can use resources, but these are regulated and broken down into specific zones of extensive (subsistence - 83.36%) and intensive (13.56%) areas, as well as human settlements.

The wetland area of the SAPZsurH area was declared RAMSAR site #1000 in 1999. At the time of declaration, mangroves covered 69,711 ha, within and outside of protected areas; meanwhile a 2014 update found only 33,205 ha of mangroves, representing a 52.36% loss in 16 years, largely due to shrimp farming and hydrological changes for intensive agriculture, as well as firewood collection.

No	Protected Area	Area (Ha)
1	PNM Archipiélago Golfo de Fonseca	4,995
2	AUM Isla del Tigre	589
3	**AMHE Bahía de Chismuyo**	31,616
4	**AMHE San Lorenzo**	15,329
5	**AMHE Los Delgaditos**	1,815
6	**AMHE Las Iguanas y Punta Condega**	4,169
7	**AMHE El Jicarito**	6,919
8	AMHE San Bernardo	9,491
9	AMHE La Bernería	5,691
10	AUM Cerro Guanacaure	1,976
Total		**82,581**

Table 2: The ten protected areas of SAPZsurH. We will be working in the five areas in bold and along the outskirts of each area. **Source: ICF-DAP (2015).**

Physical description of the land, habitat types and land use

The Gulf of Fonseca is a tectonically-formed bay with a flooded coastal indentation formed by land movements associated with faulting and volcanism along the Pacific coastal areas of El Salvador, Nicaragua, and Honduras (Pritchard 1967; Ward and Montague 1996). The geomorphological characteristics of the coastal plain can be classified as a drowned river valley estuary, with extensive interdistributary tidal channels, mud flats, and deltaic-like shoal areas (Pritchard 1967). The Gulf of Fonseca is directly connected to the Pacific Ocean (ca. 30 km in width and 20 m average depth) and contains a coastal area of about 1000 km^2 of estuaries (consisting of mangrove forests, creeks, and tidal flats), islands, and seasonal lagoons (Dewalt et al. 1996) (Table 3). The mangrove forests in the Gulf of Fonseca are particularly wide because of a large tidal range of 2.3 m (Fig. 1) (Vergne et al. 1993).

No	Ecosystem	Area (Ha)	Percentage (%)
1	Shrimp and/or salt production	3,390	4.10
2	Sandy areas with minimal vegetation	4,272	5.17
3	Deciduous lowland shrubs in poor soil, well-drained	463	0.56
4	Pacific mangrove forest (limestone substrate)	38,965	47.18
5	Deciduous lowland tropical broadleaf forests, well-drained, with intervention	1,915	2.32
6	Semi-deciduous sub-montane tropical broadleaf forest	532	0.64
7	Freshwater marsh grasses	135	0.16
8	Semi-closed Pacific estuaries	13,644	16.52
9	Marine areas	7,464	9.04
10	Seasonally flooded swamps	1,042	1.26
11	Short graminoid savanna without woody cover, submontane or montane	1,390	1.68
12	Agricultural areas	9,380	11.36
TOTAL		**82,581**	**100**

Table 3: The ecosystems of the SAPZsurH protected area. **Source: ICF-DAP (2015).**

The Gulf of Fonseca mangrove forests are composed of three families and seven species: RHIZOPHORACEAE with three species *Rhizophora mangle* (Mangle rojo), *R. racemosa* (mangle colorado), *R. harrisoni* (Mangle), AVICENNIACEAE with two species *Avicennia germinans* (Curumo negro), *A. bicolor* (Curumo blanco), and COMBERTACEAE with two species *Laguncularia racemosa* (Angelin) and *Conocarpus erectus* (Botoncillo) (ICF-DAP, 2015).

The structural attributes and zonation patterns of mangrove forests in this area of the Pacific coast of Honduras (intertidal zone of subhumid coastal environments) are mediated closely with tolerance to soil regulators (high soil salinity and hydroperiod) rather than resource availability (nutrients) since the entire evaluated area showed nitrogen: phosphorus atomic ratios of 20 (range: 12.9–14.9), indicative of fertile wetland soils. *Avicennia* spp. occupied areas with higher elevations associated with higher salinities ranging from 80 to 140 g kg^{-1} in the dry season. *Rhizophora* spp. dominated lower elevations where salinities ranged from 38 to 57 g kg^{-1} in both the dry and wet seasons (Castañeda-Moya et. al 2006).

Bhomia et al. (2016) evaluated the blue carbon stocks in various mangrove forest ecosystems in four localities in the Gulf of Fonseca (Bahía de Chismuyo, Islas de Los Pájaros, San Bernardo, and San Lorenzo). The authors follow the methodologies outlined by Kauffman and Donato (2012), which consists of measuring the total carbon stocks derived from standing tree biomass, downed woody debris (deadwood on the forest floor), belowground vegetation mass, and soil (200 cm). In the soil, they found 258 ± 46 Mg C ha^{-1} between 0 and 100 cm and 242 ± 64 Mg C ha^{-1} below 100 cm, downed woody debris 5 ± 2, and trees 70 ± 37 Mg C ha^{-1}. Thus, they determined that in the Gulf of Fonseca, 86.8% of C stock is belowground.

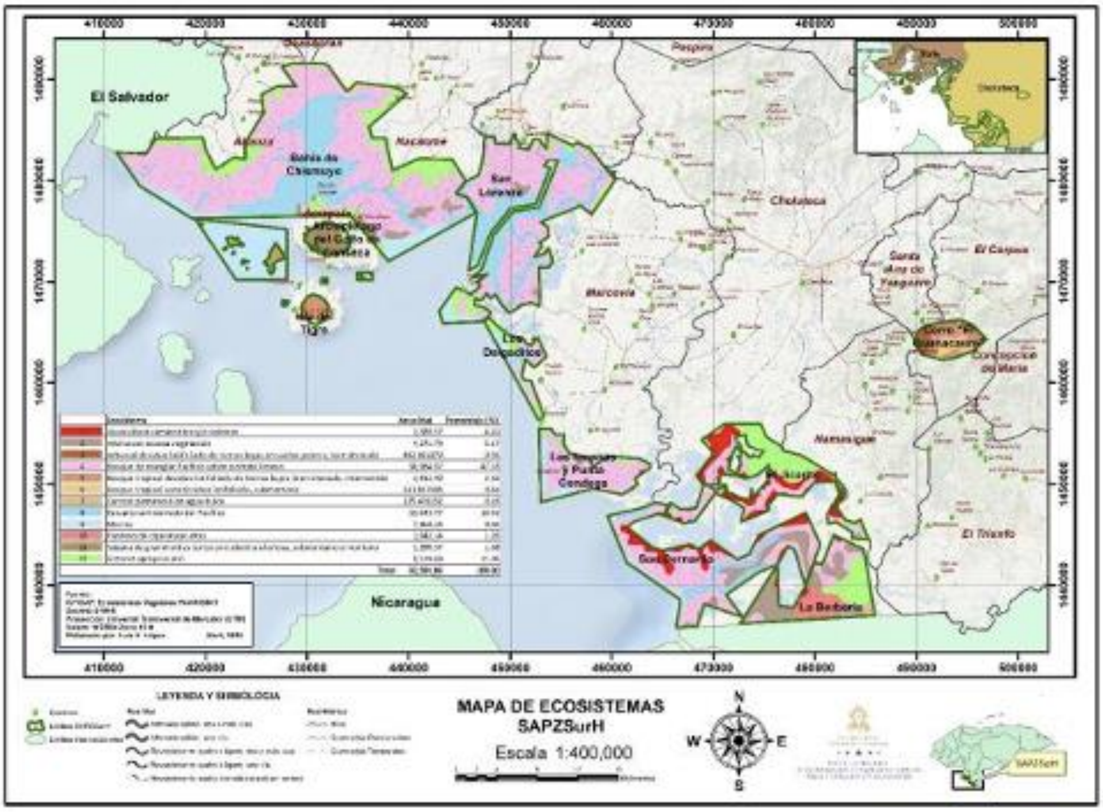

Figure 3: Map of ecosystems within the SAPZsurH protected area. **Source: ICF-DAP (2015).**

Local drivers of deforestation

The main drivers of mangrove deforestation in the Gulf of Fonseca and specifically within the project area are shrimp farming (often incentivized and subsidized by the government), the draining of wetlands for industrial agriculture, and exploitation for firewood, in that order. There is also some damage from hurricanes and other natural disasters, including Hurricane Mitch and some of these areas are included in the project, as well. ICF (2015) estimates that up to 52% of mangrove cover in SAPZsurH has been lost over the past 16 years (1999-2015). Between 1986 and 2011, the mangrove cover in the Gulf of Fonseca as a whole decreased by over 10,800 ha due to expanded shrimp farming. Within SAPZsurH specifically, shrimp farms in the protected area increased from 28.6 ha (0.1% of the area) to 2,248 ha (11.5%) in the same time period (Rico 2013). Furthermore, up to 84% of households in the Municipalities targeted in this PIN depend on firewood for fuel, and therefore a critical aspect of our interventions will be to develop management plans for alternative fuel sources to ensure this project does not cause increased extraction in other areas of the reserve.

Within the buffer zone, there are areas where sustainable mangrove extraction (for firewood or building) is allowed; however, communities are required to follow a management plan that does not destroy large areas of mangroves but this plan has not yet been developed or implemented by the government. Therefore, mangrove extraction is chaotic and disorganized, leaving many areas completely bare. While the bare patches tend to be very small (as small as one-tenth of a hectare) and haphazard, they contribute to overall degradation of the mangrove cover and therefore have been included as a critical part of this project (Fig. 4, Fig. 5, Fig. 6).

In other areas of the buffer zone, communities have been granted 30-year, renewable “usufructo” contracts by the government that provide rights to develop a site on national land as a farm or aquaculture area, or to sell the rights to work the land. Most communities or individuals that receive these contracts do not have the resources to purchase inputs that would enable them to develop the land and traditionally wait to sell it to the highest bidder (usually commercial shrimp farms). However, as shrimp farming has become increasingly controversial in SAPZsurH, many communities who were waiting to sell have become impatient and are looking for alternative sources of income rather than sitting on unproductive land.

Figure 4. A mangrove area cleared for firewood in AMHE Bahia de Chismuyo. Source: CODDEFFAGOLF (2021)

The first 700 ha proposed to be reforested in this project will focus largely on restoring areas that were deforested for firewood, as well as areas of abandoned smallholder shrimp farms that were found to be untenable and completely abandoned, with priority given to communities located within SAPZsurH. The communities who have been using the land selected for the first restoration effort have expressed that they would be interested in receiving payments and benefits to reforest the land rather than waiting for a buyer, as they are proud of their territory and want to restore the ecosystem but do not have the resources to do so alone. The following 700 ha, to be selected from the remaining polygons within and outside the park, will contain additional areas where farmers are willing to cede “usufructo” rights for project benefits.

Figure 5. A mangrove area cleared for firewood in AMHE San Lorenzo. Source: CODDEFFAGOLF (2021)

Figure 6. A mangrove area cleared for firewood in AMHE Los Delgaditos**.** Source: CODDEFFAGOLF (2021)

B2) Description of Socio-Economic Context (PV requirements 7.2.2-7.2.5)

According to 2013 Census data, the National Institute of Statistics (INE) for Honduras considers 67-72% of the population of the communities included in this project to live below the poverty line based on the ECLAC's "unmet basic needs" standard. The main economic activities in the villages targeted in this PIN are fishing and agriculture, both for subsistence and sale.

The SAPZsurH management documents state that a fisherman makes around L. 200-300 per day or US$8.50 - $12.50. A day laborer on an industrial melon, sugar, or shrimp farm might make L. 100-200 or US$6.50-$8.50 per day. However, evidence from field work by CODDEFFAGOLF and Coastal & Marine Research (CMR) demonstrate that it is normal for people to make an average of US$1-2 per day in this region given the unpredictability of work. Since the majority of the Gulf of Fonseca is within the SAPZsurH protected area or classified as national land, most people also have minimal capital assets, as private land is scarce and most boats are purchased on credit (ICF 2015). Furthermore, illiteracy in this region is as high as 22% in people over 15 and up to 75% of people have no education past the sixth grade.

Fishing and farming in the Gulf of Fonseca

The main livelihoods in the villages in this PIN proposal is subsistence/artisanal fishing, smallholder farming, shrimp farming, and mollusc gathering from the mangrove areas. In recent years, fishing has become increasingly untenable in the Gulf of Fonseca due to severe overfishing and many fishermen come home with nothing after a long day of work. However, the communities living along the coast within the SAPZsurH have cultural connections to subsistence fishing, farming, and even harvesting of mangrove firewood and require not only financial incentives, but also education to drive a cultural shift away from practices that harm mangroves.

There has been significant shrimp farming within and around the SAPZsurH protected area, both by individual families and larger private businesses. The Honduran government has historically granted concessions to both large and small-scale shrimp farmers to create aquaculture ponds within Gulf of Fonseca under 30-year, renewable “usufructo” contracts that allow communities or individuals to intensively develop the land; in most cases, “usufructo” contracts are granted to communities rather than individuals in this region. However, CODDEFFAGOLF has found that most community shrimp farmers do not have the financial resources or technical expertise to sustain their farms and end up selling them to the larger companies after a few years. In fact, many families seek out the “usufructo” contracts solely to have rights to sell if a bidder were to appear, but as shrimp farming has become controversial because of its impact on fish stocks and the local environment, many families are looking for other options for generating income from their currently unproductive land. These “usufructo” contracts give communities legal use of the land, but not ownership, within the protected areas but the communities within the selected polygons are currently receiving little to no benefit from managing this land, so have expressed a willingness to discuss financial benefits from reforesting the bare areas.

Relevant local governance structures

Local governance in the Gulf of Fonseca is organized following traditional management structures that represent communities and groups of communities within each District and Municipality. At the village level, each community is run by an official body called a “Patronato,” or community association. All oversight of the local election and management process is done by the municipality where the Patronato is located. While the Patronato is the legal, democratically-elected organization charged with improving the wellbeing and development of each community, villages also often have other political groups that hold power such as Juntas de Agua (Water Management), women’s cooperatives, fishermen's associations and others. These organizations fall under the jurisdiction of the Alcaldia, or mayor, of each village or community and will all be engaged in community consultation and development programs.

Our team will work closely with the Patronato of each village included in the project to identify the most vulnerable community members to participate in the mangrove restoration project and to join in the community development programs. The families selected are those who depend most heavily on the mangrove resources for fuel, such that they can benefit directly from the program. CODDEFFAGOLF is extremely well-connected to the Patronatos as these community associations act as a collective to elect the NGO’s Board of Directors, all of who are delegates representing 11 sub-regions (seccionales) within the SAPZsurH.

Relevant national and sub-national levels of governance structure

At the national level in terms of natural resources and protected areas, the national authorities are:

- Secretariat of Natural Resources and Environment (MiAmbiente +).
- Presidential Office for Climate Change (Clima +).
- National Institute of Forest Conservation and Development, Protected Areas and Wildlife (ICF).
- Aquaculture and Fisheries Ministry (DIGEPESCA).

In the Gulf of Fonseca, MiAmbiente, DIGEPESCA and the ICF have regional offices that contribute to the implementation and monitoring of the Management plans for the SAPZsurH.

Part C: Identification of Target Groups & Communities

C1) Summarise information for the participating communities/groups/individuals expected to benefit from the project (PV requirements 1.1, 7.2.1, 7.2.7 & 7.2.8)

Total population of Choluteca and Valle Departments, which run from the Gulf of Fonseca inland toward Tegucigalpa 626,413 as per 2015 data.

Valle Department

Total population of the Valle Department is around 178,600 as per 2015 data. We will be working with 3 villages in Valle, all located within 5 km of AMHE Bahia de Chismuyo. These villages are split across the municipalities of Nacaome, and Alianza, mentioned below in **Table 4.**

Target villages: Valle Nuevo, Calicanto, El Relleno.

Choluteca Department

Total population of Choluteca Department is around 447,900 as per 2015 data. We will be working with 17 villages in Choluteca, all located within 3 km of AMHE Bahia de San Lorenzo, AMHE Los Delgaditos, AMHE Las Iguanas y Punta Condega or AMHE El Jicarito. These villages are all located in the Marcovia, Choluteca, and Namasigue municipalities.

Target villages: San José de las Conchas, Punta Ratón, Carretales, Botadero, El Guapinol I, El Guapinol II, El Ojochal, Boca de Río Viejo, 3 de febrero, Carretales, Botaderos, Prados 1, Prado 2, San Jerónimo, El Fantasioso, El Tulito, Teonostal

Poverty Indicators

Department	Municipality	H% below NBI	Families below NBI	H% with no access to running water	H% using wood as main cooking fuel	H% with no access to bathroom facilities	% with <6 yrs education
	Nacaome	68.6%	8472	26.6%	78.5%	17.4%	77.5%
Valle	Alianza	35.7%	677	15%	81.1%	15%	78.4%
	Marcovia	68.2%	6689	23.2%	83.9%	11.8%	81.1%
	Namasigue	32%	1947	39.1%	95.5%	18.5%	87.3%
Choluteca	Choluteca	43.3%	14,523	15.8%	57.7%	7.2%	67.1%

Table 4: Indicators of poverty in the target villages in the Gulf of Fonseca. H% represents the percentage of households in the municipality. % represents the percentage of the total population in the municipality. NBI stands for Unmet Basic Needs (Necesidades Básicas Insatisfechas), a definition of poverty used by the UN Economic Commission for Latin America and the Caribbean (ECLAC).

Sources: Marcovia Poverty 2013, Alianza Poverty 2013, Nacaome Poverty 2013, Namasigue Poverty 2013, Choluteca Poverty 2013

We will be working in 20 villages across the Nacaome and Alianza Municipalities in Valle Department and Choluteca, Marcovia and Namasigue Municipalities in Choluteca Department. Approximately 1000 families have been selected to participate in the reforestation and restoration projects. Family size in Honduras averages at six people, so the total number of people directly involved in the reforestation process is estimated at a little over 5000, spread across the Valle and Choluteca departments.

The demographics of each of these areas are fairly homogeneous, with >98% of the population of the villages in these municipalities identifying as Honduran or mestizo. While the villages are not marginalized ethnic groups, these departments and municipalities make up some of the poorest communities in the country. Educational attainment in these regions is extremely low, with >75% of the population achieving fewer than 6 years of formal education. The illiteracy rate in these three municipalities sits at an average of 22.7%. Many students stop studying at an early age in order to work or because there is no secondary school nearby and families cannot afford to send their children to another village to complete their education. >70% of the population in these municipalities is unemployed or underemployed, most having never entered the formal employment sector.

Gender and age equity

The direct participants in the reforestation project will be invited to participate based on their families' dependence on the mangrove resources, mostly for firewood and food collection. The involvement of households rather than individuals ensures a diverse distribution of age and gender among participants. Furthermore, family representatives will be selected to represent the current gender demographics in Honduras, with women making up at least 52% of total project participants who will be managing the funds received from the project.

Furthermore, CODDEFFAGOLF created an Institutional Gender Equity Strategy (EIEG) for 2019-2023 that demonstrates a commitment to prioritizing the involvement of women and girls in community development projects including capacity-building and reforestation opportunities to grow their capacity to lead within local communities. Including women in resource management in the SAPZsurH protected areas is among CODDEFFAGOLF's top priorities for this project.

Part D: Land Tenure & Carbon/ES Rights

D1) Describe the land tenure context and current understanding of carbon/ES rights for the project area(s) (PV requirements 1.1 & 1.2)

All of the land in the SAPZsurH and surrounding coastal areas is considered national territory and is co-managed by ICF and CODDEFFAGOLF. ICF has the legal mandate to directly manage protected areas in Honduras or to develop co-management mechanisms, as they have in SAPZsurH with CODDEFFAGOLF. CODDEFFAGOLF has the endorsement of ICF and the Environmental Municipal Units (UMA's), as well as community and individual contracts to ensure the environmental sustainability of SAPZsurH and its surrounding areas, including the project areas. ICF has also approved the use of the land identified for this project, both within and outside the park, for mangrove restoration for the voluntary carbon market (Appendix 1).

While there is no privately-owned land within the proposed project area, there are government concessions for shrimp aquaculture and industrial farming that are designated as “usufructo” or sustainable individual use contracts. As mentioned above, many of these “usufructo” contracts have been granted to small communities who do not have the inputs to successfully develop shrimp farms and most have been abandoned. Some families hope to hold onto this land and sell it to commercial shrimp farms but in discussions with these communities, they have expressed interest in reforesting their “usufructo” land in exchange for community development initiatives that provide more secure and consistent income.

This project will focus on reforesting two main land tenure areas, listed below in order of priority.

1. **National Land, deforested for firewood:** The firewood deforested land lies outside of “usufructo” claims and is therefore the easiest and least expensive to reforest. All of the firewood deforested land in the project will be a part of the first 700 ha to be reforested and will be prioritized over other land tenure types.

2. **Ceded usufructo land, deforested for farming/aquaculture:** The second priority, which will make up a part of the first 700 ha after all firewood land has been targeted, as well as the majority of the second 700 ha, is “usufructo” land that communities have been willing to cede to the project in order to receive the financial benefits of community development. These families will forgo the potential (but uncertain) income from selling their land by offering to reforest the area following negotiations with CODDEFFAGOLF.

Carbon rights

ICF is the organization charged with updating and recording Honduras’ carbon inventories for eventual inclusion in the country’s Nationally Determined Contributions (NDCs) as defined in the Paris Agreement in 2015. Given ICF is also the co-manager of all the areas where our reforestation project will take place, this government body also issues the carbon rights for the national land in the Gulf of Fonseca.

ICF has declared that there are currently no blue carbon stocks recorded in Honduras’ NDCs and that the polygons selected for reforestation by rePLANET and CODDEFFAGOLF will not be included in the NDC map when it is created as they will be sold on the voluntary market (see Appendix 1). As the co-manager of the protected areas, CODDEFFAGOLF has received a memorandum of understanding from ICF that states that the areas addressed in this project may not be declared in the Honduras NDC for at least the next 25 years and that ICF will enable CODDEFFAGOLF to register the credits on the voluntary market when they are available. These projects may also be used as an example of blue carbon reforestation and carbon credits in Honduras to stimulate additional private funding to the region.

Part E: Project Interventions & Activities

E1) Describe the types of interventions included in the project and envisaged to generate PV Certificates (PV requirements 2.1.1-2.1.4), e.g.:

The polygons located on firewood deforested land will be reforested by teams of local community members from the villages (with a focus on the most vulnerable families that depend on these resources) within a 3-5 km radius of each polygon. In the case of “usufructo” land, communities and individuals who would otherwise depend on that land financially for the sale of firewood or other economic activities will be the ones selected to participate in restoration activities and other community development plans described below in order to replace the previous income.

CODDEFFAGOLF, ICF, and BMZ (German development bank) have created a Gulf of Fonseca mangrove restoration manual that provides a methodology that has proven successful in past restoration efforts in the Gulf of Fonseca and will use this guide to train teams and carry out the restoration. Throughout the process, CODDEFFAGOLF will hold workshops in the communities with the selected families in order to train them to participate in the restoration activities. Furthermore, all restoration activities will be overseen by CODDEFFAGOLF and audited periodically by CMR to ensure successful implementation.

Propagules will be selected from nearby, undamaged mangrove areas and will include a representative diversity of mangrove species to ensure the species planted are best-suited to their ecosystem (Bocanegra 2018). The teams will be educated to recognize physiologically mature propagules (40-50 cm long) from young mangroves that are free of parasitic plants, fungi, and pests and with no physical damage. These propagules will be transplanted within small plastic containers to the predetermined restoration site within one of the polygons and planted.

Restoration will only take place in areas where natural recolonization would not happen due to the extent of the damage. Teams will be trained to plant mangroves at a natural density and to plant a diversity of species to mimic natural ecosystems. Communities will be involved in every step of the process, from propagule collection to monitoring to ensure local communities benefit from the mangrove restoration project.

After the mangroves have been planted, CODDEFFAGOLF teams will visit the areas monthly and measure the percentage of viability of transplanted plants; any dead plants will be replaced. Monitoring will also require use of satellite imagery and local communities will also be trained to visit and photograph sites to aid in monitoring of remote locations.

Appendix 2 contains a proposed methodology for more accurately predicting carbon sequestration levels in mangroves to be used for carbon accounting for the purposes of this project.

Community Benefits

The program described above will result in an increase in mangrove cover adjacent to local villages, boosting community resilience to tropical storms, improving fishing and harvesting within and adjacent to mangroves, as well as enhancing opportunities for ecotourism along the Gulf of Fonseca. Communities will also receive financial benefits in the form of business development programs (see below), paid roles as rangers and mangrove monitors, and job creation through the process of restoration and protection of the new mangrove areas. CODDEFFAGOLF has made an effort to identify the most vulnerable families in each community who depend heavily on mangrove resources (shrimp farmers, firewood salespeople, fishermen etc) to ensure they are directly involved in the process and benefits of restoration.

Part F: Identification of Any Non-Eligible Activities

F1) Describe any additional activities to be supported or implemented by the project

All the villages involved in this project have long-term working relationships with CODDEFFAGOLF, who have implemented a number of community development initiatives in these areas over the past 30 years. Specifically for this project, CODDEFFAGOLF will use the community investment funds remaining after the restoration process is complete for programs that directly address the main community-level threats to mangroves in and around the SAPZsurH protected area by working to replace the income that families have come to expect from exploiting mangroves and the surrounding ecosystems. Furthermore, in order to convince “usufructo” tenants to participate in the project, community benefits will be weighted toward the first five years of the project to demonstrate the direct quality of life improvement that can be gained from cooperation with reforestation efforts.

Community Development Focus Areas

Slowing the expansion of shrimp farming

One of the biggest threats to mangroves near these communities is the expansion of small farms or shrimp ponds that operate at low productivity levels. This expansion can happen in two ways: a) communities with “usufructo” land can try to develop the land themselves, with low rates of success; or b) they can try to sell “usufructo” land or abandoned shrimp ponds to commercial shrimp operations. In both cases, sufficient income must be generated from reforestation to demonstrate to community members that this project is a better business decision than traditional farming. A part of CODDEFFAGOLF’s community development program will be to build community capacity to become trained and paid rangers within the SAPZsurH reserve. This opportunity will support a small portion of the population so additional funds will be used to expand existing programs that train community members through a series of workshops to conceive and develop business solutions to local problems. The idea will be to create and invest in one or several community businesses that create jobs and income without extracting mangroves. Community members have expressed a particular interest in engaging young people in these programs to combat brain drain as many young Hondurans from this area travel to cities, or even to other countries, such as the United States, in search of opportunities.

Firewood collection

The collection of firewood (live trees and deadwood) in and around SAPZsurH is legal in certain areas and under a sustainable management plan that has not yet been implemented, leading to widespread destruction of mangrove cover. The harvest and sale of mangrove wood is not only a significant economic driver in this area, but is also a cultural facet of the region as mangrove wood is the preferred firewood even up into the interior of the Departments included in this proposed project. Up to 80% of families in the target areas depend on firewood for cooking, which is predominantly, though not exclusively, mangrove wood. In order to reduce pressures on mangroves from firewood collection, CODDEFFAGOLF is developing programs to target both the supply and demand sides of this issue by replacing the income from firewood sale, as well as providing alternative fuels for cooking. Based on previous experience, new cooking methods such as solar or efficient stoves have not been well-accepted in this region due to the ease of collection of mangrove wood. Therefore, the following solutions will be implemented and tested across the communities: a) new “usufructo” contracts in which communities can harvest and sell deadwood in return for the responsibility to care for the living mangroves, monitored by CODDEFFAGOLF, b) small fast-growing wood plantations on abandoned farmland not suitable for mangrove planting that hire ex-firewood sellers, and c) innovation competitions (hackathons) to develop community-led solutions to sustainable cooking fuels/systems to replace mangrove wood. It will be important to develop clear metrics for success for these programs to scale the best programs and ensure firewood pressures do not shift to other areas of the reserve.

All activities funded from the community development funds would require that women form at least 50% of attendees and that the most vulnerable community members in each village are included. Beyond the economic development programs, CODDEFFAGOLF will also work on mass educational programs and community exchanges that enable villages located far from restoration areas (especially those with “usufructo” land) to perceive the benefits of cooperating with reforestation efforts.

Part G: Long-Term Sustainability Drivers

G1) Description of project design that will ensure the project is self-sustaining after carbon/PES revenues cease

As a co-manager of the SAPZsurH protected areas and surrounding national land, CODDEFFAGOLF is committed to maintaining the mangroves in the restored area in perpetuity. At the end of the 25-year period, the mangroves will still not be at their maximum carbon storage. There will still be additional growth in Above Ground Biomass (AGB) and Below Ground Biomass (BGB) and sequestration in the sediment will continue. The proposal would be for CODDEFFAGOLF to submit a second project to Plan Vivo for the years 25 – 50 and the credits would be directly sold from CODDEFFAGOLF to the market at a higher rate, since these would be much fewer than for the original proposal. This would provide ongoing income for the project to continue with community development projects and protection of the mangroves.

The restored area should provide significant economic benefits for the communities through improved fish and seafood stocks, protection from natural disasters (coastal storms), and opportunities for ecotourism and other small businesses to be funded by the CODDEFFAGOLF entrepreneurship programs. Several communities involved in this project already have small ecotourism projects, which will be bolstered by the existence of healthy mangroves and additional investment from community development funds.

Furthermore, the continuing work with the communities on education about the value of the mangrove and the development of small businesses or community facilities over the 25 years from the mangrove generated income, should by then have changed attitudes in the local communities towards protecting mangroves. In addition, the Opwall funded biodiversity surveys in the reforested areas will produce some income for the communities from the scientists and students who will be based in their areas for short periods every five years to gather the data required. These surveys will continue long after the first 25-year project has finished.

Part H: Application Organisation & Proposed Governance Structure

H1) Project Organisational Structure (PV requirements 3.1-3.6)

The key collaboration in the project will be between CMR and CODDEFFAGOLF, who will jointly implement the project, and rePLANET who will provide the finance and funding.

Coastal & Marine Research Honduras (CMR)

Coastal & Marine Research (CMR) was founded as a coastal research and conservation organization under the name of Investigaciones Ecológicas del

Caribe (Caribbean Ecological Research) in 2008. The organization specializes in monitoring and management of coastal and marine ecosystems, including developing protocols for biodiversity monitoring across Central America. In 2020, the organization expanded to include a coastal research laboratory with the mission of providing science-based conservation project management services to governments, NGOs, and other organizations to ensure the holistic management of coastal and marine ecosystems. Since 2008, CMR have been regional leaders in science-driven project management on Honduran coastlines.

CMR will be the main organisation on the ground providing monthly reports, auditing the finances, checking on progress and helping resolve any problems that arise for CODDEFFAGOLF. CMR will also support the fulfilment of project objectives, in addition to helping to obtain the carbon credit rights issued before the start of the project and with the extraction and analysis of carbon from cores necessary before the beginning of the project. They will be the primary liaison organization with Plan Vivo and rePLANET auditors.

Director - Juan Carlos Carrasco

Juan Carlos is the Director of Coastal & Marine Research. He is an oceanographer and biogeochemist who is currently the scientific point person for the Convention on Wetlands (RAMSAR) in Honduras, which allows him to work closely with the government. He has worked with several NGOs to manage protected areas, including as Director of a Coastal Marine National Park and Director of the Honduran Ecological Network for Sustainable Development. Juan Carlos also has significant experience in the technical and financial administration of socio-environmental projects, and he has executed more than 20 projects for the government and international organizations in Honduras and Central America.

Deputy Director of Climate and Green Economy Programs - Carolina Montalván

Carol is a biologist who runs the Climate and Green Economy programs for Coastal and Marine Research with a Master's degree in Climate Change and Green Economics. With extensive experience in coordinating national, local, and community groups around Natural Resources and Wetlands of Honduras, Carolina worked in the National Biodiversity Directorate of the Ministry of the Environment of Honduras and was the National Focal Point for the Convention on Wetlands (RAMSAR), Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES), and the Scientific Focal Point of Honduras of the Inter-American Convention for the Protection of Sea Turtles (CIT). She has worked with national and international organizations, as well as local stakeholders in Honduras and is experienced in bridging the gap between work on the ground and international funders.

CODDEFFAGOLF

CODDEFFAGOLF is a Honduran non-profit established in 1988 by a group of fishermen from the Gulf of Fonseca who were concerned about the social and environmental consequences of the expanding shrimp farming industry in the region. The non-profit is active in the regions of Valle and Choluteca in Southern Honduras where they work on projects in mangrove reforestation, coral restoration, local entrepreneurship, environmental education, and women's empowerment. CODDEFFAGOLF's long-term projects in the Gulf of Fonseca and experience in replanting mangroves ensure the successful implementation of the project over the 25 year period. The CODDEFFAGOLF team (Fig. 7) has been operating in Southern Honduras for over 30 years, including in projects to reforest over 1200 ha of mangroves.

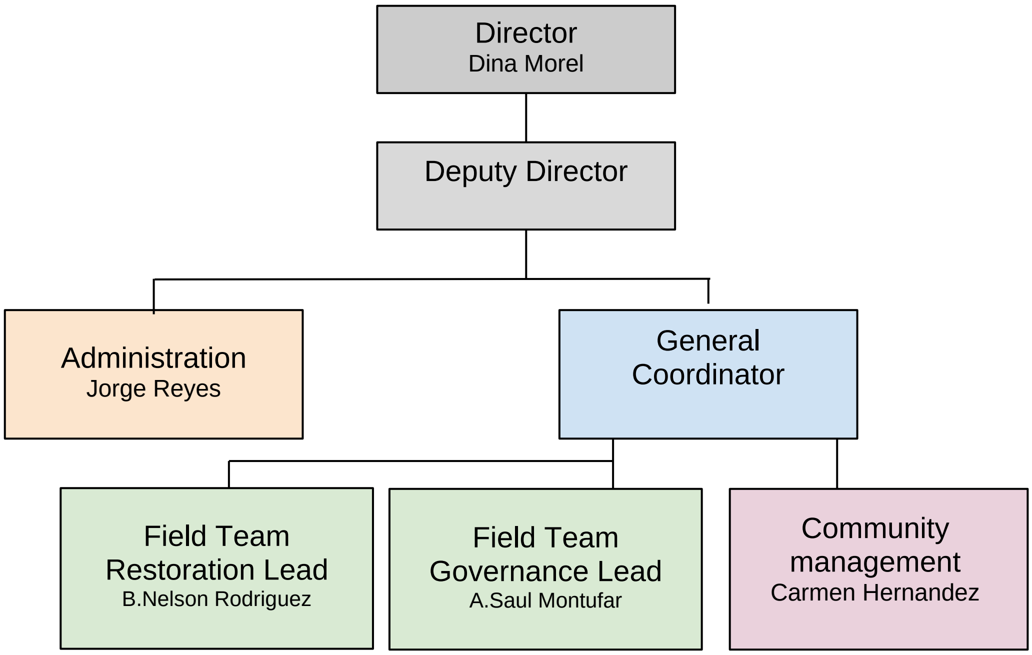

Figure 7: Management structure of CODDEFFAGOLF, with emphasis on the partners who will work directly with rePLANET.

Executive Director - Dina Elizabeth Morel Carbajal

Dina is an economist with over 30 years' experience designing, implementing, and monitoring sustainable development and conservation projects in Honduras. Dina oversees the planning and implementation of all of CODDEFFAGOLF's strategic projects and has significant experience managing mangrove reforestation in the Gulf of Fonseca specifically. She has extensive knowledge about the laws, rules, and regulations that protect the SAPZsurH area and is an experienced lobbyist used to working alongside the Honduran government as well as with local community governance structures. Dina has the skills to lead and manage the CODDEFFAGOLF team while ensuring that all development plans are appropriate for the local context and accepted by government officials in Tegucigalpa.

Deputy Director - Roger Armando Reyes Fortin

Roger is an agricultural engineer with over 20 years of experience designing and implementing strategic plans for civil society organizations in the Gulf of Fonseca. Roger's expertise lies in managing technical teams around a common goal and preparing reports for outside stakeholders, including funders, to communicate results. He also plays a key role in developing sustainable agriculture plans for CODDEFFAGOLF communities to support communities in protecting local resources such as mangroves.

Environmental Programs and Protected Areas Coordinator - Jorge Luis Reyes Rueda

Jorge is an agronomist with over five years of experience managing natural resources in the SAPZsurH protected area. He has also worked in developing entrepreneurship projects in parallel with mangrove restoration in the Gulf of Fonseca and will therefore play a key role in implementing the planting and development projects on the ground. He is well-known in the communities where the project will be implemented and can therefore help collect relevant socioeconomic and environmental data for monitoring.

Biological Monitoring Programme - Nelson Natanael Rodriguez Aguilar

Nelson is a biologist with 12 years of experience monitoring natural resources in protected areas throughout Honduras. He plays a key role in identifying areas for restoration and working alongside Juan Carlos (CMR) to develop reforestation plans that optimize the improvement of the Gulf of Fonseca coastline. Nelson is a skilled scientific communicator and will develop community management guidelines and educational materials to support the protection of the new mangrove forests, as well as training rangers to monitor and protect the areas.

Economic Development Coordinator - Jose Ely Gutierrez Fuentez

Jose has over 15 years' experience in implementing economic development projects within Honduran protected areas. He is well versed in local regulations and understands how to leverage international capital to develop and maintain long-term economic development programs in rural communities.

Community Liaison - Saul Antonio Montufar

Saul is an experienced community organizer with 25 years' experience supporting reforestation and conservation efforts in communities throughout the Gulf of Fonseca. His role focuses on translating CODDEFFAGOLF plans into actionable programs on the ground in partnership with local communities, as well as capacity-building to help communities conserve mangroves. He is also experienced in environmental conflict revolution in the Gulf of Fonseca and mass media communication about the importance of environmental projects in Honduras.

Environmental Justice & Gender Equity Lead - Carmen Cecilia Hernandez Vidal

Carmen has worked for five years to help community organizations develop action plans around justice, climate, and gender equity. She is a key actor in developing development plans that support the economic sovereignty of women and understands how to develop methodologies that fit local cultural norms to improve outcomes for women in development projects. She will ensure that all development projects associated with the reforestation areas will be used to empower women and other marginalized groups.

In addition, CODDEFFAGOLF has three experienced accountants who will manage the administrative and financial paperwork associated with the project. These team members are responsible for developing financial reports, ensuring local partners comply with tax and legal regulations, and helping with office management, purchasing, payroll, and other administrative tasks.

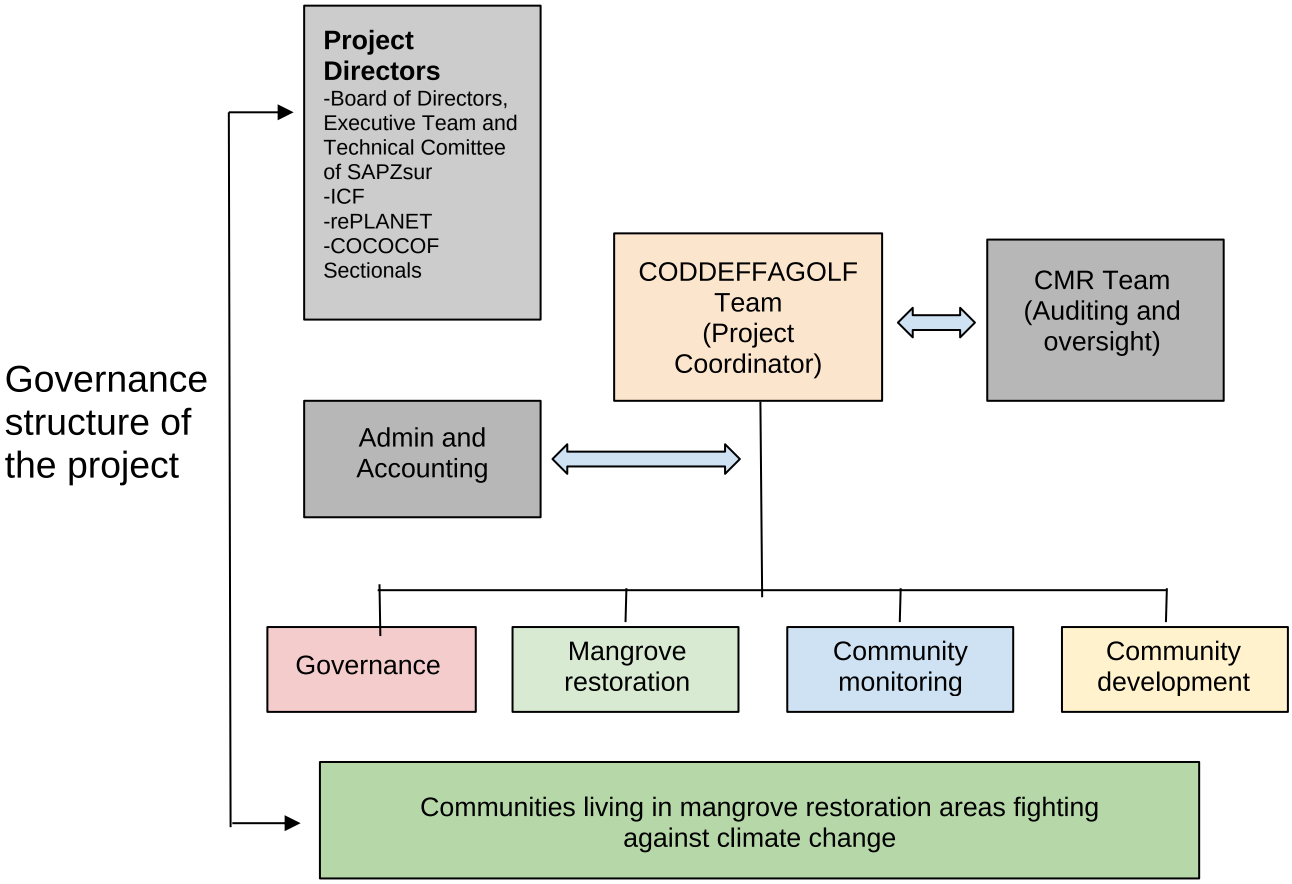

Figure 8: The overall governance structure of the project.

H2) Applicant organisation (not necessarily the project coordinator) must provide the following information about itself

The applicant organisation for delivery of the project in Honduras and receipt of the carbon credits will be CODDEFFAGOLF (see above). Coastal & Marine Research will act as the in-country managers for rePLANET on the project, working alongside CODDEFFAGOLF to ensure that projects remain on schedule and on budget.

The funding for the PIN and responsibility for future funding of the project is from a newly formed UK company (company number 13335875) called rePLANET . The purpose of this new company is to fund the development of mangrove restoration around the world using private sector funding via the voluntary carbon markets. The company has invested in the development of PINs in several countries including Honduras, Indonesia, Mexico and Guyana.

Funding to implement the projects will be generated from the sale of carbon credits to companies that have Net Zero Carbon targets. rePLANET as part of their Memorandum and Articles have agreed to not distribute any dividends for at least the first 3 years so that any profits generated will be focussed on funding additional reforestation projects with at least 60% of all funding for each project supported targeted at supporting impoverished local communities in developing countries.

The Directors of rePLANET bring the following relevant skills and experience to rePLANET:

Dr Mathis Wackernagel

Mathis is the award winning co-creator of the Ecological Footprint Group. See https://replanet.org.uk/key-staff/

Louis de Montpellier

Louis has extensive experience in international finance with senior roles in both public finance and the investment banking world. See https://replanet.org.uk/key-staff/#louisdemontpellier

Bernard Yong

Bernard is a corporate strategist with experience in engaging policy and driving growth in emerging markets. See https://replanet.org.uk/key-staff/#bernardyong

Isabel Hoffman

Isabel specialises enabling businesses to include the value of natural, social and human capital in their decision-making. She leads the work on oceans at the Capitals Coalition. See https://replanet.org.uk/key-staff/#isabelhoffmann

Dr Tim Coles O.B.E.

Tim founded and is CEO of Operation Wallacea that provides a method for funding long term biodiversity research in developing nations using tuition fees paid by students. See https://replanet.org.uk/key-staff/#timcoles

Alex Tozer

Alex is Chief Operations Officer for Operation Wallacea and specialises in resource allocation, financial management and project appraisal. See https://replanet.org.uk/key-staff/#alextozer

In addition to these two principal organisations there are three others that will provide support for the project:

Oxford University Long-term Ecology Lab

This organisation is expert at handling large data sets and developing databases and visualisation of these data sets. They have previously developed schemes to help identify the areas to minimise impacts on biodiversity (LEFT) and also to quantify ecosystem services. Their role will be to develop an online database that will contain data on each of the hectares in the scheme and which can be publicly accessed by stakeholders and interested parties online. This is to provide greater transparency of the project than can be achieved from 5-yearly audits and means that any purchaser of credits can be identified as the owner on the relevant website page for each of their hectares and they can monitor progress for themselves.

Operation Wallacea

Operation Wallacea runs annual biodiversity research in Honduras each June – August period using international and national academics funded by the tuition fees paid by the accompanying students. On a bi-annual basis some of these teams will be diverted to collect biodiversity data from the Gulf of Fonseca. These data will be provided free of charge to the project each year by the Opwall teams.

Wallacea Trust

This is a UK registered charity that supports the development of business solutions to environmental challenges and has a strong group of Trustees drawn from academic, business and NGO backgrounds. Their role will be to act as auditors on a quarterly basis by interviewing the rePLANET staff member responsible for the project to identify any weak spots in the project and advise on how to resolve any issues identified.

Part I: Community-Led Design Plan

I1) Submit a plan for achieving community participation in the project, including a mechanism for ongoing consultation with target groups and producers (PV requirement 4.1)

As co-manager of the SAPZsurH protected areas and its surrounding lands, CODDEFFAGOLF subscribes to the national protocols for mangroves restoration and reforestation, which requires community involvement in organization, training and monitoring of the entire project. All natural resource management projects must begin with a contract designed through an established process for community consultation on conservation called Community Forest Consultation (COCOCOF) developed by ICF and the Municipal Environmental Authorities (UMAs). Following the COCOCOF process, CODDEFFAGOLF field teams have visited every village involved in the project and identified that most communities depend on the mangrove forests for firewood, as well as for molluscs, fisheries, and as a potential income source from future aquaculture or sale of "usufructo" rights. During these visits, it was noted that even people from communities located far from the coastline visit the mangroves to extract wood or other resources, which spurred CODDEFFAGOLF to widen the radius of potential beneficiaries from the project to villages within 3 - 5 km of each polygon.

The community meetings during site visits to the polygons also revealed that, although firewood collection was a major cause of mangrove degradation in the Gulf of Fonseca, smallholder agriculture and shrimp farming was actually causing the most damage. Many people also expressed concern for the falling fish stocks and there was recognition that this was related to the loss of mangroves, as well as local dependence on these resources. These findings have informed CODDEFFAGOLF's two-fold approach to community engagement for reforestation that focuses first on the low-hanging fruit of firewood deforested areas - and replacing income from firewood sale - then on helping unproductive "usufructo" areas become income generators by hiring community members to reforest and engaging them in new business development opportunities. When discussed with potential beneficiary communities, there was significant willingness to cede unproductive land that was up for uncertain sale in return for participation in the reforestation project that could bring back fish and mollusc stocks, as well as providing jobs.

Throughout the project CODDEFFAGOLF staff will work closely with the communities using a mix of mass communication campaigns on the importance of mangroves, hands-on training sessions, formal training workshops, and meetings with local associations such as fishermen's groups and women's cooperatives. Communities will meet with CODDEFFAGOLF at least once a year to evaluate community development programs and determine additional uses for the funds, with a focus on projects that can develop sustainable income or resources for community use (e.g. environmental education centers, ecolodges etc).

Part of CODDEFFAGOLF's duties as the implementer of the project will be to hold and document regular community meetings, and to report on progress with the community participation aspects of the project, including the benefits (and any problems) being experienced by the communities.

Part J: Additionality Analysis

J1) Description of how project activities additional (PV requirement 5.4)

The reforestation of mangroves in and around the SAPZsurH fills a massive management gap for the region, since the government of Honduras does not have the financial resources to directly manage an area this large (>82,000 ha) given the complex technical and logistical capacity needed to coordinate regional conservation efforts.

The lack of government presence in the Gulf of Fonseca has enabled the rapid deforestation of mangrove forests and massive land use change due to a high demand for space for agriculture, livestock, and shrimp farming, as well as firewood and construction materials. Through laws that promote shrimp farming (Ley de Fortalecimiento a la Camaronicultura (Decreto No. 335-2013, La Gaceta, 11 April 2014), the government has often incentivized commercial shrimp farming within and around the SAPZsurH, which is a significant threat to mangrove cover.

Luckily, the government has recently stopped handing shrimp farming permits for “usufructo” areas, providing a unique opportunity for this project to slow or even reverse the loss of mangrove cover.

The loss of 52% of mangroves over the past 15 years in the Gulf of Fonseca has resulted in the loss of ecosystem services (fish stocks, clean water, seafood, etc) that directly impact local economies of impoverished communities currently living on $1-2 per day. However, the Honduran government does not have the financial resources to protect, let alone reforest, the mangroves in the SAPZsurH region and therefore these forests are destined to disappear in the short term. The permanent loss of these mangroves will be devastating for local communities and will undoubtedly cause a rise in poverty within this region for the communities who depend on the ecosystem services from mangroves.

CODDEFFAGOLF and CMR, in partnership with rePLANET have the interest, technical expertise, and funding necessary to implement this reforestation project in the Gulf of Fonseca. All three organizations have worked in partnership to generate and provide the necessary information for this application and have signed contracts demonstrating their commitment to implementing the reforestation program and are the only actors doing so in this area. Furthermore, Dina Morel from CODDEFFAGOLF has maintained constant communication with Alejandra Reyes, who leads the Department of Protected Areas within ICF, to generate government support for the project and to solicit a letter from the government (ICF) that states that the areas to be reforested will not be claimed within Honduras’ Nationally Determined Contributions (NDCs) and will be registered as a voluntary market project when a national map is created. Alejandra Reyes has demonstrated significant interest and excitement for the project by providing a signed letter that designates this project as belonging to the voluntary carbon market, as administered by CODDEFFAGOLF.

Part K: Notification of Relevant Bodies & Regulations

K1) Provide both of the following (scanned copy of letter, or email):

Appendix 1 contains a letter and translation from the Director of ICF stating that all the areas targeted in this project will be excluded from the Honduran NDC map when it is created (as it contains no blue carbon at this time) and that this project will be designated for the voluntary market when it is complete.

Part L: Identification of Start-Up Funding

L1) Provide details of how the project will be financed in the development phase, before full project registration

The project is being funded by rePLANET in the following stages:

Stage 1 – this is completion of the PIN with detailed budgets for how the project will be implemented. The PINs are being produced by internal staff of rePLANET and the in-field partners and the budgets represent the total costs of the project. At this stage though the amount of carbon that will be certified as part of the scheme is unknown although the total costs can be modelled against a range of carbon values to determine the likely range of costs.

Stage 2 – this is producing the Project Development Document (PDD) which will involve modelling the predicted Above Ground Biomass, Below Ground Biomass and rates of carbon accumulation in the sediment. However, it will also involve 2m coring of the sediments (see Appendix 2) in replicate areas to be reforested, taking into account variables such as time since clearance (grouped into 5-year blocks), and original position within the mangroves (carbon sediment is not uniformly distributed across mangroves from the land to the sea edges) to determine the remaining carbon that is in the sediment into which the propagules will be planted. However, whilst carbon levels will continue to decline in non-forested areas it cannot be assumed that these levels would fall to zero, so coring will need to be undertaken in a series of control site sites where mangroves were removed more than 25 years ago. The carbon levels in these control sites will then be subtracted from the remaining carbon levels in the ponds being replanted to determine the **net residual carbon** (the carbon that would be locked into the sediment at the point of mangrove restoration)**.** Production of the PDD should then enable the level of deferred carbon loss and the predicted accumulation of carbon in the sediment, AGB and BGB over the 25 years, to determine the number of carbon credits (both ex-post for the avoided carbon loss in the sediment and ex-ante for the predicted accumulation) that would be issued if the project was implemented. Completion of this stage will then determine the costs of the credits (known as the issue price).

Stage 3 – implementation. rePLANET is committed to financing the project in accordance with the agreed budget and payment schedule. In exchange CODDEFFAGOLF will transfer the carbon credits to rePLANET at the agreed issue price. The payment schedule agreed between rePLANET and CODDEFFAGOLF ensures a significant cushion between payment and when funds would be needed by CODDEFFAGOLF, so that funds are always available in the accounts to meet the financial demands each year. rePLANET will fund the project through the sale of carbon credits, and the profits from these sales will be used to fund the start-up costs for additional Plan Vivo reforestation projects.

The project is designed so that over 60% of the income from the issue price credits is going to the communities and over 80% spent within Honduras. Around 5000-6000 people in the affected communities will directly benefit from the scheme.

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Appendices

Appendix 1: Signed letter from ICF excluding our project from any future NDC maps.

GOBIERNO DE LA REPÚBLICA DE HONDURAS

INSTITUTO NACIONAL DE CONSERVACIÓN Y DESARROLLO FORESTAL ÁREAS PROTEGIDAS Y VIDA SILVESTRE

Comayagüela, M.D.C.,, 4 de agosto del 2021

Licenciada
Dina Elizabeth Morel
Directora Ejecutiva
CODDEFFAGOLF
Su Oficina

Estimada Licenciada Morel:

Me dirijo a usted en referencia a su comunicación sobre iniciativa conjunta con la organización Operación Wallacea para gestionar el proyecto "**Restoration of mangroves removed for fuel wood in the Gulf of Fonseca, Honduras**", que está orientada a establecer incentivos comunitarios para la restauración de áreas de mangle y que permitirá crear opciones de desarrollo económico local para las comunidades de las áreas protegidas; destacando que como rectores de la Política Forestal, Áreas Protegidas y Vida Silvestre, es parte de nuestro compromiso el desarrollo de iniciativas y proyectos a largo plazo que contribuyan a la sostenibilidad financiera para la gestión de ecosistemas terrestres y marino costeras.

En consideración a lo anterior, enmarcados en los convenios de comanejo vigentes con CODDEFFAGOLF y los instrumentos de gestión de las áreas protegidas de la Zona Sur de Honduras; se manifiesta el respaldo de la institución, para gestionar esta iniciativa dentro de los mercados voluntarios de carbono como parte de los esfuerzos realizados por la sociedad civil en el marco del comanejo con el Gobierno, para contribuir a la Convención Marco de las Naciones Unidas; siendo importante mantener una comunicación y coordinación durante este proceso que contribuirá al manejo y restauración del bosque manglar.

Con muestras de consideración y estima,

Cordialmente,

Ing. Angel Matute Mendoza
Subdirector de Áreas Protegidas y Vida Silvestre

Ing. Francisco Escalante
Subdirector de Desarrollo Forestal

Ing. Alejandra Reyes/ Departamento de Áreas Protegidas
Ing. Junior Alvarenga, Regional Pacifico
Archivo

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Appendix 2: Proposed methodology for more accurately predicting carbon sequestration levels in mangroves

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1. Introduction

This report discusses the problems that arise when the carbon sequestration value of the sediment below mangroves is not fully accounted for. This concerns not only annual accumulation rates but also the net residual carbon at the time of planting. The sequestering value of replanting mangrove forests is therefore significantly underestimated.

The reason that this is important is that the price of voluntary carbon credits being used by multi-national companies to achieve Net Carbon Zero targets is primarily determined by the amount of carbon sequestered over the life time of the project being certified. Thus, for reforestation projects of rainforest areas with an estimated accumulation of 100 tonnes per hectare of carbon in above and below ground biomass combined (the carbon accumulation in rainforest soils is negligible) over a 25 year period then the price of the credits are generally in the region of $15. As a result, many reforestation projects are really agro-forestry projects since the costs of the credits can be reduced to around $12 because of the income received from the coffee, cacao or other forest products which reduces the payments that need to be made to communities to continue to protect the forests. However, the net effect of these prices is that multi nationals faced with offsetting of millions of credits a year gravitate to renewable energy credits which can be bought for less than $5.

However, as identified in the Oxford Principles there needs to be a shift towards carbon removal, where offsets either directly protect existing carbon sequestration stores or remove carbon from the atmosphere as opposed to just reducing the amount of additional carbon being emitted (eg renewable energy or Tesla credits which can be sold for as little as 87 cents). These Principles should be moving multi nationals towards reforestation projects particularly those where large amounts of carbon are locked away in waterlogged and anoxic soil or sediment conditions such as peat and mangrove forests.

That this move towards reforesting mangroves using carbon credits has not yet occurred is to a large extent due to the costs of the credits being offered for reforestation projects compared with much cheaper renewable energy costs. The costs of credits in turn are related to how much carbon is being sequestered in any scheme and for mangroves it is argued in this report that it is being substantially underestimated by the current Clean Development Mechanism (CDM) accounting methods.

Section 2 reviews data on sequestration amounts of carbon in existing mangroves and compares it with predicted levels from the CDM methodologies (AR-AMS0003 and AR-AM0014). Section 3 looks at the literature for estimating above ground biomass (AGB), below ground biomass (BGB) and carbon accumulation in the sediment for 25 year restored mangroves in Indonesia and suggests conservative figures for the amount of carbon that could be accumulated form these 3 sources over 25 years. Section 4 examines data on the loss of sediment carbon once mangroves are removed, and section 5 describes how net residual carbon could be estimated at the time of planting. Section 6 describes the methods to be used for monitoring carbon accumulation over the 25 years of the project. Using this modified approach should give a much closer match between observed and predicted carbon storage in mangrove ecosystems.

2. Mangrove carbon storage

The total area of mangroves in the world has been estimated at around 130,420 km^2 (Tang et al 2018). Except for peatlands, mangroves store more carbon per unit area than any other ecosystem (Twilley et al., 2018; Along, 2020; Osland et al., 2020). In rainforests leaf falls are quickly recycled and the carbon released by oxidation. In mangroves the water logged soils in which they grow produce anoxic conditions that prevent the fallen leaves from decomposing thus oxidising their carbon – thus creating long term carbon stores. If we compare the carbon held in mangroves with that in terrestrial rainforests, Cameron et al (2021), using Fijian mangroves as an example, state that "mangrove carbon equates to 73.3% of the carbon held by rainforests, despite occupying just 7.3% of the total area". Globally, the carbon stored by mangroves is equivalent to more than twice the annual global emissions of carbon dioxide by human (anthropogenic) activities (Elwin et al 2019), an astonishing observation. According to Alongi (2014) mangroves across the world have a mean whole-ecosystem carbon stock of 956 tonnes of carbon per hectare, whereas rainforests only have 241 tonnes of carbon per hectare.

Most of the carbon in mangrove soils is derived from either fallen leaf litter, dead timber, roots, or phytoplankton brought in on the tides (Adame et al 2018). Values vary according to publications but if carbon stocks in the soil as well as those in above and below ground plant tissues are summed together (to produce an estimate of total ecosystem carbon stocks – ECS) the values range from 9.4 billion tonnes to 13 billion tonnes (9.4 Pg C to 13 Pg C) globally (Tang et al 2018). Kauffman et al (2020) report that mangroves globally store about 11.7 billion tonnes (11.7 Pg) C - an aboveground carbon stock of 1.6 billion tonnes (1.6 Pg) carbon and a below ground carbon stock in the sediments and roots of 10.2 billion tonnes (10.2 Pg C).

There are many scientific papers that provide examples of published data describing whole ecosystem (above and below ground plus soil) mangrove carbon stocks on a per hectare basis, as summarised in Table 1. The overall average of these data in the table is around 800 tonnes per hectare, but with a lot of variation. Some figures are lower than others, likely in part at least to be linked to geography, higher latitudes, variable sample depths in the soil, estuarine versus oceanic locations, and so on.

Indonesia has the largest extent of mangroves of any country in the world, estimated to cover around 2,707,572 hectares or just over 27,000 km^2 (Thorhaug et al 2020). The rough average figure for mangrove carbon stocks in Indonesia from the table is approaching 1000 tonnes per hectare. Murdiyarso et al (2015) points out that the above-ground carbon storage of natural mangrove forests in Indonesia was an average of 211±135 tonnes per hectare, and 849±323 tonnes per hectare in the sediment, giving estimates for overall ecosystem carbon stocks of 1083±378 tonnes per hectare, so approximately 78% of total ecosystem stocks are in the soil.

Jakovac (2020) estimated that restoring the 1540 km^2 mangroves lost just over the 17 years from 2000 would sequester 123 billion tonnes of carbon dioxide. Given this statistic then restoration of mangroves should surely be one of the prime targets for any reforestation initiative.

How do predicted levels of carbon using the CDM carbon methodology compare with these figures from the literature? Adame et al (2018) measuring carbon in replanted mangroves in peninsula Malaysia recorded 1169 ± 69.8 tonnes per hectare in the sediment, just 15 years after restoration, yet this should have taken 2000 years to reach this figure using the CDM methodology. Likewise Dung et al (2016) found mean sediment carbon storage of 910 ± 32.3 tonnes of carbon per hectare in 38 year old restored mangrove forests but this should have taken 1800 years to reach these levels if the CDM methodology was used. There are two possible reasons for this discrepancy – either the amounts of carbon accumulating each year in newly planted mangroves has been significantly underestimated, or the levels of carbon at planting were not measured. This report argues that both of these are significant factors in the underestimation of observed levels of carbon in restored mangrove areas.

3. Predicting carbon accumulation in 25 year old restored mangroves in Indonesia

Above Ground Biomass (AGB) can be estimated by satellite imagery (e.g. LANDSAT), LIDAR, and drone photography etc (Nguyen et al 2019, Wong et al 2020, Lucas et al 2021). AGB figures are highly tree or shrub species specific as shown by table 2. For example, work in southern Sulawesi (Indonesia) showed that the above ground biomass of *Rhizophera apiculata* in a protected area was 651.6 tonnes per hectare whereas that of *R. mucronata* also in the same protected area was only 232.1 tonnes per hectare (Kanguso et al 2018). The carbon content of AGB figures is around 50% so the carbon content will be roughly half those figures, but it is unknown how long the forests took to establish these carbon levels with the exception of Lucas et al (2019) who showed that mangroves had an above ground biomass of ~50 tonnes per hectare at 5 years after clearance which grew to more than 200 tonnes per hectare by ~30 years post-clearance.

There are allometric equations to link diameter at breast height (dbh) measurements to AGB for most species of mangrove in Kauffman & Donato (2012). However, these equations are not tied to growth rates over time, so using data from re-established mangrove areas for AGB of known ages is likely to give a more accurate estimate of likely AGB carbon levels at certain time intervals. Dung et al (2016) found AGB levels of 214.5 ± 32.5 tonnes of carbon per hectare in the Mekong Delta 38 years after having been destroyed by Agent Orange. Adame et al (2018) examining an area of mangroves in peninsula Malaysia that are harvested on a 30 year rotation were able to quantify AGB carbon accumulation over time and compare the figures with long term protected forests. They noted that after 25 years the reforested mangroves which had been subjected to light thinning at 15 years and 20 years, had a AGB carbon level of 125 tonnes per hectare.

Below ground biomass - BGB (and therefore below ground carbon storage) is composed of living and dead mangrove roots, and there is usually a good correlation between AGB and BGB (Barik et al 2021), with the latter showing lower values than the former. The ratios between AGB and BGB tend to be species specific, since different mangroves have different root structures, such as the prop roots of *Rhizophora* species the majority of which is above ground, and the “pencil” roots of *Avicennia* species where main lateral roots are in the soil sending up the aerial pneumatophores at regular intervals. So for example, *Rhizophora apiculata* was found to have an average AGB to BGB ratio of around 2.7:1 in Sulawesi, Indonesia (Chen et al 2018) and 2.2:1 in Peninsular Malaysia (Rozainah et al 2018a). It is to be expected that as the trees grow and the stem and foliage structures increase in volume, the AGB to BGB ratios increase in favour of above ground. In southern China it was found that 15 year old *Avicennia marina* had an AGB to BGB ratio of only ~1.4 whilst 45 year old trees of the same species in the same site had a ration of ~2.5 (Yu et al 2021). An average of 2.5:1 for a mixed plantation of *Rhizophora* and *Avicennia* should therefore give a conservative estimate of BGB carbon stocks – 50 tonnes per ha after 25 years based on the AGB carbon figure quoted above.

Table 3 provides some published estimates of carbon burial and accumulation in mangroves.

Again, very variable data, but based on a literature review, Lunstrum and Chen (2014) concluded that “rates of soil carbon accumulation were correlated to a number of factors, notably climate, soil texture, land-use prior to afforestation, and (tree) species”. One of the studies in table 3 is the work of Adame et al (2018) in Peninsular Malaysia who examined an area of mangroves that were being harvested on a 30 year rotation so there were stands of mangroves of known ages and areas where the residual carbon in cleared areas had been calculated.

This study suggested that reforested plots recovered soil carbon rapidly in the first 10 years post-restoration, with carbon accumulated at a rate of around 9.5 tonnes per hectare per year. However, after 10 years, accumulation rates declined to about 2.8 tonnes per hectare per year (Adame et al 2018). In S.E. China, Yu et al (2021) measured ecosystem carbon stock accumulation of 3.61, 3,43 and 2.78 tonnes per hectare per year for 15, 45 and 80-year-old mangroves respectively. Young forests in the early years of restoration accumulate soil carbon most rapidly and sequestration rates of carbon in mangroves depends on species (Kathiresan et al 2013). It is clear from table 3 that the most productive species in terms of carbon accumulation are in the mangrove genera *Avicennia* and *Rhizophora* and that over a 25 year period an accumulation rate of at least 3.5 tonnes per ha per year would be a conservative estimate. Figures as high as 7.32 tC/ha/yr have been approved for a Verra certified scheme in Myanmar.

Given the above review a mixed plantation of *Rhizophera* and *Avicennia* species in Indonesia could reasonably be expected to be certified for a total carbon accumulation over 25 years of 250+ tonnes or even higher if Verra approved accumulation rates were achieved. This would form the basis for an ex-ante credit application.

4. Residual carbon after mangrove deforestation or conversion

Richards et al (2020) estimate that the global mangrove carbon stock declined by around 15.8 million tonnes (158 Mt) between 1996 and 2016. 62% of mangrove losses around the world between 2000 and 2016 were due to conversion to aquaculture and agriculture, mainly in SE Asia (nearly 80% of these losses) where commodities including rice, oil palm and shrimp farming were dominant (Goldberg et al 2020). In SE Asia, over 114,000 hectares of mangrove have been converted to aquaculture ponds, rice or oil palm between 2000 and 2012 (Sharma et al 2020).

Mangrove conversion to other types of land use, releases massive quantities of carbon dioxide (and other greenhouse gases including methane and nitrous oxide) to the atmosphere from the carbon stocks in the sediments. Table 3 presents carbon emission data resulting from mangrove conversion from the literature. These data are very variable, but if for now we ignore the extremely low and high estimates (Atwood et al and Alongi et al) a very rough approximation suggests mangrove deforestation and conversions could result in carbon emissions of around 70 million tonnes of carbon per year. Despite these very variable figures, Indonesia had the highest potential of all countries for such losses (Atwood et al 2017). Additionally, it is likely that such emissions will continue for many years post-conversion, as soil carbon stocks In the ex-mangrove sites are broken down and carbon dioxide (plus other GHGs) are released into the atmosphere over years if not decades (Sharma et al 2020). Sippo et al (2020) suggest that even if no more mangrove deforestation occurs, continuing carbon losses to the atmosphere and the ocean from the sediment might reach 27 million tonnes of carbon globally over the next 30 years.

When mangrove forests are converted into oil palm plantations or shrimp farms, not all the soil carbon is lost. Much of the scientific literature concentrates on the carbon stocks remaining in abandoned aquaculture ponds. This carbon must be derived from stocks accumulated when the mangroves were intact – shrimp ponds do not accumulate much, if any, on their own. For example, mangroves in Eastern Kalimantan (Indonesia Borneo) were reported to hold mean total ecosystem carbon stocks of 1023±87 tonnes of carbon per hectare, compared with 499±56 tonnes carbon per hectare in adjacent abandoned shrimp ponds (Arifanti et al 2019). Research in Thailand reported that 50% of soil organic carbon and up to 90 % of total ecosystem carbon were lost when mangroves were converted to shrimp farms (Elwin et al 2019). The authors of this paper suggest that most carbon stocks that remain after mangroves are converted to shrimp farms are in the deepest soils, perhaps 2.5 metres deep or more where present.

There are few published estimates of this residual carbon stock after simple cutting of mangroves for firewood or building materials. Adame et al (2018) estimated that recently clear-cut mangrove soils had 29% less organic carbon than intact mangroves. These cleared areas in the Adame et al (2018) study were then immediately replanted so the figures relate just to the immediate losses on clearance of mangrove forest. In New Zealand, Perez et al (2017) found that mangroves deforested 10 – 12 years previously contained residual stocks of organic carbon 40% lower than the preserved (natural) mangrove forests.

One other way of assessing carbon stocks after deforestation but in the absence of any conversion to a different land use type is to use natural, climate related, dieback events or cyclone damage as ways of removing healthy mangroves. Some dead trees will remain above ground for a little while post-dieback, but in the main, the only substantial total ecosystem carbon stocks will be those below ground. A piece of research carried out in tropical Australia found that sediment (soil) carbon stocks were 183±12 tonnes per hectare in the dead forest (Sippo et al 2020). This carbon can be considered to be the residual stock remaining after the living trees had been removed. A large literature review concluded that 54%±13% of mangrove soil carbon stocks were lost when intact forest underwent one form of land use change or another (Sasmito et aL 2019) and we must assume that some of the remaining ~46% of soil carbon would gradually be released carbon back to the atmosphere via oxidation for years post-conversion.

It is clear that whilst loss of mangrove cover results in a loss of a percentage of the sediment carbon, the rate of that loss and how long the losses continue is likely to be determined by factors such as position and the land use to which the area is converted. In areas exposed to strong water currents and large tidal ranges on the seaward edge of mangroves, or on the river edge of mangrove stands, sediment stores could be scoured out to much deeper areas once the mangrove cover protecting that loss is removed. However, in other more sheltered areas (landward edge of mangrove stands) the loss of carbon would not be complete and in the absence of active management of the area (e.g. farming, aquaculture) or removal of harvesting pressure (for fuel or timber), the mangroves would return as the dominant vegetation.

The proposal for a new methodology therefore includes the concept of net residual carbon in the sediment at the point of planting. Since this will vary enormously between sites, the intention would be for control areas which were cleared of mangroves over 25 years ago to be identified for each area that is due to be planted. Global Mangrove Watch provides worldwide data on the distribution of mangroves in 1998, 2007 and 2016 and these data are the basis of many research papers about the change of mangrove cover worldwide. However, examination of Google Earth satellite data from 1985 onwards reveals the presence of mangroves in many areas that are were lost even by the time of the first Mangrove Watch data set in 1996. The dates when these areas lost their mangrove cover can be verified with elders in local villages. Determining their residual carbon after a long period where the mangroves have been removed would provide a baseline figure of the levels to which carbon would fall if the areas to be replanted were not reforested. Note each of the areas to be replanted would need to be matched to control areas that have the same level of exposure to currents and tidal range as the areas to be planted. Soil cores would also be needed for the areas to be replanted to account for the residual carbon still remaining at the time of planting (this would vary by how long the areas had been exposed by removal of the mangroves). **Net Residual Carbon** in the sediment for each block of planting would be the measured carbon at the time of planting minus the residual carbon in counterpart control areas of long deforested mangrove areas. Net Residual Carbon would form the basis of an ex-post credit application immediately after planting was completed and the carbon stores locked in. This would be a separate (albeit linked) application to the application for ex-ante credits (see section 3). Taken together though the predicted levels of ecosystem carbon in 25 year old restored mangrove stands in Indonesia should more closely match the observed levels in the literature.

5. Suggested method for estimating net residual carbon in planting areas

It is proposed that for Plan Vivo arbon credit applications that immediately prior to planting, the residual storage of carbon in the sediment of the areas to be planted should be measured from coring to a 2m depth. Multiple transects covering a cross section of the areas to be planted, running perpendicularly from the shoreline should be installed. Each transect should run from the fringe mangroves adjacent to the shoreline, through the interior mangroves to the sea/river outer edge. Six sample points at equal distances along the transect should be positioned to cover the proposed planting area. At each sample point, the first step is to measure the depth of the sediment to the bedrock or coral sand using a steel pole at each of the sample points. Once this is completed three core samples should be completed using an augur: one on the transect and two at 10m either side of the transect. After removal of the litter layer, from each core 5 samples of 5cm deep discs should be cut from the mid point of depths 0 – 15cm, 15-30cm, 30 – 50cm, 50 – 100cm and 100- 200cm, or to the maximum penetration of the corer if less than 200cm. These discs should be wrapped in aluminium foil and sealed in polyethylene bags to avoid gas exchange. All sample discs should be labelled and stored in a cooler before being transported to a freezer.

This sampling routine for the proposed planting area should be replicated in control areas which have been cleared of mangroves up to 25 years previously. Care must be taken to replicate the positioning of control areas in terms of exposure to currents, waves, tides, estuaries etc to those of the proposed planting areas. The estimated carbon tonnage in these control areas will be subtracted from the estimated carbon tonnage figure in the counterpart areas to be planted to determine Net Residual Carbon levels which will form the basis for the ex-post credit application.

The 5cm sediment disc samples would be supplied to the laboratories frozen. The analysis methods are described in Sollins et al (1999) and the method described below is taken substantially from that paper. In order to calculate bulk density each sample needs to be dried at 60 degree Celsius for 48 hours. Note that drying at higher temperatures to boil away water should not be carried out because this affects the carbon values and the same samples cannot then be used for carbon determination. Bulk density is then determined by dividing the oven-dry soil sample weight in g by the volume of the sample. The volume of each sample will be determined by V=πr2h where r is the radius of the corer and h is the height of the disc (in this case 5cm). The bulk density value is then given in grams per cubic cm.

C and N Analysis by Dry Combustion

Most dry-combustion C and N (CN) analyzers oxidize samples at high temperature (approx. 1000 °C), then measure the CO_2 and N gases evolved by infrared gas absorption (IRGA) analysis or gas chromatography (GC). Depending on the individual instrument, the maximum allowable sample size may be as small as 2 µg – 30 µg . This means each 5cm disc dried sample needs to be ground up and 3 subsamples put into the tin tray line which means that each core will need 15 samples in the line, so only 2 complete cores can be done in each run (see below). The maximum sample size depends on the C concentration, which may require some initial data before a strategy can be chosen. No hard-and-fast rules can be offered for sample size because the precision and accuracy needed for any individual sample depend on the overall sampling and data analysis scheme. Use of small samples, however, always requires careful attention to subsampling and especially to grinding.

High-temperature multiple-sample dry-combustion analyzers are manufactured by several companies including LECO and Carlo-Erba. The Carlo-Erba NA 1500 elemental analyzer is discussed here. The detection limit is 10 ppm, and measurements are reproducible to better than ±0.1% absolute value. Sample mass needed for analysis may range from 0.5 to 30 µg depending on the nature of the material. Because such a small sample is needed, material must be homogenized thoroughly by grinding several hundred grams of soil to pass a 40- to 60-mesh screen. A typical sample run comprises one or two "bypass" samples of high concentration to condition the columns, two "blanks" consisting of empty tin sample cups, three standards of known C and N composition to calibrate the instrument (EDTA is used commonly), and three to five check standards scattered throughout the sample run. Typically, 39 unknowns can be included in one run of 50 samples. Extra sample trays may be purchased and set up to make consecutive runs more convenient. Samples are weighed into tin capsules, which are loaded into an autosampler that drops the capsule plus sample into a combustion column maintained at 1020 °C. The sample and container are flash combusted in a temporarily enriched atmosphere of oxygen. The combustion products are carried by a carrier gas (helium) past an oxidation catalyst of chromium trioxide kept at 1020 °C inside the combustion column. To ensure complete oxidation, a layer of silver-coated cobalt oxidè is placed at the bottom of the column. This catalyst also retains interfering substances produced during the combustion of halogenated compounds. The combustion products (CO_2, CO, N, NO, and water) pass through a reduction reactor in which hot metallic copper (650 °C) removes excess 02 and reduces N oxides to N2 . These gases, together with CO_2 and water, are next passed through magnesium perchlorate to remove water, then through a chromatographic column to a thermal conductivity detector. The detector generates an electrical signal proportional to the concentration of N or C present. This signal is graphed on a built-in recorder and ported to a computer, which integrates the area under each curve and converts it to concentrations after each sample is run. Before the start of each run, pressure should be checked to ensure against gas leaks. Gas flow rates (helium, oxygen, and air) are checked with a stopwatch and set to the correct values. Routine maintenance involves removing the slag (residue from combustion of the tin sample capsules) from the top of the combustion column after 150 samples, then refreshing the top 10 cm of the column with Cr0 3 . The combustion column and its chemicals can be used for 350-425 samples. The reduction column can be used for up to 900 samples, or until its copper is three-fourths spent as indicated by change to a black color. The moisture trap must be changed every 300-350 samples.

Most CN analyzers read out directly in concentration units. %C is the carbon concentration expressed as a whole number. The soil carbon mass per sampled depth interval is calculated as follows:

Soil carbon in tonnes per ha = bulk density (g per cubic meter) X soil depth interval in cm X %C

6. Suggested method for monitoring the planted mangroves

Monitoring of new mangrove plantations to measure carbon accumulation and biodiversity benefits is essential (Matsui et al 2012). Survival of the transplant and resultant young trees has to be followed, and the progress of carbon accumulation in absolute terms and relative to predicted levels monitored. These data would be used for the 5-year audits to confirm this progress. At the moment, there are rather few mangrove restoration projects that are more than 20 or so years old (Sasmito et al 2019), and as these authors point out, “there is clear need for systematic long-term monitoring and evaluation of reforestation performance”.

Carbon levels in the sediment would be measured in the planted areas using the methods described in Section 5 every 10 years. Annually the above ground biomass would be measured by the Operation Wallacea international teams of scientists with accompanying students, either using the methods described in Kauffman & Donato (2012), or alternatively employing various types of remote sensing technologies (Friess et al 2016). Above ground biomass can be calculated fairly accurately using remote sensed information such as tree or canopy height fed into tree species specific allometric equations available in the published literature for specific countries or regions, and individual mangrove tree species. However, the mpost accurate method is the measurement of diameter at breast height and identification of species and given the anaul manpower available to the Opwall teams this can be achieved at no cost to the project.

Below ground biomass (BGB) can be estimated from the AGB figures using more equations which have been developed to relate various aerial parameters including diameter at breast height (dbh) wood density, frond length etc to root biomass (Elwin et al 2019), again underlining the importance of having ground surveys annually. Remote sensing is being employed more and more frequently these days to estimate AGB in mangroves, and indeed it is now a requisite for the monitoring, reporting and verification (MRV) system of the UN REDD programme (Nesha et al 2020). Satellite imagery of various types, LANDSAT for example (Lucas et al 2020a), can provide data from which canopy height amongst other things can be estimated (Lucas et al 2020b), assuming the availability of appropriate software, personnel to operate it, and funding to pay for these procedures. Unmanned aerial vehicles (UAVs – drones) are now being recommended as viable alternatives to more expensive and cloud cover dependent satellite remote sensing (Navarro et al 2020).

Annual data on the aquatic macro-invertebrate, fish, reptile, bird and mammal usage of the recovering mangroves will be collected free of charge for all RePLANET funded schemes.

Data on annual carbon sequestration, aquatic invertebrates, fish, reptile, birds and mammals together with pictures of each hectare of land and the recovering mangroves taken each 6 months by the farmers from agreed set photographic locations and linked to release of the 6-monthly payments, ownership details and beneficiaries of the annual payments, will be included on the Oxford University Long-term Ecology Lab website for all projects funded by RePLANET.

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