Project Idea Note (PIN)

Project Title:

Restoration and protection of mangroves and blue carbon ecosystems in North Yucatan, Mexico






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Acronyms

CEC	Commission for Environmental Cooperation
CIFOR	Center for International Forestry Research
CINVESTAV	Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional
CONABIO	Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
CONAFOR	Comisión Nacional Forestal
CONANP	Comisión Nacional de Áreas Naturales Protegidas
CONEVAL	Consejo Nacional de Evaluación de la Política de Desarrollo Social
COP21	United Nations Climate Change Conference, COP 21
INECC	Instituto Nacional de Ecología y Cambio Climático
LGBN	Ley General de Bíenes Nacionales
LGEEPA	Ley General de Equilibrio Ecológico y Protección Ambiental
LGVS	Ley General de Vida Silvestre
LGCC	Ley General de Cambio Climático
NDC’s	Nationally Determined Contributions
NOM	Norma Oficial Mexicana
PMC	Programa Mexicano del Carbono
PNUD	Programa de las Naciones Unidas para el Desarrollo
PROFEPA	Procuraduria Federal de Protección Ambiental
RECMCNY	Reserva Estatal Ciénagas y Manglares de la Costa Norte de Yucatán
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
RAN	Registro Agrario Nacional
SCTS	Sociedad Cooperativa Tulum Sostenible
SDS	Secretariat of Sustainable Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
ZOFEMAT	Zona Federal Maritima Terrestre

Summary Information

Project Title	Restoration and protection of mangroves and blue carbon ecosystems in North Yucatan, Mexico
Project Location – Country/Region/District	North Coast of the Yucatan Peninsula, Mexico on communal land belonging to two villages: Sisal and Dzilam de Bravo, within the Reserva Estatal Ciénagas y Manglares de la Costa Norte de Yucatán
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 fuel, construction, by hurricanes and for infrastructure development, such as highways
Summary of Proposed Target Groups (Max 30 words)	Subsistence fishermen in 2 villages on the North of the Yucatan Peninsula in Mexico facing crises and increased poverty due to overfishing and drought/floods caused by climate change

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 infrastructure development and tropical storms along the Northern Coast of the Yucatan Peninsula, Mexico. All of the land proposed for restoration in this project lies within the state reserve Reserva Estatal Ciénagas y Manglares de la Costa Norte de Yucatán (RECMCNY), which is managed by the Secretariat of Sustainable Development for the State of Yucatan (SDS Yucatan). However, the rights to ecosystem services remain with landowners and the proposed area represents a mosaic of communal, federal, and private use areas; this project will work with stakeholders to restore communal and private land within the proposed polygons.

There is significant interest from SDS Yucatan and other local government bodies in restoring the mangrove ecosystems in this area as there has been enormous investment in hydrological improvements to harmful infrastructure, but mangrove forests still have not recuperated naturally. It is recognized that the full restoration of these ecosystems will improve ecosystem services, protect communities from tropical storms, and bolster local fisheries and biodiversity within the reserve. The project also intends to drive improvements in livelihoods in the region both directly through the restoration program, as well as with a community development program focused on entrepreneurship and job creation in ecotourism, waste management, and sustainable apiculture. This process will be overseen by local development cooperative Sociedad Cooperativa Tulum Sostenible (SCTS) while restoration efforts will be led by the renowned Mexican laboratory, CINVESTAV.

Part B: Proposed Project Area

B1) Description of Project Location

Project Location

The project will be implemented across two mangrove deforested areas within a state reserve in the Northern Yucatan Peninsula in the State of Yucatan. These sites will be around the villages of Sisal and Dzilam de Bravo, which are located in the Reserva Estatal Ciénagas y Manglares de la Costa Norte de Yucatán (RECMCNY). As Table 1 shows, the proposed areas comprise 986.41 ha of destroyed mangroves within Sisal and 556.87 ha in Dzilam, directly impacting these two villages. This project proposes to restore 700 ha of mangroves split evenly across the two deforested areas. The specific 350 ha plots will be selected based on their hydrology and topography to be the most suitable sites for the project.

Table 1: Remaining areas of severely degraded or cleared mangrove habitat to be restored in Sisal and Dzilam de Bravo. We will select the most viable 350 ha from each polygon.

Restoration Area	Previous investors	Community	Protected Area	Restored area (ha)	Degraded area (ha)
Sisal	NAWCA, API, SEDUMA, CONANP, PRONATURA/ CINVESTAV, Unidad Mérida	Comunidad Sisal	Reserva Estatal Ciénegas y Manglares de la Costa Norte de Yucatán	4,195.48	986.41
Dzilam de Bravo	PRONATURA, NAWCA, SEDUMA, CONANP, API/ CINVESTAV, Unidad Mérida	Los amigos restauradores de Dzilam	Reserva Estatal Ciénegas y Manglares de la Costa Norte de Yucatán	3,258.23	556.87

Sisal

Sisal is a small village on the coast of the Hunucmá municipality in the North of the state of Yucatan. The climate is semiarid and very warm, with an average annual temperature of 25.5 C and annual rainfall of 598 mm (INEGI, 1998).

Figure 1: Aerial photographs of the area to be restored in Sisal.

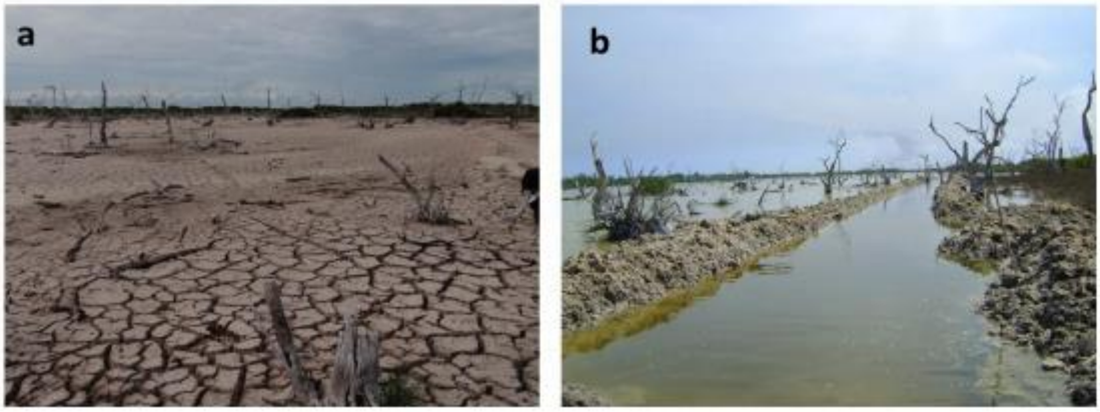


Figure 2: Sisal mangroves before restoration activities (a) and after the opening of canals in 2021

Dzilam

Dzilam is a village on the central coast of the Northern Yucatan, located 105 km from Merida. The average annual temperature is 24.8 C and receives annual rainfall of 601.8 mm.

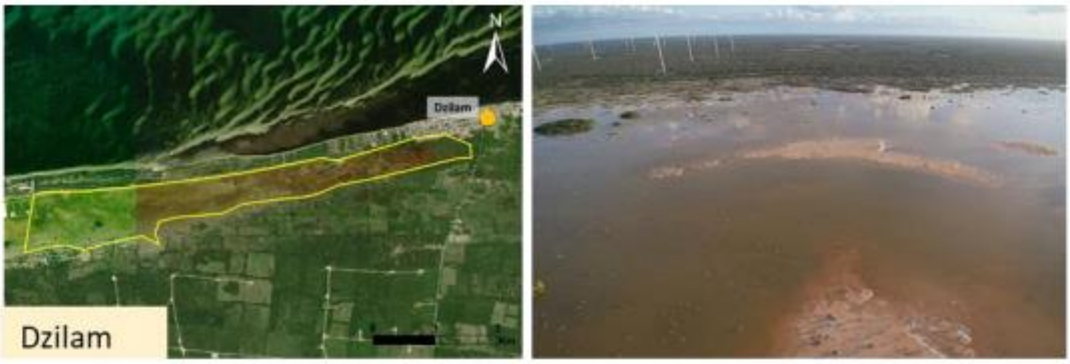


Figure 3: Aerial photographs of the areas to be restored in Dzilam.

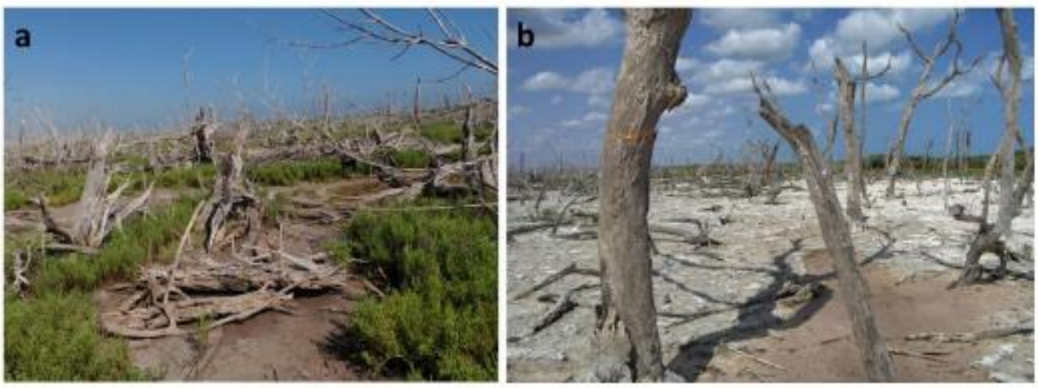


Figure 4: Dzilam de Bravo after Hurricane Isidoro in 2002.

Figure 5: Opening canals to the mangroves (a and b) by the Dzilam community brigade and the finished canal (c), all previous restoration efforts to help prepare land for restoration.

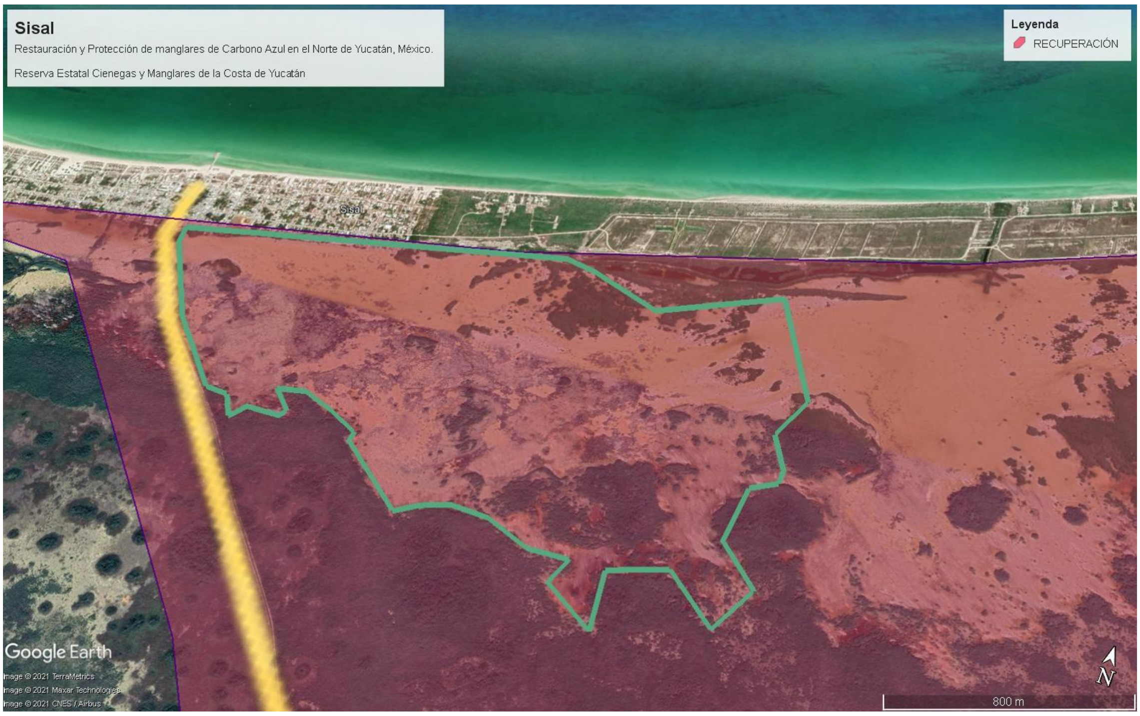


Figure 6: The proposed project area in the village of Sisal. The red outlines demarcate the larger polygons within which the restoration project will take place. The entire zone is located within the (RECMCNY).

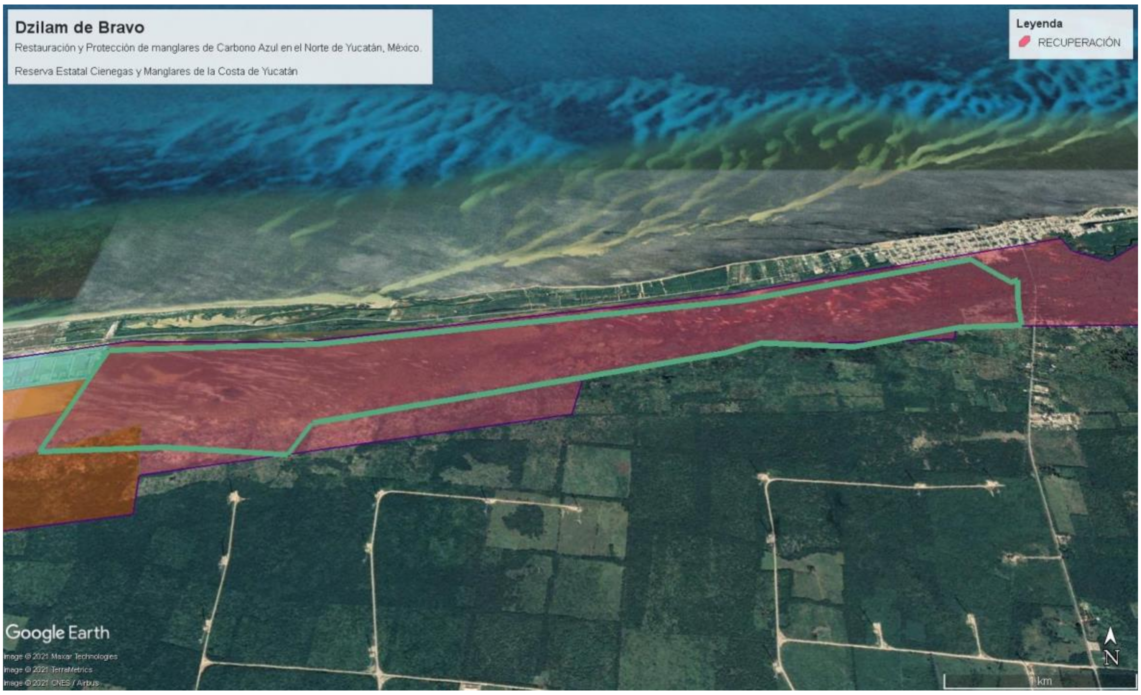


Figure 7: The proposed project area in the village of Dzilam. The red outline demarcates the larger polygon within which the restoration project will take place. The entire zone is located within the RECMCNY.

Identification of any legally designated/protected conservation areas within, overlapping or adjacent to the project area

Sisal and Dzilam are located within the Yucatan state reserve of RECMCNY. Dzilam also overlaps with the Dzilam State Reserve but none of the areas proposed for restoration within this project overlap with the Dzilam State Reserve side. The RECMCNY reserve contains a nucleus of over 8,500 ha of land (15.5% of the reserve), including the large 'petenes' or hummock forests (islets within mangrove areas) found within the mangrove zone that spreads from Sisal to Dzilam de Bravo. RECMCY extends nearly 54,800 ha including both terrestrial and marine protected areas and is managed by the Secretariat of Sustainable Development (SDS) of the Yucatan state government. RECMCNY also contains a pending new RAMSAR wetland site.

Reserva Estatal Ciénagas y Manglares de la Costa Norte de Yucatán

Categoría de Manejo:	Reserva Estatal
Ubicación:	Hunucmá, Ucú, Progreso, Ixil, Motul, Dzemul, Telchac, Sinanché, Yobaín, Dzidzantun y Dzilam de Bravo
Región:	Península de Yucatán
Institución que Administra:	Secretaría de Desarrollo Sustentable
Titular:	MIA. Sayda Melina Rodríguez Gómez
Superficie total:	54,776.726 ha.
Población total estimada:	157, 124 habitantes
Fecha de Decreto:	9/03/2010
Programa de Manejo:	06/07/2017

Designaciones Internacionales:

- Sitio RAMSAR - En proceso de revisión.

Tipos de Vegetación:

- Selva baja caducifolia
- Selva baja caducifolia espinosa
- Selva baja inundable
- Vegetación secundaria
- Duna Costera
- Petenes y Pastizales
- Sabana
- Manglar
- Hidrófitas

Figure 8: The registration and management information of the RECMCNY (https://sds.yucatan.gob.mx/areas-naturales/ficha_cienagas_manglares.php).

CINVESTAV has worked in partnership with SDS Yucatan on restoration of mangroves in Sisal and Dzilam for more than a decade. SDS Yucatan has expressed significant support and enthusiasm for this project and has declared in a letter (Appendix) that this project does not overlap with any other projects in the area - blue carbon or otherwise and that the carbon rights remain with the landowners (communities/individuals/federal) of the areas in each polygon. SDS Yucatan is prepared to work with CINVESTAV and rePLANET to enable the implementation of this project on federal, private, and/or communal territories within the state reserves.

Physical description of the land, habitat types and land use

Mexican mangroves represent 5% of the world mangroves, with Mexico as the fourth most important mangrove habitat after Indonesia, Brazil, and Australia (Rodríguez-Zúñiga et al., 2013). According to a 2009 study, the Yucatan Peninsula is home to 55% of Mexico's total mangrove cover with over 423,750 ha across the coasts of the peninsula (INECC-PNUD México, 2017). Yucatan State contains 91,356ha of mangroves covering 91% of the state coastline (CONABIO 2013). Of this expanse of mangroves in Yucatan State, 79% are located inside state or federal protected areas (Rodríguez-Zúñiga et al., 2013). The state of Yucatan is home to four mangrove species *Rhizophora mangle* (red mangrove), *Avicenia germinans* (black mangrove), *Laguncularia racemosa* (white mangrove) and *Conocarpus erectus* (button mangrove).

The climate along the coastal areas of the Northern Yucatan is more arid than in the Southern part of the Peninsula and varies significantly along the coast, becoming more humid as one travels from Northeast to Southeast. The Yucatan Peninsula is considered largely flat with a gentle slope (<5%) from the sea to the highest point. The ground is limestone karst, which means there are no surface rivers or water bodies, but there is an extensive network of subterranean water that empties into the sea either diffusely (through cracks and estuaries) or in a single spot (springs), known locally as cenotes (Herrera-Silveira et al., 1998).

Near the coast, the soil layer is very nutrient-poor, as there are no rivers to provide rich, allochthonous sediment deposits. Therefore, most of the soil layer only contains autochthonous sediments and minerals (Herrera-Silveira et al., 2013).
However, cenotes are commonly found in mangrove habitats in the Yucatan Peninsula, where the ring of cenotes meets the coastline. The coastal aquifers in this karstic system often overflow during the rainy season, creating flooded areas that become wetlands that feed mangroves, swamps, and seasonally flooded forests (Herrera-Silveira et al., 1998). As a result of the carbonate rich substrate of the region, groundwater is low in phosphorus (P), and primary productivity of coastal wetlands in the Yucatan Peninsula is greatly influenced by salinity and P availability, with higher above and below ground carbon stocks in mangrove

habitats close to cenotes where salinity is lower and P concentrations are higher (Adame et al., 2013)

Local drivers of deforestation

Changes to the complex hydrology of the Yucatan Peninsula and the associated impacts on salinity and phosphorous levels in mangrove habitats, is one of primary causes of mangrove degradation in the region in conjunction with tourism development (Herrera-Silveira et al., 2020). Consequently, deforestation is not the only driver of mangrove degradation. Currently, the Yucatan Peninsula is losing the majority of its mangroves to changes in hydrology due to the construction of roads and sewers, which have blocked the connection between coastal ecosystems and the sea, producing high levels of salinity in the sediment that kills mangroves. The proposed project seeks to rectify these changes to restore correct salinity to areas of mangrove lost to infrastructure and to reforest those areas. Mangroves are also being lost to the development of coastal tourism, changes in land use, informal human settlements, wood for construction, and for fishing gear. Furthermore, mangroves are increasingly threatened by natural phenomena like hurricanes.

In Sisal, the main threat to mangroves has been the construction of roads and of a harbour that have disrupted the flow of water into mangrove areas. Although the local community welcomed the new roads and development of the harbour, neither the communities nor state government that funded this new infrastructure were aware of the impact it would have on subterranean water flow and mangrove ecosystem. As Sisal is primarily a fishing community, they are aware of the importance of mangroves for fish nurseries and are desperate to repair the damage to the mangrove habitat to benefit their fishing industry and to provide protection from hurricanes.

In 2002, Dzilam lost very significant mangrove cover to Hurricane Isidoro. This loss has since been exacerbated by roads that interrupt the flow of water between mangroves and the coast, subsequent hurricanes and tropical storms, urban sprawl and informal settlements expanding into mangrove areas. Over the years there have been various efforts to restore lost areas of mangroves, but given the extent of damage to both sites, no project has yet succeeded in restoring the entire area that once had mangroves.

Consequently, in both Sisal and Dzilam, the communities are not the primary cause of mangrove destruction and degradation. These communities are keen to restore the mangrove ecosystem as mangroves plays a pivotal role in their fishing economy and provide protection of their villages and agricultural land from hurricanes.

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

Data from Mexico's Social Development Commission (CONEVAL) in 2020 found that 46.3% of the population of Yucatan state was living below the established poverty line. This line is defined as MX$3001 (~US$150) per person per month in urban areas and MX$1941 (~US$95) in rural areas, based on the consumer price index. Accordingly, almost half of families living in the target communities could be projected to live for under $3 per person per day. Most people in this area also have minimal capital assets, and a significant number of project participants rent their homes, boats, and fishing equipment.

The economy of the coastal Yucatan Peninsula, including in Sisal and Dzilam, has traditionally relied on fishing and salt production. However, in recent years fishing success has significantly diminished, largely due to overfishing, as fishermen are catching fewer species - such as grouper and octopus - that had previously been the largest revenue stream in these communities (Schmitter-Soto et al., 2018). This loss of income has resulted in declining standards of living in the region. It has also pushed fishermen to exploit sea cucumber, which is highly sought after but also very vulnerable given unclear regulations in Mexico around its capture (López-Rocha & Velázquez-Abunader, 2019).

Recently, the communities included in this project also became attractive as tourist destinations, mostly to high-income domestic tourists who purchase summer homes or speculative properties that bring in visitors without significantly increasing income in the community as there are few community-led tourism businesses available currently.

Relevant local governance structures

Within the State of Yucatan, municipalities are the most important government structure, each of which is led by a democratically elected municipal council made up of a president (or mayor), council members, and a syndic. The municipal governments come directly below state governments and are the main authorities responsible for the sustainable development of each municipality. Each municipality may contain territories of communally owned land belonging to communities, or collections of communities known as ejidos. These ejidos are part of an endowment that the federal government gave to indigenous communities under a certificate of agrarian rights issued by the National Agrarian Registry (RAN).

Each ejido is a legal entity with an elected president (comisario), and treasurer. Although all members of the ejido collectively own the land, the ejido is divided into zones: the urban zone, the common zone, and parcelled zones. The urban zone outlines the current and future potential for human dwellings, the common zone is an area collectively managed by all members of the ejido and the parcelled zones (parcelas) are areas of land designated for agricultural use by a specific member of the ejido and his/her family (Barnes, 2009). Ejidos may also include a designated conservation zone for which ejido members can receive ecosystem services payments from the federal government (administered by CONAFOR).

Dzilam is part of the ejido of Dzilam de Bravo and is a municipal capital meaning that it is managed directly by the municipal president, Armando Herrera. Sisal is an ejido within the Hunucmá municipality and is represented by the comisario, Miguel Antonio Ek Pech. The proposed projects would be run in conjunction with these two ejidos and the ejidos will determine how benefits are distributed across their members.

The state reserve where the proposed project will take place is within the jurisdiction of the Secretariat of Sustainable Development (SDS Yucatan). SDS Yucatan has been informed of this project and has expressed support by offering to sign a letter that states that the proposed polygons do not overlap with any existing restoration or blue carbon projects. At the community level, there are also numerous civil society and cooperative associations that share responsibility for the care and use of the land within the state reserves alongside the Yucatan Regional Committee of Coastal Natural Protected Areas. Communities living along the coastline within the parks have special use rights within certain areas of land (ejidos) for development of agriculture, fishing, ecotourism, or other low-impact activities and own the ecosystem services of communal land.

Relevant national and sub-national levels of governance structure

Mexico is a representative democratic republic with a federal system made up of 31 free and sovereign states who each manage most internal law and policy except regulations designed for the federal level, which impact all states. There are three branches of government: 1) Executive branch led by the President Andres Manuel Lopez Obrador (2018-2024) with support from 18 cabinet members and the Attorney General; 2) Legislative branch with two chambers, one for senators and another for deputies; and 3) Judicial branch, led by the Mexican Supreme Court.

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

- Secretariat of the Environment and Natural Resources (SEMARNAT)
- Attorney Federal for Environmental Protection (Profepa)
- National Forestry Commission (CONAFOR)
- Secretaria de Desarrollo Sostenible (SDS Yucatan)

SDS Yucatan manages the state reserve where the proposed project will take place and has met with the rePLANET and SCTS team to confirm that no other restoration or blue carbon projects are currently taking place within the polygons.

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 the State of Yucatan is 2.3 million people as of the 2020 Census. The Municipality of Hunucmá (Sisal) has a population of 30,730 people. The Municipality of Dzilam de Bravo (Dzilam) has a population of 7,895 people. The population of the ejidos targeted in this proposal are noted below in Table 2.

Table 2: The total population of Dzilam de Bravo and Sisal, broken down by gender indicators.

Site	**State**	**Total Population**	**Men**	**Women**
Dzilam de Bravo	Yucatan	2,936	1,474	1,462
Sisal	Yucatan	2,078	1,059	1,019

Poverty indicators:

In Yucatan State, poverty indicators over the past ten years have shown mixed results for poverty reduction strategies used in the state. For example, access to basic services (such as education, healthcare, housing, and social security) has increased while individual incomes have fluctuated. As of 2018, 79.6% of the population of the state of Yucatan would fall into Mexico's category of impoverished (CONEVAL 2020). Furthermore, across this region, 19.7% were considered to have an educational "lag" (rezago) in 2018, meaning they are under 15 and not in school or have not completed above primary school if born before 1982. Similarly, 14.1% of the population has limited access to healthcare. Finally, 19.4% of the population is suffering from food insecurity in this region, likely due to increased fishing and farming failures from overexploitation and climate change (CONEVAL, 2020).

Marginalised groups

According to a 2020 census of the state of Yucatan, 27.5% of the population of this region is indigenous. The majority of indigenous peoples in this area pertain to Maya groups; however, there are many other indigenous groups represented in this region including choles, chontales, tzoles, tzetzales, and tojolabales (Balam, 2020 cited in Chan, 2021). Approximately 7% of the population of Dzilam and 16% of the population of Sisal identifies as indigenous. SCTS has incorporated indigenous land tenure, cultural traditions, and organizational structures into the community development plans for both regions to ensure local acceptance in both communities.

Gender and age equity

SCTS is committed to ensuring that all community projects include women, youth, senior citizens, and people with disabilities and adapting training to match local capacities and needs. As such, all environmental training will be offered to the entire community and all field excursions will be designed to take into account specific needs of selected participants, including different abilities. SCTS strongly believes that diversity generates opportunity; this conviction has led the cooperative to integrate members from 18 to 70 years old, with equality of opportunity for all genders. The president of the organization is a woman, who was unanimously elected for her leadership capacity and SCTS prides itself in being a supportive space for people of all ages, abilities, genders, religions, and sexual orientations. The same policies will apply during all development activities in Sisal and Dzilam and community organizations founded through this project will be encouraged to adopt non-discrimination policies and foster the empowerment of women and other marginalized community members.

Local organisational capacity

In both Sisal and Dzilam, formal employment remains low as many people still rely on subsistence fishing for survival. Only 37% of the population of Dzilam is employed (50.6% for men and 23.3% for women) while 51.5% of Sisal is active in the labor market (63.1% for men and 39.5% for women). Around 25% of the population in both areas has completed secondary school. However, local community groups such as women's cooperatives, fishermen's associations, youth clubs, and even mangrove watch teams, are relatively common in this region and play an important role in community management in both villages.

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)

Land Tenure

Mangroves in Mexico are distributed across different zones starting in the Federal Terrestrial-Maritime Zone (ZOFEMAT), which is land in the public domain of the Federation consisting of the 20-meter strip of land, determined from the maximum high tide level that is passable and contiguous to the sea. Outside of ZOFEMAT, mangroves are located on continental lands that may be privately or publicly owned.

Privately owned land in Mexico can fall into two categories: Ejido land or titled land. Titled land has an individual owner, whereas ejido land refers to territories under common use or parcelled land that are part of an endowment that the government gave to the communities under a certificate of agrarian rights issued by the National Agrarian Registry (RAN).

All of the areas proposed for restoration in this project fall within the state reserve RECMCNY that are managed by SDS Yucatan. Original land tenure is respected in protected areas in Mexico, with the majority of land in protected areas owned by ejidos, communities and private owners. RECMCY is made up of a mosaic of use areas (communal/private/federal), split into a nucleus and buffer zones where local and indigenous communities have special use rights.

The total area of RECMCNY is 54,776.7 ha, broken down into two main management areas: the nucleus zone (split into the subzone of special protection and the subzone of restricted use), and the buffer zone (split into areas of sustainable natural resource use, special usage, public use, and recuperation). The special protection area is reserved for conservation only, while the restricted use area allows research and environmental education. Within the buffer zone, the sustainable use area (SZAS) is the largest region and allows activities such as agroforestry, low impact livestock farming, apiculture, and forestry. The special use area overlaps with a large portion of the mangroves and is used for artisanal fishing and ecotourism, while the recuperation zone is where ecosystem restoration (including our restoration project) is to take place. The public use area allows for recreation, camping, and small infrastructure development. Table 3 shows the breakdown of the different zones within RECMCNY.

For both projects, we will work with SDS Yucatan to select areas of communal or private land where landowners own the carbon rights (and other ecosystem services) to prepare long-term use contracts with all stakeholders. We will avoid areas of federal land to ensure there are no conflicts regarding permits and carbon rights.

Table 3: The breakdown of land use areas within the RECMCNY.

Zone	Category	Area (ha)	% Total Area	%Total Zone
Nucleus	Special Protection	2,235	4.1%	
	Restricted Use	6,271	11.5%	
	Total Nucleus	8,506		15.5%
Buffer	Sustainable Resource Use	29,222	53.4%	
	Special Usage	2,815	5.1%	
	Public Use	1,468	2.7%	
	Recuperation Area	12,765	23.3%	
	Total Buffer			84.5%
Total		54,777	100%	100%

Carbon Rights

Mangrove ecosystems and blue carbon territories in Mexico are governed by the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). There are five legal bases that enable SEMARNAT to regulate the conservation and restoration of blue carbon ecosystems: (1) General Law of Wildlife (LGVS), (2) Official Mexican Standard NOM-059-SEMARNAT-2010 (3) General Law of National Assets (LGBN), (4) General Law of Climate Change (LGCC) and (5) General Law of Ecological Balance and Protection of Environment (LGEEPA).

To ensure equitable distribution of benefits associated with restoration of blue carbon habitats it is important to define who owns the property and who is entitled to receive its benefits (INECC-PNUD Mexico, 2017). Guidelines for implementing coastal wetland carbon projects indicate that rights to carbon and other ecosystem services should be awarded to the local landowners (UNEP & CIFOR, 2014).

Existing laws surrounding natural resource use and conservation, such as Article 27 of the Mexican Constitution, the general law of national resources (LGBN), the regulations for the use of seas, canals, beaches, federal maritime zones and fish farms (ZOFEMAT), as well as laws protecting mangroves like Official Mexican Norms NOM-059-SEMARNAT-2010 (DOF 2010) and the General Wildlife Act (LGVS) can provide a window into potential interpretations of the rights to blue carbon ecosystems in Mexico in the future. For example, LGBN states that all Mexican residents can make use of communal resources, provided that they follow the appropriate regulations. Consequently, the ownership of the territory and the allocation of carbon rights can be granted under the provisions of the National Constitution and the General Law of National Assets (LGBN).

According to this system of benefit distribution, concessions could be offered to any Mexicans who are interested in sustainably using and managing these areas. This system would enable people or businesses who are interested in conservation and restoration of blue carbon ecosystems to receive a concession that enables them to sell carbon credits in the voluntary market. On federal land, this system would be slightly more complex since there is no individual land ownership and the Mexican government has not yet determined how these ecosystem services could be distributed. However, there are cases where local communities receive ecosystem services payments from the federal government for land inside the nucleus of a federally protected area. For example, the National Forestry Commission (CONAFOR) and the NGO Fondo Mexicano para la Conservación de la Naturaleza (FMCN), signed a contract to provide ecosystem services payments for protecting forest in the nucleus of the Monarch Butterfly Biosphere Reserve (CONAFOR y Fondo Mexicano para la Conservación de la Naturaleza 2008).

The rights to carbon and other ecosystem services within the Yucatan state protected areas are owned by local landowners, whether communal or private individuals, and are not controlled by the state government (DOF, 2017). A letter has been submitted to SDS Yucatan, which states that the proposed project area does not overlap with any other restoration or blue carbon projects, either private, state, or federal. The letter will also clarify that the carbon rights belong to each local landowner and that rePLANET and SCTS will approach each landowner in question to create contracts for long-term use and benefits sharing prior to any restoration efforts. It is important to note that blue carbon is still very novel in Mexico and the government has not yet created clear regulations about signing away rights to ecosystem services from blue carbon on private, communal, and/or federal land. However, under existing legal frameworks, landowners own the ecosystem services on their land and will therefore be able to sell them at an agreed rate to rePLANET when the project is underway.

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)

The ecological restoration actions used in the proposed areas will follow the recommendations from the Mangrove Group of CINVESTAV-IPN Merida, which have been applied in numerous successful projects on the Yucatan Peninsula (Herrera- Silveira, et al, 2015a,b,c; Teutli-Hernández et al., 2020). The restoration strategy includes six steps that follow the standards and principles of restoration developed by the Society of Ecological Restoration. This strategy follows a multidisciplinary approach that includes social, ecological, and economic components to ensure the project is not only scientifically sound, but also economically viable and socially acceptable to ensure long-term sustainability.

The limestone karst substrate of the Yucatan Peninsula complicates mangrove restoration due to the virtual absence of above ground fresh water and complex network of subterranean rivers with cenotes (sink holes) as the only above ground access points to fresh water. Consequently, a series of rehabilitation methods must be deployed before attempting reforestation of mangroves with propagules to ensure the environmental conditions needed for the growth of new mangroves Herrera-Silveira, et al, 2015a,b,c; Teutli-Hernández et al., 2020). The first (and generally most costly part of the rehabilitation process) is hydrological rehabilitation such as the creation of tidal water canals and replacement of sediments, followed by topographical rehabilitation (development of dispersal areas, creation of mangrove 'islands' etc), and reforestation in suitable areas. Restoring mangrove ecosystems destroyed by roads, as proposed in this project, is extremely costly to start from zero as it requires enormous engineering projects to re-establish water flows to the mangroves. In Mexico, the Mexican Journal of Agricultural Sciences estimates the cost of this restoration (from nothing) to be between MX$40,000-60,000 (US$2000-3000) per hectare per year for at least five years to provide time for infrastructure and reforestation (Hernandez- Melchor et al., 2016).

For the proposed mangrove restoration areas in Sisal and Dzilam, a full diagnostic has already been completed by CINVESTAV as part of the regional Taab Che project. This diagnostic was designed to assess the site-specific combination of rehabilitation methods required to successfully restore mangroves (Teutli-Hernández et al., 2020) and included the following elements: evaluation of topography, hydrological assessment (level, duration and frequency of flooding, and degree of salt vs fresh water), water chemistry (salinity, nitrates, phosphates etc), sediment chemistry (bulk density, organic matter, nitrogen, phosphorous and carbon), and vegetation (composition and characteristics of remaining vegetation or adjacent vegetation in the case of completely cleared areas). In addition to site characterization, a full diagnostic of the causes of mangrove degradation (e.g., interruption of water flow due to construction of roads, hurricane damage, extension of urban area) has also been completed.

Following this diagnostic, hydrological restoration projects, such as the creation of new canals, and tunnels under roads to enable tidal water flow, have been completed with investment from CONABIO and other agencies within the Mexican government. These previous investments have also helped develop the methodology for successfully reforesting mangroves in areas made to be hypersaline by losing access to the coast. Mangrove propagules are planted on top of small ‘islands’ where rainwater helps to reduce salinity by washing away salt residue onto lower lying ground. This method combined with restoration of water flow has drastically improved the success rate of mangrove restoration in this unique karstic mangrove ecosystem (Herrera- Silveira, et al, 2015a,b,c).

These prior investments and long-term academic investigation make it possible to invest in the direct restoration and reforestation of Dzilam and Sisal without undertaking new large-scale infrastructure projects from zero as the only remaining actions for mangrove restoration are topographic restoration (creation of islands for mangrove planting) and reforesting. Moreover, building on the success of the CIVESTAV mangrove restoration work ensures a very high success rate with mangrove restoration as part of this proposed project.

Prior to beginning any project, CINVESTAV will select the work group from a representative cohort of each community, with emphasis on including women and other marginalized groups, as well as incentivizing the participation of academics, local social groups, civil society organizations, and government administrators. After establishing the project goals, the area will be surveyed and compared to a control plot to prepare the proper interventions for restoration.

Finally, the CINVESTAV team will monitor and help protect the mangroves as they grow, paying attention to target metrics for success. This monitoring will be trimestral during the first year when the plants are the most vulnerable, then will continue annually for the next five years, combined with community training programs designed to transfer monitoring responsibilities to the local community over the following 20 years.

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 northern coast. 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. Local communities will be consistently engaged through programs from Sociedad Cooperativa Tulum Sostenible (SCTS) to develop communal development plans based on a business project, with investment weighted for the first five years of intensive work.

Part F: Identification of Any Non-Eligible Activities

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

The methodology used for ecosystem restoration in this project takes into account the need to include community members in not only the restoration process, but also in monitoring and follow up, which requires providing them with equipment and capacity-building workshops (Biswas et al. 2009 in Herrera-Silveira et al., 2015a). The communities of Dzilam and Sisal have worked alongside CINVESTAV for the past 15 years and have met with SCTS prior to preparing this proposal in order to develop the first plans for the investment of the development fund.

While the destruction of mangroves in Dzilam and Sisal was caused by human intervention, it was not caused directly by the actions of the communities living in these areas. However, this project provides an opportunity to engage some of the most marginalized communities in Mexico by developing much-needed local businesses that can also help reduce pressures on mangroves and other coastal ecosystems. The idea is to develop local capacity for business development within the first five years to drive organic economic growth in each community while reducing pressures on mangroves and coastal ecosystems.

The community development efforts will be led by Sociedad Cooperativa Tulum Sostenible (SCTS), a Yucatan Peninsula-based cooperative dedicated to community development across the peninsula. Community benefits will be heavily weighted toward the first five years of the project to gain local acceptance and help jumpstart a few sustainable income streams for each community. In the first year, the goal will be to implement a series of community workshops and focus groups, with emphasis on engaging women, youth, and indigenous peoples, to develop community business plans from the grassroots level. These focus groups will look to identify common problems in the community, such as waste collection or lack of job opportunities, and propose potential solutions for support by SCTS and the development fund.

For example, Sisal has expressed interest in developing an ecotourism project in the community. While the area is not popular with foreigners, it is a destination for Mexicans from the state capital of Merida who currently have limited private and expensive options for amenities like food, restrooms and showers, and accommodation. A potential area for investment from the community development fund would be to build a community-run restaurant with public bathrooms and showers, which would create employment opportunities and attract local tourists that could drive additional businesses in the community.

In Dzilam, there is less common ground regarding a community project, but there has been significant interest in developing small businesses or projects around solid waste collection - which is a major issue in Dzilam - and apiculture, which has proved successful in other Maya communities. Dzilam's community management documents also point to an interest in developing fish farming in the oceans and rivers surrounding the community with fish, crustaceans, mollusks, and even echinoderms, but would require support in order to develop a sustainable methodology for this project.

Following the first year and based on the decided business plan, SCTS will provide hands-on support to each community to help implement the development program through a combination of workshops, training, field visits, investments and grants, technical assistance, and other programs as needed. These initiatives will also be implemented in parallel with long-term training in environmental leadership for local leaders from each community who will be prepared to lead future restoration and development projects. SCTS will be involved through the 25 years with follow-on projects, which may take the form of direct payments, ranger training, field trips with schools, additional business investment or institutional support, focus groups, workshops, and more.

Figure 9: This image shows the floating trash that has accumulated in the harbour where fishing boats are moored at the end of the day.

Part G: Long-Term Sustainability Drivers

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

CINVESTAV has worked for the past 15 years to establish an effective mangrove restoration methodology for the Yucatan Peninsula, especially in the North Yucatan. Therefore, CINVESTAV is committed to maintaining the mangroves in the protected 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. There would be an opportunity for a further project to be submitted to Plan Vivo for the generation of credits related to this carbon. 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 SCTS programs. 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 restored 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

The key collaboration for the project will be between Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV) working with the Sociedad Cooperativa Tulum Sostenible (SCTS), who will jointly implement the project, and rePLANET who will provide the finance and funding.

CINVESTAV

https://www.cinvestav.mx/

The Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV), founded in 1961, is a Mexican public institution dedicated to the development of postgraduate science, technology, and education across eight states. CINVESTAV employs nearly 650 scientists, 99% of whom hold doctoral degrees. The research center offers 63 postgraduate courses in materials science, biology, humanities and engineering. Each state-level research center was created to directly address local challenges, such as mangrove restoration in the Yucatan, which CINVESTAV Merida has been managing for over fifteen years. CINVESTAV will be the organization on the ground in charge of the restoration and maintenance of mangrove areas in Sisal and Dzilam de Bravo, as well as helping with the extraction and analysis of carbon from cores necessary before the beginning of the project.

Dr. Jorge Alfredo Herrera Silveira

Dr. Jorge Herrera is a Level 3 member of Mexico's National Researcher System from the Marine Resources department of CINVESTAV Merida. He received his doctorate in Biology from the University of Barcelona and has completed research at the Coastal Ecology Institute, the Mediterranean Agronomy Institute, the Department of Ecology at the University of Barcelona, the Tropical Ecology and Conservation Station in Costa Rica, Florida International University, University of Southwestern Louisiana, and the Pyrenean Institute of Ecology in Zaragoza. He has published more than 100 articles and book chapters, as well as leading numerous international conferences and advising organizations such as UNESCO, Ramsar, and NAFTA on mangrove restoration and blue carbon in Mexico. He is the head of the Yucatan Peninsula's mangrove monitoring program and co-chair of Mexico's coastal carbon program. Dr. Herrera will lead the restoration and monitoring program for this project using the methodology developed alongside Dr. Teutli.

Dr. Claudia Teutli Hernández

Dr. Claudia Teutli is a biologist and Doctor of Environmental Science and Technology from the University of Barcelona focused on ecological management and restoration. Her academic career began with research on adaptation and restoration of coastal ecosystems to protect communities from the effects of climate change, more recently with a focus on recuperating ecosystem services. She is the co-author of the CINVESTAV strategy for mangrove restoration, which is used by numerous federal agencies, and manages several restoration projects along the entire coast of Mexico.

Sociedad Cooperativa Tulum Sostenible S de R.L. de C.V. (SCTS)

The Tulum Sustainable, Cooperative, (SCTS) is and limited liability company with variable capital consisting of a diverse group of Tulum locals united by a desire to organize and develop projects that improve quality of life across the Yucatan Peninsula. Its members bring together interdisciplinary experience on social and environmental development projects that have generated significant impact, especially within the Tulum community. SCTS is known for its innovative approach to sustainability, including recycling programs, the Maya market, and more. Its mission is to contribute to the development of integral, sustainable communities where all inhabitants, including wildlife, can prosper. SCTS will lead the community development and investments alongside the restoration project by integrating cooperatives in Sisal and Dzilam that promote local leadership, business development, and monetization of ecosystem services. SCTS will also provide the support to rePLANET in negotiating contracts with communities and individuals regarding the rights to carbon within the polygons and payments for ecosystem services.

Miriam Tzeek

Miriam Tzeek is a biologist from UADY focused on sea turtle conservation who has worked extensively on the development and implementation of conservation projects along the Yucatan Peninsula. Prior to co-founding SCTS, Miriam worked in both the private and public sector helping build capacity for turtle conservation in local communities. She has led the Quintana Roo state committee for turtle conservation, as well as speaking in numerous conferences and publishing in a variety of scientific journals. Miriam will lead the community development project to ensure long-term sustainability of the proposed restoration, as well as helping prepare the materials for the PIN and PDD in partnership with CINVESTAV.

Carlos Meade

Carlos Meade is a social scientist from Mexico City who spent over 30 years living among indigenous communities throughout Mexico. In 1995, he founded Yaxché, Árbol de la Vida, A.C, a no gubernamental asociacion dedicated to empowering indigenous community development across the state of Quintana Roo. In recent years, he has worked as an environmental consultant focused on indigenous engagement and developing community management plans for natural resources. He also works with SCTS to support community development efforts.

Manuel del Monte Martinez

Manuel del Monte Martinez is an economist and holds a Master's degree in Environmental Planning and Sustainability. Since 2005, he has worked on forest-related community development projects around the globe, as well as in his native Mexico. Manuel has worked as a grassroots organizer and liaison for public/private partnerships. He has founded and developed cooperatives to improve quality of life and income through forest-related products such as medicinal gardens, wood furniture, coffee, honey, ornate palms, and more. He is now a consultant on corporate sustainability and biodiversity management who will support local business development in this project.

Diego Llamas

Diego Llamas is an electrical engineer who was born and raised in the Yucatan Peninsula and has a fierce love for the local environment. He led numerous student cooperatives on environmental education and protection in Italy and Canada before returning to Tulum and joining SCTS. He currently coordinates the Puntos Limpios recycling project in Tulum and supports local development efforts by integrating technology to make systems more efficient and sustainable.

H2) Applicant organisation

The applicant organization for the delivery of the project in Mexico and receipt of the carbon credits will be SCTS, who will represent and manage the relationship with local landowners (private and communal). SCTS will also provide support as in-country liaison for rePLANET on the project, while CINVESTAV will provide the technical support for restoration and reforestation in Sisal and Dzilam.

rePLANET

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 (https://replanet.org.uk) The purpose of this new company is to fund reforestation and afforestation 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 on the Yucatan Peninsula each June – August period using international and national academics funded by the tuition fees paid by the accompanying students. These data will be provided free of charge to the project biannually 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)

Participation in Plan Vivo projects must be through free, prior, informed consent (FPIC), and demonstrable through consultation and participatory design processes. Projects should, at an early stage, initiate discussions with target groups to identify project activities

Both Sisal and Dzilam have been a part of federal, state level, and CINVESTAV restoration efforts for over a decade and have demonstrated success in maintaining mangrove cover in many of these instances. However, the long-term success of this project depends on local acceptance and quality of life improvements as a result of restoration efforts through both social projects and business development, for which investment will be heaviest in the first five years of implementation.

To engage the communities with the restoration and receive local approval, SCTS visited both Sisal and Dzilam de Bravo in advance of the preparation of this project to conduct interviews with key stakeholders in each community. They discussed potential challenges the community might anticipate with a restoration project in the area, as well as possible solutions to act as a starting point for future development plans. However, SCTS has identified a need for much deeper exploration and analysis before launching any community development programs to ensure the success of invested funds. In the first year of the project, SCTS will organize representative focus groups broken down by demographics to discuss and align community priorities for future development plans using restoration funds. Once there is consensus around one or more projects of interest to the community, SCTS will provide institutional support to identify what is needed to make this project a reality, such as: workshops by specialists in the selected industry, technical administrators to help with budgets, training in marketable skills (customer service, time management etc), among others. Within the first year, SCTS will have helped both communities constitute the legal entities (cooperatives) in charge of their projects.

Projects will begin to be implemented from the start of the second year, with SCTS providing support through investment in training and capacity-building to help jumpstart the local programs. Depending on the project selected, the timeline for training and implementation will vary but this is likely to be one of the heaviest years for investment in the communities.

In the third and fourth years, SCTS will continue to invest directly in and provide technical assistance to the community businesses, as well as launching the mangrove education program and cultural revival projects through a series of workshops, field visits, conferences on selected topics, radio shows, and video courses. SCTS will also begin to identify local environmental leaders after the third year of implementation to be selected for further training in problem-solving, local development, and leadership. The idea behind this program is to generate local impetus and capacity for future environmental project development.

Since the community development funding is heavily weighted toward the first five years, from years 5-25, the SCTS will provide hands-on support to the environmental leaders to continue to develop and implement environmental education programs. Similarly, SCTS will work with the leader of the incorporated business to ensure further investment and success for the project. The goal is to provide significant independence within the communities to develop grassroots plans that help protect the mangroves while benefiting the community.

Part J: Additionality Analysis

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

This project is not the product of a legislative decree or land-use initiative that would have been commercially viable in its own right. Over the past 15 years, efforts have been made across the entire coast of Northern Yucatan to restore the mangrove ecosystems that have been destroyed by roads, hurricanes, and human settlements. Dozens of these projects, largely state-funded, have been costly failures as they were not able to correct hydrology issues in the area or resolve the challenge of hypersalinity caused by the road blockage. Millions of dollars have been invested into this area to build canals, move sediments, and replant propagules, which until recently had only limited success. Dr. Jorge Herrera of CINVESTAV, who will lead the technical team for this project, developed a methodology for reforestation of mangroves using a combination of hydrology restoration and small sediment islands that has been successful across implementation sites across the North Yucatan over the past five years. In many of these areas, including the proposed project sites, much of the most expensive hydrology work has been completed, but it has become clear that mangroves will not repopulate naturally and must be planted in order to fully restore the area.

In Sisal, efforts were made to build and reopen canals under the roadway to reintroduce water to the area and these have been maintained since 2011. However, many areas remain deforested due to the cost associated with replanting and maintaining the hydrology of the area and government funds to pursue these projects are limited. Similarly, in Dzilam, in 2012 the area was studied to reveal a need to improve canals for water flow to the mangroves, a project that received government investment. Some small areas were reforested at this time to test the new methodology, but the area has not yet been completely restored.

Although there have been numerous projects within the proposed restoration areas, these have not yet been fully reforested largely due to a lack of resources. Most projects in this area are developed as two-year government or non-profit grants that eventually run out and do not plan for follow-up on maintenance, monitoring, or income generation for communities. This project specifically breaks that cycle by planning to generate sustainable, long-term income streams that protect mangroves for 25+ years with community support.

CINVESTAV Merida and SCTS, in partnership with rePLANET have the interest, technical expertise, and funding necessary to implement this reforestation project in the Northern Yucatan. 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 restoration program and are the main actors doing so in this area. Furthermore, Miriam Tzeek from Coperativa Society Tulum Sustainable has maintained constant communication with SDS Yucatan, who manages the state reserves, to generate government support for the project and solicit a letter from the commission that states that the areas to be restored do not overlap with existing blue carbon projects.

Type of Barrier	**Description of barrier**	**How barriers will be overcome by project activities**
Financial / Economic	Insufficient financial resources to implement and maintain project activities	Funding mechanism for the project will enable long term funding to support planting, monitoring and community development activities through the sale of carbon credits
Technical	Technical and organisational capacity for mangrove restoration does not currently exist within the communities Capacity for business development currently not present within communities	CINVESTAV provide this expertise and community involvement is integral to their methods SCTS provide training, workshops and ongoing support
Ecological	Further hydrological adjustments needed to correct salinity level disruption from roads and infrastructure work	The methods used have been tested with success in several areas
Social	High levels of unemployment and relatively low levels of education mean that increasing pressure is placed on mangroves areas for alternative uses	Employment opportunities, capacity building programmes, educational workshops and ongoing support throughout project to help improve livelihoods within the communities
Cultural	Previous government programs to solve local challenges like waste management and large scale restoration have been unsustainable, breeding skepticism toward new solutions	SCTS diagnostic interviews and programs seek community input throughout the development process to ensure solutions are culturally-appropriate and financially sustainable over the 25 years and beyond.

Part K: Notification of Relevant Bodies & Regulations

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

During the 2021 United Nations Climate Change Conference (COP21) all 196 participating countries adopted the 2015 Paris agreement, in which countries independently determine how to lower their carbon emissions, and outline pledges called Nationally Determined Contributions (NDCs). Conservation and restoration of natural ecosystems that sequester and store carbon such as forests can be included in NDCs as measures of mitigation or adaptation to climate change. 151 countries contain at least one blue carbon ecosystem (seagrass, saltmarshes or mangroves) and 71 countries contain all three.

Mexico was the first developing country to present its NDC in 2015. The Mexico NDC recognizes the importance of conservation of blue carbon ecosystems in mitigating the countries emissions and includes conservation management, and restoration measures of these habitats as methods of adaptation to climate change. In addition, the Ministry of the Environment and Natural Resources (SEMARNAT) in conjunction with the National Commission of Protected Natural Areas (CONANP), have promoted the incorporation of actions that promote the conservation of blue carbon ecosystems in policy instruments (CONANP 2015) including the new Special Program on Climate Change (PECC) 2020-2024. In line with this focus from SEMARNAT and CONANP, the National Wetlands Committee of Mexico included the promotion of integration and strengthening the issue of blue carbon within the framework of the process of updating Mexico´s NDC as a priority recommendation for the Federal Administration 2019-2024.

Coastal wetlands´ land-use change emissions and wetlands´-avoided emissions are not yet included in the national greenhouse gas accounting. Moreover, there is no map or other information to indicate which areas of blue carbon habitats would be included in the NDC and which areas would be available for the voluntary carbon market. It is highly likely that blue carbon ecosystems located inside federally protected areas, where land tenure belongs to the federal government will soon be included in the NDC, but as Mexico has a strong history of respecting original land rights and the ecosystem services that they provide, blue carbon ecosystems and associated carbon credits that are located on privately owned or community land (ejidos) are expected to remain the property of the landowners.

However, as the vast majority of blue carbon ecosystems in Mexico are located inside federal or state protected areas and are managed by SEMARNAT, it is expected that all blue carbon projects in Mexico will have to work in conjunction with the government, even if the carbon rights technically belong to the landowners. The proposed projects in Sisal and Dzilam involve mangrove restoration on ejido land located inside the buffer zone of the Yucatan state protected area of RECMCY, managed by SDS Yucatan. Consequently, development of this project must be in conjunction with both the ejidos and the Yucatan state government.

A letter (see below) has been sent to SDS Yucatan to confirm that there are no overlapping blue carbon or restoration projects within the proposed polygons and that communities have a right to sell their carbon rights on their land. In a meeting with the SDS Yucatan team, the organization expressed support for the project and a signed letter has been provided giving formal approval for the project (appendix 1). Further letters and contracts will be solicited from individual landowners and/or communities whose land overlaps with the proposed polygons prior to beginning any restoration work.

Secretaría de Desarrollo Sustentable del Gobierno del Estado de Yucatán

Tulum, Quintana Roo, 16 de agosto de 2021

Asunto: Carta de no inconveniente

RePlanet
Limited Corporation

Centro de Investigación y de
Estudios Avanzados del
Instituto Politécnico Nacional
(CINVESTAV)

Sociedad Cooperativa Tulum Sostenible
SC de RL de CV (SCTS)
PRESENTES

Mediante la presente hago de su conocimiento que en los siguientes polígonos (en correo electrónico adjunto) pertenecientes a las áreas de Reserva Estatal Ciénagas Y Manglares De La Costa Norte De Yucatán entre las comunidades de Sisal y Dzilam, desde años atrás, se ha trabajado en la restauración de las áreas de manglar, sin embargo falta por concluir.

En la actualidad en dicha área mencionada no contamos con algún otro proyecto de restauración o de protección de ecosistemas de Carbono Azul activo así como tampoco proyectos con comunidades que reciban beneficios generados por la venta de créditos de carbono azul, por lo que **no** encontramos **inconvenientes** para la realización de algún proyecto de este tipo en dichas áreas.

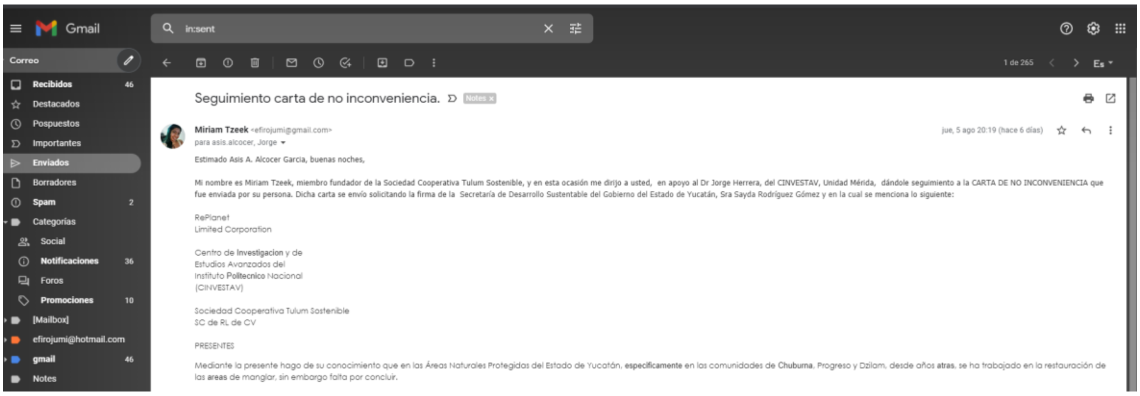
En cuanto a los derechos de carbono, estos pertenecen, a los dueños propietarios de los terrenos, por lo que la Secretaría a mi cargo no tiene injerencia con respecto a este tema, por lo tanto RePLANET, CINVESTAV y SCTS deberán acercarse a cada uno de los propietarios para acordar los términos del cobeneficio.

Por lo anterior hago de su conocimiento nuestro respaldo al proyecto de "Restauración y protección de manglares y ecosistemas de Carbono Azul en la Península de Yucatán, México" que propone RePLANET; el Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional(CINVESTAV) y la Sociedad Cooperativa Tulum Sostenible, SC DE RL de CV con el fin de apoyar a los compromisos del Gobierno de México asumidos en 2015 ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático (CMNUCC), así como a su interés de trabajar de manera colaborativa con la comunidad internacional al establecer compromisos en materia de adaptación al cambio climático y mitigación de Gases y Compuestos de Efecto Invernadero (GyCEI), para la Contribución Determinada a nivel Nacional (NDC, por sus siglas en inglés) en concordancia con la Ley General de Cambio Climático (LGCC) y de conformidad con las decisiones 1/CMA.2 y 1/CP.21 y el Artículo 4 del Acuerdo de París.

Sin otro particular me despido de usted, enviandole un cordial saludo.

ATENTAMENTE:
Secretaría de Desarrollo Sustentable del Gobierno del Estado de Yucatán

Sayda Rodríguez Gómez



Seguimiento carta de no inconveniencia.

Miriam Tzeek <efirojumi@gmail.com>
para asis.alcocer, Jorge
jue, 5 ago 20:19 (hace 6 días)

Estimado Asis A. Alcocer Garcia, buenas noches,

Mi nombre es Miriam Tzeek, miembro fundador de la Sociedad Cooperativa Tulum Sostenible, y en esta ocasión me dirijo a usted, en apoyo al Dr Jorge Herrera, del CINVESTAV, Unidad Mérida, dándole seguimiento a la CARTA DE NO INCONVENIENCIA que fue enviada por su persona. Dicha carta se envío solicitando la firma de la Secretaría de Desarrollo Sustentable del Gobierno del Estado de Yucatán, Sra Sayda Rodríguez Gómez y en la cual se menciona lo siguiente:

RePlanet
Limited Corporation

Centro de Investigacion y de
Estudios Avanzados del
Instituto Politecnico Nacional
(CINVESTAV)

Sociedad Cooperativa Tulum Sostenible
SC de RL de CV

PRESENTES

Mediante la presente hago de su conocimiento que en las Áreas Naturales Protegidas del Estado de Yucatán, especificamente en las comunidades de Chuburna, Progreso y Dzilam, desde años atras, se ha trabajado en la restauración de las areas de manglar, sin embargo falta por concluir.

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 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 restored 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 SCTS will transfer the carbon credits to rePLANET at the agreed issue price. The payment schedule agreed between rePLANET and SCTS ensures a significant cushion between payment and when funds would be needed by SCTS, 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.

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Appendix 1

Letter from SDS Yucatan giving formal approval for the project

Juntos transformemos Yucatán GOBIERNO DEL ESTADO | SDS SECRETARÍA DE DESARROLLO SUSTENTABLE

Dirección de Gestión y Conservación de Recursos Naturales
Número de oficio: VI-1767-2021
Asunto: Carta no inconveniencia.

Mérida, Yucatán a 16 de noviembre de 2021

Dr. Tim Coles OBE
RePlanet, Limited Corporation

Dr. Jorge Herrera Silveira
Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV)

Biol. Miriam Tzeek Tuz
Sociedad Cooperativa Tulum Sostenible
S.C. de R.L. de C.V. (SCTS)
Presentes

En relación al oficio recibido ante esta Secretaría el día 27 de octubre del presente año, en donde RePLANET; la Sociedad Cooperativa Tulum Sostenible, S.C. de R.L. de C.V. y el Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV), representado por el Dr. Jorge Herrera; solicitan a la Secretaría de Desarrollo Sustentable de Yucatán, una "Carta de No Inconveniencia" con respecto al proyecto **"Restauración y protección de manglares y ecosistemas de Carbono Azul en la Península de Yucatán, México"**; el cual tiene como objetivo secuestrar dióxido de carbono mientras se restauran los ecosistemas de manglares que han sido dañados por el desarrollo de infraestructura y las tormentas tropicales a lo largo de la costa norte de la península de Yucatán, México. En los municipios de Hunucmá en la localidad de Sisal y en el municipio de Dzilam de Bravo en la localidad del mismo nombre.

Y con referencia a la documentación entregada y el análisis de la propuesta técnica del Proyecto de Restauración, proporcionado ante la SDS, vía correo electrónico el día 26 de octubre del presente año, por la Bióloga Miriam Tzeek Tuz; se realiza la siguiente opinión técnica:

El proyecto consta de dos polígonos que para efectos de esta respuesta se denominará "polígono 1" al polígono que se encuentra ubicado en la localidad de Sisal, del municipio de Hunucmá y posee (según el archivo kmz entregado) una superficie de 277,44 ha., mientras que se hará referencia como "polígono 2" al polígono ubicado en la localidad de Dzilam de Bravo, municipio del mismo nombre; con una superficie aproximada de 446.62 ha (según el archivo kmz entregado).

Ambos polígonos se encuentran dentro de la Reserva Estatal Ciénagas y Manglares de la Costa Norte de Yucatán**; el polígono 1**, está dentro de la zona de amortiguamiento; en la **Subzona de Recuperación (SZR1)**, que según su programa de manejo especifica que esta subzona está destinada a la aplicación de programas de restauración de manglares y duna costera que conlleven a mejorar la conectividad hidráulica y recuperación biológica.

Es por ello que las actividades que se podrán llevar a cabo en esta subzona son las relacionadas a la rehabilitación y restauración de los ecosistemas que se encuentren fundamentadas en los programas de restauración ecológica, así como actividades de investigación, monitoreo y educación ambiental y ecoturismo con manejo artesanal y múltiple de recursos naturales de subsistencia, con la autorización correspondiente. No omito decir, que la zona restringe cualquier otro uso o aprovechamiento de los recursos naturales hasta que la recuperación de tales sitios haya sido completada con éxito.

Juntos transformemos **Yucatán** GOBIERNO DEL ESTADO | **SDS** SECRETARÍA DE DESARROLLO SUSTENTABLE

Dirección de Gestión y Conservación de Recursos Naturales
Número de oficio: VI-1767-2021
Asunto: Carta no inconveniencia.

El **polígono 2**; se encuentra en la zona de amortiguamiento de la reserva en la **Subzona de Aprovechamiento Especial (SZAE8),** esta zonas son principalmente manglares y lagunas costeras donde históricamente se ha realizado un aprovechamiento de autoconsumo. Se podrán llevar a cabo en esta subzona actividades de ecoturismo. Tanto la ficha entregada como el resumen ejecutivo, manifiestan que se realizaran acciones de restauración ecológica para estos sitios señalados e indican que dichas acciones seguirán las recomendaciones del Grupo Manglares del CINVESTAV-IPN Unidad Mérida.

En consecuencia a lo expresado anteriormente, le informo que está Secretaría **NO ENCUENTRA NINGUNA INCONVENIENCIA** para realizar dichas acciones de **restauración ecológica** en las zonas propuestas en el ANP Estatal Ciénagas y Manglares de la Costa Norte de Yucatán; siempre y cuando las actividades y acciones utilicen métodos beneficiosos para el ecosistema.

En cuanto a los derechos de un proyecto de carbono, hay que aclarar que las Áreas Naturales Protegidas de México, son declarativas no expropiatorias; por lo que dentro de las mismas, pueden haber diferentes tipos de régimen de propiedad; en consecuencia, La Secretaría de Desarrollo Sustentable; **NO tiene injerencia** con respecto a este tema, se recomienda a los interesados acercarse tanto a las dependencias pertinentes como a cada uno de los propietarios para acordar los términos necesarios.

Les recuerdo que según las disposiciones del ANP, se esperan los datos y resultados, del proyecto. No obstante cabe mencionar que la información proporcionada es únicamente para registros de la SDS, sin ningún fin de lucro o divulgación.

Finalmente, no omito mencionar que esta carta no exime al solicitante el dar cumplimiento con trámites de otras instituciones en el caso de ser necesario.

Esperando que le sea útil este documento y deseándole el mayor de los éxitos con esta iniciativa, me despido de usted.

ATENTAMENTE,

M.I.A. SAYDA MELINA RODRÍGUEZ GÓMEZ.
SECRETARIA.

C.c.p. MGA. Toshio Julián Yokoyama Cobá.- Director de Gestión y Conservación de Recursos Naturales.-Edificio.
C.c.p. LARN. Asis Alberto Alcocer Garcia.- Jefe del Departamento de Conservación Ambiental.-Edificio.

TJYC/AAAG/jraa**

Appendix 2

Proposed carbon accounting method to be used subject to approval at PDD stage by Plan Vivo

Dr Tim Coles, Operation Wallacea
Dr Ian Hendy, University of Portsmouth
Professor Martin Speight, St Anne's College, University of Oxford

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 lifetime 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 it 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 carbon 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 oxide 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 most accurate method is the measurement of diameter at breast height and identification of species and given the annual 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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