DELTA BLUE CARBON - 1

THE INDUS DELTA MANGROVE RESTORATION PROJECT PHASE 1

Document Prepared By:

Indus Delta Capital
The Government of Sindh
and Silvestrum Climate Associates

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Project Proponent(s)	Government of Sindh Forest Department Barrack-No.10, Block-4A, Sindh Secretariat, Karachi, Pakistan Indus Delta Capital Limited Gabrielle House, 332-336 Perth Road, Ilford, IG2 6FF, UK Main Contact: Indus Delta Capital – Mr Nadeem Khan +44 208 532 4500 nadeem.khan@indusdeltaredd.com

Prepared By	Indus Delta Capital; see above Silvestrum Climate Associates – Dr Igino Emmer igino.emmer@silvestrum.com
Validation Body	AENOR INTERNACIONAL S.A.U. Mr Jose Luis Fuentes +34 914326000 jfuentes@aenor.com
Project Lifetime	60 years: 19 February 2015 to 18 February 2075
GHG Accounting Period	60 years: 19 February 2015 to 18 February 2075
History of CCB Status	This is the first version for seeking validation under both the Climate, Community and Biodiversity Standard as well as the Verified Carbon Standard.
Gold Level Criteria	Phase 1 of Delta Blue Carbon (DBC-1) will meet the Gold Level criteria for climate change adaptation, community and biodiversity as summarised below. *Climate change adaptation* DBC-1 will result in an estimated 142,050,139 tCO_2e of emission removals over the 60-year project lifetime. This will be achieved through the restoration and ongoing protection of 224,997 hectares of mangroves by making use of Mangrove Stewardship Agreements to work in partnership with local forest-dependent communities. The project's activities assist these communities to adapt to the probable impacts of climate change. By improving the financial security and wellbeing of communities in and around the Project Area, DBC-1 will decrease people's vulnerability to climate change-related shocks. The improved provision of mangrove ecosystem goods and services will also improve the climate change resilience of local people. By revitalising the degraded coastal habitat and ensuring its long-term sustainability, the project activities will also yield substantial climate change adaptation benefits for the biodiversity in the region. *Community* More than 42,000 people live within the Project Zone, in 60 coastal villages.

They meet the definition of smallholder/marginal groups as defined by international and national standards of deprivation, poverty and marginality. More than 70% of the people in the Project Area live below the poverty line and are surviving on less than US$ 1.25 a day (2005 purchasing power parity, PPP).

Most communities lack access to safe and affordable drinking water, and are deprived of basic education, health and hygiene facilities. They also lack proper housing and shelter facilities and are extremely vulnerable to various types of disasters including tsunamis, cyclones, floods and droughts.

DBC-1 community development activities – outlined in detail in Chapter 4 – generate both short-term and long-term net positive well-being benefits for local community members, including women and those from vulnerable/marginalised groups.

Biodiversity

DBC-1 is being implemented in the coastal portion of the Indus eco-region which is one of the 40 most biologically rich ecoregions in the world. The Project Zone meets the definition of Key Biodiversity Area (KBA) on account of both vulnerability and irreversibility criteria. It is characterised by the presence of threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability in a threatened arid zone mangrove ecosystem.

The region is home to 11 globally threatened species (according to the IUCN Red List), including the Indus River dolphin (*Platanista gangetica ssp. minor*; EN), the Indian Ocean humpback dolphin (*Sousa plumbea*; EN*)* the Indian pangolin (*Manis crassicaudata*; EN) and the fishing cat (*Prionailurus viverrinus*; VU).

DBC-1 positively impacts these species of special concern by revegetating the degraded coastal ecosystem. It will also address the threats facing them and their habitats through a number of approaches. These include:

- Preventing habitat and coastal biodiversity loss through the regeneration of 247,112 ha of mangroves, as well as controlling the ongoing drivers of mangrove deforestation and degradation
- Controlling poaching and illegal trade through the effective enforcement of wildlife law
- Resolving governance issues
- Awareness raising amongst stakeholders
- Training and capacity building of communities and other stakeholders
- Mobilisation of human, technical, material and financial resources for biodiversity conservation.

Expected Verification Schedule	To be confirmed

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List of Abbreviations and Acronyms

Abbreviation/Acronym	Description/Explanation
AD	Activity data
AFOLU	Agriculture, forestry and other land use
AGB	Aboveground biomass
ARR	Afforestation, reforestation and re-vegetation
AUDD	Avoided unplanned forest degradation and deforestation
BD	Bulk density
BSL	Baseline
C	Carbon
CBD	Convention on Biological Diversity
CCB	Climate, Community and Biodiversity
CCBS	Climate, Community and Biodiversity Standard
CH_4	Methane
CIFOR	Centre for International Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CIW	Conservation of intact or partially degraded wetlands
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPDE	Carbon preservation depositional environment
CR	Critically endangered (IUCN Red List)
CSO	Civil society organisation
DEM	Digital elevation model
DM	Dry matter
DRM	Disasters risk management
DRR	Disaster risk reduction
EN	Endangered (IUCN Red List)
ER	Emission reduction
EU	European Union
FAO	Food and Agriculture Organization
FDG	Focus group discussion
FPIC	Free, prior and informed consent
FSC	Forest Stewardship Council
GHG	Greenhouse gas

GIS	Geographic information system
GM	Grievance manager
GMO	Genetically modified organism
HCV	High conservation value
IBAs	Important bird areas
IFL	Intact forest landscapes
IFM	Improved forest management
ILO	International Labour Organization
IPAs	Important plant areas
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KBA	Key biodiversity area
LFA	Log frame analysis
MFF	Mangroves for the Future
MoU	Memorandum of understanding
MRV	Monitoring, reporting and verification
MSA	Mangrove Stewardship Agreement
MU	Management unit
NDC	Nationally determined contribution
NDMA	National Disaster Management Authority
NGO	Non-governmental organisation
N_2O	Nitrous oxide
NTFP	Non-timber forest product
PoA	Programme of activities
P&C	Principles and criteria
PD	Project description
PFI	Pakistan Forest Institute
PLA	Participatory learning and action
PPP	Purchase power parity
PRA	Participatory rural appraisal
QA/QC	Quality assurance and quality control
RCP	Representative concentration pathway – time-dependent projection of atmospheric greenhouse gas concentrations
REDD+	Reducing emissions from deforestation, forests degradation, sustainable forest management and enhancement of forest carbon stocks

RRA	Rapid rural appraisal
RTE	Rare, threatened or endangered
RTK	Real time kinematic - technique enhancing the precision of position data derived from satellite-based positioning systems
RWE	Restoration of wetland ecosystems
SBIA	Social and biodiversity impact assessment
SDG	Sustainable development goal
SLR	Sea level rise
SO	Social organisation
SOC	Soil organic carbon
SOP	Standard operating procedure
TNC	The Nature Conservancy
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
US$	United States dollar
VCS	Verified Carbon Standard
VCU	Verified carbon unit
VDC	Village development committee
VER	Verified emission reduction
VO	Village organisation
VU	Vulnerable (IUCN Red List)
VVB	Validation and verification body
WHO	World Health Organization
WO	Women organisation
WPS	(With-) project scenario
WRC	Wetland restoration and conservation
WRI	World Resources Institute
WWF	World-Wide Fund for Nature

1 SUMMARY OF PROJECT BENEFITS

1.1 Unique Project Benefits

Outcome or impact estimated by the end of project lifetime	Section reference
1) Improved protection from storm surges and other coastal hazards for communities and coastal infrastructure	3.4.3
2) A significant increase in spawning places for fishes, shrimps and other marine life. This impact is estimated to boost income from fishing	5.1.2
3) Conservation of Historical and Cultural Heritage Sites and Cultural Artefacts	4.1.1
4) Inspiration, knowledge and information services. Many artists, musicians, academicians, and researchers get inspiration, knowledge and information from mangrove forests and their ecosystems.	4.1.3
5) Aesthetic values and iconic seascapes. Tidal wetlands areas are iconic landscapes and seascapes with immense aesthetic values and opportunities for spiritualism and places for recreation and being part of the nature	4.1.3

1.2 Standardised Benefit Metrics

Category	Metric	Estimated by the end of project lifetime	Section reference
GHG emission reductions or removals	Net estimated emission removals in the Project Area, measured against the without-project scenario	142,050,139 tCO_2e	3.2.4
	Net estimated emission reductions in the Project Area, measured against the without-project scenario	Not Applicable	
Forest[1] cover	For REDD[2] projects: Estimated number of hectares of reduced forest loss in the Project Area measured against the without-project scenario	Not Applicable	
	For ARR[3] projects: Estimated number of hectares of forest cover increased in the Project Area measured against the without-project scenario	224,997 ha	3.1.3.2.1
Improved land management	Number of hectares of existing production forest land in which IFM[4] practices are expected to occur as a result of project activities, measured against the without-project scenario	Not Applicable	
	Number of hectares of non-forest land in which improved land management practices are expected	Not Applicable	

[1] Land with woody vegetation that meets an internationally accepted definition (e.g., UNFCCC, FAO or IPCC) of what constitutes a forest, which includes threshold parameters, such as minimum forest area, tree height and level of crown cover, and may include mature, secondary, degraded and wetland forests (*VCS Program Definitions*)

[2] Reduced emissions from deforestation and forest degradation (REDD) - Activities that reduce GHG emissions by slowing or stopping conversion of forests to non-forest land and/or reduce the degradation of forest land where forest biomass is lost (*VCS Program Definitions*)

[3] Afforestation, reforestation and revegetation (ARR) - Activities that increase carbon stocks in woody biomass (and in some cases soils) by establishing, increasing and/or restoring vegetative cover through the planting, sowing and/or human-assisted natural regeneration of woody vegetation (*VCS Program Definitions*)

[4] Improved forest management (IFM) - Activities that change forest management practices and increase carbon stock on forest lands managed for wood products such as saw timber, pulpwood and fuelwood (*VCS Program Definitions*)

Category	Metric	Estimated by the end of project lifetime	Section reference
	to occur as a result of project activities, measured against the without-project scenario		
Training	Total number of community members who are expected to have improved skills and/or knowledge resulting from training provided as part of project activities	34,400	4.5.2
	Number of female community members who are expected to have improved skills and/or knowledge resulting from training as part of project activities	6,000	4.5.2
Employment	Total number of people expected to be employed in project activities,[5] expressed as number of full-time employees[6]	Ca. 1,000	4.5.2
	Number of women expected to be employed as a result of project activities, expressed as number of full-time employees	Ca. 400	4.5.2
Livelihoods	Total number of people expected to have improved livelihoods[7] or income generated as a result of project activities	Entire Project Zone[8]: Ca. 43,000 people	4.2.1
	Number of women expected to have improved livelihoods or income generated as a result of project activities	Women in ca. 5,000 households	4.2.1

[5] Employed in project activities means people directly working on project activities in return for compensation (financial or otherwise), including employees, contracted workers, sub-contracted workers and community members that are paid to carry out project-related work.

[6] Full time equivalency is calculated as the total number of hours worked (by full-time, part-time, temporary and/or seasonal staff) divided by the average number of hours worked in full-time jobs within the country, region or economic territory (adapted from the UN System of National Accounts (1993) paragraphs 17.14[15.102];[17.28])

[7] Livelihoods are the capabilities, assets (including material and social resources) and activities required for a means of living (Krantz, Lasse, 2001. *The Sustainable Livelihood Approach to Poverty Reduction*. SIDA). Livelihood benefits may include benefits reported in the Employment metrics of this table.

[8] The Project Zone for this ARR/RWE project activity is defined as the area that includes the Project Area – where the project proponent executes the mangrove reforestation – and the wider area including villages where the project is directly impacting stakeholders and where an associated mangrove conservation project is executed by the same project proponent.

Category	Metric	Estimated by the end of project lifetime	Section reference
Health	Total number of people for whom health services are expected to improve as a result of project activities, measured against the without-project scenario	Entire Project Zone: Ca. 43,000 people	4.5.2
	Number of women for whom health services are expected to improve as a result of project activities, measured against the without-project scenario	Women in ca. 5,000 households	4.5.2
Education	Total number of people for whom access to, or quality of, education is expected to improve as result of project activities, measured against the without-project scenario	Entire Project Zone: Ca. 43,000 people	4.5.2
	Number of women and girls for whom access to, or quality of, education is expected to improve as result of project activities, measured against the without-project scenario	Women in ca. 5,000 households	4.5.2
Water	Total number of people who are expected to experience increased water quality and/or improved access to drinking water as a result of project activities, measured against the without-project scenario	Entire Project Zone: Ca. 43,000 people	4.5.2
	Number of women who are expected to experience increased water quality and/or improved access to drinking water as a result of project activities, measured against the without-project scenario	Women in ca. 5,000 households	4.5.2
Well-being	Total number of community members whose well-being[9] is expected to improve as a result of project activities	Entire Project Zone: Ca. 43,000 people	4.5.2

[9] Well-being is people's experience of the quality of their lives. Well-being benefits may include benefits reported in other metrics of this table (e.g., training, employment, livelihoods, health, education and water), and may also include other benefits such as strengthened legal rights to resources, increased food security, conservation of access to areas of cultural significance, etc.

Category	Metric	Estimated by the end of project lifetime	Section reference
	Number of women whose well-being is expected to improve as a result of project activities	Women in ca. 5,000 households	4.5.5
Biodiversity conservation	Expected change in the number of hectares managed significantly better by the project for biodiversity conservation,[10] measured against the without-project scenario	Ca. 350,000 ha	5.2.1
	Expected number of globally Critically Endangered or Endangered species[11] benefiting from reduced threats as a result of project activities,[12] measured against the without-project scenario	Four	5.5.1

[10] Managed for biodiversity conservation in this context means areas where specific management measures are being implemented as a part of project activities with an objective of enhancing biodiversity conservation, e.g., enhancing the status of endangered species

[11] Per IUCN's Red List of Threatened Species

[12] In the absence of direct population or occupancy measures, measurement of reduced threats may be used as evidence of benefit

2 GENERAL

2.1 Project Goals, Design and Long-Term Viability

2.1.1 Summary Description of the Project (G1.2)

The Delta Blue Carbon Project – Phase 1 (DBC-1) is an initiative to promote climate change mitigation and adaptation, maintain biodiversity and create improved livelihoods, well-being and employment for forest-dependent communities in the Project Zone[13].The Project Zone is an area of 350,000 ha of the Sindh Indus Delta Region in the Thatta and Sujawal districts of Sindh Province in south-eastern Pakistan. The delta is a vast complex of tidal river channels and creeks, low-lying islands, mangrove forests and inter-tidal areas. The delta's mangrove forests are unique in being the largest area of arid climate mangroves in the world.

A global ecoregion in WWF's The Global 200, the region holds great ecological significance, supporting unique animal and plant species. The Indus River is the main migration route of thousands of birds, which cross over the Himalayas.

The ARR/RWE Project Area is of High Conservation Value (see Section 5.1.2). The project directly supports the livelihoods of 60 villages around the perimeter of the Project Area. These communities represent ca. 5,000 households and ca. 43,000 individuals. Over a number of decades, mangrove forests in the Indus Delta have experienced massive-scale deforestation and degradation due to a number of contributing factors. These include their use by the local communities as a source of fuelwood, fodder and open range grazing by livestock (see Section 2.1.5.1). The situation has been exacerbated by the reduced supply of fresh water and sediments into the delta area due to upstream activity (see Section 2.1.5.2).

In response to the threats to the delta, the Government of Sindh conceived the Delta Blue Carbon – Phase-1 (DBC-1), a public-private partnership through its Forest and Wildlife Department and Indus Delta Capital Ltd, a climate and development focused private. The project was originally conceived as a REDD+ project activity. This CCB&VCS Project Description proposes the ARR/RWE project activity for validation separately. The AUWD project is anticipated to be added at a later stage. To date (by end of year 2020), an area of some 75,000 hectares has been restored with mangrove plantations. A total area of 224,997 ha will be planted during the project lifetime. All planting is done in partnership with local communities in the Project Zone. A ward and watch system is formalised through Mangrove Stewardship Agreements (MSAs) with various community groups, from which they derive further income. The primary method for the identification of stakeholders in DBC-1 was through participatory rural appraisals and comprehensive SBIA workshops (Section 2.1.8).

The project's climate, community and biodiversity objectives include (see Section 2.1.11): upscaled mangrove reforestation, participatory planning and awareness raising, access to education, sustainable fisheries, access to safe drinking water and healthcare, improved protection and law enforcement, community-based business development and access to microfinance, sustainable energy development,

[13] As defined in Section 1.2.

training and capacity building of Sindh Forest Department, promotion of various gender development and income generating activities for women.

The project's climate benefits include the sequestration of and estimated 142,050,139 tCO_2e over its lifetime of 60 years at an estimated average of 2,407,629 tCO_2e annually (see Section 2.1.17).

2.1.2 Project Scale

Project Scale	
Project	
Large project	X

2.1.3 Project Proponent (G1.1)

Organisation name	Indus Delta Capital Limited
Contact person	Mr Nadeem Khan
Title	CEO
Address	Gabrielle House, 332-336 Perth Road, Ilford, IG2 6FF, UK
Telephone	+44 20 85324500
Email	nadeem.khan@indusdeltaredd.com

Organisation name	Government Of Sindh Forest and Wildlife Department
Contact person	Mr Riaz Wagan
Title	Chief Conservator of Forests, Sindh (Mangroves and Rangelands)
Address	Secretary Forest and Wildlife Department, Barrack-No.10, Block-4A, Sindh Secretariat, Karachi, Pakistan
Telephone	+92 2199203105 or +92 3002391663
Email	riazwagan@yahoo.com

2.1.4 Other Entities Involved in the Project

Organisation name	Silvestrum Climate Associates
Contact person	Dr Igino Emmer
Title	Principal, Carbon Project Development

Address	25 Taylor Street, San Francisco CA 94102
Telephone	+31 653699610
Email	igino.emmer@silvestrum.com

Organisation name	Blue Ventures
Contact person	Ms Leah Glass
Title	Technical Advisor – Mangroves and Blue Carbon
Address	Mezzanine, The Old Library, Trinity Road, St Jude's, Bristol BS2 0NW, UK
Telephone	+44 20 76978598
Email	leah@blueventures.org

Organisation name	Pollination Group
Contact person	Mr Martijn Wilder
Title	Founding Partner
Address	21 Gloucester Place London, W1U 8HR
Telephone	+44 20 33551556
Email	martijn.wilder@pollinationgroup.com

Organisation name	Pakistan Forest Institute (PFI)
Contact person	Mr Amjad Ali Sheikh
Title	Director General
Address	Post Office Forest College University of Peshawar, Pakistan
Telephone	+92 919216123
Email	dfpfi@gmail.com

2.1.5 Physical Parameters (G1.3)

Table 1. Project Area Extent Boundaries.

Extent Boundary	Location (Easting, Northing UTM Zone 42N)
Northern Extent GPS Point	399845.43 m E, 2687145.84 m N
Eastern Extent GPS Point	425833.82 m E, 2675297.60 m N
Southern Extent GPS Point	337553.67 m E, 2656048.05 m N
Western Extent GPS Point	317896.66 m E, 2734708.54 m N

Topography

The Sindh Indus Delta area and coastal region is located in the south-eastern part of Pakistan. The area stretches between the Indian border along Sir Creek in the east to the border with Balochistan Province in the west. The Indus coastal area can be divided into two compact blocks: The Northern Block and the larger Southern Block. The Indus River, which forms the deltaic region with the coast, meets the Arabian Sea just to the east of the city of Karachi. It forms the 5th largest delta in the world. Approximately 300,000 km^2 of the Indus watershed – of which 50% is located outside Pakistan (India, China and Afghanistan) – is drained by the Indus River[14].

The delta is the most prominent ecological feature of the Sindh coast, the coastal morphology of which is characterised by a network of tidal creeks formed as a result of changes in riverbeds and a large number of small and large islands with mangrove vegetation ranging from dense mangrove forests to sparsely vegetated coastal areas. The Indus Delta has the largest area of arid climate mangroves in the world. The Karachi coast constitutes a coastal belt of about 100 km in length situated between the Indus Delta on the southeast and Hub River on the west. Most of the coast, with the exception of mangrove wetlands areas, is sparsely vegetated. This delta feeds the world's second largest sediment body, the Indus Fan, which lies under the shelf and continental slope of Pakistan and western India, stretching 1500 km south towards the Carlsberg Ridge. The Indus Delta is comprised of 17 major creeks, numerous minor creeks and extensive areas of mangrove forests and tidal wetlands. The dense mangrove forests are mainly located in the pockets created by the creeks. Covering an area of about 667,209 ha, the delta constitutes an important ecosystem in this region. It is almost entirely dependent upon freshwater discharges from the Indus River and a small quantity of freshwater from domestic and industrial effluents of Karachi.

Soils

[14] Mangroves of Pakistan -Status and Management (2005)
https://www.iucn.org/sites/dev/files/import/downloads/pk_mangroves_of_pakistan_status_and_management.pdf

Soils found in the Indus Delta are not peatlands but instead mineral lands. Depth varies and is subject to deposition and erosion. The soils tend to be well drained and low lying. The morphological development of the Indus Delta is primarily the result of interaction of fluvial and marine processes. The delta and its soils have historically been formed in an arid climate and under conditions of high river discharge, moderate tide range (2.6 m), extremely high wave energy (14 x 10' erg/sec), and strong monsoon winds from the southwest in summer and from the northeast in winter (Wells and Coleman, 1985)[15] .

The resulting delta soils are sandy and its shape lobate, somewhat lacking in luxuriant vegetation and dissected by numerous creeks and tidal channels. The annual seaward progradation of the delta has been at about 30 m over the last 5,000 years. Morphology of the Indus Delta lies midway between that of a fluvially dominated delta (elongate, protruding distributaries) and a high-energy wave-dominated delta (beach, beach-ridge, and downdrift deposits). Sands provide a substrate for the subaerial delta. Silts and clays provide material for fill in abandoned channels, delta front outer shelf deposits, and downdrift sedimentation to the east. Coarse sediments of the Indus River generally remain on the inner shelf or are transported to deeper water via the Indus submarine canyon. Little of the fine-grained sediment remains within the delta, since maximum river discharge occurs during southwest monsoons, resulting in transport of the muds southeast into the Runs of Kutch. Extensive engineering works for irrigation purposes have reduced sediment load to the present $13x10^9$ metric tonnes per year. This decrease in sediment load, together with the extreme levels of wave energy, has caused rapid wave reworking and transgression of the Indus Delta. The end product is a wave-dominated delta, characterised as a transgressive sand body, capped by extensive aeolian dune deposits (Well and Coleman, 1985).

Climate, precipitation and hydrology

The climate of the Indus Delta area is tropical. While it is dominated by monsoon regime in the eastern part of the country, in the coastal areas it receives minimal rainfall. The average annual rainfall on the coast of Sindh amounts to about 200 mm. The southwest monsoon season lasts from May to September and the northeast from November to March, with April and October being the transition months. Wind speeds during SW monsoons are about 25-30 Knots and those during NE 5-10 Knots. Atmospheric and oceanic circulation during the SW monsoon is therefore more vigorous than during NE monsoon. The SW monsoon circulation appears to penetrate deeper, affecting the movements of water masses below the thermocline, whereas the drift during the NE monsoon is rather shallow. The tides are of the mixed semidiurnal type with two highs and two lows every day, high tide reaches 2.6 m.

The surface air temperature ranges between 23.8°C and 28.7°C for the delta in the Project Area and 23.5°C and 29.1°C for Karachi. No definite trend has been observed in case of cyclonic storms and severe cyclonic storms. The Indus Delta receives its fresh water and sediment supply from the Indus River, which flows through the delta before reaching the Arabian Sea.

Historical freshwater and sediment supply into the Indus Delta area

[15] Technical report no. 424 deltaic morphology and sedimentology with special reference to the Indus River Delta J T Wells and J M Coleman 1985.

In natural conditions, the Indus River had one of the largest sediment loads in the world, building an extensive delta on the high-energy coast of the Arabian Sea. However, water and sediment discharge to the delta have been drastically altered since the mid 1950s due to large-scale industrial activity (See Table 2). The present-day river and delta have been hugely impacted by; (1) dams constructed upstream, (2) barrages and their irrigation canals, (3) artificial flood levees, (4) sediment impoundment behind upstream reservoirs, and (5) inter-basin diversion.

The silt-dominated river formerly transported between 270 million to 600 million metric tonnes of sediment per year to its delta (Haq and Millman, 1986)[16]. Currently, the river carries as little as 13 million metric tonnes per year (see Table 3). The upstream activity has also slashed the annual freshwater flow downstream from of its former peak in the 1950s of >126 billion m^3 to a low of around 10 billion m^3 in recent times.

However, the effect of these engineered diversions is much more alarming regarding the future conditions in the delta (Inam et al., 2004)[17]. The decrease in water and sediment discharge below the Kotri barrage, situated to the north of the Project Zone between Jamshoro and Hyderabad, has a number of environmental, social and economic consequences due to increases in the effect of waves and tides, resulting in sea water intrusion and coastal erosion.

The prevalent canal irrigation system has resulted in large-scale problems of water logging and salinity too. Approximately 60% of the aquifer underlying the Indus Delta is of marginal to brackish quality. To mitigate the menace of rising groundwater and the associated problem of waterlogging and salinity, a network of drainage canals was constructed to drain groundwater directly to the Arabian Sea. The drainage system has been less effective due to low gradient of the flat topography and has in fact resulted in the intrusion of sea water to about 80 km upstream (Panhwar,1999)[18].

The increase in salinity due to depleting freshwater has reduced the suitability of the delta for the cultivation of agricultural and horticultural crops, and raising of livestock due to loss of grazing lands. The mangrove ecosystem has also been degraded due to a combination of water flow reductions and direct human destruction and overuse (Inam et al., 2006)[19]. The effects of the upstream construction are summarised in the tables below.

[16] Haq, B.U and John D. Milliman. 1986. Marine geology and oceanography of Arabian Sea and coastal Pakistan.

[17] Inam, A., Khan, A.T.M., Amjad, S., Danish, M. and Tabrez, A.R. 2004. Natural and man-made stresses on the stability of Indus deltaic eco-region. Extended Abstract, The 5th International Conference on Asian Marine Geology, Bangkok, Thailand (IGCP475/APN).

[18] Panhwar, M.H. 1999. Seepage of water of the River Indus and occurrence of fresh ground water in Sindh. In: Meadows, A. and Meadows, P. (Eds) The Indus River: Biodiversity, Resources, Humankind. Oxford University Press, Delhi, pp. 180–197.

[19] Inam, Asif, Peter D. Clift, Liviu Giosan, Ali Rashid Tabrez, Muhammad Tahir, Muhammad Moazam Rabbani and Muhammad Danish, 2007. The Geographic, Geological and Oceanographic Setting of the Indus River. In *Large Rivers: Geomorphology and Management, Edited by A. Gupta © 2007 John Wiley & Sons, Ltd.*

Table 2. Major Dams and Barrages on Indus River.

Structure	Year of construction	Maximum discharge capacity (m^3s^{-1})
Dams		
Mangla Dam	1967	24,630
Tarbela Dam	1976	18,386
Ghazi Barotha Hydropower Project	2004	500,000
Barrages		
Sukkur Barrage	1932	1,500,000
Jinnah Barrage	1946	950,000
Kotri Barrage	1955	875,000
Taunsa Barrage	1959	750,000
Guddu Barrage	1962	1,200,000
Chashma Barrage	1971	1,100,000

Table 3. Declining water and sediment discharges downstream of the Kotri Barrage.

Period	Average annual water discharge (10^9 m^3)	Average annual sediment discharge (10^9 tonnes)
1931-1954	107	193
1955-1962	126	149
1963-1967	72	85
1968-1976	47	82
1977-1997	45	51
1993-2003	10	13

Source: Inam, Asif, Peter D. Clift, Liviu Giosan, Ali Rashid Tabrez, Muhammad Tahir, Muhammad Moazam Rabbani and Muhammad Danish, 2007. The Geographic, Geological and Oceanographic Setting of the Indus River. In *Large Rivers: Geomorphology and Management, Edited by A. Gupta © 2007 John Wiley & Sons, Ltd.*

Vegetation

The main vegetation type in the Indus Delta is the mangrove forest. Eight species of mangroves have been reported historically. At present, only four survive. *Avicennia marina* is the most common mangrove species found in the area. The other species found are *Rhizophora mucronata, Ceriops tagal* and *Aegiceras corniculatum*. Within the Project Zone, two classes of mangrove forest exist: Dense Mangroves and Sparse Mangroves, see Figure 1. In addition, a land cover type classified as highly degraded mangrove areas are

planned for planting activities to increase and improve forest cover through reforestation and assisted natural regeneration.



Figure 1. Dense Mangrove forest type in the Project Zone on the left and Sparse Mangrove on the right.

Dense mangroves are found mostly in narrow stretches in rectangular blocks along creeks and are dominated by *Avicennia marina* and also include *Rhizophora mucronata* and *Ceriops tagal*. *Avicennia marina* can attain heights up to 9 m and girth of 50 cm^2. Some growth of *Tamarix spp*, *Acacia nilotica* and *Prosopis juliflora* have been seen. Small bushes of *Calotropis procera* along with *Atriplex griffithii*, *Aerva javanica* and *Polycarpaea corymbosa* may occur as undergrowth. The forest class of Sparse Mangroves occurs more so on dry and sandy areas, such as dunes along the coastline. The vegetation mainly consists of shrubs and are *Suaeda fruticosa*, *Salsola barysoma*, *Abutilon indicum*, *Sericostoma pauciflorum, Cressa cretica, Heliotropium undulatum, H. curassavicum, Solanum surattense, Cyperus conglomeratus* and various grasses. The vegetation in the Project Area is very sparse. In places, individual mangrove trees may be found, or some mangrove vegetation along creeks (see Appendix 10. Pre-project Land Cover and Vegetation Development) but the majority of the area is either barren land or covered with low salt tolerant *Oryza coarctata* grass, see Figure 2. In the period between 2015 – 2020, DBC-1 has planted some 75,000 ha of mangroves in the coastal region.

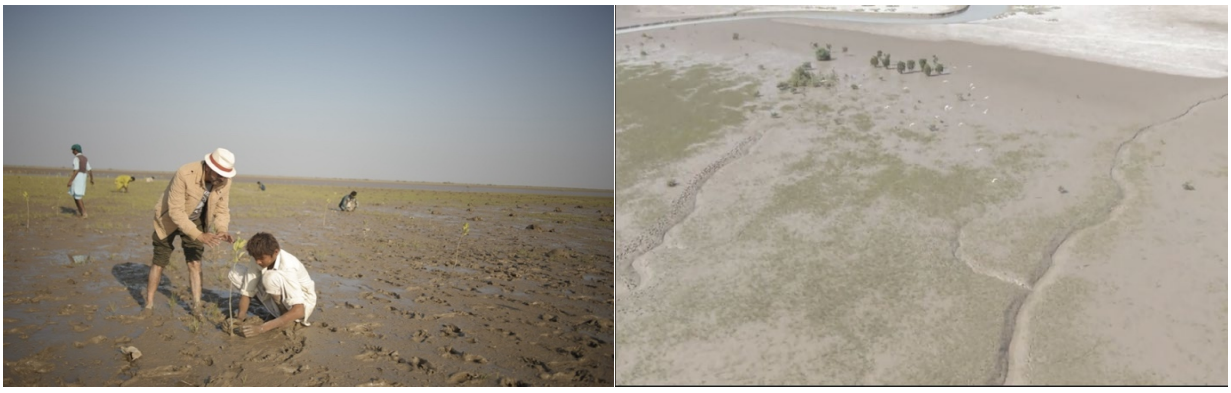


Figure 2. Typical vegetation cover in the Project Area prior to tree planting, with barren land on the left and *Oryza coarctata* grass cover with sparse mangrove trees on the right.

Table 4. Vegetation types of the Project Zone.

Vegetation type	Characteristics
Avicennia marina dominated forests (82,000 ha)	A vast area of *Avicennia marina* is found near the shoreline and on the fringes of creek systems. Other species found in the fringes include *Arthrocnemum macrostachyum*, *Aeluropus lagopoides*, *Sporobolus virginicus*, occasional *Salvadora persica*, *Aegiceras corniculata*, and *Oryza coarctata*. The latter three species are mostly found in those creeks on high lying areas, where river water flows during the flood season.
Avicennia marina dominated forests in hyper-saline areas (30,000 ha)	This type of forest is found in hyper-saline areas with *Avicennia marina* is the dominant mangrove species. These areas besides *Avicennia*, have only *Arthrocnemum*. *Aeluropus* and *Sporobolus*. While *Avicennia marina*, *Aegiceras corniculata*, *Oryza coactata* and *Sporobolus virginicus* are exclusively present on intertidal areas, *Arthrocnemum* and *Aeluropus* also occur inland as well.
Rhizophora mucronata and Avicennia *marina* mixed (45,000 ha)	This mixed forest type predominantly arises through the plantation of *Rhizophora mucronate* on degraded delta lands. Areas where they are found tend to be regularly inundated and therefore have lower salinity. Due to natural regeneration a mix of around fifty percent *Avicennia* and fifty percent *Rhizophora* develops. The forest also has the other non-mangrove vegetation including *Salvadora oleoides*, *Tamarix aphylla* and *Calligonum polygonoides*.
Rhizophora mucronate dominated forest (10,000 ha)	This forest type is predominantly comprised of *Rhizophora mucronata* that has been planted on blank degraded islands. The natural regeneration of *Avicennia marina* in this particular area is negligible due to non-availability of seed source. At the fringes, some non-mangrove vegetation is found including *Suaeda fruticosa* and *Salsola foetida*.

Studies in the literature on the extent, status and trends of mangroves in Pakistan and the Indus Delta report quite variable estimates but show a declining trend. The following table gives estimates of mangrove forests in Pakistan as given in various study reports.[20]

[20] Qamar, Mahmood Khalid. 2009. Mangroves of the Active Indus Delta-Changes and Their Causes. Ph.D. Dissertation. National College of Business Administration & Economics, Lahore.

Table 5. Various estimates of mangrove forest area in Pakistan.

Study/Source	Description/Reference	Area (ha)	Year
Biodiversity Management Information System (997)	Analysis of low-quality hard copy land use maps	380,000	1950
Champion et al. (1965)	Rough estimate. As reported in Government of Pakistan. Forestry Sector Master Plan, Pakistan, PAK/88/018	400,000	1965
Ministry of Food, Agriculture and Cooperatives (1981), Government of Pakistan	Tropical Forest Resources Assessment Project, Forest Resources of Tropical Asia FAO, UNEP. pp 475	345,000	1980
Saenger et al. (1983)	Secondary reference. No primary source provided	249,500	1983
Government of Pakistan (1985)	Secondary reference. No primary source provided	280,000	1984
Kogo et al. (1985)	The Mangroves of Pakistan.1986. The Pakistan Journal of Forestry 36(4)	283,000	1985
Mirza et al. (1988)	Mangroves of Baluchistan, Pakistan: An Overview. Pakistan Journal of Marine Biology (Mar. Res.), 5(2):195-200, 1999	250,233	1988
Government of Pakistan (1992)	Remote sensing	207,000	1990
UNESCO (1992)	Protected Areas with Mangrove Habitat. Draft Report. World Conservation Monitoring Centre, Cambridge, UK pp 60	261,720	1991
Spalding et al. (1997)	Sustainable Management of Mangrove Ecosystem in the Indus Delta. In: Moser, M. and van. Western, J, eds. Wetlands and Waterfowl Conservation in South and West Asia. IWRB Publications, No. 25. Gloucester, UK	168,300	1993
Pakistan Forest Institute (2004)	Remote Sensing. Global Forest Resource	159,000	1997

	Assessment (FRA) 2005 thematic study on mangroves. Unpublished.		
World Conservation Institute (2000)	Secondary reference. No primary source provided	154,000	2000

2.1.6 Social Parameters (G1.3)

Main settlements

The Indus Delta falls within the districts of Thatta, Sujawal and Badin of the Sindh Province. Pakistan's fifth largest city, Hyderabad, lies about 130 miles north of the mouth of the Indus River. Towns are found throughout the delta, but there are no large cities south of Hyderabad. Karachi, Pakistan's largest metropolis, lies west of the delta on the coast of the Arabian Sea. The deltaic coast is sparsely populated with small predominantly fishing communities living along the creek system of the coast. No major infrastructure development has taken place and no significant commercial industrial activities occur there.

DBC-1 Project Zone comprises of 60 villages bordering the Project Area, with a total of 4,911 households and a human population of 42,483. Based on the recent Population Census of 2017 and data collected from the local communities during numerous socio-economic surveys conducted in the region, there are 22 identified ethnic groups that inhabit the area (see Appendix 1. Stakeholder Identification Table and Appendix 2. Socio-Economic Characteristics of Project Zone Communities). Project Zone villages are located in the Keti Bandar, Mirpur Sakhro and Ghorabari talukas (administrative districts) of Thatta, and the Karo Chann and Shah Bandar talukas of Sujawal District. The population growth rate in Thattta is 2.61% and 2.23% in Sujawal. The population in these areas comprises of 52% male and 48% female (Bureau of Statistics, Government of Sindh, 2018)[21].

The population structure of these areas is given below.

Table 6. Population Structure in Percentages in the Project Zone.

Age Category	Thattta Taluka	Mirpur Sakhro Taluka	Ghorabari Taluka	Keti Bandar Taluka	Thatta District
≤ 2 years	6.45	6.12	6.69	5.82	6.32
> 2 years & ≤ 6 years	13.50	14.35	13.47	15.48	13.97
> 6 years & ≤ 12 years	16.87	18.22	19.75	17.19	17.81
> 12 years & ≤ 18 years	12.36	12.86	14.06	13.35	12.89

[21] Bureau of Statistics, Government of Sindh. 2018. Kehkashan Clifton, Karachi: Development Statistics of Sindh.

> 18 years & ≤ 30 years	19.89	18.71	16.74	17.33	18.76
> 30 years & ≤ 45 years	18.84	17.76	17.07	18.18	18.4
> 45 years & ≤ 60 years	7.91	8.00	8.87	9.23	8.21
> 60 years	4.16	3.98	3.35	3.41	3.90
Sample size of the survey	3,147	2,613	1,195	704	7,659

Source: Malik, Muhammad Asghar, Wajeeha Raza and Riaz Karimi. 2019. Health expenditure and utilization survey Thatta district, 2019 Department of Community Health Sciences, The Agha Khan University.

For a full description of the communities, see Section 4.1.1.

Land ownership, land use and economic activities

All lands in the Project Area are classified as Protected Forests and are state property. Therefore, their ownership vests in the Government of Sindh.

Most of the communities included in the Project Zone are relatively homogenous and comprise mainly of coastal fisherman and their families. Fishing is the most important source of revenue for people living in the creeks. Catches of mangrove dependent fish in the entire delta have been valued at US$ 20 million annually, shrimp at US$ 70 million and mud crabs at US$ 3 million.

As of 2018, more than 140,000 hectares of land adjacent to the Project Area was being used for agriculture, mostly to cultivate rice, followed by sugarcane and wheat. Barley, gram, oil seeds, maize, millet, cotton and jowar are other important crops.

Fruits such as coconut, banana, mango and papaya are also grown. However, ongoing sea intrusion is negatively impacting the situation by turning cultivable land into barren patches. Rearing of livestock (historically camels) is also on the decline in the region due to prevailing climactic conditions and increasing poverty.[22]

Unregulated and excessive past harvesting

[22] COMDEKS Country Program Landscape Strategy for Indus Delta: Pakistan, SGP OP-6, 2017.

Mangroves have been exploited for their economic and ecologic use in Pakistan for more than two centuries. Over this time, the wood from these forests has been used as fuelwood and fodder by all incoming and outgoing tribes on their long trading routes that passed through the area and connected the Middle East with Asia.[23] Before some 344,000 ha of mangrove forests were declared Protected Forests in 1958, these areas had no restrictions and local people would cut trees without inhibition or oversight. Estimates suggest that the stocked mangroves in the Indus delta were in the range of 160,000 hectares with another 100,000 hectares of very sparse or no vegetation (Qureshi, 1985)[24].

For the most part, local communities felled trees adjacent to their habitations. This resulted in considerable deforestation and degradation. Subsequently, the de-vegetated areas also became vulnerable to encroachment and land-use change. Even after 1958 and their declaration as Protected Forests, the felling of mangrove forests continued, but this time to generate revenue for the Government and to develop port infrastructure. The cutting of dead, dying and moribund trees for meeting the domestic requirements of local people continued to be allowed too. This practice continues today as some of the poorer communities in the area, particularly within the creek system, still rely on mangrove wood as their major source of fuel.

Grazing, browsing, lopping of branches and plucking of leaves and propagules

Mangroves play an important role in providing animal feed to the livestock of not only the coastal population but also to camel herds from parts of upper Sindh that come to the delta area during flood season. Mangrove lands serve as rangelands and domestic animals such as cattle, buffaloes, camels and goats use mangroves foliage as their feed[25]. The villagers along the coast rear their cattle on *Avicennia* leaves and propagules. The *Avicennia* fodder is either directly fed to the animals or is chaffed and mixed with wheat straw and other cattle feed. The damage to the mangrove forest on account of grazing of cattle and buffaloes is not significant and is localised to areas that are in close proximity to the coastal villages.

However, the damage to mangroves on account of browsing by camels has been serious and extensive. The camels not only browse on mature as well as young mangrove plants, but they also trample any newly emerging natural regeneration or planted propagules, thereby causing serious damage to both mature mangroves as well as young saplings.

During flood season, camels from the upper and interior parts of Sindh Province migrate to mangrove forests in herds. These animals are owned by the professional camel owners/grazers or big landlords. They move in hundreds during the months of June and July each year and stay in mangrove areas up until October. Usually, the camel herds are left on coastal islands, where they are looked after by one or two attendants. However, since the frequency of river floods has decreased during the last 20 years, this trend is beginning to decline.

[23] MFF Pakistan. 2014. Pakistan National Strategy and Action Plan. MFF Pakistan, Pakistan. 56 pp

[24] Qureshi, M, T. 1985. Working Plan of Mangrove Forests Coastal Forest Division (1985-86 to 2004-05). Sindh Forest Department, Karachi.

[25] IUCN Pakistan. 2005. Mangrove of Pakistan: Status and Management.

Camel farming is the major profession of the tribe of Sindh known as 'Jat', settled on both sides of the Indus River, especially in the deltaic areas near the sea creeks. Camels bred here are favoured not only in Sindh but also exported to Persian Gulf countries.

Most of the camels in the coastal villages are sent to the mud flats / small islands between the creeks near the sea, where they feed on the mangroves. The feeding areas are usually located at a distance of about 7-10 miles from their settlements. In addition, fodder is also lopped for feeding young camels that are unable to live independently on the coastal islands with the herds. The last census of camels was carried out by Sindh Forest Department in 1995. The estimates of the total population of camels in the area provides an insight to the issue of pressure on mangroves by camel browsing in the area. These estimates are given in Table 7.

Table 7. Camel population in mangrove forest area as per census done in 1995.

	Left banks side of River Indus Sujawal District	Approximate No. of camels
1.	Shah Bundar Area	1,000
2.	Jati (Mughal Bhim) Area	500
	Total Sujawal District	**1,500**
	Right bank side of River Indus Thatta District	
1.	Mirpur Sakro Area (Villages Jhor Patar and Mahal	1,500
2	Gharo to Mirpur Sakro Area	500
3.	Rehri/Bhambore/Dhabeji Areas	500
4.	Keti Bundar and Adjoining Areas	1,000
	Total Thatta District	**3,500**
	Total Sujawal and Thatta Districts	**5,000**

FAO (2009) estimated that there are 8,000 camels, 5,000 buffaloes and cattle and 1,000 goats in the Indus Delta area. All these animals use mangrove forests as grazing lands. Assuming that on an average 30 kilograms of mangrove leaves and branches constitute the daily diet of a camel during feeding in the mangrove forests, the total loss of the mangroves comes to about 120,000 kilograms or 120 tonnes per day. Considering the total area of mangrove forests in the delta, the camel browsing rate comes to about 1.30 kilogram per hectare per day.

Health, education and sanitation

Many communities in the Project Zone lack access to safe and affordable drinking water. A significant number of villages get their water from lined canals. The canals are seasonal, though, and have water available only during the high flood season (July-August).

Hygiene conditions in the villages are extremely poor, making the population pre-disposed to various types of diseases. Achar Mibar Goth is the only village in the Project Zone that has sanitation facilities, although they are sub-standard. All other villages surveyed lack even basic sanitation facilities.

These marginalised communities also seriously lack access to health and education facilities and other essential services, due to location, and inadequate infrastructure, staff and operational funds availability.

Thirty-one villages in the Project Zone have a literacy rate less than 0.1% and 10 villages have a literacy rate up to 0.6%. Maximum literacy observed was in the village of Allah Warayo Bhatti, in Sujawal District, at 75%. The female literacy rate is substantially lower than male literacy. Alarmingly, 42 villages have a 0% female literacy rate. The highest female literacy rate was again found in Allah Warayo Bhatti at 23.5%.

Poverty

Due to its narrow and non-diversified economic base, there are few employment and income earning opportunities for the local communities. As a result, more than 70% of the coastal population of the area live below the poverty line. The cost of living in the area is high due to the cost involved in transporting goods in. Formal credit facilities through banks are limited due to collateral requirements. Hence, communities depend on informal sources of borrowing money through money lenders who charge high interest rates.

The physical, social and institutional context in which the majority of youth, women and elderly live can be characterised as an impoverished one which is typified by social problems, economic deprivation, low-esteem and poor hygiene and health conditions. This socioeconomic setting makes them vulnerable to the vagaries of natural and anthropogenic shocks.

Relevant historic conditions

The Indus Delta coast runs from Korangi Creek in the west to Sir Creek in the east and is a complex system of swamps, streams and mangroves. The delta area has been placed amongst the 200 most important eco-regions in the world by WWF[26]. This coastal region has a rich culture and history dating from more than 8,000 years ago.

Sindh Province and the delta area have remained centres of various dynasties and civilisations which have ruled the area from time to time. The history of the province and the area can be divided into three major Eras-Ancient Era, Muslim Era, and Modern Era.

[26] Salman, M. and S. Habib. 2020. Understanding the Eastern Coast of Pakistan. Maritime Study Forum.

The ancient era history includes the Indus Valley Civilisation, with remnants of thousand-year old cities and structures having advanced features such as city-planning, brick-built houses, sewage and drainage systems, as well as public baths; a writing system which to this day has not been fully deciphered; the domestication of bovines, sheep, elephants and camels by the people; knowledge of metallurgy; and flourishing of arts and crafts including the use of beads, seals, pottery and bracelets.

The Macedonian Fleet of Alexandar the Great is said to have anchored for some time in the delta area[27], which was destroyed by an earthquake generated in the Makran Coast in 325 B.C[28].

The delta is reported to have a port city called Debal by 6th Century A.D. Pirates of Nagamar tribe are said to have been using this port city for their raids against the Umayyads, which in turn have led to an incursion by Muhammad bin Qasim and the Muslim Conquest of Sindh in 710 A.D.

Debal had remained a port until 1223 A.D. but was abandoned due to lack of access to the sea by the time Ibn Batuta reached the delta area[29].

Sindh Province and the delta area continued to be reigned by the Muslim rulers.

Major historical periods of the Muslim rule of the area include The Arab Conquest, The Habbari Arab Dynasty, The Ghaznavids, The Soomra, The Samma Dynasty and The Delhi Sultanate, The Arghun-Tarkhan Dynasty, The Mughals and the Kalhoras. The delta area in the Muslim Rule period has remained under the control of increasingly autonomous province centred at Mansura.

The Samma Dynasty in 1333 AD has ruled all of the delta and had established their capital first at Samu-I and later shifted to Thatta. It was during this dynasty that the "golden age of native rule" (1461-1509 AD) happened in the delta and Sindh, under the rule of Jam Nizamuddin II.

During the Mughal Empire (1591-1592), the delta came under the province of Multan and was ruled by Mirza Ghazi Beg, but was ceded to Nadir Shah in 1739. The Kalhoras have ruled the region till 1783 from whom the power was transferred to Talpur until the British invaded the area in 1843[30].

The Modern Era history starts with the conquest of Sindh by the British in 1843, who had two objectives in their rule of Sindh: the consolidation of British rule and the use of Sindh as a market for British products and a source of revenue and raw materials. With the appropriate infrastructure in place, the British hoped to utilise Sindh for its economic potential[31]. In 1947, the Indus delta, along with rest of Sindh became a part of Pakistan.

[27] https://en.wikipedia.org/wiki/Indus_River_Delta.

[28] Pararas-Carayannis, G. 2006. Alexander the Great-Impact of the 325 B.C. Tsunami in the Northern Arabian Sea Upon his Fleet. Disaster Archaeology.

[29] https://en.wikipedia.org/wiki/Indus_River_Delta.

[30] Ibid.

[31] https://en.wikipedia.org/wiki/History_of_Sindh.

Mangroves and wetlands in the delta area remained open access resources, until the management responsibility for mangrove forests in the Indus Delta was transferred to the Sindh Forest and Wildlife Department in 1957. All mangrove forests and all mangrove lands in the delta area extending over more than 667,000 hectares have been declared as “Protected Forests” by 2010 under Section 29 of the Pakistan Forest 1927 and all trees there have been declared as reserved under Section 30. Section 32 of the said Act empowers the Government to make rules for the management of these forests and to prohibit any actions deemed necessary for the protection of these forests under Section 33. The delta area also has a number of Ramsar Sites.

Migration

As a result of resource degradation, a large exodus of people has taken place from the Indus Delta. Around 90,000 people have been displaced and around 120 villages have been depopulated. One factor driving this move was the shortage of local bushes and plants that were used for preparing various materials (especially by the Jatt villagers). Others have migrated due to the lack of potable drinking water in the area. The Pakistan Fisherfolk Forum estimates that 14,400 people from the delta coast, majority of them fishermen, are amongst those that have left. Gharochan was a bustling city in the delta until the 1970s. Its port was used to export locally produced silk, rice and wood. However, rising salinity destroyed the local agriculture, and the port was lost to the encroaching Arabian sea by 2006.

Socio-cultural information

The main ethnic groups found in the Project Zone include Jatt, Mallaah, Mohano, Soomro, Samon and Memon. Appendix 2. Socio-Economic Characteristics of Project Zone Communities gives the socio-economic characteristics of the communities within the Project Zone.

2.1.7 Project Zone Map (G1.4-7, G1.13, CM1.2, B1.2)

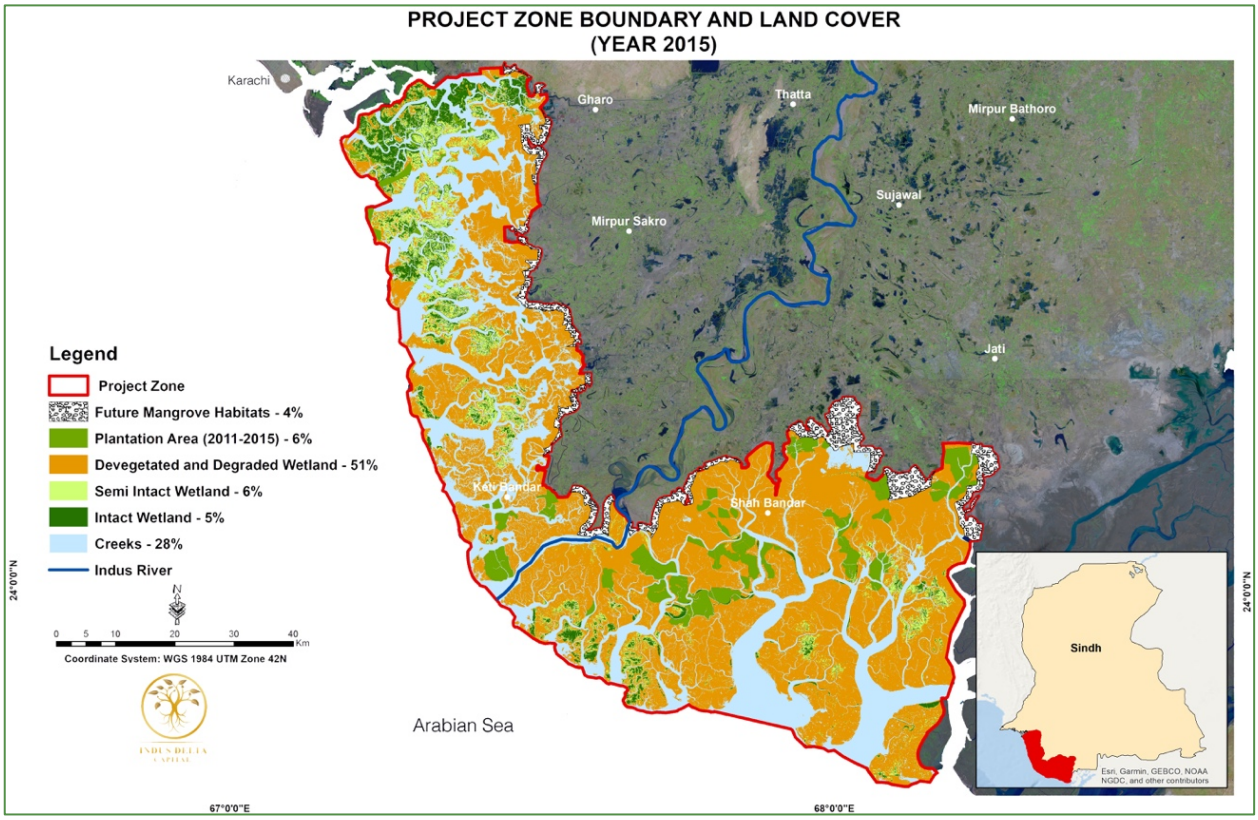


Figure 3. Map delineating Project Zone and land cover at project start in 2015. The Project Area for the ARR/RWE project activities is a portion of this larger area, see Section 3.1.3.2).

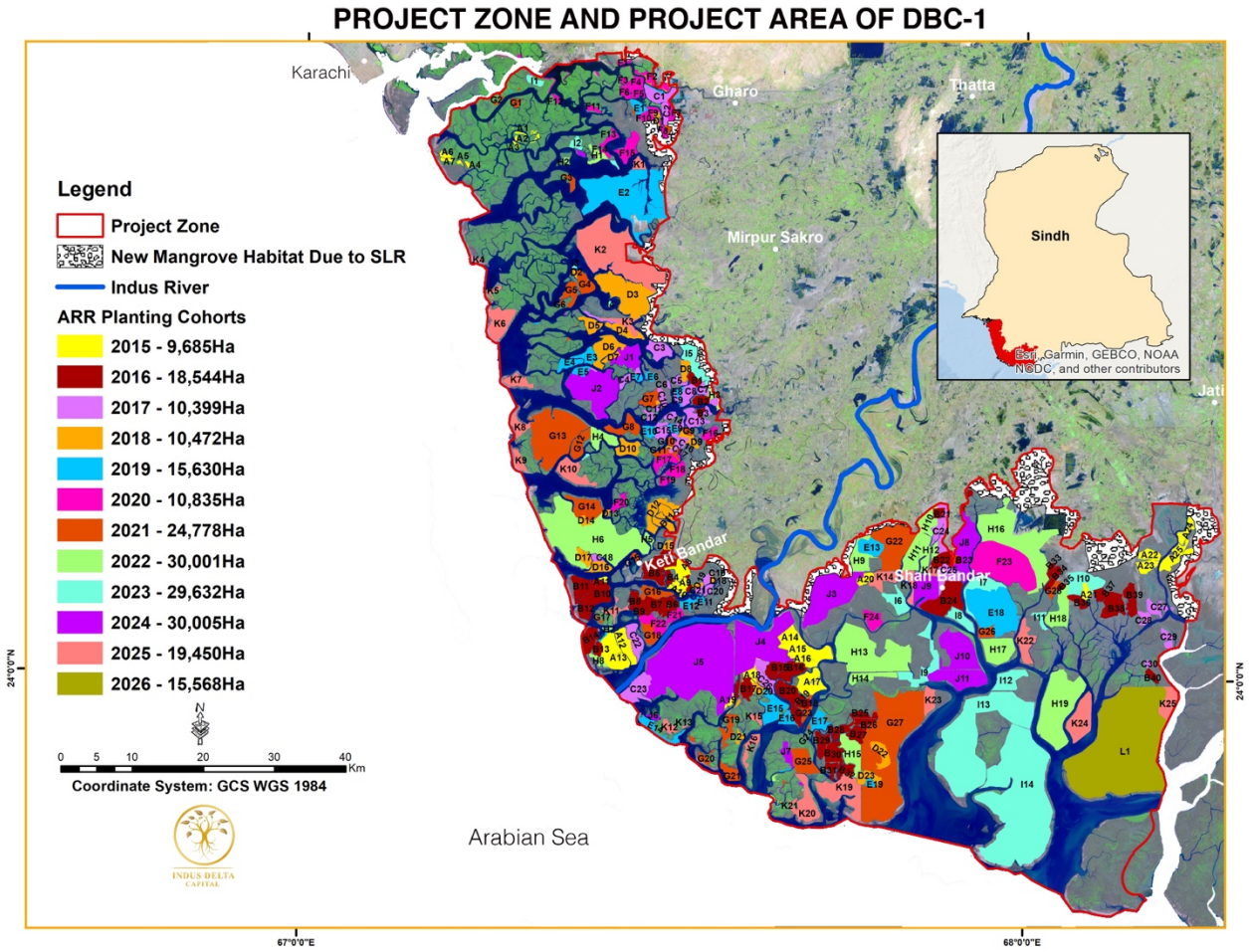


Figure 4. Project Zone, and ARR/RWE project boundary as represented by planting cohorts from project start (2015) to 2026, and new mangrove habitats due to 100 years of sea level rise (see Section 3.1.3.2.2).

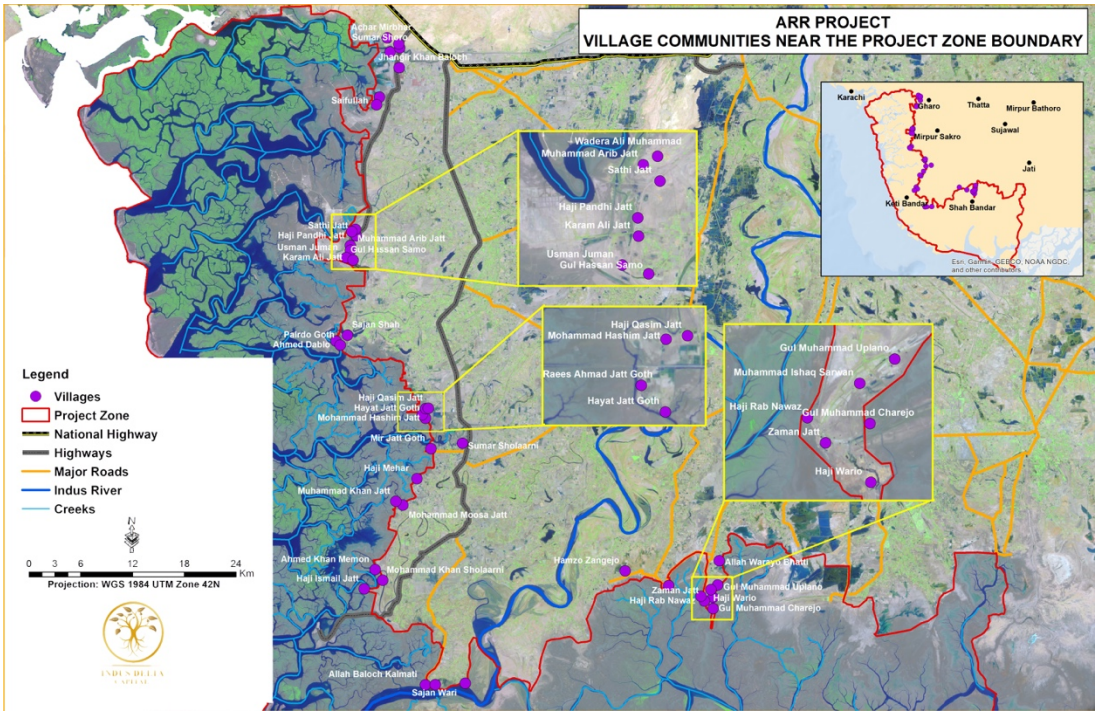


Figure 5. Map delineating location of villages along the Project Zone boundary.

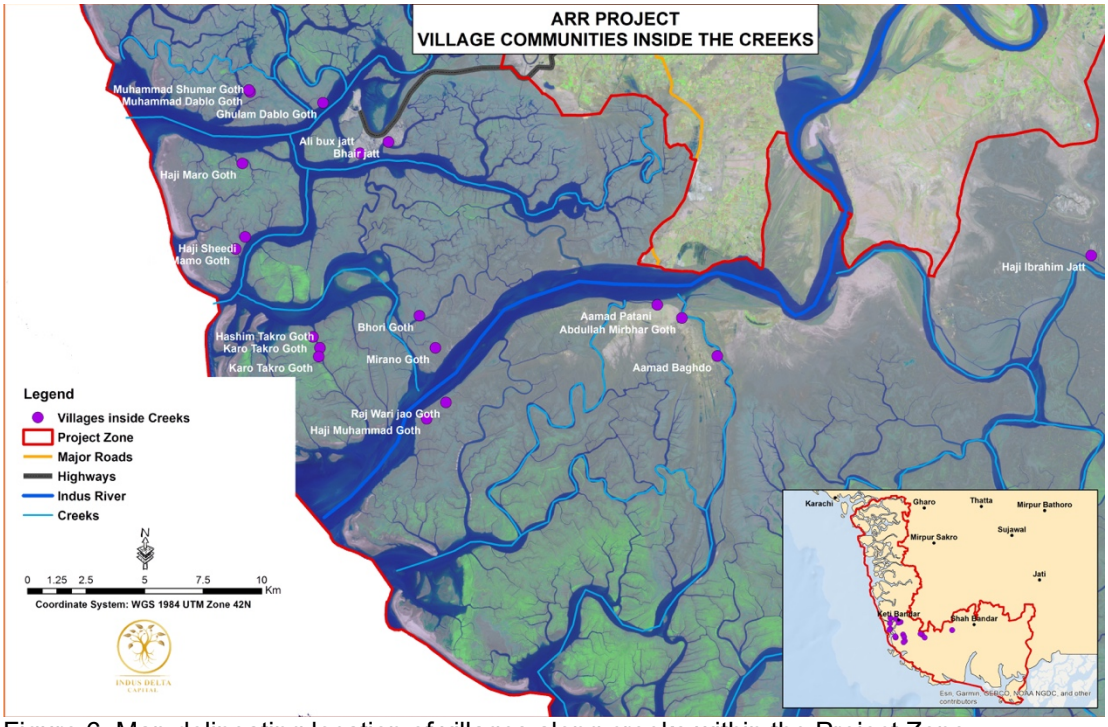


Figure 6. Map delineating location of villages along creeks within the Project Zone.

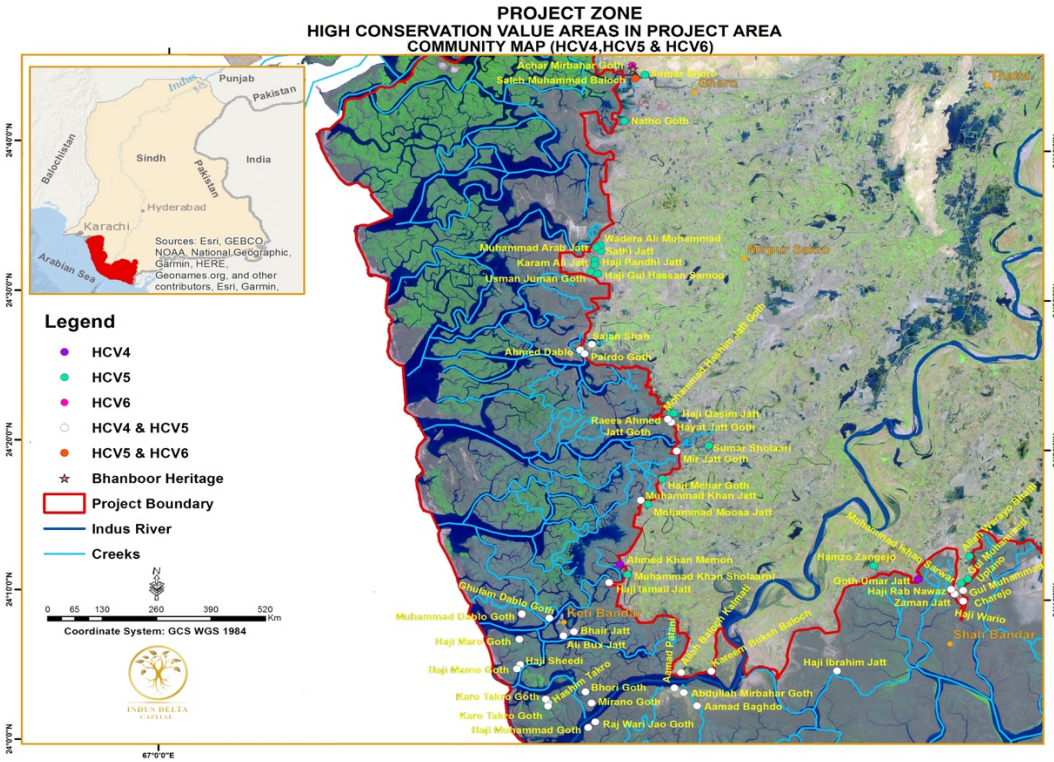


Figure 7. Map delineating Community HCV areas within the Project Zone.

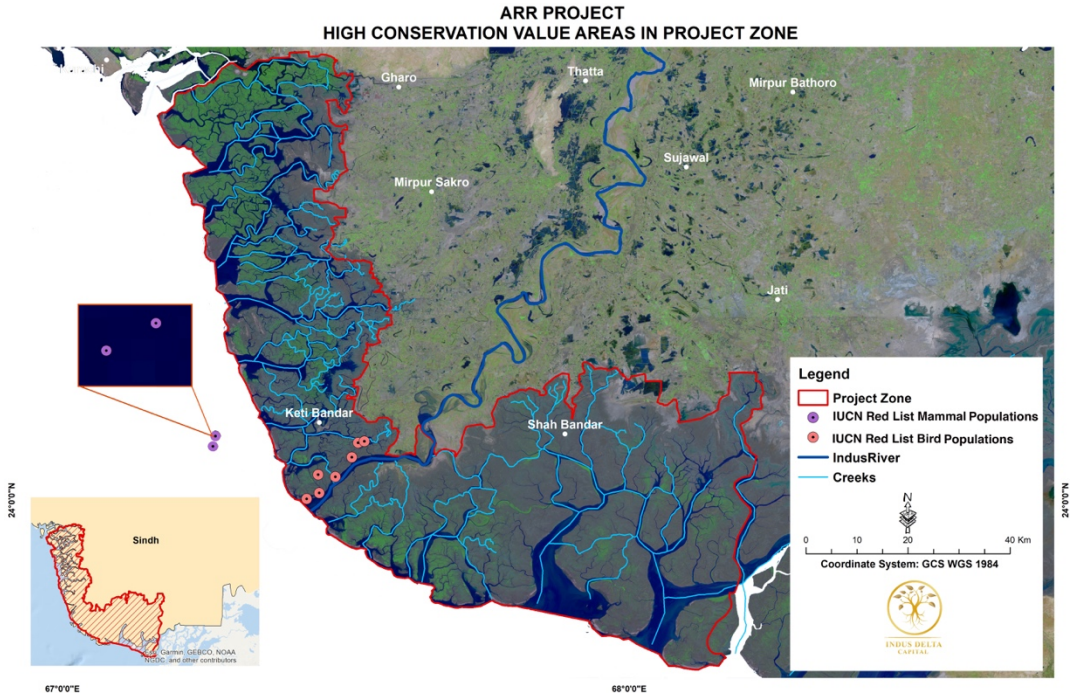


Figure 8. Map delineating Biodiversity HCV areas within the Project Zone.

2.1.8 Stakeholder Identification (G1.5)



Figure 9. Map delineating areas where SBIA assessments were held.

The Forest Department of the Government of Sindh and Indus Delta Capital have been working together in the Thatta and Sujawal districts since 2012. Before the project start date (2015) a spatial analysis of the Project Zone was conducted to determine the location of all of the communities near the areas where restoration work was to begin. A comprehensive participatory rural appraisal with each community identified in the analysis was then conducted by project staff. During this process, Indus Delta Capital and the Sindh Forest Department worked together to develop a full understanding of all stakeholders in the region, building on the extensive work already conducted by the Forest Department who have had a presence in the area for the past 30 years. This approach strengthened as well as built new linkages with key stakeholders.

To further enable a truly participatory process, Social and Biodiversity Impact Assessment (SBIA) workshops were held in strategic locations in the Project Zone with key representatives of community groups. These events were held in Keti Bandar, Shah Bandar and Bhambhor. (Full reports of these workshops are available to the VVB if required).

Workshops were conducted in accordance with the CCBA Social and Biodiversity Impact Assessment Manuals - Core Guidance and Toolboxes for Social Impact Assessment and Biodiversity Impact Assessments.

- The first workshop was held at the Sindh Forest Office in Keti Bandar. There were 45 participants from nearby villages, mostly located in the western and northern communities. The villages were: Haji Muhammad Siddique, Miro Dablo, Ali Bukhsh Jatt, Haji Moosa, Gharo, Haji Umar Khan Lashari, Ronja Mallah, Qazi Muhammad, Jelani Muhalla and Shedi Muhala.
- The second workshop took place at the Sindh Forest Offices in Shah Bandar. There were 50 participants from Shah Bandar villages, mostly located in the eastern communities. Those villages were: Gul Muhammad Uplano, Haji Allah Warayo Muhammad, Ramo Uplano, Haji Deno Uplano, Haroon Samoo and Hashim Parhyar.
- The third workshop was conducted at Bhambhor. It had 50 participants from Bhambhor villages, mostly located in the eastern communities. The villages were: Somar Shoro, Achar Mirbahar, Natho, Saifullah, Jahangir Khan Balouch and Muhammad Hashim Mirbahar.

Participants consisted of representatives from all stakeholder groups including local administration, village elders, local community leaders, indigenous women and youth representatives.

The SBIA workshops started with an evaluation of the background conditions in the Project Zone, including the identification of key problems (focal issues) that the project needed to address to be successful. The workshops settled on three priority focal issues for DBC-1:

Focal issue 1: Mangrove forest degradation due to unregulated and unsustainable use

Focal issue 2: Poverty and impoverished community well-being

Focal issue 3: Continued and accelerated wildlife habitat and biodiversity loss and fisheries degradation

SIBA participants then examined these issues in depth to establish the causal logic leading to the identified problems. Based on their assessments, the attendees then undertook a stakeholder analysis to determine who is most likely to be impacted or otherwise drives the factors contributing to the focal problems (see Table 8, below)

They also projected what would happen to these key factors in the absence of the project (Without project scenario – see Section 4.1.4). Expert knowledge of the project proponents was used to analyse the outputs and identify any other additional factors that stakeholders may have overlooked.

See Appendix 2. Socio-Economic Characteristics of Project Zone Communities for a full list of Project Zone communities.

2.1.9 Stakeholder Descriptions (G1.6, G1.13)

2.1.9.1 General

Sixty villages bordering the Project Area, with a total of about 4,911 households with a population of 42,483 were selected to define the Project Zone. They were identified by the project proponent as most associated with natural resource use and forest loss within and bordering the Project Area and thus are most likely to

be positively impacted by project activities. Project Zone community members only have tenure to private land outside of the Project Area, but have some customary use rights within the Project Area. Consequently, the Project Zone has been identified as the area where project activities that directly affect land and associated resources – including activities such as those related to provision of alternate livelihoods and community development – must be implemented. Inhabitants there can be divided into the following ethnic groups: Jatt, Mallah, Mirbhar, Sodhi, Machi, Kalmati, Syed, Dabla, Lashari, Sholarni, Shoro, Baloch, Memon, Patani, Baghda, Bhatti, Uplano, Charejo, Zangeji, Khashkheli, Samon, and Sarwan. They are all Sindhi language speaking communities. The majority of the people belong to the Jatt ethnic group numbering 24,725 and thus constitute 58.2% of the total population. Fishing is the predominant livelihood in the Project Zone and the majority of the population lives near or off the Coastal Highway, while a small proportion live inside creeks (see Appendix 1. Stakeholder Identification Table and Appendix 2. Socio-Economic Characteristics of Project Zone Communities).

2.1.9.2 Stakeholders benefiting from status quo

The following list of community groups and specific stakeholders was derived from the stakeholder analysis performed during the SBIA workshops (see details for selection and inclusion rationale in Table 8).

- Money lenders/creditors
- Livestock grazers/fodder collectors
- Upstream dwellers
- Fuelwood gatherers
- Employers

2.1.9.3 Stakeholders adversely affected by status quo

- Community in general including both present and future generations
- Government and local authorities
- Youth and women
- Workers and jobseekers
- Borrowers and debtors
- Fishermen

Table 8. Results from the stakeholder analysis exercise during the SBIA Workshops.

Focal issue 1: Mangrove forest degradation due to unregulated and unsustainable use

Direct factor	Who benefits	How do they benefit?	Who loses?	How they lose?
	- Fuelwood	- Free collection of	- Fishermen	- Loss of nursery and

Continued and accelerated forest degradation	gatherers - Livestock grazers - Upstream dwellers	biomass for energy - Free grazing of livestock - More freshwater available for irrigated agriculture	- Local communities as a whole - Future generations - Local authorities	habitat for shrimps and fish, hence loss of income and livelihoods - No chance to see, study and understand mangrove forests - Unprepared and not equipped to face climate change and natural disasters - Lost potential for eco-tourism development - Lost motivation to join conservation activities - Unable to collect revenues for various ecosystem services

Focal issue 2: Poverty and impoverished community well-being.

Direct factor	Who benefits	How do they benefit?	Who loses?	How they lose?
High cost of living	No one		- Fishermen - Local communities as a whole - Future generations - Women	- Spend to go to distant health posts and schools - Living in poor health conditions prone to childhood diseases - No or little education - High infant mortality rate and death during childbirth - Lack of education, skills and jobs
Low income	- Money lenders - Employers - Wholesale buyers of fish	- Get high rates of interest for loans - Labour exploitation - Paying below market rate for fish	- Borrowers - Employees - Fishermen	- Very low incomes paid to labourers for hard work - Getting caught in a circular debt trap - Losing income through receipt of lower prices for fish caught, due to lack of cold storage and fraudulent weighing

Focal issue 3: Continued and accelerated wildlife and habitat loss and fisheries degradation.

Direct factor	Who benefits	How do they benefit?	Who loses?	How they lose?
Inability to restore degraded mangrove areas and wetlands	No one		- Communities including fishermen, livestock owners, agriculturists - Youth and the next generation - Government	- Loss and continued decline of access to various ecosystem services of mangroves - Communities and other stakeholders lose confidence in the organisation to protect and develop the resource - Decrease in staff motivation and organisational pride
Lack of wildlife habitat/ fisheries degradation	No one		- Fishermen - Communities - Government	- Declining catches - Human-wildlife conflicts Inability to enjoy nature due to loss of wildlife and biodiversity resources - Loss of potential for eco-tourism

2.1.10 Sectoral Scope and Project Type

Sectoral scope: 14

Project activity type: Combined ARR and RWE

Afforestation, Reforestation and Revegetation (ARR): This activity increases carbon stocks in woody biomass and in soil by restoring mangrove tree cover through planting and human-assisted natural regeneration.

Restoring Wetland Ecosystems (RWE): This category increases carbon sequestration in a degraded tidal wetland through restoration of a native plant community.

This is not a grouped project. This is a large-scale project.

2.1.11 Project Activities and Theory of Change (G1.8)

Based on the focal issues, strategic project entry points were discussed during the SBIA workshops and identified as core project activities. When implemented they would follow the theory of change logic developed in the results chains (see Figure 11, Figure 12 and Figure 13) to lead to the desired outcomes.

These proposed project activities were further guided by the knowledge and experience of the project proponents.

To date, the project proponents have been successful in implementing a number of these activities and intend to maintain and expand them further with carbon revenues. This approach will be the most direct way to deliver benefits to the communities in a timely fashion. Furthermore, several new activities, directly supporting their sustainability will also be possible with carbon revenues.

The key project activities are defined below, followed by detailed results chains:

Upscaled ARR

The project has already carried out hugely successful ARR activities over an area of around 75,000 hectares, Carbon funds will be used to scale up, accelerate and finance planned ARR activity to achieve project targets. These funds will also allow the project to enter into further Mangrove Stewardship agreements and create significantly more jobs and income for Project Zone community members, to ensure the ongoing protection of the restored areas.

Participatory planning and awareness raising

The project has a dedicated community liaison team that uses diverse methods to educate and sensitise the population about the environment. With carbon funds the project will hire more personnel to continue capacity building for community groups and institutions directly involved in the management of natural resources. Participatory village and household level planning are integral to the programme's plans and the key to its continued success.

Access to education for all

Proceeds from the project will be used to improve access to education in these communities. Funding is needed to improve the infrastructure of existing school buildings within the Project Zone. Most are in an extremely rundown state and lack the most basic of resources to remain functional. A school bursary scheme will also be set up and transport for students to the nearest schools from the most isolated areas will be provided. An adult literacy programme will also be implemented in targeted areas.

Sustainable fisheries

There is on-going unregulated and unsustainable exploitation of fish and other marine resources in the Project Zone as a result of which certain valuable marine fisheries resources stocks are declining rapidly. Harmful fine mesh nets fixed in the creek areas catch large quantities of juvenile fish without any consideration of target or non-target species. These harmful practices and weak governance are leading to the depletion of some of the stocks. Proceeds from carbon finance will be used to work with the local fishing communities and the relevant governmental authorities to arrest this alarming trend.

This will be achieved by organising fishing communities into Fishing Stewardship Committees (FSCs) with clear terms of reference and engagement under terms of partnership agreements. A participatory development of and adherence to voluntary standards for sustainable fishing will be implemented. In partnership with the Department of Fisheries an awareness raising and capacity building programme will be developed to encourage sustainable fishing practices. Fishing communities will be supported in exploring alternative income and livelihood sources to reduce pressure on fish and other marine resources.

The project will also facilitate the networking and linking of fishing community members to microfinance and credit institutions.

Access to safe drinking water and healthcare

The project has already provided clean drinking water access for up to 500 people a day. It has upgraded and renovated a badly rundown rural health centre in Keti Bandar and provided it with medical equipment and an ambulance. It has constructed an essential health unit in an isolated area within the Project Zone as well as built a large community centre at the juncture of three villages. Further carbon funds from the project will be used to upscale and add these activities to all areas, as well as construct urgently needed communal washrooms in the most deprived villages.



Figure 10. Health centre renovated, and ambulance donated by the project in Keti Bandar. Health facility built by the project in Ali Mohammed Jatt, serving five isolated villages in the Project Zone.

Improved protection and law enforcement

Protection and law enforcement activities will continue to seek to prevent illegal exploitation of the Project Area for fuelwood cutting and illegal grazing of livestock as well as poaching and killing of wildlife species. Carbon funds will be used to substantially increase manpower used to enforce these measures.

Community-based business development and access to microfinance

Community livelihood development is a core priority of the project. The goal is to bring substantial benefits to the Project Zone communities through sustainable economic development by supporting activities identified during the participatory planning process and SBIAs. Some key activities identified were: Crab farming/aquaculture, livestock rearing, training for sorting, processing and marketing fish – as well as providing cold storage facilities and new fishing nets.

The project will seek to assist sustainable local development through carbon funds along with access to microfinance in partnership with, Akhuwat, the world's largest interest free micro finance programme.

Sustainable energy development

The project promotes the use of sustainable and renewable energy sources. Through the community-based planning process, the project will seek to increase energy efficiency and the number of communities who

have access to cleaner, renewable energy. Initially, the work will focus on a number of pilot villages, to learn and develop methods, and then will be expanded across the Project Zone.

Sustainable energy sources that will be considered include efficient cook stoves, solar panels, lamps and pumps. This intervention will be particularly targeted at communities living inside the creeks.

Training and capacity building of Sindh Forest Department

The Sindh Forest Department has a crucial role to play in the successful implementation of the project. The capacity of its staff at various levels therefore will be built up through various training and capacity building workshops. For this purpose, a proper capacity gaps assessment will be conducted through a structured analysis approach. Based on these assessed capacity gaps, a modular training and capacity enhancement programme will be designed and implemented.

Promotion of various gender development and income generating activities for women

Using carbon funds, targeted activities for mainstreaming of gender development into the local economy will be designed and implemented for their economic and social empowerment.

A specific local level gender development activity to be implemented by the project is a vocational training programme in midwifery and first aid. Income generating activities identified include crab farming, sorting, drying and packaging of anchovy fisheries, sewing and embroidery, poultry farming (quails and chicken) and kitchen gardening.

All of the above activities will be implemented in partnership and with the support of the relevant departments of the provincial Government of Sindh.

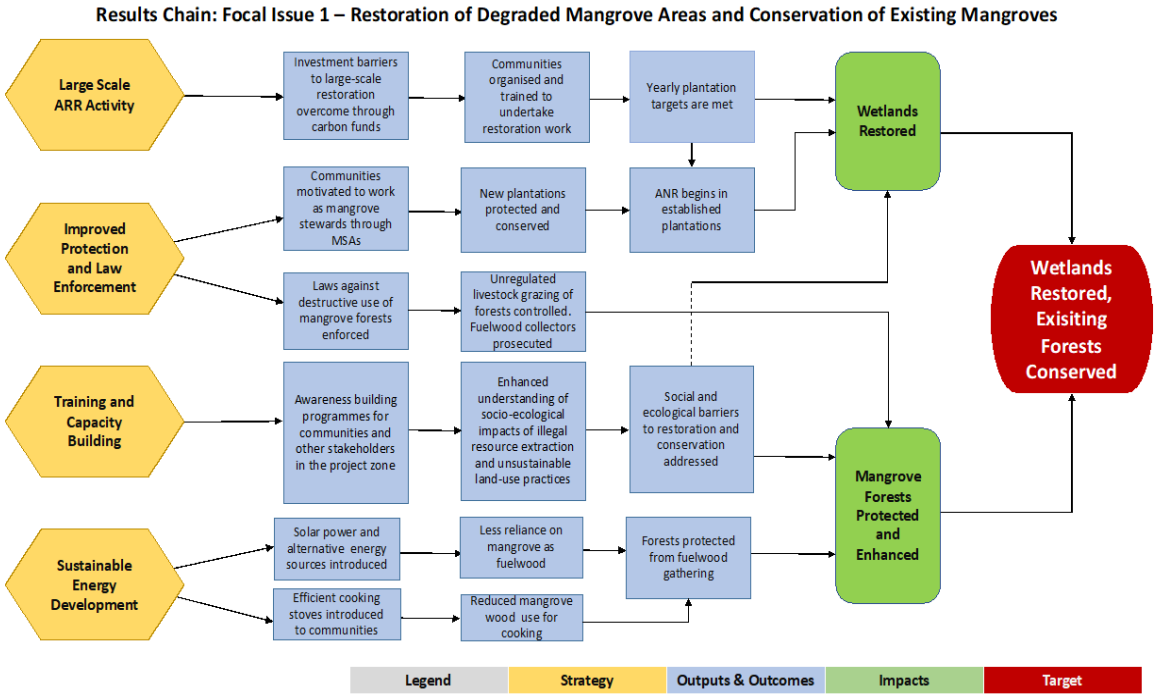


Figure 11. Results chain for focal issue 1: Restoration of degraded mangrove areas and conservation of existing mangroves.

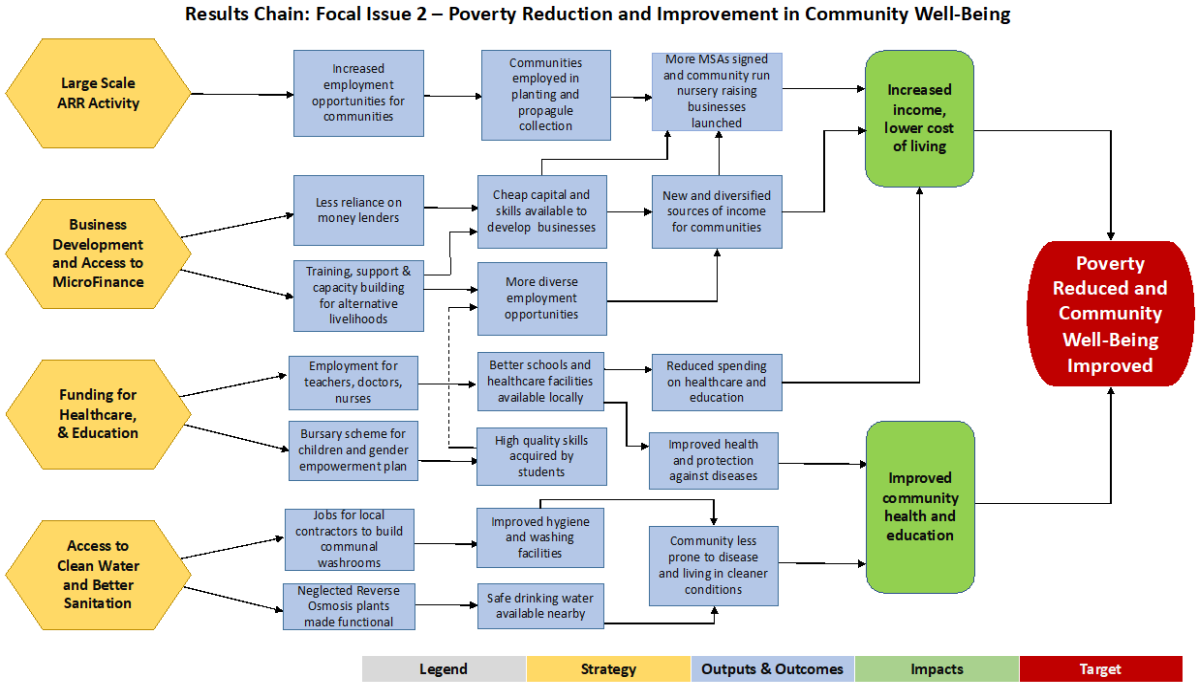


Figure 12. Results chain for focal issue 2: Poverty Reduction and improvement in community well-being.

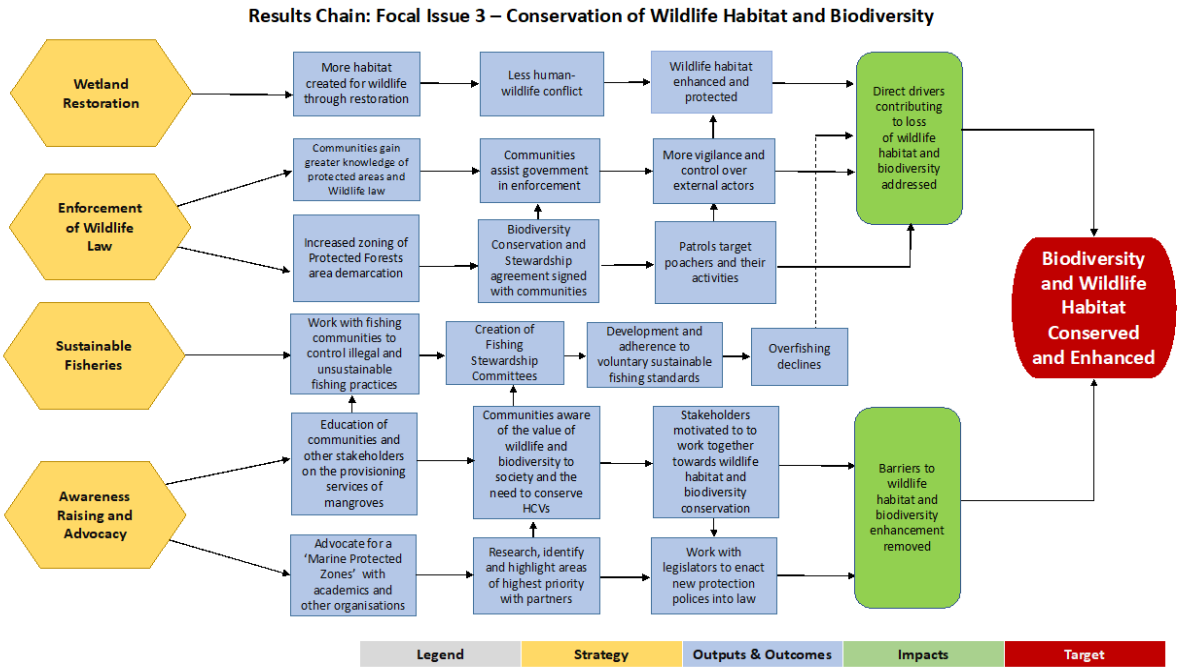


Figure 13. Results chain for focal issue 3: Conservation of wildlife habitat and biodiversity.

Table 9. Project activities and their expected positive impacts towards the three primary activity areas.
Activity area 1: Restoration and conservation of mangrove resources.

Defined activities
Upscaled ARR
Direct employment generation and training on income generating activities
Strengthening community organisation and further Mangrove Stewardship Agreements (MSAs) with local communities
Participatory planning and increasing environmental awareness
Sustainable energy development
Training and capacity building of stakeholders – Sindh Forest Department and local communities
Laws against destructive processes enforced

Expected positive impacts
Drivers working against restoration of degraded land tackled

Wetland ecosystems restored, enhanced and protected
Enhanced knowledge, job skills and positive attitudinal changes
Effective law enforcement, increased motivation and increased patrolling
Direct drivers of mangrove forest degradation addressed

Activity area 2: Poverty reduction and improvement of community well-being

Defined activities
Direct employment generation and training on income generating activities for both male and female community members
Access to safe drinking water and healthcare
Education improvement
Community-based business development and microfinance
Sustainable energy development
Strengthening community organisation
Participatory planning and increasing environmental awareness

Expected positive impacts
Increased and diversified sources of income
Improved health
Enhanced knowledge, job skills and positive attitudinal changes
Reduced poverty
Improved human well-being

Activity area 3: Conservation and enhancement of wildlife habitats and biodiversity

Defined activities
Upscaled ARR

Strengthening community organisation and Mangrove Stewardship Agreements (MSAs) with local communities
Participatory planning and increasing environmental awareness and advocacy
Effective law enforcement through capacity building, increasing motivation and increasing patrolling

Expected positive impacts
Expanded and enhanced mangrove ecosystem integrity to provide for wildlife habitat and biodiversity conservation
Reduced wildlife and biodiversity degradation and their impacts
High Conservation Values, especially HCV 1, 2 and 3, safeguarded
Enhanced perception/recognition of the value of various ecosystem services of mangroves
Increased economic and environmental benefits from wildlife and biodiversity conservation

2.1.12 Sustainable Development

Pakistan has affirmed its commitment to the 2030 Agenda for Sustainable Development by adopting the Sustainable Development Goals (SDGs) as its own national development agenda. The main themes related to these goals and provisions for monitoring are listed below.

No poverty, decent work and economic growth

Stakeholders benefit from direct employment in the project and from its livelihood enhancement measures. The project has a 60-year lifetime and will employ large numbers of local community members in a number of capacities. It will also work with the most vulnerable and impoverished communities and focus on providing livelihood support to the neediest members. *(SDG 1, 8).*

No hunger

Various interventions will contribute towards achievement of this goal in the Project Zone. These include improvements in agriculture and livestock production, a sustainable fisheries programme and increased income through employment and other livelihood improvement measures. *(SDG 2).*

Good health and well-being, clean water and sanitation

One of the core goals of DBC-1 is the improved well-being of communities in the Project Zone. This is being achieved through providing community members with access to affordable and quality health care facilities. The project also has specific provisions for ensuring community access to safe and clean drinking water and will also work on improving sanitation and hygiene facilities. (*SDG 3, 6*).



Figure 14. Reverse Osmosis plant in Pandi Jatt made functional by the project providing clean water for up to 500 people a day and (right) a community centre built in Arap Jatt for communal use.

Quality education

During the SBIAs, two types of educational support were requested by local leaders: primary and secondary education, as well as support to improve adult literacy, particularly amongst women. The project plans to support primary and secondary education by improving access to schools for children, improving infrastructure of existing schools and implementing an adult literacy programme. *(SDG 4, 10*).

Life below water

The project will work with fishing communities in the delta area in pursuit/support of sustainable fishing practices and through its advocacy push for the declaration and proper management of coastal areas in the Indus Delta. DBC-1 will also support small-scale artisanal fishing communities within the framework of Fish Stewardship Committees and work with relevant partners in Provincial Government to implement and enforce applicable national and international sea laws. *(SDG 14*).

Life on land

The project is a working on and taking a number of actions that will contribute to the conservation, restoration and sustainable use of mangroves forests, coastal biodiversity and their ecosystem services. DBC-1 has planned measures to increase the awareness and capacity of local communities and other stakeholders in a bid to end poaching and trafficking of protected species of fauna. Moreover, the proponents are working on integrating ecosystem and biodiversity values into local, provincial and national planning development processes. (*SDG-15*).

Gender equality

The project will implement various gender development interventions which will contribute to the economic and social empowerment of women at the community level. These interventions among others include income generating activities for women, provision of better nutrition, health and hygiene. *(SDG 5, 10).*

Affordable and clean energy

DBC-1 will promote the use of renewable and sustainable energy sources through various interventions. It will also implement the provision of solar energy to selected communities, especially those living in the creeks. (*SDG 7).*

Climate action

DBC-1 is a climate change mitigation project which will directly contribute to GHG emissions reductions and removals. It will also contribute to mainstreaming environmental and climate change related concerns into over-all development planning at the local, district, provincial and national levels. Furthermore, DBC-1 will strengthen the resilience of communities living within the Project Zone and support their adaptation to climate-related hazards and natural disasters. (*SDG 13)*.

2.1.13 Implementation Schedule (G1.9)

Date	Milestone(s) in the project's development and implementation
2015- Present	Large-scale ARR/RWE activity: Engaging and employing local community members plantation activities begin in the Project Area on degraded lands. To date more than 75,040 ha have been planted and restored. A Mangrove Stewardship model was developed, where community members implement a ward and watch system to protect planted areas in return for a monthly income.
2015-present	Community participation: DBC-1 has conducted participatory rural appraisals (PRAs) in 60 villages in the Project Zone. Three SBIA workshops held with key stakeholders from all areas of the Project Zone, where focal issues were agreed upon and key activities and interventions decided.
2015-2074	Begin and end date of crediting period
2018-present	Community development: New health centre constructed in an isolated area of Project Zone, allowing the most isolated communities to have access to basic healthcare. Keti Bandar rural health centre renovated and upgraded. Medical equipment and ambulance also provided. Community centre built for use by villagers in the area of Arap Jatt. Management of defective reverse osmosis plants taken from the government in Haji Pandi Jatt. Now providing clean drinking for 500 people on a daily basis. Food and supplies distributed to the most vulnerable communities during the COVID lockdown.
2021	Project documentation completed and submitted to Verra for validation/verification.
2021	Monitoring plan executed to prepare for verification
2021-2027	Further plantations of 149,375 ha of degraded land. Upscaling of community livelihood improvement interventions to cover entire Project Zone.
2021-2075	VCS/CCB Verification and dissemination of verified monitoring reports, VCS/CCB monitoring event and reports generation in 5-yearly cycles.

2.1.14 Project Start Date

A contractual agreement between Indus Delta Capital Limited and The Sindh Forest Department, Government of Sindh, became effective on February 19, 2015, the date of signing this agreement. The contract covers both mangrove conservation and restoration. The parties agreed to work together to implement project activities as well as develop the carbon asset in order to obtain carbon financing for further large-scale restoration and conservation work and community development. Indus Delta Capital Limited is entitled to a share of all VCUs/credits relating to the reduction in greenhouse gas emissions generated by the AUWD, ARR/RWE and WRC activities. Therefore, the incentive from the planned sale of VCUs/credits was seriously considered in the decision to proceed with the project activity. The project start date marks the starting point of mangroves forests and wetlands conservation and mangrove afforestation and restoration activities in the field.

2.1.15 Benefits Assessment and Crediting Period (G1.9)

The project lifetime is 60 years commencing from the project start date of February 19, 2015, with an end date of February 18, 2075. The crediting period will be the same 60 years as the lifetime of the project.

2.1.16 Differences in Assessment/Project Crediting Periods (G1.9)

The GHG emissions accounting, climate adaptive capacity and resilience, community, and biodiversity assessment periods are identical for DBC-1.

2.1.17 Estimated GHG Emission Reductions or Removals

Project year	Calendar year	Estimated GHG emission reductions or removals (tCO_2e)
1	2015	37,719
2	2016	192,432
3	2017	462,307
4	2018	785,003
5	2019	918,916
6	2020	1,580,348
7	2021	2,060,015
8	2022	2,673,162
9	2023	3,419,415
10	2024	3,818,606
11	2025	5,144,231

12	2026	5,958,777
13	2027	6,619,386
14	2028	7,055,399
15	2029	6,819,447
16	2030	7,367,384
17	2031	7,311,935
18	2032	7,155,761
19	2033	6,924,172
20	2034	4,716,942
21	2035	6,318,149
22	2036	5,976,914
23	2037	5,624,547
24	2038	5,269,362
25	2039	2,924,970
26	2040	4,575,793
27	2041	4,247,028
28	2042	3,932,420
29	2043	3,633,445
30	2044	1,345,412
31	2045	3,086,866
32	2046	2,841,134
33	2047	2,612,042
34	2048	2,399,011
35	2049	185,491
36	2050	2,019,874
37	2051	1,853,735
38	2052	1,700,600
39	2053	481,986
40	2054	0
41	2055	0
42	2056	0

43	2057	0
44	2058	0
45	2059	0
46	2060	0
47	2061	0
48	2062	0
49	2063	0
50	2064	0
51	2065	0
52	2066	0
53	2067	0
54	2068	0
55	2069	0
56	2070	0
57	2071	0
58	2072	0
59	2073	0
60	2074	0
Total estimated ERs (including buffer)		142,050,139
Total number of crediting years		60
Average annual ERs		2,407,629

2.1.18 Risks to the Project (G1.10)

The VCS requires that a non-permanence risk assessment be carried out in accordance with the most recent AFOLU Non-Permanence Risk Tool (v4.0). By applying this guidance, a risk rating was determined for the project and a non-permanence risk buffer of 10% was estimated, see Appendix 12. Risk Analysis.

Natural Risks

The Indus Delta region is not susceptible to severe natural destructive events. The area is subject to very little geological activity and as a native ecosystem the risks from disease and pests are minimal. The risk of fire is negligible due to regular inundation and high humidity under the forest canopy and in the whole of the intertidal zone. Also, government has standing orders with respect to forest fires prevention, suppression and reporting. In the event a forest fire, it has to be reported on immediate basis and a fire

damage report prepared. This fire damage report among others needs to have details with respect to the date and time the fire occurred, how it occurred, specific location of the fire, extent/area affected, and damages caused by the fire. No such fire damage incidents in the Indus Delta mangrove forests have been reported over the past more than two decades.

Seasonal flooding does occur during the annual monsoons but the mangroves species in the delta are well adapted and resilient to the hydrological cycle. However, long-term global climate change does pose a risk to the GHG mitigation outcomes of the project. Consequently, the negative ecological effects due to rapid sea level rise and associated coastal inundation and erosion have been accounted for in Chapter 3 of this document (see Section 3.2).

Human-induced Risks

The major human-induced risk to the project is the unsustainable and unregulated use of mangrove forests, along with the failure of restoration work. Measures to end destructive practices that can impact the project negatively have been put in place through a participatory approach with forest-dependent communities in the Project Zone (see Section 2.1.1). The main mitigation activity against failure in plantation is through ongoing protection and through community-led Mangrove Stewardship Agreements, which ensure that restoration work is protected and allowed to develop and establish over the project's lifetime.

2.1.19 Benefit Permanence (G1.11)

DBC-1 is a long-term 60-year project that has generated and will continue to generate substantial climate, community and biodiversity benefits. Project activities are specifically designed and being implemented to ensure sustainable community benefits. All measures are being implemented with the full consensus and support of – as well as in partnership with – each community in the Project Zone. These focus on the development of enhanced and alternative livelihoods which aim to improve local economies in ways so as to relieve pressure on the adjacent natural ecosystem (see Section 2.1.1).

The following measures have specifically been designed and are being implemented to maintain and enhance the climate, community, and biodiversity benefits beyond the project lifetime and to address any non-permanence related risks:

Institutionalisation of main Project interventions into regular functioning of Sindh Forest, Wildlife, Fisheries and other relevant departments

The various project interventions such as protection and sustainable management of restored mangrove forests, coastal and marine biodiversity conservation, and various supportive socio-economic development activities will be fully institutionalised into regular and everyday functioning of relevant departments, which will continually remain engaged with the local communities.

Capacitating and engaging community organisations

The various awareness raising, training, capacity building and continued engagement of local communities in an organised manner would have increased their knowledge and skills and improved attitudinal orientation for responsible and sustainable management of various coastal and marine resources including mangroves, fisheries, biodiversity and other resources.

Putting in place well-established and functional linkages with other partner organisations

Over the course of project implementation during the sixty-year period, community will develop well-established and functional linkages with other partner organisations in the government sector, private sector, NGO sector and civil society. These symbiotic relationships will contribute to maintain and enhance the climate, community and biodiversity benefits of the project beyond the project crediting period.

Sustainable management of restored ecosystems and stable and increased availability of various ecosystem services

Since the various coastal and marine resources are now restored and brought under sustainable management regimes to the benefits of all segments of society. Therefore, there will be increased and stable availability of various ecosystem services (provisioning, regulating, supporting, cultural and information) and their benefits even beyond the project crediting period.

Diversification and increase in incomes of local communities

The various project interventions will contribute to and result in sustained, diversified and increased incomes for the various socio-economic groups in the Project Zone, which will keep accruing beyond the project crediting period.

Employment and business opportunities generation

Because of socio-economic development, environmental rehabilitation and social capital development in the form of knowledgeable and capacitated communities there will be available vast and varied employment and business opportunities in the Project Zone. The restored economy, ecology and society will constitute an upward trend.

Decrease in cost of living

Due to addressing the various issues that were responsible for increased cost of living in the Project Zone, the cost of living will be brought down and hence the local communities will not be forced to resort to unsustainable resource use.

More efficient and effective allocation and utilisation of various coastal and marine as well as financial resources at the community level

Greater awareness raising and capacity building of local communities will lead to more efficient and effective allocation and utilisation of various coastal and marine as well as financial resources, thereby avoiding overexploitation and wastage and leading to resource conservation.

Increase in adaptive capacity and resilience to deal with various types of shocks

Communities over the project's lifetime will develop the needed resources, skills, institutions, processes and strategies that will increase their adaptive capacity and resilience thereby enabling them to deal with all types of shocks and trends (economic, climate and other natural disasters).

Reducing threats to mangrove lands, biodiversity and institutionalising biodiversity conservation and sustainable fishing through various institutional arrangements with local communities

Local communities have been made stewards of mangroves and biodiversity conservation and sustainable fishing through making them partners in their restoration, conservation, and sustainable management through the mechanism of Mangrove Stewardship Agreements, Biodiversity Stewardship Agreements and Fish and Sustainable Fishing Stewardship Agreements.

Project longevity

It is a sixty-year project with the option of extending up to 100 years. This generational longevity of the project will ensure that the various project benefits with respect to climate, community and biodiversity are now fully engrained into the working of society and therefore their sustained availability has now become part and parcel of their life.

2.1.20 Financial Sustainability (G1.12)

The project proponents are: 1) the Forest Department of the provincial Government of Sindh, which is a supported administrative unit with its own development budgets and 2) Indus Delta Capital. which has bought in non-leveraged capital through its owners and network of investors. Predicted carbon revenues and precise annual budgets demonstrate sufficient cash flow from sales of VCUs to sustain the project through to the end of the crediting period. The project proponents have created a detailed financial model for the development and financial management of DBC-1 and this document is available to the VVB. The project proponents have not received any grants for start-up costs or to fund the project design and development.

2.1.21 Grouped Projects

This is not a grouped project.

2.2 Without-project Land Use Scenario and Additionality

2.2.1 Land Use Scenarios without the Project (G2.1)

The full baseline scenario analysis as per CDM AR tool 2 (Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities) is described in Section 3.1.4.

Scenario 1: Continuation of the pre-project land use

No barriers are identified for this scenario.

The land subject to the project activity is degraded mangrove habitat. The planting areas of this ARR/RWE project activity are sited in a coastal location where the population pressure and short-term economic incentives increased the degradation of the mangroves over several decades. The most plausible baseline scenario is identified as degraded tidal wetland, more specifically: degraded mangrove habitat. The current degraded state is characterised by a near absence of sources of mangrove propagules, high salinity, and trampling of and damage to any newly emerging natural seedlings/natural regeneration by camels/other livestock and browsing by camels/other livestock, and lopping of branches of mangroves and mangrove propagules for fodder and fuelwood purposes. Ecological conditions for natural establishment of mangroves will not occur in the absence of the project activity.

Scenario 2: Natural regeneration of mangroves within the project boundary

Ecological barriers have been identified for this scenario.

There are ecological barriers that hinder the natural re-generation process in the Project Area. These include the very low availability/long distance from mangrove propagule sources to certain areas

(particularly high lying areas or those without natural vegetation), flushing out of the propagules out of the site with tide water (especially those of *Avicennia marina*, which have smaller propagules), and damage to the degenerated areas on account of biotic pressure, such as grazing and fodder collection.

Scenario 3: Mangrove regeneration within the project boundaries without being registered as a VCS project

Various barriers have been identified for this scenario.

Investment barriers, other than economic/financial barriers

There is neither credit nor credit funding for non-profitable activities beyond the programme Mangroves for the Future of which this ARR/RWE project activity is part.

Technological barriers

The contribution of the technical assistance for mangrove restoration is necessary for the project's success. Without the project, local communities will not have access to necessary materials, i.e., they will not be able to collect and plant mangrove propagules at a scale that is required for restoring the vast de-vegetated areas. They also will be limited by the lack of knowledge and infrastructure for implementation of the technology needed for restoration of the area under ecological principles.

Social barriers

Most of the population residing in the region comprises fishermen. To maintain these kinds of traditional fisheries, having an intact mangrove habitat is essential, which significantly supports the local livelihood. Large-scale awareness raising and mobilisation of the community is key to restore the region with a mangrove ecosystem providing multiple benefits, both economically as well as ecologically. The reality, however, is that if there is no organised programme to involve communities and monitor efforts, these programs are unlikely to be developed by local communities themselves.

Social barriers that will hinder large-scale mangrove restoration in the area include range from lack of opportunities and skills, poverty, illiteracy.

2.2.2 Most-Likely Scenario Justification (G2.1)

Continuation of the existing and pre-project land use and land use change scenario is considered as the most likely scenario.

The scenario justification is provided in Section 3.1.4.

2.2.3 Community and Biodiversity Additionality (G2.2)

Project additionality for climate benefits under the VCS has been demonstrated in Section 3.1.5, which gives the method used for demonstrating additionality.

Outcomes of the SBIA workshops and Participatory Rural Appraisals (PRAs) conducted by the proponents, have revealed that benefits to communities and the region's biodiversity would not occur in the absence of the project and its anticipated carbon revenues. In the absence of the project, restoration and conservation work would not be implemented due to lack of funds and no environmental and community livelihood benefits would be realised.

In such a scenario, continued degradation of the natural resource base on account of unsustainable resource and land use practices would persist and poverty in the area would increase over time along with biodiversity degradation. As a result, communities would remain vulnerable to various economic, social, ecological and climate change related shocks and will lack the needed resilience. Required reforms in policy, legal and institutional structures and processes that are conducive to and supportive of sustainable community development would also not materialise in the absence of the project. Table 10 details the main benefits to communities and biodiversity that would not occur in the absence of the project. Further information about the community and biodiversity benefits expected from project implementation is presented in Sections 4.2 and 5.2, respectively.

Table 10. Community and biodiversity benefits that would not occur in the absence of the project.

Type of benefit	Expected benefit (long-term impact)
Community	Increased economic, food, environmental and livelihoods security due to greater availability of fishes and other natural resources
	Increased capacities (knowledge, skills and attitudes) for sustainable fishing and other natural resources on which their livelihoods depend
	Increase in and diversification of income and livelihoods sources through jobs and business opportunities creation and reduced dependence on natural resources as a source of livelihood
	Increased access to low cost and institutional credit and financial resources due to linkages development
	Improved access to markets
	Social and economic empowerment, especially of the marginal and vulnerable groups
	Improved access to human well-being facilities such as health, education, safe and affordable drinking water, hygiene, energy, civic and cultural
	Expanded and easy access to various public and private sector service providers
	Increased human capacities due to knowledge, skills and positive attitudinal changes and perspective on life brought about as a result of training and capacity building activities
	Social capital development and improved negotiation and conflict resolution skills
	Reduced vulnerabilities to climate change and other related disasters such as sea level rise, sea water intrusion, coastal erosion, droughts, flooding, and other extreme weather events, etc.
	Increased coping capacities to deal with economic, social and environmental shocks and trends.

	Improved local level governance of natural and other livelihood resources due to greater information availability, transparency, accountability and management capacities.
Biodiversity	Increased integration of marine, coastal and terrestrial ecosystems thereby leading to increase in biodiversity of all these ecosystems
	Development of common institutional platforms for integrated and coordinated work in pursuit of biodiversity conservation and sustainable management
	Greater knowledge generation, dissemination and availability on coastal biodiversity
	Improved planning, policies and governance mechanisms for biodiversity conservation and sustainable management
	Partnerships development for enhanced and upscaled actions for biodiversity conservation
	Increased awareness creation and capacities building about the various ecosystem services of biodiversity
	Restoring the health and integrity of wetlands and marine ecosystems and resources including mangrove forests, fisheries and other resources
	Increase in the extent and area of intact wetlands and marine ecosystems thereby leading to their quantitative and qualitative improvements and increased resilience to shocks including climate change
	Reduction of threats to biodiversity
	At scale enhancement of coastal biodiversity at various levels – ecosystem, species and genetic
	Habitats restoration for endemic, threatened, vulnerable and other at-risk species and species of special concern
	Institutional capacity building for sustainable management of fisheries, biodiversity, mangroves and other coastal and marine resources
	Partnerships development for biodiversity conservation
	Increased financial resources availability for biodiversity conservation and sustainable management
	Reduction in perverse incentives that lead to biodiversity degradation and introduction of environmental fiscal reforms initiatives that support biodiversity conservation and sustainable management
	Management, institutional and technological innovations for biodiversity conservation and sustainable management

2.2.4 Benefits to be used as Offsets (G2.2)

DBC-1 is not claiming any other offsets or credits from the community or biodiversity benefits produced by the project.

2.3 Stakeholder Engagement

2.3.1 Stakeholder Access to Project Documents (G3.1)

Various project documents which do not fall within the domain of commercially sensitive information will be publicly available and hence all stakeholders will have access to them. A hard copy in English and Sindhi of the full PD, the monitoring results and reports, and the feedback and grievance redress procedure will be made available for public viewing at the project offices in the UK and Pakistan. The PD will also be posted on the project's website at: www.indusdeltaredd.com. An executive summary in Urdu and Sindhi will be posted in public places in the Project Zone, along with a contact email address. Internet access is limited in many parts of the Project Zone, but mobile phones are commonplace, and WhatsApp is the preferred method of communication for most community members. Hence, a WhatsApp group will be set up and key community contacts added to the group to receive regular bulletins and allow them to give their feedback.

2.3.2 Dissemination of Summary Project Documents (G3.1)

Summary project documentation, including information required for G1.1-9, has been actively disseminated to communities in a number of ways. The English language version of the summary project documentation has been translated in Urdu (national language) and Sindhi (local language). Copies of these translated documents have been kept in and are available in the two regional project offices (Keti Bandar and Shah Bandar) and the main project office at Karachi. These documents have also been shared, discussed and fully explained to communities in various meetings and workshops. Further, these are uploaded to the project website.

The project has a full-fledged communication and information dissemination strategy to share all the needed information in a proactive and fruitful manner to the various stakeholder groups including the local communities. As part of this communication strategy, the project is already sharing project documents and all relevant information for awareness raising, getting feedback and capacity building.

Summary information on monitoring results will also be actively disseminated to communities in line with the project communication and information sharing strategy and plan.

The project has a community message board at each of the two key locations – Keti Bandar and Shah Bandar, in order to reach all community members when sharing important project information. A poster/notice in Urdu and Sindhi advertising the public comment period for the PD will be posted in communities throughout the Project Zone. It will include details on how a comment can be made to the CCB. The project's community outreach workers will also contact members through their local networks in the Project Zone and inform them of the notice period for comments.

2.3.3 Informational Meetings with Stakeholders (G3.1)

Since the project began, information regarding DBC-1 has been communicated to stakeholders through a series of meetings that have taken place in socially and culturally-appropriate settings for both male and female community members.



Figure 15. Household surveys were conducted by project staff in villages throughout the Project Zone.

These Participatory Rural Appraisals (PRAs) were conducted by the project's community development officers (both male and female) and experienced members of the Sindh Forest Department. All meetings were widely publicised and known events. Participants of the meetings also included local elected officials and representatives of administration (see Appendix 3. PRAs and FPIC Meetings). These meetings were meant to establish a closer liaison with these key stakeholders. They were held in Sindhi language to ensure that the information was communicated to and understood by all participants. The overall vision, goal, development objectives and project activities pertaining to climate, biodiversity and community development were shared and explained to attendees during each session. This was followed by an open discussion and question and answer session. To gain a greater understanding of community issues and needs, many one-to-one household meetings were also conducted in various villages in the Project Zone.

2.3.4 Community Costs, Risks, and Benefits (G3.2)

DBC-1 is a public-private partnership (PPP) based participatory project and has been designed through engagement of relevant communities and stakeholders. From its inception, the project has involved local communities in decision-making. Discussions and collaboration between the project partners with the goal of initiating and implementing a restoration project in the Indus Delta area first began in 2012, leading to an initial Memorandum of Understanding (MoU) in 2013 and subsequently a project agreement in 2015 between the project partners. The Sindh Forest Department has been active in the area maintaining and building relationships with the communities since early 1970s. These communities are therefore familiar with the proponents and open communication channels were established with them prior to the start of the project's design phase. During the last couple of years, the project proponents have conducted numerous surveys and studies in the area and a suite of community meetings that focused on Free, Prior and Informed Consent. These interactions and meetings also served as and provided the basis for establishing and communicating the project's costs, risks and benefits with the communities (see Section 4.5).



Figure 16. World record attempt to plant the most trees in a day which was held in the Project Area.

Two project sub-offices have been established, one each in Keti Bandar and Shah Bandar Areas. These field offices serve as information hubs for DBC-1 and are open to all community members and stakeholders who wish to gain information about the project and/or submit comments or grievances.

In 2018 the proponents organised and held events for attempting to break the Guinness World Record for planting of maximum saplings per day (pictured above).

2.3.5 Information to Stakeholders on Validation and Verification Process (G3.3)

See Sections 2.3.1 and 2.3.2.

2.3.6 Site Visit Information and Opportunities to Communicate with Auditor (G3.3)

The project has and will actively communicate to community members and stakeholders about the start of the public comment period and the methods with which they can submit comments on the project as well as how to view full project documentation (see Sections 2.3.1 and 2.3.2). This has been accomplished by communicating the project public comment period and remote validation process (necessitated by the COVID-19 pandemic and the resultant travel restrictions imposed by governments) dates to previously identified stakeholders, community leaders, leaders of various community groups and public officials.

Hence, in accordance with Verra's COVID-19 Travel Guidance for Projects (dated 18 March 2020) and considering that the VCS does not explicitly mandate site visits, provided that a reasonable level of assurance is achievable by other means, the VVB has carried out a remote audit that will ensure the achievement of the assurance level required by the VCS.

The remote audit was based on the following auditing techniques:

- Document review and cross checks between the information provided in the PD and supporting information and evidence provided by the project proponent.
- Review, based on the selected methodologies, tools and other applied methodological regulatory documents, of the appropriateness of formulae and accuracy of calculations.

- Skype calls and teleconference interviews and email communications with relevant stakeholders and personnel responsible for the implementation of project activities and the elaboration of project's documents.
- Cross checks between information provided by interviewees to ensure that not relevant information has been omitted.

The proponents have facilitated the remote validation process and arranged meetings between communities and other stakeholders with the VVB and will also arrange for community and other stakeholders' meetings during future verification site visits.

The remote process was carried out from 25th to 27th of May 2021. The interview sessions were started at 12:00 (Pakistan time), 09:00 (CEST). During these meetings, the auditor(s) were able to directly and independently ask any questions related to the project.

2.3.7 Stakeholder Consultations (G3.4)

The Sindh Forest Department has been interacting and maintaining a regular dialogue with stakeholders in the coastal area communities for more than 30 years. In addition to those regular contacts, the process of community and stakeholder identification was further supplemented by a series of interviews conducted by project staff at the community level since the launch of the project. As a result of the various socio-economic studies and meetings/workshop discussions – coupled with an analysis of rights and a literature review – the proponents have gained an in-depth knowledge of all relevant stakeholders.

Through this process it has been possible to obtain a well-informed and comprehensive understanding of all communities and community groups in the Project Zone and obtain their FPIC for project activities.

In total for the FPIC process and other project related activities, more than 45 meetings have been held since 2013 which have been attended by hundreds of community members from the Project Zone.



Figure 17. Key Informant Ainy Zehra leads an SBIA workshop meeting or female community members.

Significant time was given between the initial contacts with the community, subsequent discussions at the community level and the time that any formal decision-making was expected from the community. For

details of these consultative meetings including the dates, locations and participants of the meetings (see Appendix 3. PRAs and FPIC Meetings).

As a result of these discussions and consultations, a number of insights have emerged about the characteristics of stakeholders and community groups, their impacts on the project and their interactions with other groups. See Appendix 4. Stakeholder Analysis for a full stakeholder analysis. Local leaders and other key informants are also of immense value for providing useful information about the communities and conditions in the Project Zone as they have been based in the area and witnessed conditions evolve over time. As a result, they possess substantial knowledge and enjoy the trust of the local population.

Key informants consulted include:

Mr. Riaz Ahmed Wagan is the Chief Conservator of Forests, Coastal Areas and Rangelands Region, Sindh Forest Department. He has been working in the region for the past 25 years and has built strong linkages and has gained the trust of the communities in the Project Zone on behalf of the Government.

Mr. Arif Ali Khokar is the Conservator of Forests, in charge of Coastal Forest Circle. He is an expert on mangroves, biodiversity conservation and coastal areas development. He has also been associated with mangroves protection, conservation and development as well as community development in the region for the past 20 years and was instrumental in maximising the impact of the SBIA workshops.

Mr. Niaz Soomro is the lead person for community outreach in the Thatta and Karachi Districts. Over the past 20 years he has led community development and biodiversity conservation activities in the region and has gained the trust of the communities in and around the Keti Bandar area.

Mr. Shakeel Memon is a community activist and community development specialist. He hails from the Project Area and is a valuable resource for the project in community engagement.

Miss Ainy Zehra is a highly respected published academic, who has worked in the environmental sector for the past 10 years. She has been involved in delivering capacity building workshops at the local and national level over the past 10 years on various subject in including wetlands management, biodiversity conservation, REDD+ and 'Human Resource Management for Uplift of Rural Society'. She was instrumental in delivering and leading the project's SBIA workshops.

Building on this extensive knowledge base several SBIA assessments were conducted with all key stakeholder representatives in strategic locations throughout the Project Zone to maximise coverage and participation (see Section 2.1.8).

Using the project theory of change and its logical framework participants developed the project vision, goals and objectives, outputs and project activities in participatory fashion.

As a result, the proponents along with other project stakeholders and communities have been able to identify and prioritise focal issues, potential risks and mitigating measures as well as indicators to be used for tracking their impact (see Sections 4.4.1and 5.5.1).

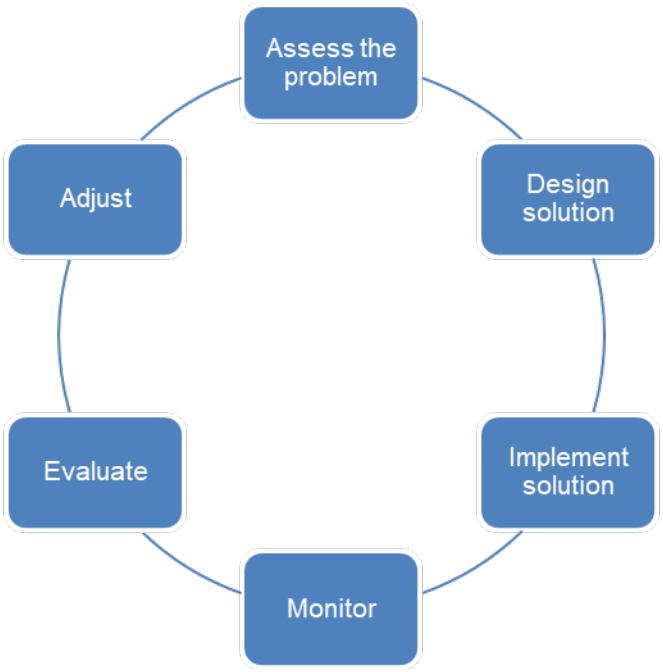
2.3.8 Continued Consultation and Adaptive Management (G3.4)

Project proponents recognise and acknowledge the fact that mangroves and other coastal and marine ecosystems restored under the project are in a constant state of flux due to a number of climatic, ecological, and anthropogenic phenomena. Therefore, uncertainties abound in these systems as well as the

effectiveness and outcomes of the various decisions taken regarding their management. To cater to these, project proponents have developed an information collection, communication and consultation plan about the implementation of various project interventions.

Using this plan, a number of approaches and processes will be followed to regularly collect information about the outcomes of implemented decisions through surveys, focus group discussions, workshops, thematic studies, etc. Using the collected information, any potential problems and barriers hampering the achievement of objectives will be identified and assessed in Climate, Social and Biodiversity Impact Assessment Workshops.

Using these workshops and in consultation with communities and other stakeholders, solutions to those problems will be designed. These solutions would then be implemented, monitored and evaluated. Any further adjustments will be made again, if there is need for such adjustments. This adaptive management process will be implemented in cyclic, systematic and iterative manner as diagrammatically depicted below:



Project activities are monitored and evaluated on a regular basis according to the project's monitoring plans and standard operating procedures (SOPs) with respect to these various activities. The information becoming available as a result of these monitoring and evaluation activities and continued consultations with stakeholders will be fed into future actions and decision making so as to enable adaptive management of the project and its interventions.

2.3.9 Stakeholder Consultation Channels (G3.5)

Keeping in view the various constraints (language and literacy related constraints; mobility, access and time related constraints; socio-cultural and low confidence levels related constraints) faced by local communities in the Project Zone to effectively participate in planning and decision making, DBC-1 has developed a Project Communication Strategy which makes use of a number of stakeholder consultation channels and mechanisms to share information with and get feedback from the various stakeholder groups. These include the formation of stakeholder roundtables and forums, establishment of village development committees and women groups, Mangrove and Biodiversity Conservation Stewardship Committees, Fisheries Stewardship Committees, formation of dedicated stakeholders virtual groups (for sharing voice and text messages in Sindhi and Urdu for sharing information about project and getting community members and other stakeholders feedback), community motivators and activists, as well as all the channels as given in and made use of in the project feedback and grievance redress mechanism of the project.

Using these various stakeholder consultation channels, the project has used a number of consultation methods such as meetings, workshops (including SIA workshops), focus group discussions, surveys and organised special events (Guinness World Records setting, etc.) and days (Mangroves and Wetlands Day, Forest Day, Biodiversity Day, Environment Day, Plantation Day, etc.) for continued consultation with stakeholders.

A complete report of the various meetings and workshops, including pictures, video and meeting results are available and will be provided to the VVB.

2.3.10 Stakeholder Participation in Decision-Making and Implementation (G3.6)



Figure 18. Mr Arif Ali Khokar (left) begins proceedings at an SBIA workshop.

To ensure effective participation of DBC-1 communities, it was important to hold meetings and consultations at places and during time periods where stakeholders could attend and were held in culturally appropriate and a gender sensitive manner. Consultation agendas were extended to communities beforehand and in timely manner, using all the methods of communication available to the project proponents. All meetings and communications were conducted in Sindhi or Urdu languages so that every participant could effectively

understand and fully participate in the structured discussion. Participants were also given sufficient time to do subsequent consultations at the community level before formal decision making.

2.3.11 Anti-Discrimination Assurance (G3.7)

The project is committed to the fair treatment and equal opportunity for all stakeholders, community members and employees. Neither the project, nor any agent of the project, will discriminate against any person for any reason, including – but not limited to – gender, religion, nationality, tribe, or sexual identity. DBC-1 is committed to providing a workplace and programmes that are safe and free from all kinds of harassment. The project has drafted an anti-discrimination and non-harassment assurance document outlining its full policy. This document will be made available to the VVB.

2.3.12 Feedback and Grievance Redress Procedure (G3.8)

The project employs a proactive feedback and grievance redress policy through a structured process. The importance of an effective non-judicial complaint mechanisms as a means of redress in the event of disputes between the proponents and communities is key to successful project implementation.

Developing robust complaint procedures for local community members not only serves as a platform to resolve grievances but will help open channels for more effective communication.

Furthermore, the mechanism does not in any way inhibit their access to legal or judicial recourse processes. The proponents believe complainants should be free to pursue legal or judicial processes at any stage if they feel their concerns are not being adequately addressed by the mechanism. The project implements a seven-step grievance resolution mechanism (set out in an SOP which will be made available to the VVB) as outlined below.

Step 1: Engage Community Member and Receive Grievance

Our dedicated grievance manager (GM) will receive the grievance and is responsible for documenting and recording it into a stakeholder complaints log database. Stakeholders can make their initial complaint in person or by using any of the communication methods described above in Sections 2.3.1 and 2.3.2. The mechanism is accessible, and the proponents will promote external awareness of its existence and guide to its use.

Step 2: Carry out a Preliminary Assessment

An initial assessment of the grievance will be conducted by the GM. Grievances will be classified into a number of categories, such as environmental, cultural heritage, land disturbance, recruitment procedures, health and safety, human rights, physical or economic displacement or related to a specific community development activity. For each of these categories, the relevant person within the company will be assigned to deal with the specific details of investigating the grievance.

Step 3: Respond to Grievance

A written communication to the complainant to acknowledge the grievance and provide information as to expected next steps and timing for resolution of the grievance will be provided within seven working days of the receipt of the grievance. Where illiteracy is common, consideration will be given to the means of

communicating this message. In such cases a community outreach worker will communicate the information in person through the available channels.

Step 4: Investigate and Resolve

The relevant person(s) will investigate the underlying cause(s) of the grievance and develop actions needed to prevent recurrence of a similar grievance. The approach and team membership to complete the investigation will depend upon the category and level of the grievance. Some investigations may require a simple examination of the situation, whereas others may require discussions with many stakeholders, both internal and external. Wherever possible communities and respected third parties will be involved in the design and implementation of solutions.

Step 5: Conclusion

The GM will follow the investigation procedure in order to develop recommendations to ensure the grievance does not reoccur. The aggrieved parties will be engaged and their views about the company recommendations sought through dialogue. If the complainant is satisfied, then the GM manager shall seek their sign-off that the grievance has been resolved. This process will be completed within 28 days of receiving the initial complaint.

Step 6: Further Action

If the complainant is not satisfied with the proposed solution, the GM will initiate further investigation to determine what different approach may be taken. In the case that satisfaction cannot be achieved, the grievance may be referred for third party mediation, arbitration or courts.

Step 7: Monitoring and Evaluation

Part of the grievance management procedure will be entering the details and each step of progress into the company's stakeholder engagement database. At monthly intervals, the number and nature of grievances received, resolved and outstanding will be tallied and reported to management and advisers. Bi-annually, the trends and time taken for grievance resolution shall be analysed and the evaluation used for assessing the efficacy of the mechanisms. If the procedure is not managing to resolve the majority of grievances within the set time frames, then the mechanism will be adjusted. Better indicators of success are that resolution is received to the satisfaction of both parties within the agreed amount of time specified in the procedure on a majority of cases and that there are not recurring complaints about the same issues.

2.3.13 Accessibility of the Feedback and Grievance Redress Procedure (G3.8)

Sections 2.3.1 and 2.3.2 describe the mechanisms in place to enable accessibility of the feedback and grievance redress procedure and how it will be advertised and made publicly available.

2.3.14 Worker Training (G3.9)

The project is committed to investment in training and capacity building of all concerned people and organisations. This commitment to training and capacity building therefore extends from project staff, to project-area communities, and to local collaborators (both NGO and government).

This training and capacity building initiative can take many forms, from work shadowing, internships, ad hoc training, to implementation of formal training and learning sessions. Appendix 5. Training and Capacity

Building summarises some of the main aspects of the project's training and capacity building programme. Both in-house resources, various government departments – as well as external and outsourced individuals and organisations – will be used for implementation of the training and capacity building. This training program is also subject to revision and further enhancement on a needs basis from lessons learnt during implementation.

2.3.15 Community Employment Opportunities (G3.10)

Local employment generation is a priority for DBC-1, and local sourcing is strongly encouraged at all levels of the project. The proponents recognise that local hiring, especially women and members of marginalised and vulnerable communities is a major benefit to the implementation and operation of the project due to the familiarity and knowledge local people possess of the landscape and the ecosystem. Their involvement will also ensure the sustainability of the project interventions throughout the project's lifetime and beyond.



Figure 19. The project is already employing hundreds of members of the local communities to carry out restoration work.

IDC and DBC-1 have developed an Equal Employment Opportunity Policy (EEOP). This EEOP will be provided to the VVB on request for review. Based on this EEOP, future DBC-1 job positions in the project's central office will be openly advertised through the project office within the Project Area.

However, due to poor literacy and poor access to education in the Project Zone, the majority of the local workforce is only qualified to carry out manual labour jobs. The project has put into place measures to raise education standards and diversify livelihood options for community members through a suite of initiatives (see Section 2.1.1), but these will take to come to fruition.

In the meantime, the project is committed to only employing Project Zone residents and contractors to implement the large scale ARR activities in the Project Area. Due to the scale of the restoration this has already created hundreds of jobs and once carbon revenues allow the proponents to significantly scale up activities, hundreds more will find employment.

From the above, it can be seen that people from the communities are and will be given an equal opportunity to fill all worker positions (including management) if the job requirements are met. The project follows a well-laid out worker selection process as explained and given in its Policy and Procedure for workers

selection for various positions. This Policy and SOPs document also explains that where relevant and needed, various measures are designed to ensure community members, including women and vulnerable and/or marginalised people, are given a fair chance to fill positions for which they can be trained.

The Equal Employment Opportunity Policy and SOPs are made available to the VVB.

2.3.16 Relevant Laws and Regulations Related to Worker's Rights (G3.11)

The Constitution of Pakistan contains a range of provisions with regards to labour rights. These are found in Part II: Fundamental Rights and Principles of Policy. Specific Articles of the Constitution dealing with labour rights include the following:

- Article 11 of the Constitution prohibits all forms of slavery, forced labour and child labour
- Article 17 provides for a fundamental right to exercise the freedom of association and the right to form unions
- Article 18 proscribes the right of its citizens to enter upon any lawful profession or occupation and to conduct any lawful trade or business
- Article 25 lays down the right to equality before the law and prohibition of discrimination on the grounds of sex alone
- Article 37(e) makes provision for securing just and humane conditions of work, ensuring that children and women are not employed in vocations unsuited to their age or sex, and for maternity benefits for women in employment

All Constitutional Provisions with regard to Fundamental Rights and Principles of Policy shall be followed in their letter and spirit. Pakistan also has a suite of laws and regulations related to workers' rights. Labour laws of the country fall into the following core legal categories: Laws relating to industrial relations; Laws relating to employment and service conditions; Laws relating to occupational safety and health; Laws relating to human resource development; Laws relating to labour welfare and social security. Key elements of these labour laws will be embodied in the employment contracts of workers.

Workers will be informed about their rights at the point of their employment during the employee orientation. Applicable Labour Policies in the country include Government of Pakistan Labour Policy 2010 and Sindh Government Labour Policy 2018. These Labour Policies are also custodians of labour rights. At the national level there is the full-fledged Ministry of Labour, Manpower and Overseas Pakistanis dealing with labour issues in the country.

At the provincial level, Sindh Province also has a Labour Department. These Ministries and Labour Department ensure implementation of the country's and province's labour laws, regulations and policies and protect labour rights. Pakistan joined the ILO (International Labour Organisation) in 1947. The country has ratified 34 ILO Conventions. Of these, 33 are already in force in the country. The project proponents being a governmental organisation and a socially responsible private sector company will ensure that any relevant international conventions or government laws and regulations (provincial and national) are fully followed.

2.3.17 Occupational Safety Assessment (G3.12)

DBC-1 abides by all relevant Pakistani and Sindh Province worker's rights laws and regulations as set out in Pakistan Labour Policy 2010 and Sindh Government Policy (Sindh Labour Policy 2018). These policies are divided into and address the following four aspects of labour issues in the country:

- Legal Framework
- Advocacy: Rights of Workers and Employers
- Skill Development and Employment
- Manpower Export
- Providing proper training on safety procedures, evacuation, communication, equipment use, and shelter making in order to ensure worker safety and mitigate potential risks inherent to certain field activities.

During the employee orientation sessions, workers are informed about the potential safety risks of their job and of methods to mitigate the risks. A hard copy of the relevant laws is kept at the project office and any worker is free to consult these at any time during working hours.

Given the nature of the project and its geographical surroundings, it is recognised that certain occupations inherently present a risk to the health and safety of workers, in particular occupations that require spending long periods walking in the difficult environment of mangrove forests.

These include, though not exclusively, workers doing plantation and nursery work, plot samplers and forest protection staff, who are faced with challenging soil conditions as well as the risk of encountering various forest offenders. The project has created a comprehensive health and safety plan that ensures that all workers' health and safety is protected, and that all workers are fully informed about workplace risks and safe practices to mitigate those risks.

These include training in safe working practices, first aid training for some staff members as well as the enforcement of requirements for safe handling of equipment and other materials.

This health and safety plan additionally provides a comprehensive list of the measures that will be taken to inform employees of their rights, to assign roles and responsibilities to supervisors and workers and provide a safe workplace culture. This document will be revisited regularly and revised as needed to ensure that it contains current information and includes all job categories and potential risks.

A copy of the plan will be provided to the VVB and will be kept at the project office and be readily available for any consultation.

2.4 Management Capacity

2.4.1 Project Governance Structures (G4.1)

DBC-1 is developed and managed by the Government of Sindh and Indus Delta Capital Limited, who have entered into public-private partnership arrangements through a 60-year agreement, renewable up to 100 years for the protection, conservation and ecosystem restoration of mangrove wetlands in the Sindh Indus Delta area. By collaborating with the project-area communities and partner organisations, Forest

Department of Government of Sindh and Indus Delta Capital Limited take full responsibility to manage, finance and implement project activities for the duration of the project.

The teams of the Sindh Forest Department and Indus Delta Capital have developed complementary roles for the smooth design and implementation of DBC-1. They coordinate project implementation and operations with all relevant project stakeholders.

Based on their competencies and attributions, following are the specific roles and responsibilities of Sindh Forest Department and Indus Delta Capital:

Sindh Forest Department

- Communication and liaison with various tiers of Government, including Federal Government, Provincial Government and Local Government
- Obtaining approvals and No Objection Certificates where applicable
- Liaison with sectoral departments such as Fisheries, Agriculture, Livestock, Environment, Local Government, etc.
- Liaison with policy makers and political leaders
- Law enforcement and prosecution of offenders
- Relevant policies and plans implementation
- Design, planning, implementation, monitoring and evaluation of mangrove restoration and coastal and marine biodiversity conservation activities
- Facilitation and liaison with local communities
- Obtaining of Free, Prior and Informed Consent of local communities
- Social organisation of local communities
- Execute Mangrove Stewardship Agreements (MSAs) with local communities
- Execute Fisheries Stewardship Agreements (FSAs) with local communities through Fisheries Department
- Execute Biodiversity Conservation Agreements (BSAs) with local communities through Wildlife Department
- Provision of satellite imageries and maps
- Facilitation in implementation of climate monitoring plan
- Facilitation in implementation of community monitoring plan
- Facilitation in implementation of biodiversity monitoring plan
- Any other function as per public-private partnership agreement between Government of Sindh and Indus Delta Capital Limited

Indus Delta Capital Limited

- Collect information for the preparation of PD

- Conduct baseline studies such as biodiversity study, socio-economic study, etc.
- Procure and engage experts
- Select relevant methodologies for preparation of PD
- Prepare PD
- Engage VVB for PD validation
- Arrange funds for implementation of various project interventions as per agreement executed with the Government of Sindh
- Implement the climate monitoring plan
- Implement the community monitoring plan
- Implement the biodiversity monitoring plan
- Prepare the monitoring report
- Engage verifiers for verifying the monitoring report
- Market the carbon credits
- Distribute the government share of carbon revenue to Government of Sindh
- Any other function as per public-private partnership agreement between Government of Sindh and Indus Delta Capital Limited

Other involved entities in DBC-1 are performing their respective roles as per their agreed terms of engagement. For example, Pakistan Forest Institute is supporting the project in research and development and soil and biomass carbon accounting. Silvestrum Climate Associates are collaborating with and supporting the project in wetlands methodological development as well as carbon project development. Blue Venture's team of experts is helping the project in bottom-up and sustainable fisheries management and community development. Experts from Pollination Group have been involved in project due diligence and carbon credits marketing, as well as financial resources mobilisation.

2.4.2 Required Technical Skills (G4.2)

There is a suite of key technical skills which are required to implement DBC-1. These include an understanding of the science and art of ecosystem restoration, forest and biodiversity conservation, geographic information systems and remote sensing, biomass sampling, coastal ecology and Greenhouse Gas Accounting. Implementation of project activities also requires experience of implementing community and livelihood development programmes, effective forest protection enforcement and monitoring and overall project management. The Sindh Forest Department is the lead agency in coastal areas management and biodiversity conservation. Its staff are trained in project management, remote sensing, biomass sampling and coastal ecology. They have the human resources to support these areas of DBC-1.

Indus Delta Capital Limited is also a leader in forest and biodiversity protection as well as community development. Its staff are highly trained in forest carbon projects design, development and management, remote sensing, biomass and soil sampling and coastal ecology.

They have the human resources to support these areas of DBC-1. Therefore, all the proposed project activities will be implemented primarily by the Government of Sindh Forest Department and Indus Delta Capital Limited in collaboration with the local communities and other partner organisations when deemed appropriate and useful.

These includes those partners listed in above in Sections 2.1.3 and 2.1.4 but also includes a range of other collaborators, including other provincial government departments.

This core team is based in the project headquarters in Karachi and in field offices in Keti Bandar and Shah Bandar and maintains a presence throughout the Project Zone. In addition to the above-mentioned in-house experts, DBC-1 partners and collaborates with a wide-range of institutions both as implementing partners and as sources of technical advice.

Silvestrum Climate Associates are the technical leads in preparation of this document and the application of the methodology to the Project Area. The company's core team has a long history of collaboration that extends well beyond the tenure of the firm. As innovators and long-time practitioners in climate adaptation, climate mitigation, climate change policy, engineering, and environmental science, the Silvestrum team unites insights from successful projects and policies from across the world, combining cutting-edge research with decades of hands-on experience.

UK registered non-profit Blue Ventures will provide ad-hoc technical support related to the sustainable fisheries management activities. Blue Ventures' team of technical advisors brings almost 20 years of experience working with coastal communities across the tropics to develop bottom-up fisheries management and improvement plans.

2.4.3 Management Team Experience (G4.2)

Project Management Leads

Mr. Nadeem Raza Khan; Founder & CEO, Indus Delta Capital

Mr. Nadeem Khan is the founder and CEO of Indus Delta Capital and has been at the forefront of the business since its inception. He has played a prominent role in changing the view in the country on key green initiatives and the value of nature-based solutions, which has had a positive impact on both the people and the environment. He was instrumental in developing the pioneering Public-Private Partnership with the Government of Sindh for DBC-1 and has spearheaded the development of the project and business. He possesses the required qualifications and experience for implementation of the key project activities such as communications management, training and capacity building, advocacy work, administration and human resource management, financial management and over-all project management.

Previous to this Mr. Khan had a distinguished career in the international media as a Managing Editor for various leading business titles and national newspaper groups. Mr. Khan has held senior management roles in media companies in the UK (News International), UAE (Arab Media Group) and Lebanon (Daily Star/Wall Street Journal newspaper group). For the past 7 years he has used his skills and experience to focus on environmental issues in Pakistan. Mr. Khan, with his fellow directors, also manages the relationships between Indus Delta Capital and its business partners and is the key point of contact for DBC-1.

Mr. Riaz Ahmed Wagan; Chief Conservator of Forests - Mangroves and Rangelands, Government of Sindh

Mr. Wagan, in his capacity as Chief Conservator of Forests, is the Chief Technical Advisor to the Government of Sindh on mangroves and coastal areas. He is an expert and lead authority in the country on mangroves restoration and conservation activities and has been the driving force behind the provincial government's wetland restoration efforts. He has 27 years of field experience, administration, human resources management as well as financial management. Mr. Wagan has masterminded the vast restoration work in the Indus Delta and has planned and led implementation activities in the field in partnership with forest-dependent communities and other key stakeholders.

Mr. Wagan also heads communications management, advocacy work and training and capacity building activities for his team at the Forest Department and key community figures in the Project Zone. He has conducted coastal area conservation and development activities with all project stakeholders as well as various international organisations like IUCN-International Union for Conservation of Nature, and WWF-World Wide Fund for Nature. He has an MSC in Forestry from Pakistan as well as a Master's in Environmental Management from the Australian National University, Canberra, Australia.

Mr. Rizwan Patel; Director, Indus Delta Capital

Mr. Rizwan Patel is a highly successful and respected UK-based entrepreneur. He started his business career by setting up Letting International Ltd, a property investment company in 1992. Under his leadership the company has grown into a thriving multi-million-pound business with four key divisions. Rizwan is a serial entrepreneur who has a keen sense of social responsibility and his company helps support numerous initiatives for the benefit of local communities in the areas he operates in.

He was quick to support DBC-1 as an investor in its early stages. He is an advocate of the value of nature-based solution in the battle against climate change and has had strong input into the design of livelihood measures for the Project Zone communities. He manages key business relationships for Indus Delta Capital and is instrumental in driving private sector funding into the project.

Mr. Alamgir Khan Gandapur; Indus Delta Capital, Project Management

Mr. Gandapur is a forester with over 40 years of experience. He has been working on climate change, biodiversity conservation and community development initiatives throughout his 35-year-long career with government. During this period, Mr. Gandapur has helped shape the forestry sector in Pakistan. He now brings his specialism and expertise in large-scale project management to the Indus Delta restoration project, which he is spearheading from the company's base in Karachi. He has held multiple senior positions.

He was the focal person of Climate Change and REDD+ Issues for Government of Khyber Pakhtunkhwa from 2010 until his retirement from government service in 2013. Mr. Gandapur has a passion for sustainable development, forests and biodiversity conservation and poverty alleviation issues. He has been developing and managing projects and programmes related to these issues besides also teaching them at the graduate and post-graduate levels. He developed and oversaw the institutional reforms in the forestry sector in Khyber Pakhtunkhwa. As part of this process, he developed the Provincial Forest Policy, Provincial Forest Law/Ordinance, Forest Development Fund (FDF), Planning Reforms Proposals and proposals for the establishment of bodies for stakeholder participation in the forestry sector. He has also worked as a consultant for the REDD+ project of Government of Gilgit Baltistan, Pakistan where he drafted the Gilgit-Baltistan Forest Act 2019, Gilgit Baltistan Wildlife Act, 2020, Gilgit Baltistan Non-Timber Forest Product Rules, 2016, Gilgit Baltistan Forest Management Code, as well as the Gilgit-Baltistan Sustainable

Landscape Initiative (GB-SLI) and preparation of Forest and Landscape Management Plans for various districts in Gilgit Baltistan. He has post graduate degrees in forestry, economics, development, agriculture and environmental and resource economics. He also holds post-graduate diplomas in human resource management, international law of Human Rights and remote sensing and geographic Information systems, and Specialized Certificate in Terrestrial Carbon Accounting from University of California, San Diego, CA, USA.

Previous posts he has held include:

- Chief Conservator of Forests, Government of Khyber Pakhtunkhwa (2012 – 2013).
- Project Director Development of forestry sector resources for carbon sequestration in Khyber Pakhtunkhwa (2010 – 2011).
- Conservator of Forests, Malakand Forest Circle (2008 – 2009)
- Project Manager, Environmental Fiscal Reforms (EFR) project, IUCN-The World Conservation Union (2007). (Swiss-assisted project)
- Director Community Development, Extension and Gender Development (2006). Deputy Director Research and Development (2005)
- Team Leader Institutional Reforms Project (1998 – 2003). (Swiss and Dutch-assisted project)
- Project Director Sarhad Provincial Conservation Strategy (SPCS), IUCN-The World Conservation Union (1997). (Swiss-assisted project)
- Project Director Upland Rehabilitation project. (1996) (EU-assisted project)
- Chief Environment, Tourism, Archaeology, Sports, Culture, Museums and Libraries, Planning and Development Department, KP Government (1995).
- Chief Agriculture, Livestock, Forestry, Fisheries and Wildlife, Planning and Development Department, KP Government. (1993 – 1994).
- Divisional Forest Officer, Social Forestry (1992). (Dutch-assisted project)
- Deputy Director Planning, Forestry, Fisheries and Wildlife Department, Khyber Pakhtunkhwa (1991).
- Divisional Forest Officer Afforestation, Nurseries and Research (1979). (World Bank-assisted project)
- Team Leader of numerous Fact Finding, Project Formulation, and Monitoring and Evaluation Missions for various donors (FAO, UNDP, Dutch, Swiss).

Mr. Arif Ali Khokar; Conservator of Forests, Government of Sindh

Mr. Khokar is the expert on mangroves and coastal areas development. He has also been associated with mangroves protection, conservation and development as well as community development for more than 20 years and has used his successful experiences in the design of project interventions. He maintains close

interactions with the various project stakeholders throughout the Project Zone. He provides his technical expertise as mangrove resource, biodiversity conservation and community development expert.

Mr. Niaz Soomro; Forest Officer - Coastal Areas, Thatta and Karachi District

Mr. Niaz Soomro is the lead person in Coastal Areas in Thatta and Karachi Districts. His specialism is in community development and biodiversity conservation activities in the Project Area with all stakeholders. He provides his expertise and regular support to the project in these matters and is a direct link with community members in the Project Zone.

In addition to these managers and specialists, there is a strong team of consultants from the Pakistan Forest Institute and other development and research organisations, like the National Institute of Oceanography, to support the project team with a wealth of community development, land management, carbon project experience and GIS and remote sensing expertise.

2.4.4 Project Management Partnerships/Team Development (G4.2)

All relevant management experience is present in DBC-1, as detailed in Sections 2.4.1 and 2.4.3.

2.4.5 Financial Health of Implementing Organisation(s) (G4.3)

The project proponents are the Sindh Government and Indus Delta Capital Limited. Both these entities have at their disposal the needed financial resources for initial project implementation and carbon asset development. Indus Delta Capital Limited has invested the required funds and resources from the private sector to fulfil its contractual obligation to the project.

The Provincial Forest Department, Government of Sindh receives an annual budget support from the government for implementation of its development portfolio including this project. The proponents have created a detailed financial model for the development and financial management of DBC-1. Predicted credit sales and an accurate estimated annual budget demonstrate sufficient cash flow from predicted contracted sales to sustain the project through to the end of the crediting period. This document is available to the VVB.

2.4.6 Avoidance of Corruption and Other Unethical Behaviour (G4.3)

The project has developed and is implementing an Anti-corruption Policy and SOPs which provide assurance that the project proponent and any other entities involved in the project design and implementation are not involved in, or complicit in, any form of corruption such as bribery, embezzlement, fraud, favouritism, cronyism, nepotism, extortion, and collusion.

This policy and SOPs is being implemented through relevant organs in the company and is being monitored at the highest level by the CEO.

Thus, necessary steps have been taken to avoid corruption and other unethical behaviour. These steps among others include the establishment of a UK private limited liability company, the opening and management of a joint bank account for project funds management, development of transparent financial transactions mechanisms, instituting internal and external monitoring of physical and financial aspects of the project, rigorous funds auditing arrangements and promotion of a culture of transparency and ethical

behaviour. These internal and external control mechanisms and their relevant documents will be shared with the VVB.

2.4.7 Commercially Sensitive Information (Rules 3.5.13 – 3.5.14)

There is some project information which is required by the VCS and/or CCB standards but is of confidential or sensitive in nature and therefore cannot be released publicly by the Government of Sindh.

Commercially sensitive information that the Government of Sindh is required by law to keep confidential (section 10. (1) of Sindh Act No.XV of 2017 relating to Right to Information) has been excluded from the public version of the PD. It will be shared with VVB on need basis. This information as per requirements of VCS and/or CCB will be supplied freely to the VVB as appendices to this PD. Some of this information, however, will not be included in the public version.

All information related to the determination of the baseline scenario, demonstration of additionality, and estimation and monitoring of GHG emission reductions and removals (including operational and capital expenditures) are not considered to be commercially sensitive and therefore have been provided in the public versions of the project documents.

2.5 Legal Status and Property Rights

2.5.1 Statutory and Customary Property Rights (G5.1)

Land use: Land use within the Project Area is described in Section 2.1.5.

Statutory and Customary Rights

Statutory and Customary Rights in the Project Zone are covered by the Constitution of Pakistan and applicable Land Laws and Forest Law. The Constitution of Pakistan allows private ownership of land and other property. Articles 23, 24, 25, 172 and 173 of the constitution deal with private property rights. These are described below.

Article 23 declares that: Every citizen shall have the right to acquire, hold and dispose of property in any part of Pakistan, subject to the Constitution and any reasonable restrictions imposed by law in the public interest.

Article 24 makes the following provision with respect to the acquisition of the private property: 'No property shall be compulsorily acquired or taken possession of save for a public purpose and save by the authority of law which provides for compensation therefore and either fixes the amount of compensation or specifies the principles on and the manner in which compensation is to be determined and given'.

Article 25 of Constitution: Ensures the equality of citizens in terms of property rights, both male and female, but the state can take affirmative action for women.

Article 172 states that: ‘Any property, which has no rightful owner shall, if located in a province, vest in the government of that province and in every other case, in the Federal Government’.

Article 173, the Federal Government and the Provincial Governments can grant, sell, dispose or mortgage any property that vests in them. These governments can purchase or acquire property. All properties acquired for the purposes of the federation or of a province shall vest in the Federal Government or the

concerned Provincial Government. Women are entitled to the fundamental right to own, hold and transfer property under the laws of Pakistan.

Provisions of Laws regarding Land Ownership

Land ownership or proprietorship in Pakistan (including Azad Jammu and Kashmir and Gilgit-Baltistan) falls into one of the three following categories (Soofi, 2017)[32].

1) State owned land, 2) Privately owned land, 3) Village common land

1) State Owned Land: Lands owned by government are called State owned or "Crown" land (Sarkaari zameen). It means that their ownership or legal entitlement vests in the government. Government means the federal or provincial or local government. Depending on how the State land is used or managed, State land may fall into one of the following categories (UNHABITAT, 2011)[33]:

- State land assigned to individuals for various uses including cultivation, storage etc. on a temporary basis. This type of land can normally be resumed by the state.
- State land granted to individuals under various schemes like cattle breeding, horse studs etc. In this category, the ownership belongs to the state and it is possessed by the citizens on a temporary basis against a nominal annual rent to be paid by user to the state.
- State Land is cultivated directly under the State. Under this arrangement, the land is cultivated by tenants and agreed rent is paid either in cash or in kind to the state.
- State land that is temporarily allotted on some payment schedule to the citizens under various colony schemes so that the citizens could make these lands cultivatable. After these are made usable or cultivatable, then the ownership may be transferred in the name of that citizen.
- State lands that are under the control of some government department, such as Forest Department, Board of Revenue, etc. Lands under the Forest Department are further classified as Reserve Forests, Protected Forests and Unclassed Forests.
- State lands that are barren and are not under cultivation or cannot be made cultivatable due to its inhospitable terrain or unsuitable soil. These lands at times are also called Wastelands.

2) Privately Owned Land: Privately owned lands are the exclusive property of the private individual or entity. Private owners have full rights to use, manage, sell, gift, exchange or dispose of their private land in any manner they wish subject to some legal limitations. For instance, the law of pre-emption imposes certain restrictions on the sale of rural land to people who are residents of other areas. The Constitution and laws give equal rights of ownership, tenancy, and sale and purchase of land to women. Private owned land is subject to automatic inheritance under the Muslim personal law and the property rights devolve after

[32] Soofi, A.B. 2017. Report on the legal, Institutional and policy framework for REDD+ In Pakistan.

[33] UN-Habitat, "A Guide on Land and Property Rights in Pakistan," (Islamabad, Pakistan, December 2011).

the death of a legal owner on his/her legal heirs as per pre-determined shares under the implementation of a will, if any. The right to give away land under a will is also restricted under the Muslim personal law.

3) Village Common Land: Village Common Land or Community Land is commonly called 'Shamilat' or 'Shamilat Deh'. It is jointly owned and possessed by the landowners of that village and is meant to be used for common purposes and uses of the village community. These common uses, among others, include grazing grounds, firewood collection, graveyards, community buildings, mosques, schools, dispensaries, playgrounds, village ponds, village roads, passages for the movement of cattle, etc. (UN-HABITAT, 2012). Shamilat land is usually a grant given by the State, out of State land, to the owners of the village to be used for their common purposes and is usually granted at the time of settlement.

All persons recorded as owners of land in a village are also joint owners of Shamilat of the village, their shares being proportionate to the size of their holding. When they sell their land, the share of Shamilat also goes to the new buyer of the land accordingly. Landowners cannot sell their share of Shamilat without selling a part or the whole of their landholding. Similarly, co-owners of land cannot move to encroach upon more Shamilat land than is already allotted to them and encroachers can be ejected by moving an application before the revenue authorities. There is another category of Shamilat in certain areas in Pakistan where no settlement has taken place. Under this category, large tracts of lands are jointly owned by many people and their shares are expressed in terms of fractions of the total area in one Khasra Number, a particular number allotted to that piece of land by the revenue authorities.

Laws Regulating Property Rights Laws Regulating Property Rights

There are numerous laws that regulate the ownership, transfer, acquisition, taxation, registration, tenancy etc. of immovable property. Following legislations are the important ones (Soofi, 2017):

- The Transfer of Property Act, 1882
- The Government Tenants Act, 1893
- The Land Acquisition Act, 1894
- The Registration Act, 1908
- The Sindh Tenancy Act, 1950
- The Land Record Manual
- The Land Administration Manual
- The Settlement Manual

Legal Categories of Forest Lands

There are three legal categories of state-owned forest lands: Reserve Forests, Protected Forest, and Unclassed. Mangrove forest in the Project Area have been declared as Protected Forests and their ownership vests in the state. Private individuals have no legal rights to mangroves or any of their produce unless specifically permitted by the government. There are also no customary laws prevailing in the Project Area that in any way hinder the implementation of project activities.

Based on the above analysis of statutory and customary rights prevailing in the Project Area, there are no legal lacuna to the implementation of project activities.

2.5.2 Recognition of Property Rights (G5.1)

Land in the Project Area is surveyed, demarcated and has been titled and all property and property rights clearly recognised and delineated. The Forest Department and the project worked with communities to clarify the Project Area boundaries and rights of various stakeholders to land, territories and resources. The rights of the stakeholders are defined and properly documented and based on these recognised and enforceable under the law. The project has established its area boundaries both digitally and physically on the ground. Its ownership of and rights to the resources found therein are clearly recognised and so are the recognition of the rights of local people.

2.5.3 Free, Prior and Informed Consent (G5.2)

The project does not encroach uninvited on private property, community property or government property. Tenure of the Project Area is outlined in Section 2.5.9. Furthermore, Section 2.3.7 outlines the comprehensive procedure of FPIC activities which ensures that all stakeholders and communities are consulted.

2.5.4 Property Rights Protection (G5.3)

The project maps and boundary demarcation also allow the Project Area communities to understand their spatial positions in relation to the Project Area, and to be able to plan their future land use within their village boundaries without disputing other village territories. The project does not require involuntary removal or relocation of communities or any activities important for their livelihood and culture.

2.5.5 Illegal Activity Identification (G5.4)

All the mangrove forests in the Project Area are Protected Forests under section 29 of the Forest Act 1927 and the trees found in these forests as reserved under section 30 of the same Act. As per section 33 of the Forest Act, a person is not allowed to do the following acts in Protected Forests:

(a) fell, girdle, lop, taps or burn a tree reserved under section 30, or strips off the bark or leaves from, or otherwise damages, the tree

(b) contrary to any prohibition under section 30, quarries any stone, or burns any lime or charcoal, or collects, subjects to any manufacturing process, or removes any forest produce

(c) contrary to any prohibition under section 30, breaks up or clears for cultivation or any other purpose any land of the forest

(d) sets or kindles fire without taking reasonable precautions to prevent its spreading to any tree reserved under section 30, whether standing, fallen or felled, or to any closed portion of the forest

(e) leaves any fire burning in the vicinity of any reserved tree or closed portion of the forest

(f) fells any tree or drags any timber and damages any reserved tree

(g) permits livestock to damage any reserved tree

(h) infringes any rule made under section 32

A person doing any of the above activities which have been declared illegal as per law, is punishable in accordance with the provisions of section 33 of the Forest Act.

Thus, under the provision of the Forest law, the Project Area mangroves forests and plantation should be protected from resource extraction or conversion to other land uses. These activities, however, do occasionally occur within these Protected Forests.

To curb these illegal activities and to control deforestation and forest degradation in the area, DBC-1 activities include stricter law enforcement through greater surveillance and vigilance and more effective patrolling by Forest Department staff. It has also entered into Mangrove Stewardship Agreements and strengthened community organisations. These measures will lead to increased protection in the Project Area and enforcement of the boundary against illegal incursions. The strengthening of these community organisations will give empower local communities and give them the ability to protect mangrove forests and newly planted areas. Accordingly, effective law enforcement and income diversification will shift the local economy over time toward legal and sustainable coastal and land resources use.

2.5.6 Ongoing Disputes (G5.5)

The Project Area is free of land grabbing, territorial displacement, or deprivation from access to resources. There have been only a few minor disputes amongst the communities of various villages or within communities of a village over land, territory or resources in the Project Zone during the last 20 years. Most of their disputes have been pertaining to migrant herders bringing camels for grazing into the delta area during the flood season.

All such disputes are resolved through local mediation measures by the communities themselves and there is no resort to government or other official channels for dispute resolution. Also, the likelihood of disputes on land, territories and resources to occur in the future is low. Therefore, there is no potential for the project to prejudice any decision or outcome of a dispute through its activities. Using a precautionary approach, the project has a protocol for disputes resolution at the community level.

2.5.7 National and Local Laws (G5.6)

The project is designed and implemented in full compliance with the national laws and policies of Government of Pakistan and provincial laws and policies of the Sindh Province. This includes laws, rules, regulations and policies governing aspects of forest conservation and management related initiatives of the national and provincial level governments. Relevant policies, laws and regulations on land use, forestry and climate include:

- Pakistan National Forest Policy 2017
- Sindh Provincial Forest Policy 2019 (draft)
- Pakistan Environment Policy 2005
- Sindh Provincial Environment Policy 2018 (draft)
- Pakistan National Climate Change Policy 2012
- Framework for Implementation of Climate Change Policy 2014

- Pakistan Forest Act 1927 in its application to Sindh Province
- Sindh Grazing Rules 1936
- Sindh Provincial Forest Act, 2019 (draft)
- Sindh Wildlife Act, 2014
- Sindh Environmental Protection Act 2014
- Pakistan Climate Change Act 2017

2.5.8 Approvals (G5.7)

The Sindh Forest and Wildlife Department, Government of Sindh along with Indus Delta Capital Limited are the project proponents. The Project Area is comprised completely of Protected Forests the ownership of which vests in the state. The Government of Sindh through an agreement has given its approval for implementation of this project. As per agreement between Government of Sindh Forest Department and Indus Delta Capital Limited, the proponents have obtained the FPIC of the local communities. Therefore, approvals for the project both at the state level as well as community level are present.

2.5.9 Project Ownership (G5.8)

The Project Area is legally state-owned property and has been declared as Protected Forests under section 29 of the Pakistan Forest Act 1927. Trees in these Protected Forests have been declared as Reserve Trees under section 30 of the same Act. The ownership of mangroves and all other forest produce thus vest in the state through the Sindh Forest Department. It being the owner of mangroves and its various forest products, has all the rights (the right to own, sell, use, manage, etc.) associated with the ownership of mangroves. Using these ownership rights, The Sindh Forest Department has entered into agreement with the Indus Delta Capital Limited.

An enforceable and irrevocable agreement was signed in 2015 between Indus Delta Capital and the Government of Sindh in its capacity as holder of the statutory, property right in the land, vegetation and conservational and management process that generates GHG emission reductions or removals which vests project ownership in the project proponent. The agreement and complete due diligence of the contract and relevant laws – prepared by the proponent's lawyers Baker McKenzie, London – can be provided to the VVB for the validation/verification process.

2.5.10 Management of Double Counting Risk (G5.9)

DBC-1 will be validated under the Verified Carbon Standard (VCS) and the Climate, Community, and Biodiversity (CCB) standards (Third Edition, Gold Level). The project has not sought nor will seek to generate any other form of environmental or social credit.

2.5.11 Emissions Trading Programs and Other Binding Limits

The project is being developed under the VCS and CCB Standards and is not subject to any additional emission trading programs or other binding limits. Currently, there are no jurisdictional or sub-jurisdictional GHG emission reduction programmes in Pakistan or Sindh Province.

2.5.12 Other Forms of Environmental Credit

Besides VCS validation, DBC-1 will also be validated under the Climate, Community, and Biodiversity (CCB) standards (Third Edition, Gold Level). The project has neither sought nor received any other form of GHG-related environmental credit.

2.5.13 Participation under Other GHG Programs

DBC-1 has not participated under other GHG Programs. This is the first and only application for DBC-1 to a GHG credit program. No lands of DBC-1 are included in any other GHG program.

2.5.14 Projects Rejected by Other GHG Programs

DBC-1 has neither applied for nor has been rejected by any other GHG programme.

2.5.15 Double Counting (G5.9)

DBC-1 is not subject to any additional emission trading programs or other binding limits of either Government of Pakistan or Government of Sindh. The project is being developed under the VCS and CCB standards. The credits generated from the project will be sold as offsets on the VCS registry, the serial number of the issued credits can be tracked to avoid any potential double counting.

3 CLIMATE

3.1 Application of Methodology

3.1.1 Title and Reference of Methodology

VCS methodologies and modules

Available at: https://verra.org/methodologies/

- VM0033 Methodology for Tidal Wetland and Seagrass Restoration v2.0~~1.1~~
- VCS module VMD0019 Methods to Project Future Conditions
- VCS module VMD0052 Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities

CDM methodologies and tools

Available at: https://cdm.unfccc.int/methodologies/ARmethodologies/approved and https://cdm.unfccc.int/methodologies/ARmethodologies/tools/

- CDM AR Tool for testing significance of GHG emissions in A/R CDM project activities v1
- CDM AR Tool 2 Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities v1
- CDM AR Tool 3 Calculation of the number of sample plots for measurements within A/R CDM project activities v2.1
- CDM AR Tool 5 Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities v1
- CDM AR Tool 14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities v4.2

3.1.2 Applicability of Methodology

VM0033 applies to tidal wetland restoration project activities. The project is located in the Indus Delta, as indicated in Figure 3. The project boundary includes deforested mangrove habitats, as well as future wetlands as a result of sea level rise.

The project meets the applicability conditions of this methodology and modules and tools it references, as justified in Table 11.

The following have no internal applicability conditions:

- VMD0019 Methods to Project Future Conditions
- CDM AR Tool 3 Calculation of the number of sample plots for measurements within A/R CDM project activities v2.1
- CDM AR Tool 5 Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project

activities v1

- CDM AR Tool 14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities v4.2

Table 11. Analysis op applicability conditions of applied methodologies and tools.

A. VM0033 Methodology for Tidal Wetland and Seagrass Restoration v1.1

Applicability condition		Justification
This methodology is applicable under the following conditions		
1) Project activities which restore tidal wetlands (including seagrass meadows, per this methodology's definition of tidal wetland) are eligible	Yes	The project is a reforestation project of mangrove trees. Mangroves live in the intertidal zone.
2) Project activities may include any of the following, or combinations of the following: a) Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands) b) Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas) c) Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas) d) Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange, or reducing nutrient residence time)	-	Not relevant
e) (Re-)introducing native plant communities (e.g., reseeding or replanting)	Yes	The project meets the description of e) (Re-) introducing native plant communities, because the project is a reforestation project of mangrove trees. The project also meets the description of f)

f) Improving management practice(s) (e.g., removing invasive species, reduced grazing)		Improving management practices, by introducing Mangrove Stewardship Agreements, which, amongst other things, removes grazing from the Project Area.
3) Prior to the project start date, the project area: a) Is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant: The project area has been abandoned for two or more years prior to the project start date	Yes	The Project Area comprises of de-vegetated and degraded mangrove areas that have remained abandoned for two or more years prior to the project start date in 2015. Neither their extent has changed in the past two or more years as there has been no conversion of these de-vegetated areas to another land use/land cover class such as mangrove forest through ARR, agriculture, settlements/infrastructure, etc.
Use of the project area for commercial purposes (i.e., trade) is not profitable as a result of salinity intrusion, market forces or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur	Yes	Being highly saline and therefore having no potential for any productive agricultural activity, being devoid of any marketable timber or other coastal resource that can be commercially harvested or marketed, and over-all land capability classification, use of the project area for commercial purposes is not profitable. It is far more profitable to undertake productive activities on adjoining agricultural lands than on these de-vegetated and abandoned mangrove areas. The area is also inaccessible for any cheap and commercial level transportation of inputs and goods to the area or out of the area due to its to non-accessibility via road or boat transport. This further reduces its suitability for any commercial activity.
Degradation of additional wetlands for new agricultural sites within the country will not occur or is prohibited by enforced law	-	Project meets conditions 3a1 and 3a2
OR b) Is under a land use that could be displaced outside the project area), although in such case baseline emissions from this land use must not be accounted for, and where degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law	-	Project meets condition 3a

OR c) Is under a land use that will continue at a similar level of service or production during the project crediting period (e.g., reed or hay harvesting, collection of fuelwood, subsistence harvesting)	-	Project meets condition 3a
4) Live tree vegetation may be present in the project area, and may be subject to carbon stock changes (e.g., due to harvesting) in both the baseline and project scenarios	-	No justification required
5) The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur	-	Not relevant, because prescribed burning is not a project activity
6) Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management		Not relevant, because organic soils are absent within the project boundary. See Section 3.2.1.1
7) Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic (e.g., drainage of the peat, arson)		Not relevant, because organic soils are absent within the project boundary. See Section 3.2.1.1
8) In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting		Not relevant, because organic soils are absent within the project boundary. See Section 3.2.1.1
This methodology is not applicable under the following conditions		
1) Project activities qualify as IFM or REDD	No	This is an ARR WRC project activity
2) Baseline activities include commercial forestry	No	Baseline activities do not include commercial forestry and are limited to:

		- Pockets of unregulated free-range grazing of camels, buffaloes and other livestock - Mangrove fuelwood collection - Inadequate or no investment in the restoration of degraded mangrove areas
3) Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters	No	Project activities do not lower the water table and are limited to: - Collection of propagules - Planting of mangrove saplings - Activities with communities such as: - Protection of planted areas through control and regulation of camels and other livestock grazing - Increasing access to safe and affordable drinking water - Enhancing children's access to education - Improving access to health facilities - Developing civic facilities - Raising awareness of communities and other stakeholders - Implementing training and capacity building activities for communities and other relevant stakeholders
Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area	No	The project does not cause any alteration of the hydrology. See Section 3.2.3.2 for further elaboration.
Project activities include the burning of organic soil	No	This is not a project activity. Organic soils are absent within the project boundary (see Section 3.2.1.1).
Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period	No	The application of nitrogen fertiliser is not a project activity

B. VMD0052 Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities

Applicability condition		Justification
This module is applicable to tidal wetland restoration and conservation project activities as defined below		
Tidal Wetland Conservation	-	Not relevant as this is a tidal wetland restoration

Activities that reduce GHG emissions by avoiding degradation and/or the conversion of tidal wetlands that are intact or partially altered while still maintaining their natural functions, including hydrological conditions, sediment supply, salinity characteristics, water quality and/or native plant communities.		project activity.
Tidal Wetland Restoration Reestablishing or improving the hydrology, salinity, water quality, sediment supply and/or vegetation in degraded or converted tidal wetlands. For the purpose of this methodology, this definition also includes activities that create wetland ecological conditions on uplands under the influence of sea level rise or activities that convert one wetland type to another or activities that convert open water to wetland. Project activities restoring tidal wetlands may include any of the following, or combinations of the following: • Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands) • Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas) • Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted	Yes	The project is a reforestation project of mangrove trees. Mangroves live in the intertidal zone.

areas) • Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time) • (Re-)introducing native plant communities (e.g., reseeding or replanting) • Improving management practice(s) (e.g., removing invasive species, reduced grazing) • In RWE-ARR project activities, the prescribed burning of herbaceous and shrub aboveground biomass (cover burns) may occur		

C. CDM AR Tool 2 Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities v1

Applicability condition		Justification
The tool is applicable under the following conditions		
Forestation of the land[1] within the proposed project boundary performed with or without being registered as the A/R CDM project activity shall not lead to violation of any applicable law even if the law is not enforced.	Yes	The project does not lead to violation of any applicable law even if the law is not enforced. The condition is met as there is no violation of the applicable law. The applicable laws are the Pakistan Forest Act 1927 and Sindh Grazing Rules 1936. The provisions of both these applicable laws are being adhered to. See Section 3.1.4.
This tool is not applicable to small - scale afforestation and reforestation project activities.	Yes	This is a large-scale project activity.

Note: Since projects using this methodology are eligible to apply the activity method for demonstrating additionality, all elements of the tool related to additionality must be disregarded.

D. CDM AR Tool 4 Tool for testing significance of GHG emissions in A/R CDM project activities v1

Applicability condition		Justification
The tool shall be used in the application of an A/R CDM approved methodology to an A/R CDM project activity:	Yes	The VCS allows this tools to be used across all its approved methodologies.

a) To determine which decreases in carbon pools, and increases in emissions of the greenhouse gases measured in CO_2 equivalents that result from the implementation of the A/R project activity, are insignificant and can be neglected.		
b) To ensure that it is valid to neglect decreases in carbon pools and increases in GHG emissions by sources stated as being insignificant in the applicability conditions of an A/R CDM methodology.	Yes	The tool is used to assess the significance of the emissions of fossil fuel use.

3.1.3 Project Boundary

3.1.3.1 Temporal boundaries

A possible temporal boundary is the soil organic carbon depletion time (SDT) in the baseline scenario, which limits the period during which the project is eligible to claim emission reductions from restoration. Projects that do not quantify reductions of baseline emissions (i.e., those which limit their accounting to GHG removals in biomass and/or soil) need not estimate SDT.

This ARR/RWE project does not claim avoided emissions (stop loss) from the soil, as a result of the restoration activities.

3.1.3.2 Geographic boundaries

3.1.3.2.1 ARR/RWE project boundary

The whole of the Project Area is denominated as “Protected Forests”, which are state property. Therefore, the Government of Sindh is the land rights holder and user rights holder. Government notifications declaring the area as Protected Forests have been made available for review by the VVB.

As outlined in Section 2.1.1, the project was conceived as a REDD+ project activity including both AUDD/CIW and ARR/RWE on tidal wetlands. This CCB&VCS Project Description proposes the ARR/RWE project activity for validation separately. The outer boundary in the map in Figure 4 (which shows the planting polygons for each planting year) delineates the Project Zone, which is similar to this REDD+ area. The ARR/RWE Project Area *sensu stricto* is delineated by the various planting cohorts (totalling 224,997 ha, see Table 16 in Section 3.2.2.1), and the areas that are expected to be gained due to sea level rise (new mangrove habitats), see Figure 20 and the explanation in Section 3.1.3.2.2.

3.1.3.2.2 Project boundary and sea level rise

IPCC most-likely local sea level rise scenario

The sea level rise scenario used for the analyses is the IPCC's RCP8.5, which assumes a rise of 0.52 to 0.98 m by 2100. A conservative approach of using a 1 m rise in century sea level rise was taken, although the local tectonic activity suggests that the rate of sea level rise around Karachi is slightly less than the global average (Khan and Rabbani, 2000)[34].

Loss of tidal wetlands due to sea level rise

Since the cumulative damming efforts from the 1950s through to the 1970s, the Indus Delta has shifted from a mostly pro-gradational environment to one of erosion. Erosion is defined as the loss of tidal wetland sediments due to wind/wave activity that is occurring before submergence. The current erosion rate is variable depending on location and the timeframe examined. Kanwal et al. (2020)[35] calculated that the average erosion rate between 1989 and 2018 was 12.5 and 19.96 m yr^{-1} west and east of the Indus River, respectively, and that the maximum erosion rate ranged from 52 to 72 m yr^{-1}. Other estimates of erosion range from an average of 34.3 m yr^{-1} between 1990 and 2017 (Siyal, 2018)[36] to erosional hotspots with 31 to 176 m yr^{-1} loss rates (Chaudhry, no date)[37]. An average rate of 19.96 m yr^{-1} from Kanwal et al. (2020) was used and applied to areas of the Delta bordering the Arabian Sea. This rate was chosen based on the rigor of the analysis and the rate from the eastern bank was applied to the western bank of the Indus River to be conservative. This rate assumes conservatively that no changes in outflow from the Indus River occurs during the project period, specifically greater flow of freshwater and sediment supply resembling pre-damming conditions. The likelihood of this occurring is very minimal and would require either many consecutive dam failures or a multinational plan to increase river input to the Indus Delta throughout the year.

In collaboration with NASA, a 2019 Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) was acquired and transformed using the Earth Gravitational Model (EGM) ellipsoid model so that elevations were relative to sea level. The units are in metres and at the integer (whole number) level. To assess the accuracy of the DEM, a local survey team collected elevation data across a range of current

[34] Khan, T. M. A. and M. M. Rabbani. 2000. Sea level monitoring and study of sea level variations along Pakistan coast: a component of integrated coastal zone management. National Institute of Oceanography, Karachi, Pakistan.

[35] Kanwal, S., X. Ding, M. Sajjad and S. Abbas. 2020. Three Decades of Coastal Changes in Sindh, Pakistan (1989–2018): A Geospatial Assessment. *Remote Sensing* 12(1):8.

[36] Siyal, A.A. 2018. Climate change: Assessing impact of seawater intrusion on soil, water and environment on Indus delta using GIS & remote sensing tools. US. Pakistan. Center for Advanced Studies in Water (USPCAS-W), MUET, Jamshoro, Pakistan

[37] Chaudhry, Q., no date. Pakistan Coastal Erosion Management Plan. IUCN Pakistan.

and future restoration sites in the western portion of the Indus Delta using a real time kinetic (RTK) GPS unit with a vertical accuracy of 2-3 cm[38]. A total of 430 elevation points was taken across 20 sites. The elevation ranges were consistent with the DEM, meaning that the surveyed elevation was within 1 m of the DEM[39], and no transformation was needed. Using this DEM, it was confirmed that the elevations along the coastal margins of the Indus Delta are uniform and the DEM was not used further in this particular analysis.

To assess the combined effects of sea level rise and erosion, a simple mathematical calculation tool was used (Appendix 6. Coastal Wetland Soil Carbon Stock Accounting Tool). The tool was parameterised using project-specific values, the RCP8.5 century sea level rise of 1 m and an erosion rate of 19.96 m yr^{-1} (Appendix 7. Application of the Coastal Wetland SOC Accounting Tool in the Indus Delta). The model was applied to the Project Area closest to the shoreline (approximately 2.1 km inland from the current shoreline). The calculation tool did not lend evidence to the drowning of the interior areas of the Indus Delta due to sea level rise. Therefore, only the coastal erosion scenario was applied. The amount of lateral retreat in metres that occurred in this scenario was recorded in five-year increments.

Using GIS, spatial buffers[40] were created to represent the tidal wetland loss using the lateral retreat values for each five-year increment, and it is assumed that the erosion was occurring from the coastline inland. The amount of area within each plantation that is predicted to be lost along the coastline was calculated for each time increment, accounting for the year that the planting occurred.

Conversion of terrestrial upland sites to tidal wetlands due to sea level rise

The terrestrial upland edge across the Indus Delta is expansive and relatively uniform, with a minor gradual slope. Therefore, the creation of newly inundated lands due to sea level rise is anticipated to be expansive. Based on the DEM, it is assumed that a 1 m increase in elevation occurs over a 1,000 m distance (this is not a rounded value but an estimate from the DEM).

Using the DEM and recent satellite imagery, the current project boundary was adjusted assuming that up to 1,000 m of adjacent terrestrial upland sites will be inundated after 100 years. Due to the coarseness of the DEM, this could not be done using GIS processing alone. The imagery was used to inform major boundaries such as roads, large man-made canals carrying fresh water, and villages. The DEM was used to inform where significant increases in elevation occur (hillsides). Not all of the potential adjacent terrestrial upland areas that are likely to be flooded were included within the project boundary.

[38] There are no survey-grade benchmarks within the vicinity of the Project Area. Therefore, the RTK base station was set up in the same location every day and the same reference point was surveyed to monitor vertical accuracy. All sites surveyed were within the communication range for the base station (approximately 60 km).

[39] The elevations presented in the DEM are integer based, meaning that the values are whole numbers. The RTK elevation survey provides sub-metre elevations with 2-3 cm accuracy. If the survey elevation data could either be rounded up or down to the nearest whole integer and that matched the DEM, they were deemed in alignment with each other.

[40] A spatial buffer is a classification of area within a given proximity, measuring a distance from an object in GIS, whether a point, line, or area.

Figure 20 delineates the areas within the Project Area that – by year 2114 – are expected to be eroded, that remain intertidal, i.e., are persistent, and that have become intertidal and thus form new mangrove habitats. (Five-yearly incremental maps are available as GIS data.)

PROJECTION OF ERODED, PERSISTENT AND NEW TIDAL WETLAND AREA IN YEAR 2114

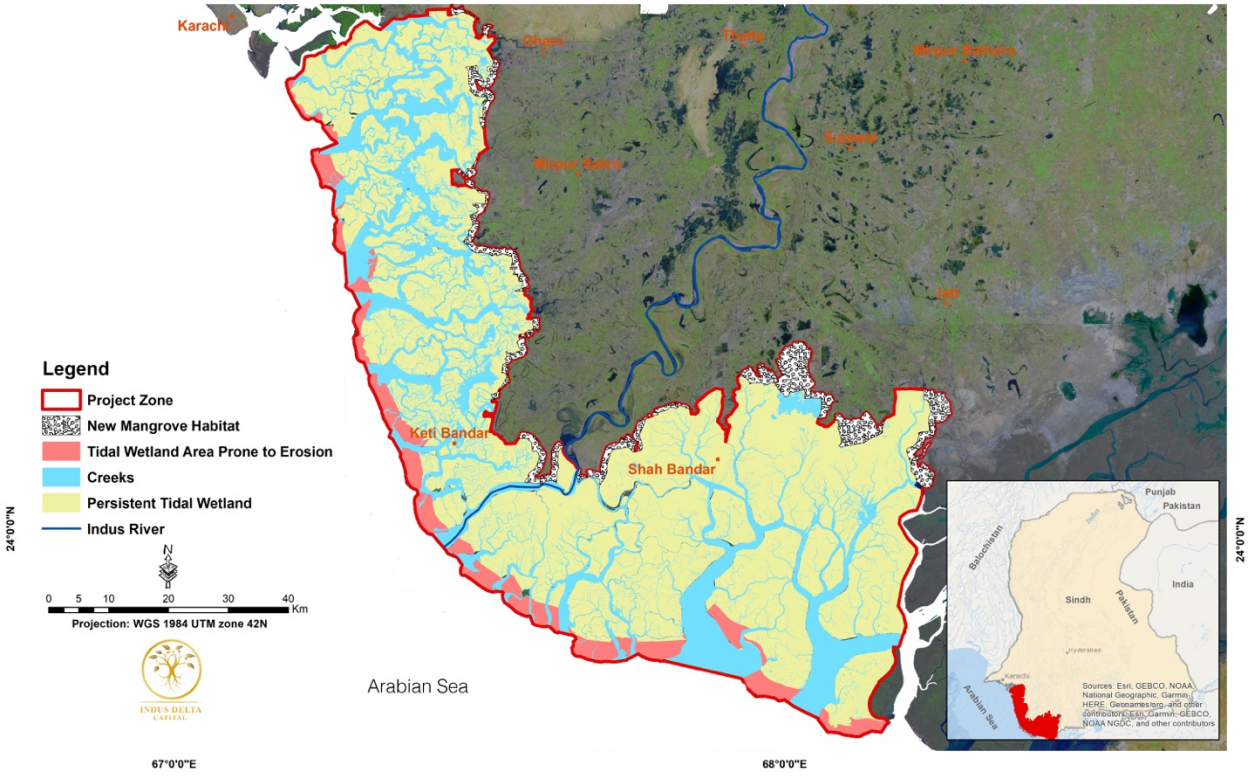


Figure 20. Projection of eroded, persistent and new tidal wetland area over 100 years of expected sea level rise.

3.1.3.2.3 Ineligible wetland areas

For projects quantifying CO_2 emission reductions, areas which do not achieve a significant difference (≥ 5%) in cumulative carbon loss over a period of 100 years beyond the project start date are not eligible for crediting based on the reduction of baseline emissions, and these areas must be mapped.

The ARR/RWE project does not claim avoided emissions (stop loss) from the soil as a result of the restoration activities. Therefore, the difference in SOC stocks between the baseline and project scenarios at the 100-year time mark does not need to be assessed.

3.1.3.3 Carbon Pools

Table 12. Carbon pools included in or excluded from the ARR/RWE project boundary.

Carbon Pool	Included?	Justification/Explanation

Above-ground tree biomass	Yes	Above-ground tree biomass in the baseline scenario is included Above-ground tree biomass in the project scenario is included
Above-ground non-tree biomass	No	*Oryza coarctata* grass may be present seasonally in both the baseline and the project scenarios but carbon stocks are very low
Below-ground biomass	Yes	Below-ground biomass in the baseline scenario is included Below-ground biomass in the project scenario is included
Litter	No	This pool is optional for WRC methodologies
Dead wood	No	This pool is optional for WRC methodologies
Soil	Yes	Soil organic carbon in the baseline scenario is included Soil organic carbon in the project scenario is included
Wood products	No	Not relevant for the baseline scenario Conservatively not accounted for in the project scenario

3.1.3.4 Sources of Greenhouse Gasses

Table 13. GHG sources included in or excluded from the ARR/RWE project boundary

Source		Gas	Included?	Justification/Explanation
Baseline	The production of methane by microbes	CH_4	No	No changes in salinity or CH_4 emissions as a result of the project. Baseline and project emissions, if any, will cancel each other out.
	Denitrification/nitrification	N_2O	No	This is the same as for CH_4. Furthermore, no changes in agricultural land use because of the project. Due to salinisation of the land surrounding the Indus Delta, agricultural production is decreasing in the area and subsequently less fertiliser is being used.
	Burning of biomass and organic soil	CO_2	No	Conservatively excluded, if occurring at all in the baseline scenario
		CH_4	No	Ditto
		N_2O	No	Ditto
	Fossil fuel use	CO_2	No	Conservatively excluded
		CH_4	No	Ditto
		N_2O	No	Ditto

Source		Gas	Included?	Justification/Explanation
Project	The production of methane by microbes	CH_4	No	See baseline
	Denitrification/nitrification	N_2O	Yes	See baseline
	Burning of biomass	CO_2	No	Not a project activity
		CH_4	No	Ditto
		N_2O	No	Ditto
	Fossil fuel use	CO_2	No	In AR-ACM003, GHG emissions resulting from combustion of fossil fuel and transportation attributable to the project activity are considered. Moreover, project activities include planting of trees and do not include the movement of soil. This PD provides an estimate of GHG emissions due to fossil fuel use and justifies that these emissions are *de minimis*.
		CH_4	No	Ditto
		N_2O	No	Ditto

3.1.4 Baseline Scenario

The baseline scenario has been determined using the latest version of CDM AR tool 2 (Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities).

Applicability

The project does not lead to violation of any applicable law even if the law is not enforced. The condition is met as there is no violation of the applicable law. The applicable laws are the Pakistan Forest Act 1927 and Sindh Grazing Rules 1936. The provisions of both these applicable laws are being adhered to.

STEP 0. Preliminary screening based on the starting date of the ARR/RWE activity

The project passes this screening as the project start date is after 31 December 1999.

See Section 2.1.14 for more information.

STEP 1. Identification of alternative land use scenarios to the proposed project activity

Sub-step 1a. Identification of alternative land use scenarios to the proposed project activity

The following possible alternatives to the project activity have been evaluated:

- Continuation of the pre-project land use (as described below)
- Natural mangrove regeneration of the land within the project boundary

- Mangrove reforestation of the land within the project boundary performed without being registered as a project activity intended for the carbon market

Sub-step 1b. Consistency of credible alternative land use scenarios with enforced mandatory applicable laws and regulations

To demonstrate that identified alternatives to the project activity are in compliance with all the applicable legal and regulatory requirements, the applicable laws and regulations that are implemented are listed below.

- The Pakistan Forest Act, 1927, in its application to Sindh Province
- Sindh Grazing Rules, 1936

The above regulatory framework was taken into consideration while evaluating the alternatives to the project activity and the following alternatives listed are in compliance with the applicable laws and regulations.

STEP 2. Barrier analysis Sub-step 2a. Identification of barriers that would prevent the implementation of at least one alternative land use scenarios

The table below displays the barrier analysis matrix, which identifies alternatives and barriers. A more complete discussion of the barriers follows.

Table 14. Barrier analysis matrix.

Alternative land use scenarios / Barriers	Investment	Institutional	Technological	Ecological	Social	Land tenure
1. Continuation of pre project land use						
2. Natural mangrove regeneration of land within the project boundaries				X		
3. Mangrove reforestation within the project boundaries without being registered as a VCS project	X	X	X		X	

Based on this barrier analysis matrix, scenario 2 (natural mangrove regeneration) faces ecological barriers, while scenario 3 (mangrove reforestation without being registered as a VCS) is constrained by investment, institutional, technological and social barriers as explained below.

Investment Barriers: There is neither grant funding nor credit or credit funding available to Sindh Forest Department from any funding agency to invest in the restoration of the degraded mangrove lands. Sindh Forest Department receives grant funding from the Government of Sindh for implementation of its various development projects through the mechanism of Annual Development Programme (ADP). In the past many years, it has received very little funds to invest in the restoration of these degraded lands. To show that this is the case, copies of ADP are made available to the VVB. Also, local communities are poor and have no

financial means of their own or access to any credit funding or any motivation (these being state owned lands) to invest.

Institutional Barriers: Sindh Forest Department due to lack of funds is not able to effectively enforce its law in the Project Area which has led to degradation of mangrove forests in the area. Similarly, there is no formal provision in the applicable law asking for or mandating the restoration of these degraded lands nor any Sindh Government Provincial Forest Policy having provisions in this regard. Pakistan Forest Act, 1927 Chapter related to Protected Forests has been made available to the VVB.

Technological Barriers: Without project funding, Sindh Forest Department as well as local communities do not have access to enough planting material, equipment, infrastructure and other technological requirements for large-scale restoration of mangroves. Neither Forest Department nor local communities have received any assistance for overcoming these technological barriers (procurement of planting material, equipment and other technological items needed for restoration of degraded mangrove lands). Finance Department non-release of statement of regular budget by Forest Department for these activities have been made available to the VVB.

Ecological Barriers: Lack of availability of natural propagules for natural regeneration and the washing away of any available propagule by tide water have led to none or very minimal regeneration in the Project Area. Historical satellite pictures and maps based on these pictures are given in Appendix 10 of this document. They support the fact that none or only minimal natural regeneration has happened in the past due to these ecological barriers.

Social Barriers: Demographic pressure on land (e.g., increased demand on land due to population growth and greater loss of land due to sea intrusion) and biotic pressure in terms of grazing, fodder and fuelwood collection, etc. are hampering the natural regeneration of these lands under the baseline scenario. Population growth rate statistics and pictures of animals grazing, fodder and fuelwood collection have been made available to the VVB.

Land Tenure Barriers: Being state-owned lands, local communities have no incentive to invest in the restoration of these degraded mangrove lands. Government notification declaring these lands as Protected Forests have been made available to the VVB.

These are explained in more detail below.

Sub-step 2b. Elimination of land use scenarios that are prevented by the identified barriers

The above matrix eliminates scenario 2 based on ecological considerations and scenario 3 on investment, institutional and technological barriers basis. A host of sources including government management plans, laws, reports, expert reports, research papers by academics and researchers, and reports by international bodies and organisations demonstrate the existence and significance of these identified barriers.

[4142434445464748] The only likely scenario that is expected to continue is scenario 1, the pre-project land-use. Therefore, this is the most likely land-use scenario and hence will be used as the business-as-usual or baseline scenario.

Scenario 1: Continuation of the pre-project land use

No barriers

The land subject to the project activity is degraded mangrove habitat. The planting areas of this ARR/RWE project activity are sited in a coastal location where the population pressure and short-term economic incentives increased the degradation of the mangroves over several decades. Between 1950 and 2000, there was a major loss of mangrove forest cover in Pakistan. The factors responsible for the degradation of Indus Delta mangroves were reduced flow of fresh water and silt from the Indus River, inflow of pollutants from industries, navigational activities and intermix of industrial effluents, browsing and grazing by livestock, wood and fodder harvesting, meandering and erosion of creek banks, over-fishing and gradual rise in sea level (Amjad et al., 2007).[49]

The most plausible baseline scenario is identified as degraded tidal wetland, more specifically: degraded mangrove habitat. The current degraded state is characterised by a near absence of sources of mangrove propagules, high salinity, and trampling of and damage to any newly emerging natural seedlings/natural regeneration by camels/other livestock and browsing by camels/other livestock, and lopping of branches of mangroves and mangrove propagules for fodder and fuelwood purposes. Ecological conditions for natural establishment of mangroves will not occur in the absence of the project activity, as outlined in Scenario 2.

Scenario 2: Natural regeneration of mangroves within the project boundary

[41] Qureshi, Tahir, M. 1984. Working plan of Mangroves (Coastal) forest.

[42] Rasool, Fayyaz. 1997. Mangrove Restoration Project in Pakistan. Technical Report.

[43] IUCN. 2005. Mangroves of Pakistan: Status and Management.

[44] MFF. 2010. Pakistan: National Strategy and Action Plan

[45] Mukhtar, Irum and Abdul Hannan. 2012. Constrains on mangrove forests and conservation projects in Pakistan. J Coast Conserv (2012) 16:51–62

[46] Lavieren, Hanneke Van, Mark Spalding, Daniel M. Alongi, Mami Kainuma, Miguel Clüsener-Godt, Zafar Adeel. 2012. Policy Brief: Securing the Future of Mangroves.

[47] Wagan, Riaz. 2013. Management of Mangroves by Sindh Forest Department.

[48] FAO. 2016. Mangrove related policies and institutional frameworks in Pakistan, Thailand and Vietnam.

[49] Amjad, A.S., I. Kasawani, and J. Kamaruzaman.2007. Degradation of Indus Delta Mangroves in Pakistan. *International Journal of Geology* 3(1): 1-8.

Ecological barriers

There are ecological barriers[50] that hinder the natural re-generation process in the Project Area. These include the very low availability/long distance from mangrove propagule sources to certain areas (particularly high lying areas or those without natural vegetation), flushing out of the propagules out of the site with tide water (especially those of *Avicennia marina*, which have smaller propagules), and damage to the degenerated areas on account of biotic pressure, such as grazing and fodder collection.

Appendix 10. Pre-project Land Cover and Vegetation Development provides additional information on the limited presence of natural regeneration of mangroves in the Project Area.

Scenario 3: Mangrove regeneration within the project boundaries without being registered as a VCS project

Investment barriers, other than economic/financial barriers

The rationale behind the project is twofold: restoring of degraded mangrove wetlands and providing an economic stimulus in a depressed area by revitalising the important livelihood function of fisheries for local communities.

There is neither credit nor credit funding for non-profitable activities beyond the programme Mangroves for the Future of which this ARR/RWE project activity is part. The programme is developed in consultation with local communities, which have already demonstrated a successful track record in environmental awareness and mobilising local people to participate in mangrove regeneration. Local communities do not have the financial or technical capacity to implement the project without the involvement of the Sindh Forest Department, which in turn does not have the needed resources to invest at a scale that is required to restore mangrove areas, reduce deforestation and undertake ARR, biodiversity conservation and community development activities.

Technological barriers

The contribution of the technical assistance for mangrove restoration is necessary for the project's success. Without the project, local communities will not have access to necessary materials, i.e., they will not be able to collect and plant mangrove propagules at a scale that is required for restoring the vast de-vegetated areas. They also will be limited by the lack of knowledge and infrastructure for implementation of the technology needed for restoration of the area under ecological principles.

Social barriers

[50] In the project, all of these ecological barriers are duly taken care of when propagules are taken to sites where they otherwise do not reach, their flushing with tide water is stopped when pits are made for planting, and grazing and fodder collection are controlled in newly planted areas by the Forest Department. Once plantations are established, then through root zone development natural regeneration begins to occur. The protection of the Project Area against drivers of forest degradation is also significant.

Most of the population residing in the region comprises fishermen. To maintain these kinds of traditional fisheries, having an intact mangrove habitat is essential, which significantly supports the local livelihood. Large-scale awareness raising and mobilisation of the community is key to restore the region with a mangrove ecosystem providing multiple benefits, both economically as well as ecologically. The reality, however, is that if there is no organised programme to involve communities and monitor efforts, these programs are unlikely to be developed by local communities themselves.

Social barriers that will hinder large-scale mangrove restoration in the area include:

- Widespread and abject poverty throughout the Project Zone
- Lack of options and opportunities for earning alternative sources of livelihood in the baseline scenario
- Lack of knowledge, skills and other human capabilities and capacities for earning diversified and high levels of income
- Demographic pressure on land due to population growth and loss of land due to saltwater intrusion and coastal erosion
- Inability to stop unauthorised practices such as livestock grazing in newly planted areas
- Lack of organisation of communities to undertake the restoration works
- Chances of any social conflict among various interest groups in the area
- Inability to engage in raising awareness of the local communities and mobilising them for restoring the degraded areas

3.1.5 Additionality

This project is eligible to use an activity method for the demonstration of additionality of tidal wetlands conservation and restoration project activities provided in Module ADD-AM (Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities).

Step 1: Regulatory surplus

The project is not mandated by any law, statute or other regulatory framework, or any systematically enforced law, statute or other regulatory framework. While asking for protection of existing forests, the applicable law (Pakistan Forest Act, 1927[51]) in its application to Sindh Province) does not mandate replanting or restoration of mangrove forests.

Step 2: Positive list

The project demonstrates that it meets all of the applicability conditions listed in Section 3.1.2, and in so doing, it is deemed as complying with the positive list. The project is, therefore, additional.

[51] https://sindhforests.gov.pk/page-forest-act

3.1.6 Methodology Deviations

None

3.2 Quantification of GHG Emission Reductions and Removals

3.2.1 Baseline Emissions

3.2.1.1 Stratification

Organic soil

The Project Area does not include organic soils (Figure 21).

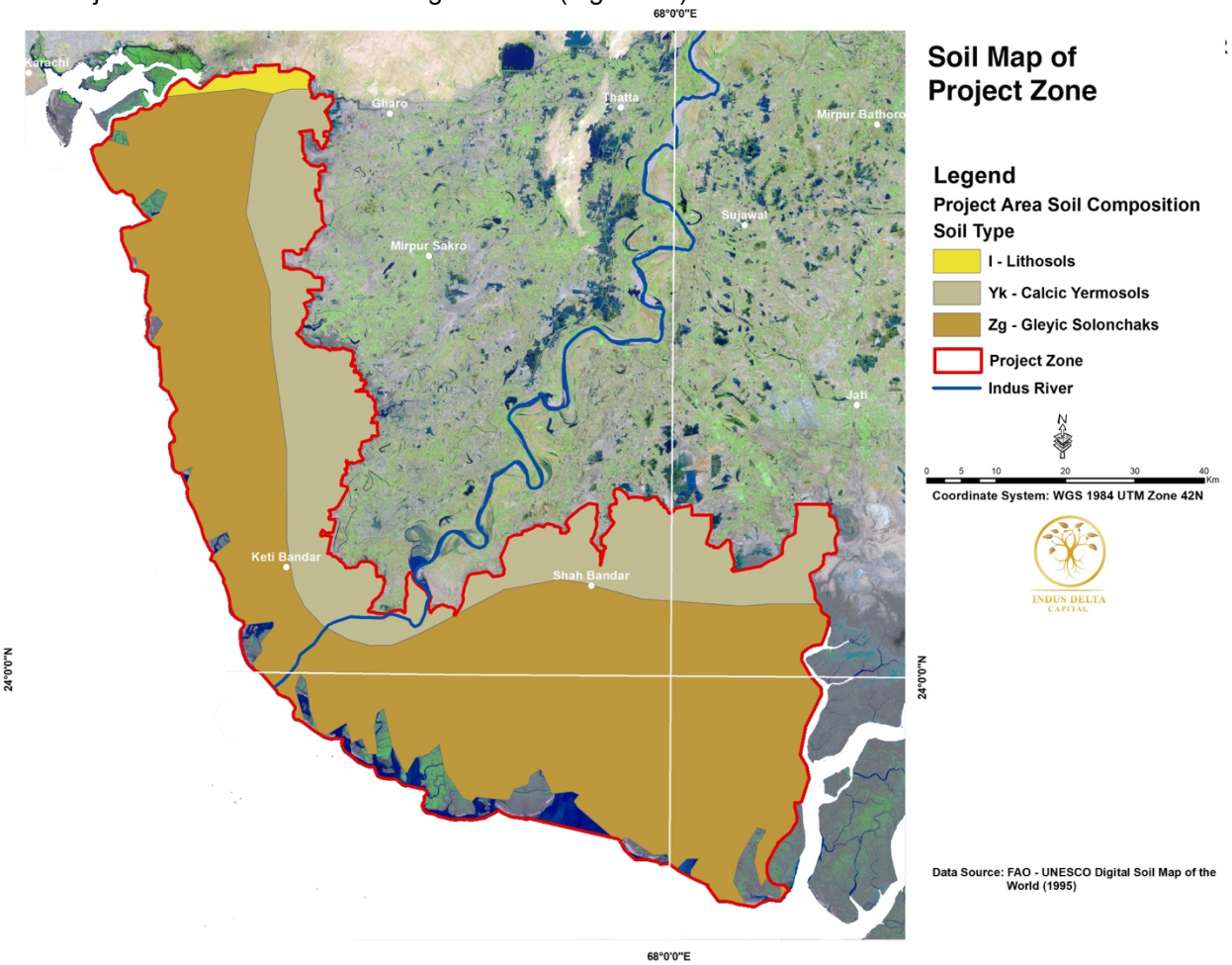


Figure 21. Soil map of the Project Area highlighting the absence of organic soils.

Native ecosystems

To claim emission removals from ARR or WRC activities, evidence must be provided that the Project Area was not cleared of native ecosystems to create GHG credits. Such proof is not required where such clearing took place prior to the 10-year period prior to the project start date.

The mangroves in the Indus Delta are naturally generated through a succession process on suitable islands in the creek systems created by the Indus River and its many tributaries. Over millennia, the Indus River has been continually changing course and there is evidence that it once flowed near Karachi before shifting eastwards. Currently, the river runs near Khobar Creek in the centre of the Delta (Qureshi, 1985)[52].

In the British era (1858-1947), the estimated area of the Indus Delta was 1,000,000 ha (10,000 km^2) (Haig, 1894)[53], with the Delta stretching from Kotri to Umerkot.

Natural stands of mangroves thrived in the areas where the Indus River and its tributaries brought silt and freshwater from upstream, which, when mixed with saline water from the Arabian Sea, created a conducive environment for their development.

Estimates suggest that at that time the mangroves within the current project region were in the range of 160,000 ha with another 100,000 ha of very sparse or no vegetation (Qureshi, 1985). Due to low population density, these areas were almost undisturbed and mangrove exploitation for fuelwood was insignificant.

The fertile high-lying deltaic areas, mainly at the interface of the Indus River and away from the coast, were cultivated on fresh water from the river, or a mixture of saline and fresh water having very low salinity levels. During that era, the communities of Kharo Chan, Keti Bundar and Shah Bundar had very good agrarian economy and these areas would produce red rice in abundance on fresh water, as reported in gazetteers and revenue records (Hague, 1894).

On the basis of field survey maps and abstract of land uses in each ‘deh’, and from historical revenue record of Taluka Keti Bundar, Kharo Chan and Shah Bundar, the total area under red rice cultivation within the current Project Area was estimated at 74,732 ha (Appendix 8. Statement Showing the Estimated Areas Under Red Rice Cultivation in Indus Delta and Figure 22).

However, with the construction of dams, barrages and earthen embankments on both sides of the river from 1932 onwards, freshwater flooding frequency fell, and the movement of the Indus was confined within the protection embankments. The agricultural lands were developed on the inland irrigation system after the construction of Kotri Barrage in 1955 and onwards to help local people in cultivating the barren lands of districts Thatta and Badin. However, due to excessive withdrawal of water upstream, the downstream end areas of Kotri Barrage gradually received little or no water. Consequently, red rice cultivation areas were gradually reduced and eventually completely abandoned in the 1960s.

Natural mudflats are not part of the Project Area due to their low-lying nature and wave wash action. All project plantations – and future planned plantations – are on degraded mangrove areas or abandoned red

[52] Qureshi, M, T. 1985. Working Plan of Mangrove Forests Coastal Forest Division (1985-86 to 2004-05). Sindh Forest Department, Karachi.

[53] Haig, M, R. 1894. Indus Delta Country: A memoir Chiefly on Its Ancient Geography and History. London, 1894.

rice cultivation areas. Natural mud flats are hard to map and they change continually in the dynamic delta environment. In the field, however, they are easily discernible and not included in the planted polygons. Accordingly, there is no conversion of any sort of ecosystem in these deltaic areas or conversion of native systems to create GHG credits within the Project Area.

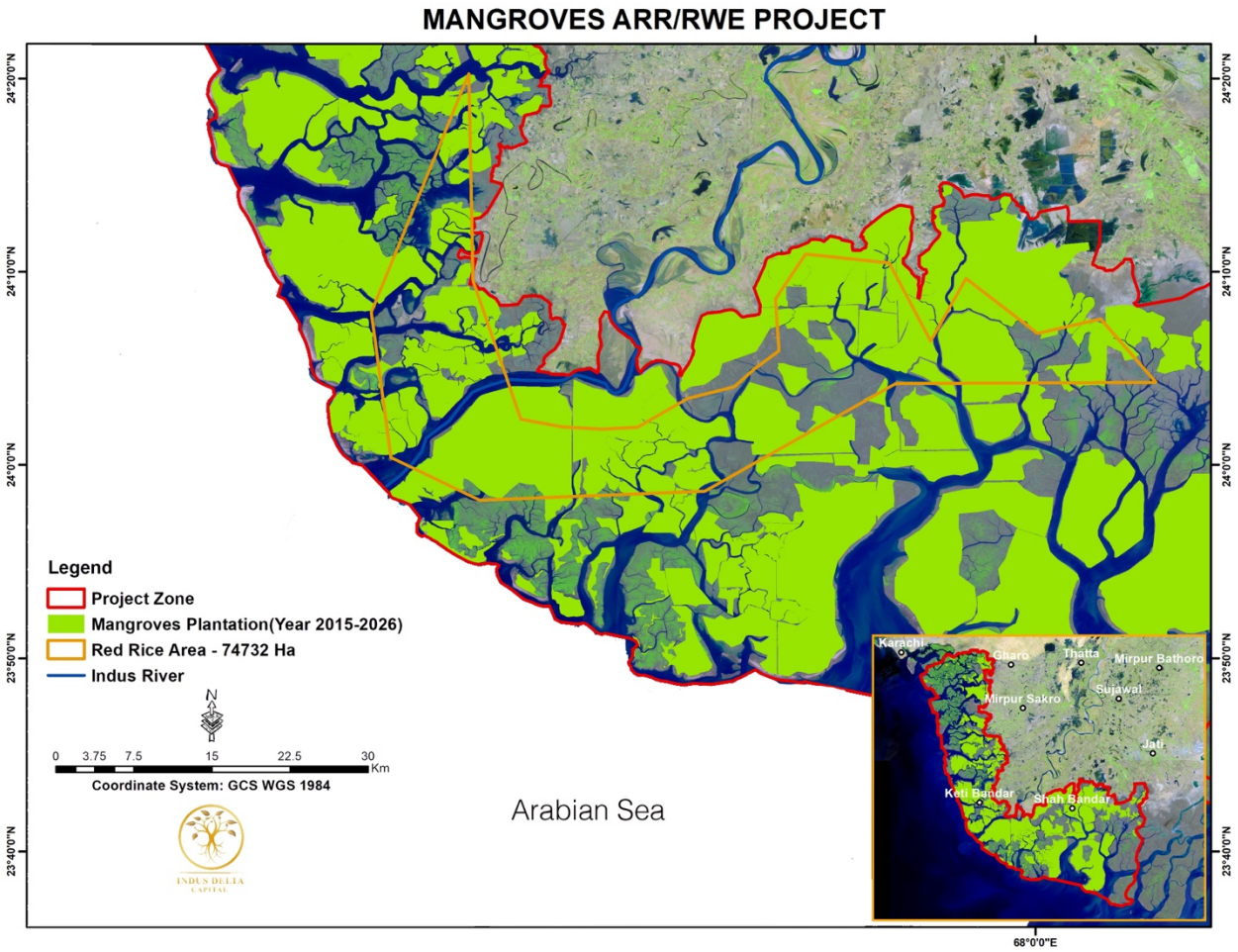


Figure 22. Extension of former red rice fields within the Project Area.

Stratification of salinity for the accounting of CH_4

Due to the large reduction in river flow due to the damming of the Indus River, the amount of freshwater that reaches the Delta has been drastically reduced since the 1950s. Historical data of downstream from Kotri Barrage discharge is shown in Figure 23 below. Therefore, the Indus Delta is largely a marine-driven system. Rice fields have been abandoned prior to project implementation (see above) and since then salinity levels have only increased. Soil salinity within the Delta within the top 20 cm was between 31 and

65 deciSiemens per metre, which is approximately 25 to 52 ppt (Solangi et al., 2019[54]). This salinity range is above the salinity threshold where methanogenesis occurs, which is approximately 20 ppt. Project activities, specifically planting, do not change the flow or salinity of the water within the project boundary so it is extremely unlikely that a change in salinity will occur. The default value for CH_4 emissions above 20 ppt would be applied for both the baseline and project scenarios and thus would negate each other.

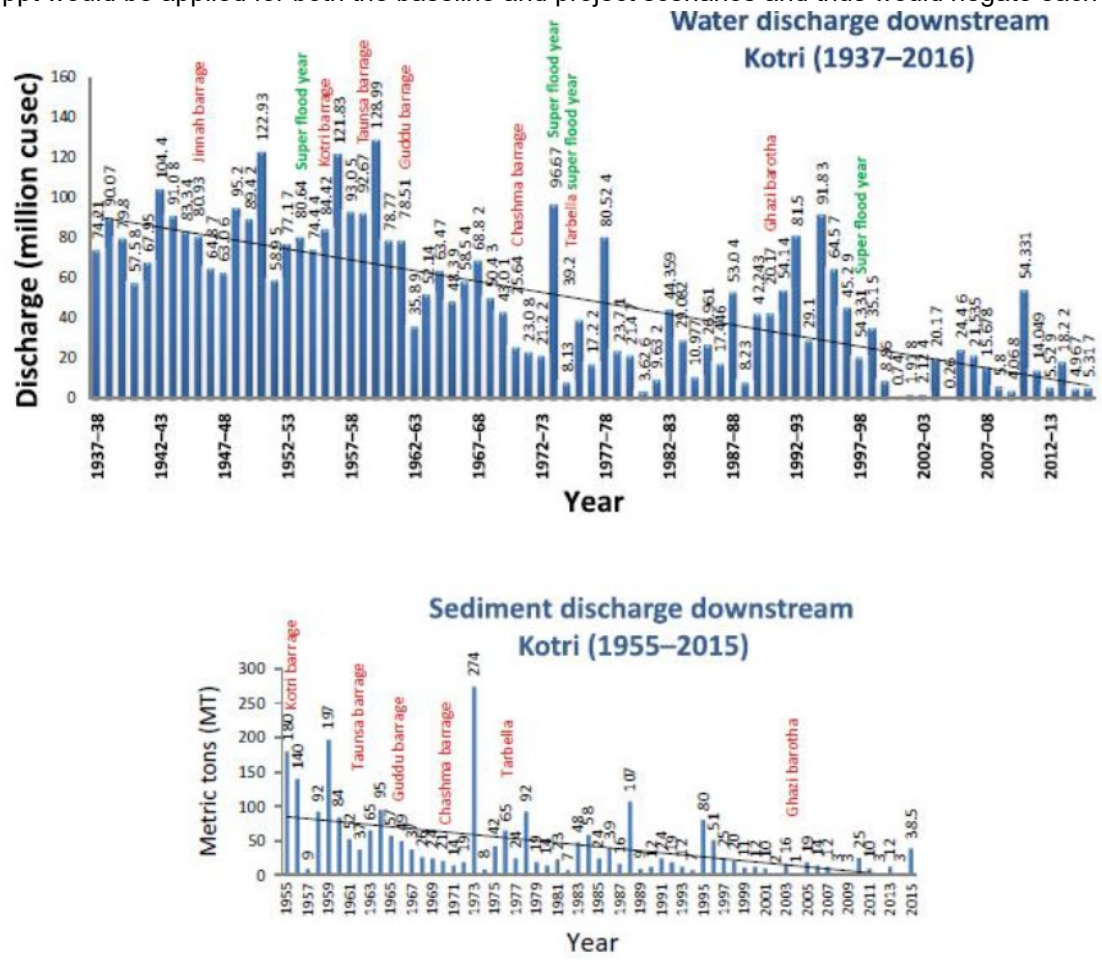


Figure 23. Downstream discharge from Kotri Barrage (million cusec), from 1937 to 2016, and sediment discharge (MT, 1 ton = 0.98 metric tonne), from 1955 to 2015 (Kidwai et al., 2019)[55].

[54] Solangi, G. S., A. A. Siyal, M. M. Babar, and P. Siyal. 2019. Spatial Analysis of Soil Salinity in the Indus River Delta, Pakistan. *Engineering, Technology and Applied Science Research* 9(3): 4271-4275.

[55] Kidwai, S., W. Ahmed, S. M. Tabrez, J. Zhang, L. Giosan, P. Clift, and A. Inam. 2019. The Indus Delta - Catchment, River, Coast, and People. *In* Coasts and Estuaries (pp. 213-232). Elsevier.

Key variables for stratification

The Project Area does not include organic soils. Mineral soils in the Indus Delta are relatively low in SOC and this soil characteristic provides no basis for the distinction of strata.

In the baseline scenario, the degraded mangrove habitats are almost completely void of any vegetation. The presence of ground vegetation (*Oryza coarctata* grass) only grows in the rainy season and is not a permanent cover. Therefore, vegetation cover does not give rise to strata. Natural regeneration of mangroves does occur to a limited extent, but carbon stocks in this vegetation not significant, as shown in Appendix 10. Pre-project Land Cover and Vegetation Development.

For baseline accounting, the de-vegetated and degraded mangrove area delineated in Figure 20 above is considered as one area, subdivided into persistent tidal wetland, wetland lost due to sea level rise and new mangrove habitats (see Section 3.1.3.2.2). Such sub-strata are defined in 5-year time steps.

Loss of wetland due to sea level rise causes a loss of SOC. Areas (i.e., strata) lost have been assessed as outlined in Section 3.2.1.5.5. Results are the same as for planted areas in the project scenario, see Section 3.2.2.5.1.5 and Table 16.

3.2.1.2 Projection of Future Conditions

Ex-ante projections of GHG pools and emissions under the baseline scenario are determined by future conditions and associated key variables that can be projected by follow the procedures in VCS module VMD0019 (Methods to Project Future Conditions). Results of the application of this module are provided in Appendix 9. Projection of Future Conditions in the Baseline and Project Scenarios.

3.2.1.3 Emissions and removals in the baseline scenario

Net CO_2e emissions in the baseline scenario are calculated using the following equations.

$$GHG_{BSL} = GHG_{BSL\text{-}biomass} + GHG_{BSL\text{-}soil} + GHG_{BSL\text{-}fuel} \quad (18)^{56}$$

$$GHG_{BSL\_biomass} = -\sum_{t=1}^{t^*}\sum_{i=1}^{M_{BSL}}\left(\frac{44}{12}\times\Delta C_{BSL\_biomass,i,t}\right) \quad (19)$$

$$GHG_{BSL\_soil} = \sum_{t=1}^{t^*}\sum_{i=1}^{M_{BSL}} GHG_{BSL\_soil,i,t} \quad (20)$$

$$GHG_{BSL\_fuel} = \sum_{t=1}^{t^*}\sum_{i=1}^{M_{BSL}} GHG_{BSL\_fuel,i,t} \quad (21)$$

[56] Equation numbers as in VM0033.

Where:

GHG_{BSL}	Net CO_2e emissions in the baseline scenario up to year *t**; t CO_2e
$GHG_{BSL\text{-}biomass}$	Net CO_2e emissions from biomass carbon pools in the baseline scenario up to year *t**; t CO_2e
$GHG_{BSL\text{-}soil}$	Net CO_2e emissions from the SOC pool in the baseline scenario up to year *t**; t CO_2e
$GHG_{BSL\text{-}fuel}$	Net CO_2e emissions from fossil fuel use in the baseline scenario up to year *t**; t CO_2e
$\Delta C_{BSL\text{-}biomass,i,t}$	Net carbon stock changes in biomass carbon pools in the baseline scenario in stratum *i* in year *t*; t C yr^{-1}
$GHG_{BSL\text{-}soil,i,t}$	GHG emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t CO_2e yr^{-1}
$GHG_{BSL\text{-}fuel,i,t}$	GHG emissions from fossil fuel use the baseline scenario in stratum *i* in year *t*; t CO_2e yr^{-1}
i	1, 2, 3 …M_{BSL} strata in the baseline scenario
t	1, 2, 3, … *t** years elapsed since the project start date

Fossil fuel combustion in the baseline scenario is not a significant emissions source in this ARR/RWE project activity, as it does not move soil material.

Results are provided in Table 22.

3.2.1.4 Net carbon stock change in biomass carbon pools in the baseline scenario

The baseline scenario represents degraded mangrove habitats almost void of any vegetation and without significant natural recovery. GHG removals in this baseline vegetation is considered *de minimis*. However, to be conservative, GHG removals in the project scenario will be corrected for the presence of baseline mangrove vegetation by excluding a portion of the Project Area. This portion is estimated at 1.1%. See Appendix 10. Pre-project Land Cover and Vegetation Development for a complete analysis.

3.2.1.5 Net GHG emissions from soil in the baseline scenario

3.2.1.5.1 Net GHG emissions from soil

Net GHG emissions from soil in the baseline scenario are estimated as:

$$GHG_{BSL\text{-}soil,i,t} = A_{i,t} \times (GHG_{BSL\text{-}soil\text{-}CO2,i,t} - Deduction_{alloch} + GHG_{BSL\text{-}soil\text{-}CH4,i,t} + GHG_{BSL\text{-}soil\text{-}N2O,i,t}) \quad (26)$$

$$GHG_{BSL\text{-}soil\text{-}CO2,i,t} = GHG_{BSL\text{-}insitu\text{-}CO2,i,t} + GHG_{BSL\text{-}eroded\text{-}CO2,i,t} + GHG_{BSL\text{-}excav\text{-}CO2,i,t} \quad (27)$$

Where:

$GHG_{BSL\text{-}soil,i,t}$	GHG emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t CO_2e yr^{-1}
$GHG_{BSL\text{-}soil\text{-}CO2,i,t}$	CO_2 emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}

$Deduction_{alloch}$	Deduction from CO_2 emissions from the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon; t CO_2e ha^{-1} yr^{-1}
$GHG_{BSL\text{-}soil\text{-}CH4,i,t}$	CH_4 emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
$GHG_{BSL\text{-}soil\text{-}N2O,i,t}$	N_2O emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
$A_{i,t}$	Area of stratum *i* in year *t*; ha
$GHG_{BSL\text{-}insitu\text{-}CO2,i,t}$	CO_2 emissions from the tidal wetland SOC pool of *in-situ* soils in the baseline scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
$GHG_{BSL\text{-}eroded\text{-}CO2,i,t}$	CO_2 emissions from the eroded tidal wetland SOC pool in the baseline scenario in stratum *i* in year *t* ; t CO_2e ha^{-1} yr^{-1}
$GHG_{BSL\text{-}excav\text{-}CO2,i,t}$	CO_2 emissions from the tidal wetland SOC pool of soil exposed to an aerobic environment through excavation in the baseline scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
i	1, 2, 3 … M_{BSL} strata in the baseline scenario
t	1, 2, 3, … *t** years elapsed since the project start date

Areas are provided in Table 15.

Excavation occurred prior to the project start date associated with the establishment of fields for red rice production since the early 19th century[57]. SOC in piled-up soil has been exposed to oxidation for a long period and may have reached a steady state value. Therefore, $GHG_{BSL\text{-}excav\text{-}CO2,i}$ is not accounted for, which is always conservative for the baseline scenario.

3.2.1.5.2 CO_2 emissions from soil – *in situ*

The baseline scenario represents degraded mangrove habitats almost void of any vegetation and without any significant natural recovery, see Section 3.1.4. The presence of ground vegetation (*Oryza coarctata* grass) is only seasonal as the grass only grows during the rainy season and is not a permanent cover. Under such circumstances, SOC levels will continue to decline and eventually reach a steady state.

As outlined in Section 3.1.3.2.3, the ARR/RWE project does not claim avoided emissions (stop loss) from the soil, as a result of the restoration activities.

CO_2 emissions from the *in-situ* soil in the baseline scenario are conservatively not accounted for.

Deduction for allochthonous carbon

[57] Burnes, A. 1837. On Sindh. *Journal of the Royal Geographical Society of London* 7:11-20.

A deduction for allochthonous carbon would only apply if $GHG_{BSL\text{-}insitu\text{-}CO2,i,t}$ was negative (sequestration). Since the baseline scenario does not involve accumulation of SOC, a deduction for allochthonous carbon is not necessary.

3.2.1.5.3 CH_4 emissions from soil – *in situ*

CH_4 emissions from soil in the baseline scenario are not accounted for as CH_4 emissions do not increase in the project scenario compared to the baseline scenario, see Section 3.2.1.1.

3.2.1.5.4 N_2O emissions from soil – *in situ*

N_2O emissions from soil in the baseline scenario are not accounted for, as N_2O emissions do not increase in the project scenario compared to the baseline scenario, see Section 3.2.1.1.

3.2.1.5.5 CO_2 emissions from soil – *eroded*

As outlined in Section 3.1.3.2.2, sea level rise will over a period of 100 years cause erosion and a loss of wetland area. The predicted loss of wetland area has been calculated in 5-year time steps. For each time step, the release of carbon and emission of CO_2 to the atmosphere from the eroded wetland soil has been calculated using the following equations.

$$GHG_{BSL\text{-}eroded\text{-}CO2,i,t} = 44/12 \times C_{BSL\text{-}eroded,i,t} \times C\%_{BSL\text{-}emitted,i,t} / 100 \quad (48)$$

$$C_{BSL\text{-}eroded,i,t} = C\%_{BSL\text{-}eroded,i,t} \times BD \times Depth\_e_{BSL,i,t} \times 10 \quad (49)$$

Where:

$GHG_{BSL\text{-}eroded\text{-}CO2,i,t}$	CO_2 emissions from the eroded tidal wetland SOC pool in the baseline scenario in stratum *i* in year *t* ; t CO_2e ha^{-1} yr^{-1}
$C_{BSL\text{-}eroded,i,t}$	Soil organic carbon stock in eroded tidal wetland soil material in the baseline scenario in stratum *i* in year *t*; t C ha^{-1}
$C\%_{BSL\text{-}emitted,i,t}$	Organic carbon loss due to oxidation, as a percentage of C mass present in eroded tidal wetland soil material in the baseline scenario in stratum *i* in year *t*; %
$C\%_{BSL\text{-}eroded,i,t}$	Percentage of carbon of tidal wetland soil material eroded in the baseline scenario; %
BD	Soil bulk density; kg m^{-3}
$Depth\_e_{BSL,i,t}$	Depth of the eroded area from the surface to the surface prior to erosion in the baseline scenario in stratum *i* in year *t*; m

As part of project planning, eight 1-m long soil cores were collected in degraded mangrove habitat throughout the Project Area, which visually is similar to a mudflat[58] environment with little (low-lying grass, *Oryza coarctata*) to no vegetation. The cores were collected following the methods described in Section 3.3.3.4. The average carbon stock within the top metre of soil is 163.6 t C ha^{-1} (range: 82.9 – 206.2 t C ha^{-1}; standard deviation: 43.7; standard error: 17.8 t C ha^{-1}; 95% CI: 30.3).

When coastal erosion occurs, the entire marsh plain is eroded. It is assumed that the top metre of soil is eroded ($Depth\_e_{i,t}$ = 1 m)[59]. Areas of strata *i* and years *t* of erosion are provided in Table 16. The method for calculating these areas is outlined in Section 3.1.3.2.2.

For tidal marsh and mangrove systems, a default factor for $C\%_{BSL\text{-}emitted,i,t}$ may be used in the absence of data suitable for using the published value approach, using the values provided below for the specified carbon preservation depositional environment (CPDE).

In absence of any other data relevant for the Project Area, $C\%_{BSL\text{-}emitted,i,t}$ is quantified using the default value for the relevant CPDE, using the following equation:

If CPDE is "Normal Marine" or "Deltaic fluidized muds", then $C\%_{BSL\text{-}emitted,i,t}$ = 80% (51)

This means that 80% of the SOC eroded from the tidal wetland is emitted as CO_2.

3.2.2 Project Emissions

3.2.2.1 Stratification

Key variables for stratification

Soils in the Indus Delta will accumulate SOC due to the ARR/RWE project activity. SOC levels will, therefore, be closely correlated with crown or vegetation cover. *Avicennia* plantations show a 50% canopy cover after 6-7 years. *Rhizophora* plantations are quickly colonised by *Avicennia marina* propagules, and thus show a similar rate of canopy development (see Appendix 11. Mangrove Canopy Cover Development).

In the project scenario, the planting cohorts – starting in year 2015 and ending in year 2026 – are the dominant factor in *ex-post* stratification. The map showing the planting cohorts is provided in Figure 4. The coloured polygons delineate the areas planted and to be planted with mangrove species under the ARR/RWE project activity. Table 15 provides a list of strata *i* and years *t*.

In addition, it is assumed that the areas that will become intertidal due to sea level rise (i.e., new mangrove habitats) will be gradually colonised by mangrove species because of the nearby presence of mangroves seeds and propagules. Furthermore, some wetland area is expected to be lost due to sea level rise, similar to the scenario described for the baseline (see Section 3.2.1.1).

Thus, additional factors in *ex-post* stratification include:

[58] These are degraded mangrove areas reminiscent of mudflats. Native mudflats are not part of the Project Area.

[59] This depth will be uses in both baseline and project scenario consistently

1. The loss of planted area due to sea level rise, giving rise to a zone actively reforested with mangrove trees but then submerged/eroded and lost ("LOSS") – (Figure 20; Table 16)
2. The gain of new mangrove habitat due to sea level rise ("GAIN") – (Figure 20; Table 16)

Table 15. Annual planting executed and targeted.

Year	Area planted (ha)
2015	9,685
2016	18,544
2017	10,399
2018	10,472
2019	15,630
2020	10,835
2021	24,778
2022	30,001
2023	29,632
2024	30,005
2025	19,450
2026	15,568
Total	224,997

Table 16. Planted areas lost due to sea level rise, and mangrove habitat gained due to sea level rise, in 5-year steps.

Year	Area lost (ha)	Habitat gained (ha)
2020	322	630
2025	598	688
2030	632	765
2035	2,561	842
2040	2,656	900

2045	2,673	936
2050	2,687	971
2055	2,661	979
2060	2,601	970
2065	2,555	993
2070	2,524	1,028
2075	2,502	1,025
2080	2,478	1,014
2085	2,450	1,021
2090	2,388	1,017
2095	2,367	1,011
2100	2,319	893
2105	2,241	800
2110	2,201	670
2115	2,174	622

Stratification of salinity for the accounting of CH_4

CH_4 emissions from soil in the project scenario are not accounted for, as CH_4 emissions do not increase in the project scenario compared to the baseline scenario, see Section 3.2.1.1.

The Indus Delta is a marine dominated system; freshwater flow from the Indus River is very limited due to upstream damming and only occurs during the monsoon season. Methane emissions are not expected to change with project activity because there is no alteration in freshwater flow and therefore the CH_4 emissions with the project are expected to be the same as in the baseline. Any changes, if they occur, to the freshwater input from the Indus River will happen regardless of project activity.

3.2.2.2 Projection of future conditions

Ex-ante projections of GHG pools and emissions under the project scenario are determined by future conditions and associated key variables that can be projected by following the procedures in VCS module VMD0019 (Methods to Project Future Conditions). Results of the application of this module are provided in Appendix 9. Projection of Future Conditions in the Baseline and Project Scenarios.

3.2.2.3 Emissions and removals in the project scenario

Net CO_2e emissions in the project scenario are calculated using the following equations.

$$GHG_{WPS} = GHG_{WPS\text{-}biomass} + GHG_{WPS\text{-}soil} + GHG_{WPS\text{-}burn} + GHG_{WPS\text{-}fuel} \quad (69)$$

$$GHG_{WPS\text{-}biomass} = -\sum_{t=1}^{t^*}\sum_{i=1}^{M_{WPS}}\left(\frac{44}{12}\times \Delta C_{WPS\text{-}biomass,i,t}\right) \quad (70)$$

$$GHG_{WPS\text{-}soil} = \sum_{t=1}^{t^*}\sum_{i=1}^{M_{WPS}} GHG_{WPS\text{-}soil,i,t} \quad (71)$$

$$GHG_{WPS\text{-}burn} = \sum_{t=1}^{t^*}\sum_{i=1}^{M_{WPS}} GHG_{WPS\text{-}burn,i,t} \quad (72)$$

$$GHG_{WPS\text{-}fuel} = \sum_{t=1}^{t^*}\sum_{i=1}^{M_{WPS}} GHG_{WPS\text{-}fuel,i,t} \quad (73)$$

Where:

GHG_{WPS}	Net CO_2e emissions in the project scenario up to year t^*; t CO_2e
$GHG_{WPS\text{-}biomass}$	Net CO_2e emissions from biomass carbon pools in the project scenario up to year t^*; t CO_2e
$GHG_{WPS\text{-}soil}$	Net CO_2e emissions from the SOC pool in the project scenario up to year t^*; t CO_2e
$GHG_{WPS\text{-}burn}$	Net CO_2e emissions from prescribed burning in the project scenario up to year t^*; t CO_2e
$GHG_{WPS\text{-}fuel}$	Net CO_2e emissions from fossil fuel use in the project scenario up to year t^*; t CO_2e
$\Delta C_{WPS\text{-}biomass,i,t}$	Net carbon stock change in biomass carbon pools in the project scenario in stratum i in year t; t C yr^{-1}
$GHG_{WPS\text{-}soil,i,t}$	GHG emissions from the SOC pool in the project scenario in stratum i in year t; t CO_2e yr^{-1}
$GHG_{WPS\text{-}burn,i,t}$	GHG emissions from prescribed burning in the project scenario in stratum i in year t; t CO_2e yr^{-1}
$GHG_{WPS\text{-}fuel,i,t}$	GHG emissions from fossil fuel use the project scenario in stratum i in year t; t CO_2e yr^{-1}
i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3, … t^* years elapsed since the project start date

3.2.2.4 Net carbon stock change in biomass carbon pools in the project scenario

Calculations follow the equations provided in VM0033 and CDM AR Tool 14[60].

[60] Applicability conditions included in AR-ACM0003 and associated tools that exclude project activities on wetlands can be disregarded as set out in VM0033.

$$\Delta C_{WPS\text{-}biomass,i,t} = \Delta C_{WPS\text{-}tree/shrub,i,t} + \Delta C_{WPS\text{-}herb,i,t} \quad (74)$$

Where:

$\Delta C_{WPS\text{-}biomass,i,t}$	Net carbon stock change in biomass carbon pools in the project scenario in stratum *i* in year *t*; t C yr^{-1}
$\Delta C_{WPS\text{-}tree/shrub,i,t}$	Net carbon stock change in tree and shrub carbon pools in the project scenario in stratum *i* in year *t*; t C yr^{-1}
$\Delta C_{WPS\text{-}herb,i,t}$	Net carbon stock change in herb carbon pools in the project scenario in stratum *i* in year *t*; t C yr^{-1}
i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3, … *t** years elapsed since the project start date

Herbal vegetation development is not significant.

$$\Delta C_{WPS\text{-}tree/shrub,i,t} = 12/44 \times (\Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t}) \quad (75)$$

Where:

$\Delta C_{BSL\text{-}tree/shrub,i,t}$	Net carbon stock change in tree and shrub carbon pools in the project scenario in stratum *i* in year *t*; t C yr^{-1}
$\Delta C_{TREE\_PROJ,t}$	Change in carbon stock in tree biomass in the project scenario in year *t*; t CO_2-e yr^{-1} (derived from application of AR Tool 14; calculations are done for each stratum *i*)
$\Delta C_{SHRUB\_PROJ,t}$	Change in carbon stock in shrub biomass in the project scenario in year *t*; t CO_2-e yr^{-1} (derived from application of AR Tool 14; calculations are done for each stratum *i*)

Change in carbon stock in trees in a year is estimated as follows (Equation 11 from AR Tool 14):

$$\Delta C_{TREE,t} = \frac{C_{TREE,t_2} - C_{TREE,t_1}}{T} \times 1\ year$$

Where:

$\Delta C_{TREE,t}$	Change in carbon stock in trees within the project boundary in year t; t CO_2e
$C_{TREE,t2}$	Carbon stock in trees within the project boundary at time t_2; t CO_2e
$C_{TREE,t1}$	Carbon stock in trees within the project boundary at time t_1; t CO_2e
T	Time elapsed between two successive estimations ($T = t_2 - t_1$;); yr

Procedures for the *ex-post* assessment of carbon stocks in tree biomass are provided in Section 3.3.3 (Monitoring Plan).

As outlined in Section 3.2.1.4, natural regeneration of pre-existing mangrove trees is accounted for by excluding a portion of the Project Area of 1.1% from the GHG removals. All present mangrove trees will be included in the monitoring of the project scenario.

For the *ex-ante* calculations of the project scenario, the year of planting will be used as starting point for biomass increase in mangroves.

GHG removals by biomass carbon pools other than tree biomass are conservatively not accounted for.

Ex-ante CO_2 emissions or removals by mangrove plantations have been calculated for:

- Areas actively reforested with mangrove trees ("ARR")
- Areas actively reforested with mangrove trees but then submerged/eroded and lost due to sea level rise ("LOSS")
- Area of new mangrove habitat gained due to sea level rise ("GAIN")

See Figure 20 for a map delineating these areas.

Forecasts of CO_2 removals are based on:

- Annual areas of tree planting under "ARR" (Table 15)
- Loss of planted area under "LOSS" (Table 16)
- Gain of new mangrove habitat under "GAIN" (Table 16)
- General growth model for mangrove forest with *A. marina* and *R. mucronata* – see below
- An instant loss of biomass and emission of CO_2 under "LOSS" – see below
- A conservative deduction factor for CO_2 removals by mangrove growth under "GAIN" – see below

General growth model for mangrove forest with *Avicennia* and *Rhizophora* under "ARR"

On the basis of a chronosequence of mangrove plantations in and in the vicinity of the Project Area, a general local growth curve was developed, see Appendix 13: Mangrove Growth Curve for *Ex-ante* Calculations for a further explanation.

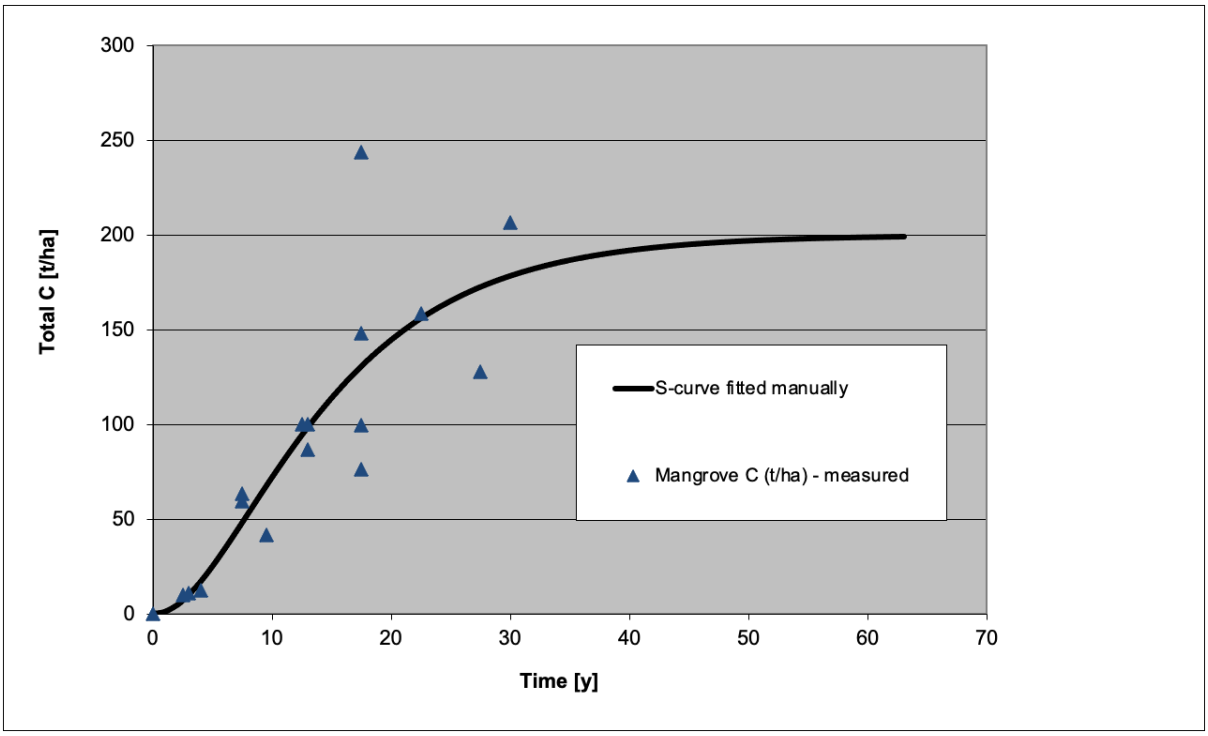


Figure 24. General growth model for mangrove plantations in the Indus Delta for *ex-ante* estimates of GHG removals, based on a sampled chronosequence.

Loss of biomass under "LOSS"

VM0033 sets out that the consequences of submergence of a given stratum due to sea level rise is that carbon stocks from aboveground biomass are lost to oxidation and it is assumed that this carbon is immediately and entirely returned to the atmosphere. For such strata:

$$\Delta C_{WPS\text{-}biomass,i,t} = 12/44 \times (C_{WPS\text{-}biomass,i,t} - C_{WPS\text{-}biomass,i,(t\text{-}T)}) / T \quad (22)^{61}$$

For the year of submergence (see Table 16):

$$C_{WPS\text{-}biomass,i,t} = 0$$

Where:

$\Delta C_{WPS\text{-}biomass,i,t}$	Net carbon stock change in biomass carbon pools in the project scenario in stratum *i* in year *t*; t C yr^{-1}
$C_{WPS\text{-}biomass,i,t}$	Carbon stock in biomass in the project scenario in stratum *i* in year *t* (from $C_{TREE\_PROJ,t}$ in AR Tool 14); t CO_2e

[61] Suffixes adjusted for the project scenario

i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3, … *t** years elapsed since the project start date
T	Time elapsed between two successive estimations ($T=t_2 - t_1$)

Growth model under "GAIN"

It is assumed that upland areas that will become intertidal due to sea level rise (i.e., new mangrove habitats) will be gradually covered by mangrove species as a result of the nearby presence of mangroves seeds and propagules[62]. The general growth model presented above will be applicable, but with a reduction factor of 70% for a conservative carbon sequestration rate.

3.2.2.5 Net GHG emissions from soil in the project scenario

3.2.2.5.1 Procedures

3.2.2.5.1.1 Net GHG emissions from soil

Net GHG emissions from soils in the project scenario are estimated as:

$$GHG_{WPS\text{-}soil,i,t} = A_{i,t} \times (GHG_{WPS\text{-}soil\text{-}CO2,i,t} - Deduction_{alloch} + GHG_{WPS\text{-}soil\text{-}CH4,i,t} + GHG_{WPS\text{-}soil\text{-}N2O,i,t}) \quad (79)$$

$$GHG_{WPS\text{-}soil\text{-}CO2,i,t} = GHG_{WPS\text{-}insitu\text{-}CO2,i,t} + GHG_{WPS\text{-}eroded\text{-}CO2,i,t} + GHG_{WPS\text{-}excav\text{-}CO2,i,t} \quad (80)$$

Where:

$GHG_{WPS\text{-}soil,i,t}$	GHG emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t CO_2e yr^{-1}
$GHG_{WPS\text{-}soil\text{-}CO2,i,t}$	CO_2 emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
$Deduction_{alloch}$	Deduction from CO_2 emissions from the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon; t CO_2e ha^{-1} yr^{-1}
$GHG_{WPS\text{-}soil\text{-}CH4,i,t}$	CH_4 emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
$GHG_{WPS\text{-}soil\text{-}N2O,i,t}$	N_2O emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t CO_2e ha^{-1} yr^{-1}
$A_{i,t}$	Area of stratum i in year t; ha
i	*1, 2, 3* …M_{WPS} strata in the project scenario
t	*1, 2, 3* … *t** years elapsed since the project start date

Excavation is not a project activity. Therefore, $GHG_{WPS\text{-}excav\text{-}CO2,i}$ is not included.

[62] Although natural regeneration at the start of the project is amost non existent, by the time the new habitats occur, the Project Zone is almost entirely covered with mangrove forest, which will be an ample sources of propagules.

3.2.2.5.1.2 CO_2 emissions from soil – *in situ*

At the project start date, the average carbon stock within the top metre of soil is 163.6 t C ha^{-1} (range: 82.9 – 206.2 t C ha^{-1}; standard error: 17.8 t C ha^{-1}), as for the baseline scenario (see Section 3.2.1.5.5).

As suggested in Figure 25, SOC is set to increase upon the establishment of a mangrove tree cover. In an initial inventory of a chronosequence of mangrove plantations mostly outside of the Project Area, dating from 5 to 30+ years ago, a trend in the increase of SOC can be observed, resulting in an estimated 1.90 t C $ha^{-1}yr^{-1}$ based on the trend line. The project will further investigate if a statistically reliable SOC accumulation rate can be derived based on feasible monitoring procedures, using the following equation from VM0033:

$$GHG_{BSL\text{-}soil\text{-}CO2,i,t} = 44/12 \times -(C_{BSL\text{-}soil,i,t} - C_{BSL\text{-}soil,i,,(t\text{-}T)}) / T \quad (36)$$

For this PD, the *ex-ante* calculations are conservatively based on the application of the default value provided in VM0033.

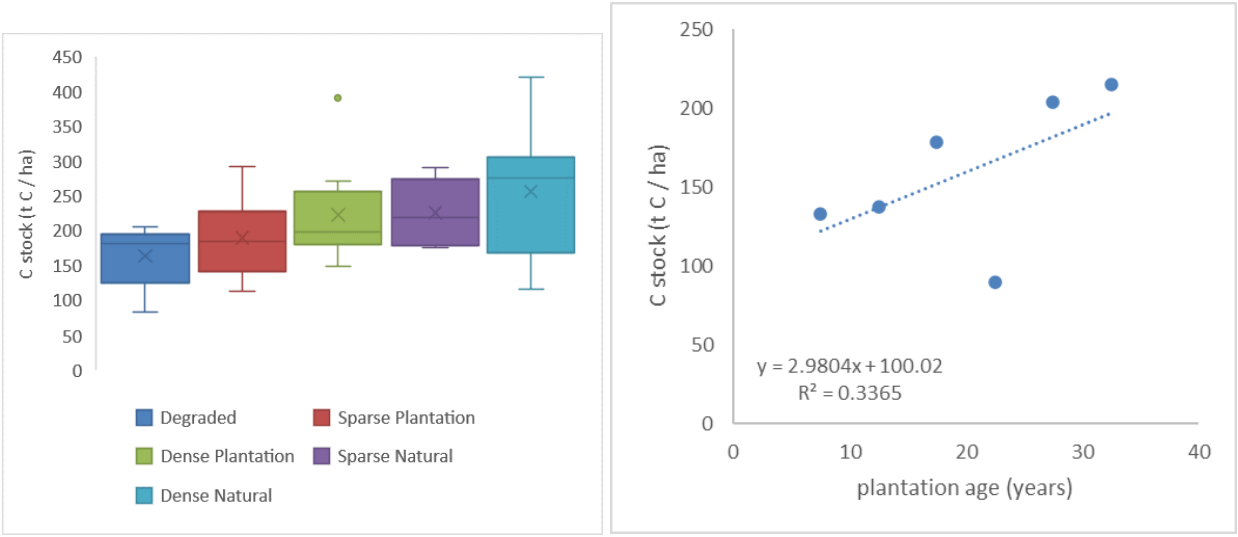


Figure 25. Lefthand side: SOC (t C ha^{-1}) in the top 1 m of bare soil and under various mangrove covers plantations within the Project Zone (the mean is represented by an X; the median is represented by the line within the box; an outlier is represented by a point outside of the box). Righthand side: SOC in 1 m cores across a chronosequence of mangrove plantations within the Project Zone (age represents the midpoint in each age bracket).

Default factor

In the absence of suitable local data, the default factor for SOC accumulation is used:

$GHG_{WPS\text{-}insitu\text{-}CO2,i,t}$ = -1.46 t C ha^{-1} yr^{-1} × 44/12 (33)[63]

The default value, adjusted for allochthonous carbon, is conservatively used at the start of this project. The above default factor may only be applied to areas with a crown or vegetation cover of at least 50%. For areas with a crown or vegetation cover of less than 15%, this value may be assumed to be insignificant and accounted for as zero. For areas with a crown or vegetation cover between 15 and 50%, a linear interpolation may be applied.

In the Indus Delta, the mangrove plantations reach a crown cover of at least 50% after 6-7 years (see Appendix 11. Mangrove Canopy Cover Development). Since some variability exists, we apply a conservative canopy development, with 15% cover reached after 5 years and 50% cover reached after 10 years. A linear interpolation is applied between 5 and 10 years.

Deduction for allochthonous carbon

$Deduction_{alloch} = GHG_{WPS\text{-}insitu\text{-}CO2,i,t} \times (\%C_{alloch} /100)$ (38)

Where:

$Deduction_{alloch}$	Deduction from CO_2 sequestration in the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon; t CO_2e ha^{-1} yr^{-1}
$GHG_{WPS\text{-}insitu\text{-}CO2,i,t}$	CO_2 emissions from the tidal wetland SOC pool of *in-situ* soils in the project scenario in stratum *i* in year *t*; t CO_2e yr^{-1}
$\%C_{alloch}$	Percentage of the total soil organic carbon that is allochthonous; %
i	1, 2, 3 …M_{BSL} strata in the project scenario
t	1, 2, 3 … *t** years elapsed since the start of the project activity

This equation applies if $GHG_{WPS\text{-}insitu\text{-}CO2,i,t}$ is negative (sequestration). Since the project scenario involves the accumulation of SOC due to mangrove reforestation, a deduction for allochthonous carbon is required.

To account for allochthonous carbon, the generalised estimate of the deduction due to allochthonous carbon was used from Needelman et al. (2018)[64]:

$\%Deduction_{alloch} = 213.17 \times \%C^{-1.184}$

[63] Suffixes adjusted for the project scenario

[64] $y = 213.17x^{-1.184}$ from Needelman, B. A., I. M. Emmer, S. Emmett-Mattox, S. Crooks, J. P. Megonigal, D. Myers, M. P. J. Oreska, and K. McGlathery. 2018. The science and policy of the verified carbon standard methodology for tidal wetland and seagrass restoration. *Estuaries and Coasts* 41(8): 2159-2171.

where *%Deduction*$_{alloch}$ is the percentage of allochthonous carbon deduction from as a percentage of total C, and *%C* is the percent of soil C. This equation thus relates *%C* in the soil to the estimated proportion that is allochthonous. The average *%C* from 8-m-long cores collected within eight natural dense mangroves from within the Indus Delta was used. The average value from subsamples collect below the rooting zone is 2.02% (standard deviation: 0.62; standard error: 0.1; 95% confidence interval: 0.43), which results in a 92.7% deduction. Therefore, *Deduction*$_{alloch}$ equals 1.35 t C yr^{-1}, or 4.95 t CO_2e yr^{-1}.

Accounting for *Deduction*$_{alloch}$, the CO_2 emission from soil is -0.40 t CO_2e yr^{-1} (-0.11 t C yr^{-1}) if the vegetation cover requirement of 50% or more is met. This value is comparable to measured soil C accumulation rates calculated for arid mangroves in the United Arab Emirates (Crooks et al. 2020[65]), where the species composition is comprised of short statured (<5 m) *A. marina* and the soil conditions are comparable to the Indus Delta (e.g., low soil organic carbon; high dry bulk density). The average soil C accretion rate based on ten cores collected from five sites was -0.58 t C ha^{-1} yr^{-1} (range: -0.25 – -1.11 t C ha^{-1} yr^{-1}; standard error: 0.1) using ^{210}Pb radiometric dating, which, accounting for allochthonous carbon, is -0.115 t C ha^{-1} yr^{-1} (-0.42 t CO_2e ha^{-1} yr^{-1}).

Table 17. GHG emissions from the SOC pool according to vegetation cover development in the project scenario.

Year	Vegetation cover %	Default accumulation rate ((1.46 × *vegetation cover*) – *Deduction*$_{alloch}$) t C ha^{-1}	*GHG*$_{WPS\text{-}insitu\text{-}CO2,i,t}$ t CO_2 ha^{-1} yr^{-1}
1	<15	0	0
2	<15	0	0
3	<15	0	0
4	<15	0	0
5	15	-0.032	-0.117
6	22	-0.047	-0.172
7	29	-0.062	-0.227
8	36	-0.077	-0.281
9	43	-0.092	-0.336

[65] Crooks, S., K. Poppe, A. Rubilla, and J. Rybczyk. 2020. Mangrove Soil Carbon Accumulation of the United Arab Emirates: Trial Application, Report by and AGEDI/Environment Agency Abu Dhabi, Silvestrum Climate Associates and Western Washington University.

10	50	-0.107	-0.391
>10	>50	-0.107	-0.391

3.2.2.5.1.3 CH_4 emissions from soil – *in situ*

CH_4 emissions from soil in the baseline scenario are not accounted for, as CH_4 emissions do not increase in the project scenario compared to the baseline scenario, see 3.2.1.1.

3.2.2.5.1.4 N_2O emissions from soil – *in situ*

N_2O emissions from soil in the baseline scenario are not accounted for, as N_2O emissions do not increase in the project scenario compared to the baseline scenario, see 3.2.1.1. Furthermore, no changes in agricultural land use because of the project is expected. Due to salinisation of the land surrounding the Indus Delta, agricultural production is decreasing in the area and subsequently less fertiliser is being used (see Section 3.1.3.4).

3.2.2.5.1.5 CO_2 emissions from soil – *eroded*

As outlined in Section 3.1.3.2.2, sea level rise will over a period of 100 years cause erosion and a loss of wetland. The loss of wetland area has been calculated with 5-year time steps. For each time step, the release of carbon and emission of CO_2 to the atmosphere from the eroded wetland soil has been calculated using the following equation.

$$GHG_{WPS\text{-}eroded\text{-}CO2,i,t} = 44/12 \times C_{WPS\text{-}eroded,i,t} \times C\%_{WPS\text{-}emitted,i,t} / 100 \quad (48)$$

$$C_{WPS\text{-}eroded,i,t} = C\%_{WPS\text{-}eroded,i,t} \times BD \times Depth\_e_{WPS,i,t} \times 10 \quad (49)$$

Where:

$GHG_{WPS\text{-}eroded\text{-}CO2,i,t}$	CO_2 emissions from the eroded tidal wetland SOC pool in the project scenario in stratum *i* in year *t* ; t CO_2e ha^{-1} yr^{-1}
$C_{WPS\text{-}eroded,i,t}$	Soil organic carbon stock in eroded tidal wetland soil material in the project scenario in stratum *i* in year *t*; t C ha^{-1}
$C\%_{WPS\text{-}emitted,i,t}$	Organic carbon loss due to oxidation, as a percentage of C mass present in eroded tidal wetland soil material in the project scenario in stratum *i* in year *t*; %
$C\%_{WPS\text{-}eroded,i,t}$	Percentage of carbon of tidal wetland soil material eroded in the project scenario; %
BD	Soil bulk density; kg m^{-3}
$Depth\_e_{WPS,i,t}$	Depth of the eroded area from the surface to the surface prior to erosion in the project scenario in stratum *i* in year *t*; m

$Depth\_e_{WPS,i,t}$ is the same as in the baseline scenario, as outlined in Section 3.2.1.5.5.

The Indus Delta is currently in an erosive state (see Section 3.1.3.2 for details) and erosion is occurring with or without the presence of mangroves. For the *ex-post* assessment at verification, $C_{WPS\text{-}eroded}$ will be calculated as the SOC at the project start date increased with the accumulation since year of plantation as outlined in Section 3.2.2.5.1.2 and Table 16. For the *ex-ante* estimate of $C_{WPS\text{-}eroded}$, it is conservatively

assumed that the eroded planting polygon has a carbon stock similar to what would have accumulated at *t* = 100, which gives a greater loss of carbon due to erosion.

The procedure for quantifying $C\%_{WPS\text{-}emitted,i,t}$ is the same as for the baseline scenario, see Section 3.2.1.5.5.

Based on Expert Judgement[66] it is confirmed that connectivity occurs between eroded wetland and the river-estuary system.

The area of mangrove plantations eroded every 5 years was calculated as outlined in Section 3.1.3.2.2.

3.2.2.6 Net GHG emissions from fuel use in the project scenario

Fossil fuel emissions in the baseline are conservatively not accounted for. Where emissions from the use of vehicles and mechanical equipment in WRC project activities are above *de minimis* as compared to the baseline scenario, such emissions must be estimated by applying CDM AR Tool 5 (Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities). The following equation is used:

$$GHG_{WPS\text{-}fuel,i,t} = ET_{FC,y} \quad (84)$$

Where:

$GHG_{WPS\text{-}fuel,i,t}$	GHG emissions from fossil fuel use in the project scenario in stratum *i* in year *t*; t CO_2e yr^{-1}
$ET_{FC,y}$	CO_2 emissions from fossil fuel combustion during the year *y*; t CO_2 (derived from application of AR Tool 5 (Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities); calculations are done for each stratum *i*)
i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3, … *t** years elapsed since the project start date

The application of the tool yields an outcome of 482 t CO_2 yr^{-1}, see Table 18.

AR Tool 4 (Tool for testing significance of GHG emissions in A/R CDM project activities) states that the sum of decreases in carbon pools and increases in emissions that may be neglected shall be less than 5% of the total decreases in carbon pools and increases in emissions, or less than 5% of net anthropogenic removals by sinks, whichever is lower.

The following equation applies:

[66] Dr Steve Crooks: Wetland Scientist at Silvestrum Climate Associate; Dr Ibrahim Zia: Sectional Head of Physical Oceanography Department, National Institute of Oceanography, Pakistan

$$RC_{E_i} = \frac{E_i}{\sum_{i=1}^{I} E_i}$$

(eq. nr. not provided)

Where:

RC_{Ei}	Relative contribution of each source *i* to the sum of project and leakage GHG emissions
E_i	GHG emissions by sources of project and possible decreases in carbon pools and leakage emissions *i*
i	Index for individual sources of project and leakage GHG emissions
I	total number of sources considered

Fossil fuel emissions are the only emissions source considered in the assessment of *de minimis* emissions sources in the project scenario. Comparing these with the results from carbon sequestration in biomass and soil (Sections 3.2.2.4 and 3.2.2.5, respectively) shows that the fuel emissions are 1.4% of net removals in 2016, declining to 0.28% in 2017, 0.11% in 2018 and then to less than 0.1% in subsequent years – all less than 5%. Therefore, fossil fuel emissions are a *de minimis* emissions source (Table 18).

Table 18. Fossil fuel emissions as a percentage of net GHG removals.

Year	$GHG_{WPS\text{-}biomass}$ + $GHG_{WPS\text{-}soil}$	$GHG_{WPS\text{-}fuel}$	%
2016	34,325	481.8	1.40
2017	175,115	481.8	0.28
2018	420,704	481.8	0.11
2019+	714,361+	481.8	<0.1

3.2.3 Leakage

The project meets the applicability conditions and requirements set out by VM0033 (see Sections 3.2.3.1 and 3.2.3.2 below), therefore:

$GHG_{LK} = 0$.

3.2.3.1 Activity-shifting leakage and market leakage

Meeting the applicability conditions of methodology VM0033 ensure that activity-shifting leakage and market leakage do not occur. This project meets these applicability conditions, as justified in Section 3.1.2, point 3.

Since this ARR/RWE project activity is associated with a REDD+ activity (see Section 2.1.1), it is worthwhile to outline the wider project activities implemented outside the ARR/RWE Project Area to avoid activity-shifting and market-effect leakage.

Table 19. Leakage management activities undertaken by the wider REDD+ project.

Leakage Management Activity	Description
Improved and Intensified livestock farming	Livestock is an important component in the livelihoods of local communities, and they have been using mangroves as a grazing land as well as for cutting of mangroves branches, leaves and propagules as fodder. These communities will be trained to practice rotational grazing, keep livestock numbers according to the carrying capacity of the site, and avoid areas where there is risk of trampling of young natural re-generation or newly planted area. Other associated activities include provision of alternative sources of livestock fodder through promotion of multi-purpose fodder tree species outside the Project Area, enhancement and diversification of their income sources through training of the communities in climate-smart livestock management practices, and vaccination of livestock to prevent losses on account of death of animals by various diseases. For the latter set of activities, linkages will be developed by Sindh Forest Department with Livestock Department.
Promotion of Agroforestry	The project will promote the planting of fast-growing multi-purpose tree species that will provide alternative sources of timber, fuelwood, fodder and income to the local communities.
Promotion of fuel-efficient cooking stoves	Fuel-efficient stoves are one means of saving on the usage of wood as a source of energy. Their wider use by the local communities alongside other alternative sources of energy will reduce the community demand for mangrove wood as a source of wood.
Promotion of alternative energy sources	Local communities use mangrove and other wood as a source of energy. To meet their energy needs, the project promotes the planting of other tree species for fuelwood purposes in the adjoining areas outside the Project Area so as to cater to their energy needs. It also promotes the use of solar energy and other energy sources besides various energy conservation measures.
Awareness raising	Awareness raising about mangroves and coastal ecosystems among the various stakeholder groups is an important project objective. Toward this end it is implementing a number of activities. These include awareness creation about the various ecosystem services of mangroves and coastal ecosystems(provisioning services such as spawning sites and nursery habitats for various types of fishes and shrimps, production of various non-wood products, etc.; regulating services such as role in climate change mitigation and adaptation, regulation of the harmful impacts of tsunamis, etc.; supporting services such as habitat provision for various types of wildlife; and information, cultural and recreational services), best practices in the conservation, development and sustainable management of mangroves, and mobilisation of financial resources for their conservation and sustainable development. Among other stakeholder groups, an important target groups for these awareness raising activities are the various agents of deforestation and forest degradation such as local communities and immigrants who could potentially shift their harmful deforestation and forest degradation activities to the leakage

	belt.
Trainings and capacity building	Training and capacity building of local communities and other stakeholder groups is crucial for mangrove conservation, development and sustainable management both in the Project Area. Training activities among others will include training in various mangrove rehabilitation and development activities (propagules collection and storage, nurseries raising, mangroves planting and after-care, etc.), eco-friendly mangrove ecosystem management, mangroves and coastal ecosystems biodiversity conservation, participatory planning, implementation, monitoring and evaluation of mangroves conservation and development interventions, rapid rural appraisal and community development measures, etc.
Effective law enforcement	Effective law enforcement is an important policy tool alongside economic incentives, awareness creation, training and capacity and social capital development. The project therefore lays emphasis on and has provisions for effective law enforcement so as to avoid the chances of activity shifting. These measures include effective enforcement of mangrove stewardship agreements, mobilisation of community and other stakeholders in support of mangroves conservation and sustainable management, more effective forest surveillance, intelligence gathering, forest offenders' apprehension, prosecution, and early and vigorous adjudication of forest offence cases. Mangrove Stewardship Agreements have been executed with local communities to involve them in the protection of newly planted mangrove areas as well protection of existing mangrove forests.

3.2.3.2 Ecological leakage

As set out in VM0033, the tidal range and sediment delivery experienced by wetlands outside the Project Area must remain within the system tolerance. To guide this assessment, Table 20 outlines avoidance criteria related to a variety of processes that may occur outside the Project Area due to an inappropriate project design.

Table 20. Processes Associated with Ecological Leakage Outside Project Boundary, Related Criteria for their Avoidance and Project Justification.

Ecological leakage process outside project boundary	Avoidance criterion and project justification
Lowering water table that causes increased soil carbon oxidation	Maintain wetland conditions (e.g., converting from impounded water to a wetland does not cause soil oxidation) Justification: The project does not alter the hydrology of the Indus Delta and adjacent lands.
Lowering water table that causes increased N_2O emissions	No conversion of non-seagrass wetland to open water Justification: The project does not alter the hydrology of the Indus Delta and adjacent lands.
Raising water table that causes increased CH_4 emissions	No conversion of non-wetland to wetland Justification: The project does not alter the hydrology of the Indus Delta and adjacent lands. Where such a conversion occurs, it is due to sea level rise.
Raising water table that causes decreased vegetation production that causes decreased new soil carbon sequestration	No causation of vegetated to non-vegetated (or poorly vegetated) conditions Justification: The project does not alter the hydrology of the Indus Delta and adjacent lands. Therefore, it does not cause an alteration of vegetation cover outside the Project Area. The presence of mangrove trees inside the Project Area will slow tidal flows and increase sediment deposition reducing sediment that flows into the sea, which does not lead to a decreased carbon sequestration outside the Project Area.

3.2.4 Net GHG Emission Reductions and Removals

The total net GHG emission reductions from the ARR/RWE project activity are calculated as follows:

$$NER_{RWE} = GHG_{BSL} - GHG_{WPS} + FRP - GHG_{LK} \quad \textbf{(84)}$$

Where:

NER_{RWE}[67] Net CO_2e emission reductions from the RWE project activity; t CO_2e

GHG_{BSL} Net CO_2e emissions in the baseline scenario; t CO_2e

[67] Also stands for $NER_{ARR/RWE}$

GHG_{WPS} Net CO_2e emissions in the project scenario; t CO_2e

FRP *Fire Reduction Premium* (net CO_2e emission reductions from organic soil combustion due to rewetting and fire management); t CO_2e

GHG_{LK} Net CO_2e emissions due to leakage; t CO_2e

The *FRP* is not relevant for this project because organic soils and fire are not present.

The results for NER_{RWE} during the project crediting period are provided in Table 22.

Estimation of uncertainty

The adjusted value for NER_t to account for uncertainty is calculated as:

$$adjusted\_NER_t = NER_t \times (100\% - NER_{ERROR} + allowable\_uncert) \quad (92)$$

Where:

$adjusted\_NER_t$ Net GHG emission reductions in year *t* adjusted to account for uncertainty; t CO_2e

NER_t Total net GHG emission reductions from the project activity up to year *t*; t CO_2e

NER_{ERROR} Total uncertainty for WRC project activity; %

allowable_uncert Allowable uncertainty; 20% or 30% at a 90% or 95% confidence level, respectively; %

For the baseline scenario, there is no uncertainty associated with key variables, because they are either *de minimis* or based on default values, see Table 21.

For the project scenario, uncertainties for most variables will be quantified in the monitoring plan. The determination of uncertainties of certain variable is conditional on the method chosen.

Table 21. Uncertainty analysis for baseline and project scenario.

Variable	Uncertainty	Comment
Baseline scenario		
$A_{i,t}$	N/A	Same as in project scenario; however, resulting uncertainty in this variable is negligible considering that baseline emissions are *de minimis*
$GHG_{BSL\text{-}biomass}$	N/A	Variable is *de minimis* (removals) or conservatively not accounted for (baseline degradation)
$GHG_{BSL\text{-}insitu\text{-}CO2,i,t}$	N/A	Variable is *de minimis* (removals) or conservatively not accounted for (baseline degradation)
$C\%_{BSL\text{-}emitted,i,t}$	N/A	Default value from specified CPDE
$C_{BSL\text{-}soil,i,t=0}$		Eight cores were collected, with an average of 163.6 t C ha^{-1}. The standard deviation is 43.7 and the 95% CI is 30.3. The uncertainty is calculated at 9.3% (100 * (95% CI / 2) / average)
$GHG_{BSL\text{-}eroded\text{-}CO2,i,t}$	N/A	Based on $C_{BSL\text{-}soil,i,t=0}$ and areas eroded

$GHG_{BSL\text{-}soil\text{-}CH4,i,t}$	N/A	Same as in project scenario (Section 3.2.1.5.3)
$GHG_{BSL\text{-}soil\text{-}N2O,i,t}$	N/A	Same as in project scenario (Section 3.2.1.5.4)
Project scenario (*ex ante*) – not monitored		
$Deduction_{alloch}$	N/A	A representative sample size was used to determine this value
$GHG_{WPSL\text{-}soil\text{-}CH4,i,t}$	N/A	Same as in baseline scenario
$GHG_{WPSL\text{-}soil\text{-}N2O,i,t}$	N/A	Same as in baseline scenario
$GHG_{WPS\text{-}fuel,i,t}$	N/A	Variable is *de minimis*
Project scenario (*ex post*)		
$A_{i,t}$		To be provided in monitoring report (Section 3.3.3.2)
$GHG_{WPS\text{-}biomass}$		To be provided in monitoring report (Section 3.3.3.3)
$C_{BSL\text{-}soil,i,t}$		To be provided in monitoring report – If method is based on field-collected data (Section 3.3.3.4)
Vegetation cover		To be provided in monitoring report – If method is based on default value (Section 3.3.3.4)

Maximum quantity of GHG emission reductions that may be claimed from the biomass and SOC pools

For projects claiming reductions of baseline GHG emissions, the maximum quantity of GHG emission reductions that may be claimed from the SOC pool is limited to the difference between the soil organic carbon stock in the project scenario and baseline scenario at the 100-year mark.

However, the project does not claim reductions from baseline emissions, only removals due to carbon sequestration in biomass and soil.

The project does account for biomass and SOC losses due to sea level rise. For projects where sea level rise may cause a loss of tidal wetland and associated biomass and/or soil organic carbon stocks, the maximum quantity of GHG emission reductions or removals that may be claimed from the biomass and soil organic carbon pool is limited to the net GHG benefit generated by the project 100 years after its start date, as follows:

$$NER_{RWE\text{-}max} = NER_{RWE} \text{ at } t = 100 \quad (86)$$

Where:

$NER_{RWE\text{-}max}$ Maximum net CO_2e emission reductions or removals that can be claimed from the RWE project activity at any point in time during the crediting period; t CO_2e

NER_{RWE} Net CO_2e emission reductions from the RWE project activity; t CO_2e

In-situ net GHG emissions in the baseline scenario are set to zero, see Section 3.2.1.5.2. Therefore, the carbon stock in the project scenario at $t = 100$ determines the maximum quantity. This quantity $NER_{RWE\text{-}max}$ equals 142,050,139 tCO_2e, see Figure 26 and Table 23. This amount is predicted to be reached in project year 40, or calendar year 2054. From this year onwards, no GHG removals will be claimed.

Estimation of non-permanence buffer and VCUs

The number of verified carbon units (VCUs) is calculated as:

$$VCU_{t2} = \left(adjusted\_NER_{t2} - adjusted\_NER_{t1}\right) - Bufferw_{t2} \quad (93)$$

Where:

VCU_{t2}	Number of VCUs in year *t2*
$adjusted\_NER_{t1}$	Total net GHG emission reductions from the project activity up to year *t1* adjusted to account for uncertainty; t CO_2e
$adjusted\_NER_{t2}$	Total net GHG emission reductions from the project activity up to year *t2* adjusted to account for uncertainty; t CO_2e
$Bufferw_{t2}$	Number of buffer credits to be contributed to the AFOLU pooled buffer account in year *t2*

$$Bufferw_{t2} = \left(NER_{stock,t2} - NER_{stock,t1}\right) \times Buffer\%_{t2} \quad (94)$$

Where:

$Bufferw_{t2}$	Number of buffer credits to be contributed to the AFOLU pooled buffer account in year *t2*
$NER_{stock,\ t1}$	Net GHG emission reductions from the project activity up to year *t1*, discarding non-CO_2 emissions from soil and biomass burning and emissions from fossil fuel use; t CO_2e
$NER_{stock,\ t2}$	Net GHG emission reductions from the project activity up to year *t2*, discarding non-CO_2 emissions from soil and biomass burning and emissions from fossil fuel use; t CO_2e
$Buffer\%_{t2}$	Percentage of buffer credits to be contributed to the AFOLU pooled buffer account in year *t2*; %

The percentage of buffer credits to be contributed to the AFOLU pooled buffer account has been determined by applying the latest version of the VCS AFOLU Non-Permanence Risk Tool, see Appendix 12. Risk Analysis.

Table 22. Net GHG Emission Reductions and Removals in Baseline and Project, and Leakage.

Project year	Calendar year	*adjusted_NER*$_t$			
		Estimated baseline removals (t CO_2e)	Estimated project removals (t CO_2e)	Estimated leakage emissions (t CO_2e)	Estimated net GHG removals (t CO_2e)
1	2015	0	0	0	0
2	2016	0	37,719	0	37,719
3	2017	0	192,432	0	192,432
4	2018	0	462,307	0	462,307

5	2019	0	785,003	0	785,003
6	2020	0	918,916	0	918,916
7	2021	0	1,580,348	0	1,580,348
8	2022	0	2,060,015	0	2,060,015
9	2023	0	2,673,162	0	2,673,162
10	2024	0	3,419,415	0	3,419,415
11	2025	0	3,818,606	0	3,818,606
12	2026	0	5,144,231	0	5,144,231
13	2027	0	5,958,777	0	5,958,777
14	2028	0	6,619,386	0	6,619,386
15	2029	0	7,055,399	0	7,055,399
16	2030	0	6,819,447	0	6,819,447
17	2031	0	7,367,384	0	7,367,384
18	2032	0	7,311,935	0	7,311,935
19	2033	0	7,155,761	0	7,155,761
20	2034	0	6,924,172	0	6,924,172
21	2035	0	4,716,942	0	4,716,942
22	2036	0	6,318,149	0	6,318,149
23	2037	0	5,976,914	0	5,976,914
24	2038	0	5,624,547	0	5,624,547
25	2039	0	5,269,362	0	5,269,362
26	2040	0	2,924,970	0	2,924,970
27	2041	0	4,575,793	0	4,575,793
28	2042	0	4,247,028	0	4,247,028
29	2043	0	3,932,420	0	3,932,420
30	2044	0	3,633,445	0	3,633,445
31	2045	0	1,345,412	0	1,345,412
32	2046	0	3,086,866	0	3,086,866
33	2047	0	2,841,134	0	2,841,134
34	2048	0	2,612,042	0	2,612,042
35	2049	0	2,399,011	0	2,399,011

36	2050	0	185,491	0	185,491
37	2051	0	2,019,874	0	2,019,874
38	2052	0	1,853,735	0	1,853,735
39	2053	0	1,700,600	0	1,700,600
40	2054	0	481,986	0	481,986
41	2055	0	0	0	0
42	2056	0	0	0	0
43	2057	0	0	0	0
44	2058	0	0	0	0
45	2059	0	0	0	0
46	2060	0	0	0	0
47	2061	0	0	0	0
48	2062	0	0	0	0
49	2063	0	0	0	0
50	2064	0	0	0	0
51	2065	0	0	0	0
52	2066	0	0	0	0
53	2067	0	0	0	0
54	2068	0	0	0	0
55	2069	0	0	0	0
56	2070	0	0	0	0
57	2071	0	0	0	0
58	2072	0	0	0	0
59	2073	0	0	0	0
60	2074	0	0	0	0

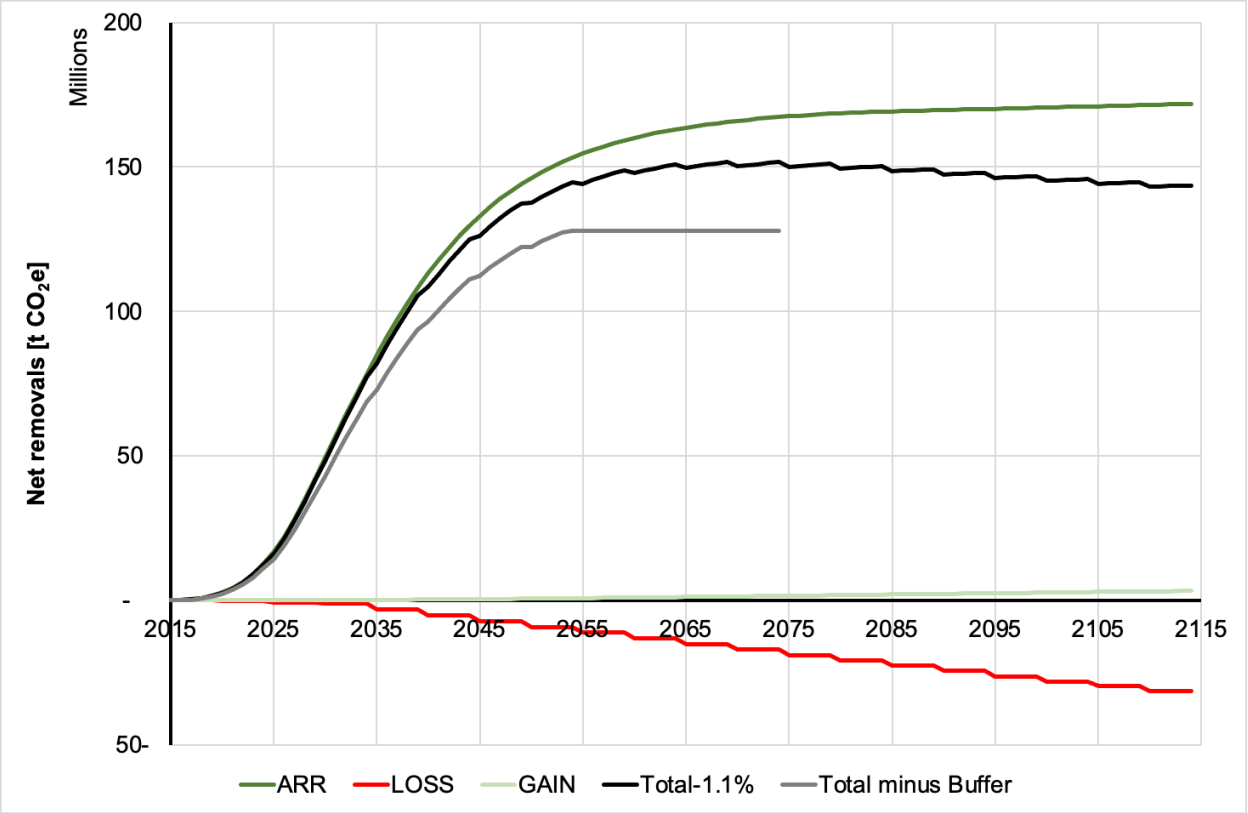


Figure 26. Summary of net GHG emissions in t CO_2e since the project start date in 2015. ARR: Net GHG removals as a result of mangrove reforestation; LOSS: Carbon loss in biomass and soil as a result of erosion due to sea level rise; GAIN: Net removals as a result of mangrove establishment in new mangrove habitats due to sea level rise.

Table 23. NER_{RWE}, buffer withholding and VCUs, cumulative up to year *t*.

Project year	Calendar year	$NER_{RWE}^{\#}$ (t CO_2e)	*Buffer (10%)* (t CO_2e)	*VCUs* (t CO_2e)
1	2015	-	-	-
2	2016	37,719	3,772	33,947
3	2017	230,152	23,015	207,136
4	2018	692,459	69,246	623,213
5	2019	1,477,462	147,746	1,329,716
6	2020	2,396,378	239,638	2,156,740
7	2021	3,976,727	397,673	3,579,054
8	2022	6,036,742	603,674	5,433,068

9	2023	8,709,904	870,990	7,838,913
10	2024	12,129,319	1,212,932	10,916,387
11	2025	15,947,925	1,594,792	14,353,132
12	2026	21,092,156	2,109,216	18,982,941
13	2027	27,050,934	2,705,093	24,345,840
14	2028	33,670,319	3,367,032	30,303,287
15	2029	40,725,718	4,072,572	36,653,147
16	2030	47,545,166	4,754,517	42,790,649
17	2031	54,912,550	5,491,255	49,421,295
18	2032	62,224,485	6,222,448	56,002,036
19	2033	69,380,246	6,938,025	62,442,221
20	2034	76,304,417	7,630,442	68,673,976
21	2035	81,021,359	8,102,136	72,919,223
22	2036	87,339,509	8,733,951	78,605,558
23	2037	93,316,422	9,331,642	83,984,780
24	2038	98,940,969	9,894,097	89,046,872
25	2039	104,210,332	10,421,033	93,789,298
26	2040	107,135,302	10,713,530	96,421,772
27	2041	111,711,095	11,171,109	100,539,985
28	2042	115,958,123	11,595,812	104,362,310
29	2043	119,890,542	11,989,054	107,901,488
30	2044	123,523,987	12,352,399	111,171,588
31	2045	124,869,399	12,486,940	112,382,459
32	2046	127,956,265	12,795,627	115,160,639
33	2047	130,797,399	13,079,740	117,717,659
34	2048	133,409,441	13,340,944	120,068,497
35	2049	135,808,453	13,580,845	122,227,607
36	2050	135,993,944	13,599,394	122,394,549
37	2051	138,013,818	13,801,382	124,212,436
38	2052	139,867,553	13,986,755	125,880,798
39	2053	141,568,153	14,156,815	127,411,338

40	2054	142,050,139	14,205,014	127,845,125
41	2055	142,050,139	14,205,014	127,845,125
42	2056	142,050,139	14,205,014	127,845,125
43	2057	142,050,139	14,205,014	127,845,125
44	2058	142,050,139	14,205,014	127,845,125
45	2059	142,050,139	14,205,014	127,845,125
46	2060	142,050,139	14,205,014	127,845,125
47	2061	142,050,139	14,205,014	127,845,125
48	2062	142,050,139	14,205,014	127,845,125
49	2063	142,050,139	14,205,014	127,845,125
50	2064	142,050,139	14,205,014	127,845,125
51	2065	142,050,139	14,205,014	127,845,125
52	2066	142,050,139	14,205,014	127,845,125
53	2067	142,050,139	14,205,014	127,845,125
54	2068	142,050,139	14,205,014	127,845,125
55	2069	142,050,139	14,205,014	127,845,125
56	2070	142,050,139	14,205,014	127,845,125
57	2071	142,050,139	14,205,014	127,845,125
58	2072	142,050,139	14,205,014	127,845,125
59	2073	142,050,139	14,205,014	127,845,125
60	2074	142,050,139	14,205,014	127,845,125

#: Up to $NER_{RWE\text{-}max}$

3.3 Monitoring

3.3.1 Data and Parameters Available at Validation

Data / Parameter	$A_{BSL,i}$
Data unit	Ha
Description	Area of baseline stratum *i* (in year *t*)
Source of data	See Section 3.1.3
Value applied	See Table 15

Justification of choice of data or description of measurement methods and procedures applied	See Section 3.1.3 – Project Boundary – for description of measurement methods and procedures applied
Purpose of data	Determination of baseline scenario
Comments	N/A

Data / Parameter	$\Delta C_{TREE\_BSL,t}$
Data unit	t CO_2e yr^{-1}
Description	Change in carbon stock in baseline tree biomass within the project area in year *t*
Source of data	See Section 3.2.1.4
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	See section 3.2.1.4 – Net carbon stock change in biomass carbon pools in the baseline scenario
Purpose of data	Determination of baseline scenario
Comments	N/A

Data / Parameter	CF_i
Data unit	t C t^{-1} d.m.
Description	Carbon fraction of dry matter in t C t^{-1} d.m. for species *j*
Source of data	Kauffman, J.B. and D.C. Donato. 2012 Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. Working Paper 86. CIFOR, Bogor, Indonesia.
Value applied	0.48 t C t^{-1} d.m. for aboveground biomass 0.39 t C t^{-1} d.m. for belowground biomass
Justification of choice of data or description of measurement methods and procedures applied	These values are deemed to be defensible default values for carbon fraction.
Purpose of data	Calculation of project emissions
Comments	N/A

Data / Parameter	$C_{BSL\text{-}soil,i,t}$
Data unit	t C ha^{-1}
Description	Soil organic carbon stock in the baseline scenario in stratum *i* in year *t*
Source of data	See Section 3.2.1.5
Value applied	163.6 t C ha^{-1}
Justification of choice of data or description of measurement methods and procedures applied	See Section 3.2.1.5 – Net GHG emissions from soil in the baseline scenario
Purpose of data	Determination of baseline scenario
Comments	N/A

Data / Parameter	$GHG_{BSL\text{-}insitu\text{-}CO2,i,t}$
Data unit	t CO_2e ha^{-1} yr^{-1}
Description	CO_2 emissions from the SOC pool of *in-situ* soils in the baseline scenario in stratum *i* in year *t*
Source of data	See Section 3.2.1.5.2
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	See Section 3.2.1.5.2 – CO_2 emissions from soil – *in situ*
Purpose of data	Determination of baseline scenario
Comments	N/A

Data / Parameter	$GHG_{WPS\text{-}soil\text{-}CO2,i,t}$
Data unit	t CO_2e ha^{-1} yr^{-1}
Description	CO_2 emissions from the SOC pool in the project scenario in stratum *i* in year *t*
Source of data	See Section 3.2.2.5.1.2
Value applied	-5.35

Justification of choice of data or description of measurement methods and procedures applied	See Section 3.2.2.5.1.2 – CO_2 emissions from soil – *in situ*
Purpose of data	Calculation of project emissions
Comments	N/A

Data / Parameter	*%C*
Data unit	%
Description	Percentage of soil organic C
Source of data	See Section 3.2.2.5.1.2
Value applied	2.02
Justification of choice of data or description of measurement methods and procedures applied	See Section 3.2.2.5.1.2 – CO_2 emissions from soil – *in situ*
Purpose of data	Calculation of project emissions
Comments	This value is used to calculate the deduction from allochthonous carbon.

Data / Parameter	$Deduction_{alloch}$
Data unit	t CO_2e ha^{-1} yr^{-1}
Description	Deduction from CO_2 emissions from the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon
Source of data	See Section 3.2.2.5.1.2
Value applied	4.95
Justification of choice of data or description of measurement methods and procedures applied	See Section 3.2.2.5.1.2 – CO_2 emissions from soil – *in situ*
Purpose of data	Calculation of project emissions
Comments	N/A

Data / Parameter	$GHG_{WPS\text{-}fuel,i,t}$

Data unit	t CO_2e yr^{-1}
Description	GHG emissions from fossil fuel use in the project scenario in stratum *i* in year *t*
Source of data	See Section 3.2.2.6
Value applied	482
Justification of choice of data or description of measurement methods and procedures applied	See Section 3.2.2.6
Purpose of data	Calculation of project emissions
Comments	N/A

Data / Parameter	*allowable_uncert*
Data unit	%
Description	Allowable uncertainty; 20% or 30% at a 90% or 95% confidence level, respectively
Source of data	See Section 3.2.2.6
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of data	Calculation of net GHG emissions reductions
Comments	N/A

3.3.2 Data and Parameters Monitored

Data / Parameter	$\Delta C_{TREE\_PRO,i,t}$
Data unit	t CO_2e yr^{-1}
Description	Change in carbon stock in trees in stratum *i* during the period between two points of time t_1 and t_2
Source of data	Derived from application of AR Tool 14 using data collected in the project area

Description of measurement methods and procedures to be applied	See Section 3.3.3.3 – Estimation of tree carbon stocks
Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on year and stratum
Monitoring equipment	See Section 3.3.3.3
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	See Section 3.3.3.3
Comments	N/A

Data / Parameter	*Crown or vegetation cover*
Data unit	%
Description	Proportion of an area covered by the crowns of live trees
Source of data	See Section 3.3.3.3
Description of measurement methods and procedures to be applied	See Section 3.3.3.3 – Estimation of tree carbon stocks
Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on year and stratum
Monitoring equipment	See Section 3.3.3.3
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	See Section 3.3.3.3

Comments	Provide any additional comments

Data / Parameter	$A_{t,i}$
Data unit	Ha
Description	Area of project stratum *i* (in year *t*)
Source of data	Delineation of strata using a Geographic Information System (GIS), integrating GPS data collected in the field.
Description of measurement methods and procedures to be applied	See Section 3.3.3.3
Frequency of monitoring/recording	Each monitoring period
Value applied	27 plots per stratum
Monitoring equipment	N/A
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	Equation 2 from CDM AR Tool 3 (Calculation of the number of sample plots for measurements within A/R CDM project activities)
Comments	N/A

Data / Parameter	*N*
Data unit	Dimensionless
Description	Number of sample plots required for estimation of biomass stocks within the project boundary
Source of data	Derived from Equation 2 from CDM AR Tool 3 using field data
Description of measurement methods and procedures to be applied	See Section 3.3.3.3

Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on stratum
Monitoring equipment	N/A
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	Equation 2 from CDM AR Tool 3 (Calculation of the number of sample plots for measurements within A/R CDM project activities)
Comments	N/A

Data / Parameter	$C_{WPS,soil,i,t}$
Data unit	t C ha^{-1}
Description	Carbon stock in the project scenario in stratum *i* in year *t*
Source of data	Equation 99 from VM0033 using data collected in the Project Area
Description of measurement methods and procedures to be applied	See Section 3.3.3.4
Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on stratum and year
Monitoring equipment	See Section 3.3.3.4
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	Equation 99 of VM0033
Comments	N/A

Data / Parameter	*%OM*
Data unit	%
Description	Percentage of soil that is organic matter
Source of data	Calculated from combustion of soil collected at various depths in a given stratum in a given year
Description of measurement methods and procedures to be applied	See Section 3.3.3.4
Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on stratum and year
Monitoring equipment	See Section 3.3.3.4
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	See Section 3.3.3.4
Comments	N/A

Data / Parameter	$\%C_{soil}$
Data unit	%
Description	Percentage of soil organic C
Source of data	Calculated from *%OM* derived from soil cores collected from the Project Area
Description of measurement methods and procedures to be applied	See Section 3.3.3.4
Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on stratum and year

Monitoring equipment	See Section 3.3.3.4
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	See Section 3.3.3.4
Comments	N/A

Data / Parameter	*BD*
Data unit	g cm^{-3}
Description	Dry bulk density
Source of data	See Section 3.3.3.4
Description of measurement methods and procedures to be applied	See Section 3.3.3.4
Frequency of monitoring/recording	Each monitoring period
Value applied	Variable depending on stratum and year
Monitoring equipment	See Section 3.3.3.4
QA/QC procedures to be applied	See Section 3.3.3.6
Purpose of data	Calculation of project emissions
Calculation method	See Section 3.3.3.4
Comments	N/A

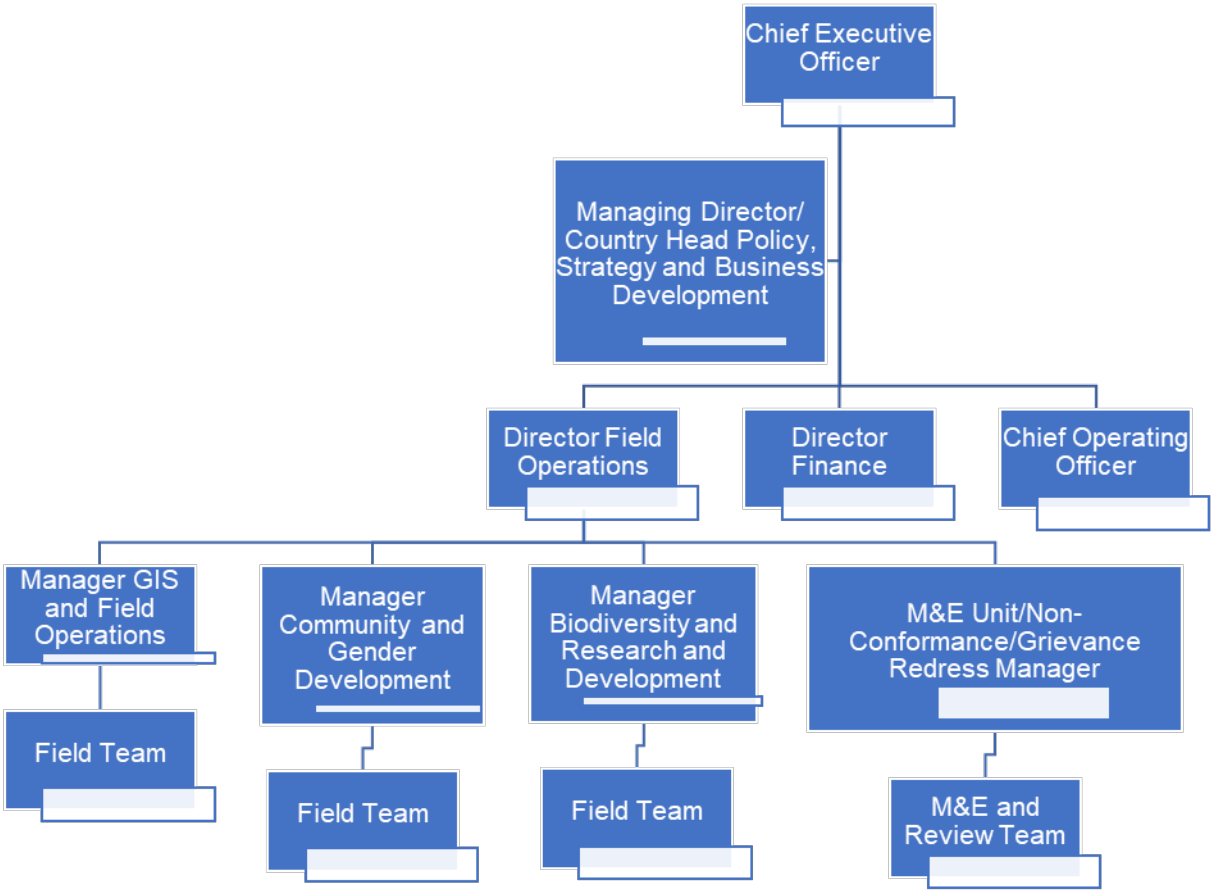
Data / Parameter	NER_{ERROR}
Data unit	%
Description	Total uncertainty for project activity

Source of data	N/A
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Each monitoring period
Value applied	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of net GHG emission reductions
Calculation method	N/A
Comments	N/A

3.3.3 Monitoring Plan

3.3.3.1 Organisational structure

The Sindh Forest Department and IDC are staffed by qualified, competent and experienced professionals who carry out monitoring of activities as per the requirements of the VCS and CCB Standards. Policies are also in place for the oversight and accountability of monitoring activities and procedure for handling non-conformances with the validated monitoring plan. These have been made available to the VVB. An outline of the IDC team organogram is given below:



The field teams for data collection comprise a team leader, resource manager, facilitator, measurement taker (s), data recorder (s), and observer (s). These teams are responsible for all data collection. The project has developed policies (given separately in SOPs) for oversight and accountability of monitoring activities as well as procedures for handling non-conformances with the validated monitoring plan. It has methods for measuring, recording, storing, aggregating, collating and reporting data and parameters set out in Section 3.3.2 above.

The data management process of the project comprises the following majore steps:

- Undertaking of field work and collection of field data as per specified SOP for data collection and procurement
- Data entry
- Data QA/QC
- Data aggregation and development of descriptive statistics

- Data analysis and use of various analytic tools
- Data storage and archiving
- Data security and back-up
- Maintenance of source documents, means of verifications and support documents
- Data availability to verifiers and other stakeholders
- Data handing over and taking over, in case of staff transfers
- Report preparation

The managers of various field units (GIS, community development, biodiversity and M&E) strictly adhere to the SOPs for the conduct of field work, data recording, data entry, data quality, data analysis and report preparation in line with the flow diagram below:



3.3.3.2 Monitoring of project implementation

Once established, every plantation will have a unique identifier and a spreadsheet will be maintained with all relevant plantation information: species planted and percent representation of each species, area of the plantation, date(s) planted, and plantation strata (year). The boundaries of each plantation will be delineated by walking the perimeter with a handheld GPS unit with tracks enabled.

3.3.3.3 Delineation of strata in the Project Area

Prior to commencement of planting activities, suitable islands for planting are selected and the spatial coordinates of each plantation are recorded with a GPS unit. Within the laboratory, the field team will hand delineate the plantation area using GIS to plan for the extent of planting so that exact labour and planting material are employed.

Propagules are planted in a 3 x 3 m grid throughout the entire plantation area that is not bifurcated by a channel 3 m or more. If a larger channel is present, it is not included in the area estimates. Once planting is complete on that island, the GIS team along with field team measure the area by traversing the plantation perimeter with a WAAS-enabled GPS unit. The GPS data are uploaded to a computer and a GIS is used to delineate the plantation and calculate the area.

The total area planted each year, $A_{WPS,i,t}$, is the sum of all plantations established in that stratum in year *t*.

There is inherent uncertainty associated with the delineation of stratum boundaries using GPS units. Unless the plantation area is delineated using an RTK GPS, which has 2-3 cm accuracy, regular handheld units have an accuracy of 2-5 m. To address this known uncertainty, two GPS units will be used in tandem when the stratum boundary is walked and the tracks created will be compared using GIS analysis. If variation between the tracks is observed, the average distance between the two will be delineated.

3.3.3.4 Estimation of tree carbon stocks

Source of data

Field collected measurements of mangrove allometry will be used to quantify above- and belowground tree carbon stocks.

Measurement methods and procedures

Tree carbon stocks will be sampled according to stratum, which is defined by the year that the area was planted. Equation 2 from CDM AR Tool 3 (Calculation of the number of sample plots for measurements within A/R CDM project activities) will be used to calculate the number of sample plots per stratum:

$$n = \left(\frac{t_{VAL}}{E}\right)^2 * \left(\sum_i w_i * s_i\right)^2$$

Where:

n	Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless
t_{VAL}	Two-sided Student's *t*-value at infinite degrees of freedom for the required confidence level; dimensionless
E	Acceptable margin of error (i.e., one-half the confidence interval) in estimation of biomass stock within the project boundary; t d.m. (or t d.m. ha^{-1}), i.e. in the units used for s_i
w_i	Relative weight of the area of stratum *i* (i.e., the area of the stratum *i* divided by the Project Area); dimensionless
s_i	Estimated standard deviation of biomass stock in stratum *i*; t d.m. (or t d.m. ha^{-1})
i	1, 2, 3, … biomass stock estimation strata within the project boundary

The number of sample plots allocated to each stratum is calculated as:

$$n_i = n * \frac{w_i * s_i}{\sum_i w_i * s_i}$$

Where:

n_i	Number of sample plots allocated to stratum *i*; dimensionless
n	Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless
w_i	same as above
s_i	same as above
i	same as above

Assuming a 90% confidence interval and margin of error of 10%, a total of 163 plots are needed to be sampled at each monitoring event, although this total will not be reached until all areas are planted. This total is based on a standard deviation of mature mangrove biomass based on a survey conducted by the Pakistan Forest Institute: 31.5 t d.m. ha^{-1}. The number of sample plots allocated to each stratum is in Table 23, and this will be reassessed using available information at during each validation.

Plot locations will be randomly located within each stratum using GIS, following CDM AR Tool 14 section 8.1.1 (Stratified random sampling). A 10 m spatial buffer will be created around the edge of each plantation to guarantee that plots are located fully within a given plantation. Upon the field visit, if any plots fall in a channel or mudflat (i.e., a location that was not originally planted within an area), the plot will be relocated to be 20 m away in the direction of where planting occurred. The coordinates of the plot centre will be recorded using a GPS unit.

Table 24. Number of tree biomass plots sampled per monitoring event.

Year planted (stratum)	# of sample plots
2015	7
2016	14
2017	8
2018	8
2019	11
2020	8
2021	15
2022	18
2023	18
2024	18
2025	18
2026	20
Total	163

Each plot will consist of an 8.92 m radius circular plot, which equates to a sampling area of 250 m^2. An initial survey will occur to determine the canopy cover within a plot. Until total tree canopy is greater than 50%, all trees with more than 50% of the basal area falling within that plot will be measured. For all trees, the following measurements will be made:

- Tree height (cm)
- Canopy width (cm)

- Diameter at base (cm; 30 cm from the ground)[68]; and
- Diameter at breast height, if applicable (DBH; 1.30 from the ground or directly above the last prop root for *R. mucronata*).

If a tree has two dominant stems below DBH height, each stem will be treated as if it is a separate tree and DBH and canopy width will be measured for both.

Once total tree canopy is greater than 50%, all trees with a height greater than 1.3 m will be measured within the 8.92 m radius circle. In a nested plot with a radius of 5.64 m (which covers 100 m^2), all trees with a height 1.3 m or less will have the following measurements collected:

- Tree height (cm)
- Canopy width (cm)
- Diameter at base (cm; 30 cm from the ground)

This sampling design is a modified version from Kauffman et al. (2020[69]).

Monitoring equipment

In the field, a WAAS-enabled GPS unit will be used to navigate to the plots and to record plot locations. Measuring tape will be used to delineate the circular plot and callipers will be used to measure the trees. A digital camera will be used to document each plot.

In the laboratory, GIS software ArcGIS version 10.7.1 or greater will be used.

Calculation method

Above- and belowground mangrove biomass will be determined following CDM AR Tool 14 (Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities) using the approach of differencing two independent stock estimations. Aboveground biomass will be determined using species-specific allometric equations (Table 24 and Table 25).

[68] This measurement was made in planted mangroves within the United Arab Emirates when trees were shorter than 1.3 m (Schile et al. 2017)

[69] Kauffman, J.B., M.F. Adame, V.B. Arifanti, L.M. Schile-Beers, et al. 2020. Total ecosystem carbon stocks of mangroves across broad global environmental and physical gradients. *Ecological Monographs*. 90(2): e01405. https://doi.org/10.1002/ecm.1405.

Table 25. Allometric equations for aboveground biomass for mangrove species found within the Indus Delta.

Species	Equation	Source
Avicennia marina	$1.8247 * (C^2 * H)^{1.0202}$	Fu and Wu 2011[70]
Rhizophora mucronata	$0.8069 * DBH^{2.5154}$	Kirui et al. 2006[71]

Where *C* = canopy diameter in metres, *H* = tree height in metres, *DBH* = diameter at breast height

Table 26. Allometric equations for belowground biomass for mangrove species found within the Indus Delta.

Species	Equation	Source
Avicennia marina	$0.6648 * AGB^{0.9437}$	Pakistan Forest Institute
Rhizophora mucronata	$0.6648 * AGB^{0.9437}$	Pakistan Forest Institute

Where *DBH* = diameter at breast height, *D* = diameter at base (30 cm from ground), *AGB* = aboveground biomass.

The plot biomass is estimated according to equations 1 through 3 in appendix 1 of CDM AR Tool 14 (Methods of plot biomass measurement: measurement of fixed area plots):

$$b_{TREE,p,i} = \frac{B_{TREE,p,i}}{A_{PLOT,i}}$$

$$B_{TREE,p,i} = \sum_{j} B_{TREE,j,p,i}$$

$$B_{TREE,j,p,i} = \sum_{l} B_{TREE,l,j,p,i}$$

Where:

$b_{TREE,p,i}$	Tree biomass per hectare in plot *p* of stratum *i*; t d.m. ha^{-1}
$B_{TREE,p,i}$	Tree biomass in sample plot *p* of stratum *i*; t d.m.
$A_{PLOT,i}$	Size of sample plot in stratum *i*; ha
$B_{TREE,j,p,i}$	Biomass of trees of species *j* in sample plot *p* of stratum *i*; t d.m.

[70] Fu, W. and Y. Wu. 2011. Estimation of aboveground biomass of various mangrove trees based on canopy diameter and tree height. *Procedia Environmental Sciences* 10:2189-2194.

[71] Kirui, B, J. G. Kairo, and M. Karachi. 2006. Allometric equations for estimating above ground biomass of *Rhizophora mucronata* Lamk. (Rhizopheraceae) Mangroves at Gazi Bay, Kenya. *Western Indian Ocean Journal of Marine Science* 5(1):27-34.

$B_{TREE,l,j,p,i}$ Biomass of tree *l* of species *j* in sample plot *p* of stratum *i*; t d.m.

Biomass of a tree in a sample plot is estimate by using Equation 4:

$$B_{TREE,l,j,p,i} = f_j(x_{1,l}, x_{2,l}, x_{3,l}, \dots) * (1 + R_j)$$

Where:

$B_{TREE,l,j,p,i}$ Biomass of tree *l* of species *j* in sample plot *p* of stratum *i;* t d.m.

$f_j(x_{1,l}, x_{2,l}, x_{3,l}, \dots)$ Aboveground biomass of the tree returned by the allometric equation for species *j* relating the measurements of tree *l* to the aboveground biomass of the tree; t d.m.

R_j Root to shoot ratio for tree species *j*; dimensionless[72]

Mean carbon stock in trees within the tree biomass estimation strata and the associated uncertainty are estimated by using equations 12 through 17 of CDM AR Tool 14:

$$b_{TREE,i} = \frac{\sum_{p=1}^{n_i} b_{TREE,p,i}}{n_i}$$

$$b_{TREE} = \sum_{i=1}^{M} w_i * b_{TREE,i}$$

$$B_{TREE} = A * b_{TREE}$$

$$C_{TREE} = \frac{44}{12} * CF_{TREE} * B_{TREE}$$

$$u_c = \frac{t_{VAL} * \sqrt{\sum_{i=1}^{M} {w_i}^2 * \frac{{s_i}^2}{n_i}}}{b_{tree}}$$

$$s_i^2 = \frac{n_i * \sum_{p=1}^{n_i} b_{TREE,p,i}^2 - (\sum_{p=1}^{n_i} b_{TREE,p,i}^2)^{\ 2}}{n_i * (n_i - 1)}$$

Where:

$b_{TREE,i}$ Mean tree biomass per hectare in stratum *i*; t d.m. ha^{-1}

$b_{TREE,p,i}$ Tree biomass per hectare in plot *p* of stratum *i*; t d.m. ha^{-1}

B_{TREE} Tree biomass in the tree biomass estimation strata; t d.m.

A Sum of areas of the tree biomass estimation strata, ha

[72] The description of R_j in CDM AR Tool 14 says that "$R_j = \frac{e^{(-1.085+0.9256\ x \ln b}}{b}$ where *b* is the aboveground biomass tree biomass per hectare (in t. d.m. ha^{-1}), unless transparent and verifiable information can be provided to justify a different value." Our method uses results from allometric equations that are added to the results for aboveground biomass, which gives the same result without the additional step of calculating R_j.

b_{TREE}	Mean tree biomass per hectare in the tree biomass estimation strata; t d.m. ha^{-1}
C_{TREE}	Carbon stock in trees in the tree biomass estimation strata; t CO_2e
44/12	Ratio of molecular weight of CO_2 to carbon
CF_{TREE}	Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$
w_i	Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata (i.e. $w_i = A_i / A$); dimensionless
u_c	Uncertainty in C_{TREE}
t_{VAL}	Two-sided Student's *t-value* for a confidence level of 90% and degrees of freedom equal to $n – M$, where *n* is total number of sample plots within the tree biomass estimation strata and *M* is the total number of tree biomass estimation strata
${s_i}^2$	Variance of tree biomass per hectare across all sample plots in stratum *i*; (t d.m. ha^{-1})^2
n_i	Number of sample plots in stratum *i*

The change in tree biomass carbon stock is determined by (Equation 1 in CDM AR Tool 14):

$$\Delta C_{TREE} = C_{TREE,t_2} - C_{TREE,t_1}$$

$$u_{\Delta C} = \frac{\sqrt{(u_1 * C_{TREE,t_1})^2 + (u_2 * C_{TREE,t_2})^2}}{|\Delta C_{TREE}|}$$

Where:

ΔC_{TREE}	Change in carbon stock in trees during the period between two points of time t_1 and t_2; t CO_2e
C_{TREE,t_1}	Carbon stock in trees, including both above- and belowground biomass, as estimated at time t_1; t CO_2e Note 1. At the first verification C_{TREE,t_1} is set equal to the carbon stock in the pre-project tree biomass (i.e., $C_{TREE,t_1} = C_{TREE\_BSL}$).
C_{TREE,t_2}	Carbon stock in trees, including both above- and belowground biomass, as estimated at time t_2; t CO_2e
$u_{\Delta C}$	Uncertainty in ΔC_{TREE}
u_1 , u_2	Uncertainty in C_{TREE,t_1} and C_{TREE,t_2}, respectively

3.3.3.5 Estimation of soil carbon stocks

Source of data

As previously stated in Section 3.2.2.5.1.2, the project is conservatively assuming the use of a default SOC accumulation rate adjusted for the deduction of allochthonous carbon. The project will further investigate if a statistically reliable SOC accumulation rate can be derived based on feasible monitoring procedures described below. In Section 3.2.2.5.1.2, Figure 25 highlights that soil C is accumulating over time within the planted areas. That trend is based only on five cores from planted areas across the Indus Delta. However, assuming that this trend will be supported with the collection of more soil cores once the project is initiated, it is estimated at 1.90 t C ha^{-1} yr^{-1} is accumulating 5 years after planting and this is based on a total soil

depth of 50 cm. The average soil C in eight cores collected in degraded areas devoid of vegetation is 1.5% C (range: 0.63 – 2.02% C, standard error: 0.17). Since this area has had no vegetation for many decades, it is assumed that this carbon within the sediment is all allochthonous carbon and results in 0.176 t C ha^{-1} in one millimetre of sediment deposition. If we assume that sediment is being deposited at the rate of sea level rise, then 2.5 to 3 mm is deposited each year, which results in 0.35 to 0.53 t C ha^{-1} yr^{-1} that is allochthonous. Deducting this from the estimated 1.90 t C ha^{-1} yr^{-1} from the trendline in Figure 25, the resulting soil C accumulation is 1.46 to 1.37 t C ha^{-1} yr^{-1}, which is much greater than the estimate using the default value adjusted for allochthonous C. Further soil core collection and analysis is needed to verify this trend, but it is likely that the determination of soil C sequestration will be based on the chronosequence method described above. Additionally, sediment tiles will be placed in newly planted areas to assess the C content of deposited sediment following methods in VM0033. The project will explore these alternatives in 2021. The collection of the field data will be the responsibility of Sindh Forest Department and the analyses will be conducted by Pakistan Forest Institute, Peshawar.

Measurement of crown or vegetation cover

The canopy cover of biomass plots described in Section 3.3.3.3 will be used to determine whether a given plot has at least 15% canopy cover or at least 50% cover. This is assessed by calculating the crown area of each tree in a plot, summing cover from all trees, and dividing that by the total plot area (250 m^2).

Measurement methods and procedures – field-collected data method

Soil sampling will occur at 10 of the 27 tree sample plots in each stratum[73], and these locations will be chosen using a random number table prior to the field campaign. At the centre of each tree biomass plot described in Section 3.3.3.3 that has not been disturbed by monitoring activity, one 50 cm soil core will be collected using an open face gouge auger (Figure 27). This auger is designed to collect undisturbed soil samples that reduce the potential of compaction in the core. In 5 cm increments, the top 30 cm of the core will be collected and individually stored to be processed in the lab. Another 5 cm sample will be collected at a depth between 45 and 50 cm. When a new plantation is established, three soil cores will be collected following the same methods described above, which is the minimum sample size needed to assess variation within a site (Howard et al., 2014[74]). The locations will be randomly generated using GIS and will be at least 100 m from each other. Samples will be kept cold until transported to the lab.

[73] The average coefficient of variation in the soil data summarised by Chmura et al. (2003) is 0.5, which equates to 10 samples per stratum following sample size calculations in Needelman et al. (2018)

[74] Howard, J., S. Hoyt, K. Isensee, M. Telszewski, and E. Pidgeon (eds.). 2014. Coastal blue carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrasses. Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Arlington, Virginia, USA.



Figure 27. Picture of a one-metre-long open face gouge auger.

Once at the lab, each sample will be dried at 70 ºC until at constant weight and weighed to determine dry weight. Bulk density will be determined by taking the dry weight of each sample and dividing by the subsample volume[75]. Each sample will be ground and homogenised. To determine if carbonates are present in a sample, a few drops of hydrochloric acid will be placed on a subsample of the dried homogenised soil; if activity is noticed, the sample will be treated using standard methods (Howard et al. 2014). A subsample from each sample will be dried, weighed, combusted at 450 ºC for 8 hours, and weighed again to determine the percent organic matter (*%OM*) by loss on ignition (LOI).

Monitoring equipment

In the field, a WAAS-enabled or higher accuracy GPS unit will be used to record the core location. An open-faced gouge corer, measuring tape, knife, spatula, and containers for securely transporting soil samples back to the laboratory will be used.

In the laboratory, the equipment used will be determined by the method used for determining organic carbon content (*%C_{org}*). In all likelihood the Loss on Ignition (LOI) method that uses combustion and empirical relationships between organic carbon and organic matter will be used for the determination of organic carbon content. The LOI method equipment includes among others mortar and pestle for homogenisation, petri dishes, beakers, desiccator, digital balance, a muffle furnace and ceramic crucibles.

Calculation method

The organic carbon content of each core will be determined following VM0033, with the subscript *WPS* substituted for *BSL*:

$$GHG_{WPS-soilCO2,i,t} = \frac{44}{12} * -\frac{C_{WPS-soil,i,t} - C_{WPS-soil,i,(t-T)}}{T} \quad (36)$$

[75] At this time, the exact volume of the subsample is not known but will be determined at the time of sampling.

Where:

$C_{WPS-soil,i,t}$	Soil organic carbon stock in the baseline scenario in stratum *i* in year *t*; t C ha^{-1}
i	1, 2, 3 … M_{WPS} strata in the project scenario
t	1, 2, 3 … *t** years elapsed since the start of the project activity
T	Time elapsed between two successive estimations ($T = t_2 - t_1$)
44/12	Ratio of molecular weight of CO_2 to carbon; dimensionless

The mass of carbon per unit area is calculated following VM0033:

$$C_{WPS,SOC} = \frac{44}{12} * \sum_{i=1}^{N_{depth}} (CF_{SOC,sample} * BD * Thickness * 100) \quad (100)$$

Where:

$C_{WPS,SOC}$	Quantification of carbon within a soil core; t CO_2e ha^{-1}
44/12	Ratio of molecular weight of CO_2 to carbon; dimensionless
N_{depth}	Number of soil horizons, based on subdivisions of the soil core
$CF_{SOC,sample}$	Carbon fraction of the sample, as determined following Equation 77 below
BD	Bulk density, as determined in laboratory; g cm^{-3}
Thickness	Thickness of soil horizon; cm
100	Conversion factor of g cm^{-3} to tonne ha^{-1}

The *%C* in each sample plot will be determined following Allen (1974)[76]:

$$\%C = \frac{\%OM}{1.724}$$

Where:

%C	Percent soil organic carbon in the sample
%OM	Percent organic matter derived from loss-on-ignition (LOI)

and

$$\%OM = \frac{d.m.\,soil\ after\ combusition}{d.m.\,soil\ before\ combustion} * 100$$

Where:

d.m.	dry mass

This equation was chosen due to the general trend of soil *%C* values that are less than 2%. Equation 95 in VM0033 that relates *%OM* to *%C* (*%C* = 0.415 × *%OM* + 2.8857) assumes a baseline *%C* content of

[76] Allen, SE 1974. Chemical Analysis of Ecological Materials, Blackwell Sci., Malden, Mass.

2.8857, which often is an overestimate of soil conditions in the Indus Delta. Thirty-five soil samples collected within the Indus Delta were analysed for both *%OM* and *%C* and the relationship between the variables results in nearly identical results to the equation by Allen (1974; Figure 28)

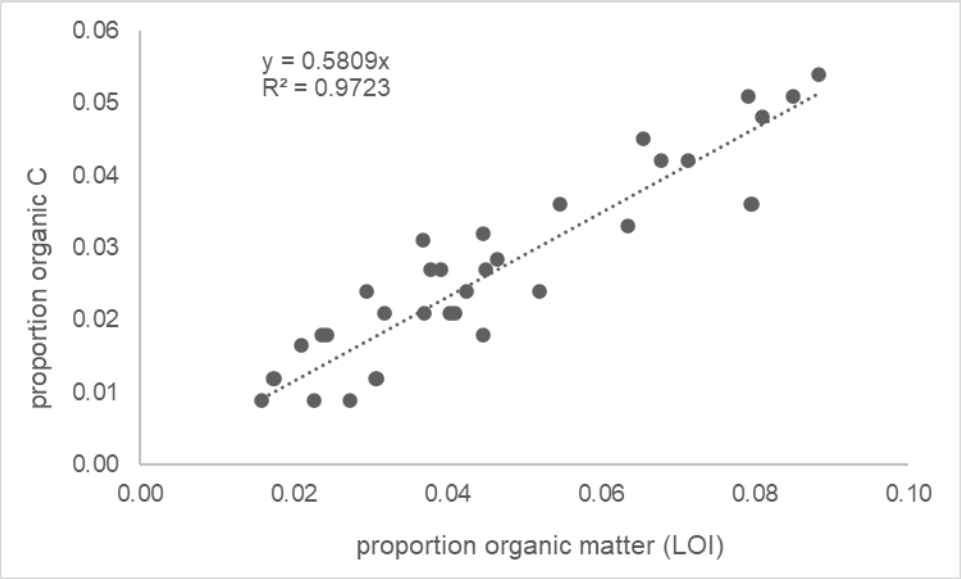


Figure 28. Relationship between the proportion of soil organic matter determined by loss on ignition and the proportion of organic carbon that is analytically determined.

3.3.3.6 Estimation of coastal erosion

Source of data

The monitoring activities will be carried out specifically as part of this project. The analyses will be conducted using GIS and ground-truthed during field campaigns.

Measurement methods and procedures

The amount of area eroded within the Project Area will be assessed every 5 years, beginning with the first assessment in 2021, which will examine erosion since 2015. At a minimum, Landsat satellite imagery (30 m resolution) will be procured over the Project Area. If higher resolution imagery is available, it will be used to enable finer-scale erosion delineation. The shoreline within the Project Area will be manually delineated using GIS for each five-year increment. The delineation will be done by one GIS specialist and confirmed by another.

The manual delineation will be ground-truthed at plantations that are closest to the coastline. In conjunction with mangrove and soil sampling, a team member with a GPS unit will walk portions of shoreline within plantations that are dispersed across the Project Area with the tracking feature enabled. These data will be downloaded in the laboratory, uploaded to the GIS and compared to the manually delineated shoreline.

The amount of erosion that occurred between image dates will be assessed using GIS.

3.3.3.7 Internal auditing and QA/QC

3.3.3.7.1 Geospatial data management

All geospatial data will be collected using latitude and longitude in the decimal degrees format and WGS84 datum. All point and line data collected in the field will downloaded after each field campaign and stored as a feature class within a geodatabase. The metadata within each feature class will be recorded and updated as needed.

3.3.3.7.2 QA/QC of data

The project has a strict protocol for rectifying any non-conformances with the validated monitoring plan and a mechanism for ensuring data quality assurance and quality control (QA/QC). To ensure that the data is accurate, precise, consistent, transparent, complete and relevant for the intended purpose, it strictly adheres to and follows the IPCC 2006 Guidelines on GHG accounting.

Data is considered of high quality and to be accurate, consistent if and when they are fit for their intended uses in operations, decision making and planning. Moreover, it is deemed of high quality if and when it correctly represents the real-world construct to which it refers.

All the interventions conducted by the project emphasise quality of monitoring data because it is explicitly evidence based and results oriented.

QA is ensured through a planned system of review procedures conducted by personnel not involved in the monitoring/inventory development process. Data QC will include a system of routine technical activities implemented by the monitoring team to measure and control the quality of the monitoring and data collection process as it is prepared.

For this purpose, a QA/QC plan has been developed as part of oversight policy and procedures. This plan outlines QA/QC activities performed, the personnel responsible for these activities, and the schedule for completing these activities. The QA/QC plan contains the following four core elements: coordination, review procedures, documentation and archiving procedures and effective use of resources in MRV requirements.

The project's QA/QC coordinator is responsible for implementing the QA/QC plan. In this role, the QA/QC coordinator:

- Clarifies and communicates QA/QC responsibilities
- Develops and maintains QA/QC checklists appropriate to various roles
- Ensures the timely and accurate completion of QA/QC checklists and related activities
- Develops an overall QA/QC timeline and when external reviews will occur
- Manages and delivers documentation of QA/QC activities for documentation and archiving
- Coordinates external reviews of estimates and reports and ensures that comments are incorporated

The project has review procedures. While undertaking an internal review of MRV procedures, methodologies and outputs, it tries to ensure the following:

- Sufficient independent expertise is available to conduct the internal review
- Applied review methods are transparent, rigorous and scientifically sound
- Review results are reasonable and well-explained
- Review approach and findings are documented and considered in continuous improvement processes

Following is a checklist for internal verification purposes. When an internal review has been undertaken, the following items are reported and documented:

- Information that has been verified internally
- Criteria that were used for the selection of verification priorities
- Verification approaches, along with relevant data that were collected
- Any limitations in the approaches that have been identified
- Comparisons that have been performed with independent inventories, datasets, scientific literature, or other studies
- Feedback received from external reviewers, with a summary of key comments, and reference to actions taken to address such comments have been addressed
- Main conclusions of the verification
- Actions taken as a result of the verification process
- Any recommendations for inventory improvements or research arising from the findings with their prioritisation; together with identification of capacity building needs where relevant

Review procedures for oversight and ensuring conformances

Although general QC procedures are designed to be implemented for all categories and on a routine basis, it may not be necessary or possible to check all aspects of input data, parameters and calculations every year. A representative sample of data and calculations from every category may be subjected to general QC procedures each year. In establishing criteria and processes for selecting sample data sets and processes, as a good practice, QC checks will be undertaken on all parts of the system over an appropriate period of time as determined in the QA/QC plan.

Documentation and archiving procedures

The project has a documentation and archiving system for its monitoring activities. This allows estimates to be reproduced, and provides safeguards against data and information loss, and supports internal and external verification processes. It also will serve as institutional memory and would store information with enough detail to support new teams or team members in their roles. This will reduce duplication of work and make efficient use of resources. Archiving of material would enable easy access to the documentation and references. Where possible all information would be stored in a central location.

As a guide, the following information would be documented and archived related to monitoring reports and any estimates:

- Activity data, also sources for information, contact persons, other contact information
- Any parameter values used and the reasoning for their choice
- Methods used, including spreadsheets, models, instructions how to do the calculations, how to apply the models, reasoning for choices made
- Archived by submission or monitoring year
- References
- Expert judgment (documentation, contact information)
- Changes made and recalculations
- Results of key category analysis
- Uncertainty analysis
- Results of QA/QC measures
- Improvement plan
- Archiving plan
- Review findings and responses

A responsible person (an archive manager/archive coordinator) has been nominated to maintain the documentation and archiving system, and a plan made for updating the documentation and the archive. This plan also includes operational elements such as what can be changed or updated, and by whom; when and how updates or changes are made, and who has access to change documentation within the archive, noting any special procedures for archiving of confidential data.

The archiving system is in both electronic and hard copy format and is located in a specified location.

The Director Field Operations is responsible for the preparation of measurement and monitoring report as per prescribed template and format of Verra for the preparation of monitoring reports. The field teams document any sampling approaches used, including target precision levels, sample sizes, sample site locations, stratification, frequency of measurement and QA/QC procedures. The Managing Director/Country Head Policy, Strategy and Business Development will review the monitoring data and report with respect to relevance, completeness, consistency, transparency and accuracy.

The final report is shared by IDC with the VVB and other stakeholders and is available to the public. Summaries of the monitoring report in Urdu language will also be prepared and shared with local community members as well as will be made available to the public as discussed in the section on dissemination of monitoring results.

3.3.3.7.3 Database management

The project will design, develop and maintain an open access database for easy availability of needed information to the relevant stakeholders. The database will have a proper directory, file folders and filing

system that will categorise and catalogue the project information based on a well-documented structure. To ensure that the data is available in timely manner, the database will be updated on regular basis as soon it becomes available after proper QA/QC of data has been done. The project will have a DBC-1 Data Archive in Virtual Data Room using Dropbox as well as on a Server in the project office data room.

The project will have a procedure for the administration, handling and management of its information. Physical information, such as signed contracts, signed commercial proposals, field measurement forms, among others, will be scanned, after which the physical version will be stored in the archive established for the purpose. The digital version will be saved in the folder structure as discussed above.

Similarly, data collected through specific forms, calculations and related results will be recorded and backed up. The personnel involved in the saving of data would make sure that it is classified and organised in a clear and simple way to avoid possible errors and inconsistencies at the time of the analysis, and that any of the project stakeholders can easily access and understand such information.

Each generated file will be named according to the following code: title of the file, date, initials of the person who created the document; for example: TitleoftheFile_210211_AKG. Each item is separated by underscores and without tildes (for greater security). When the file is modified by another person, he/she will save it with the updated date and add his/her initials.

If and when additional folders are required, they will be added, and all relevant entities will be informed about the creation of any folder

3.3.3.7.4 Document control

A Document Management and Control system will be put in place to ensure that the production of needed documents takes places under a set process ensuring the authenticity and integrity of the various project documents as well as their easy access and preservation. This system will comprise of the set of technical and administrative activities for the planning, management and organisation of the documents produced and received by DBC-1 from its origin to its final destination in order to facilitate its availability, integrity, access and preservation, regardless of whether these are physical or electronic. The storage of project information on Dropbox. enables the team to access documents from any device.

3.3.4 Dissemination of Monitoring Plan and Results (CL4.2)

The project proponent will have the climate monitoring plan available for public review at the project office. The full results of the initial climate monitoring are included in this PD, which is being made publicly available in the Project Zone. Additionally, a PD summary has been written and provided to communities throughout the Project Zone in English and Sindhi. This PD and the PD summary have additionally been posted to the project website for public review.

3.4 Optional Criterion: Climate Change Adaptation Benefits

3.4.1 Regional Climate Change Scenarios (GL1.1)

Based on various studies conducted by relevant and competent bodies, likely regional or sub-national climate change and climate variability scenarios and impacts and potential changes in the local land use scenario due to these climate change scenarios in the absence of the project are given below.

- Increased temperatures
- Erratic rainfall patterns
- Prolonged droughts
- Stronger winds
- Increased intensity and frequency of extreme weather events

Potential changes in the local land use scenario due to these climate change scenarios in the absence of the project include:

- Greater shoreline erosion due to strong wind currents and sea level rise
- Increased salinisation of terrestrial landscapes and loss of agricultural lands
- Saltwater intrusion into freshwater bodies
- Greater salinisation of underground aquifers
- Greater landward progression of inter-tidal zone

These local land use scenarios will have impacts for local communities, their livelihoods as well as biodiversity.

Pakistan was rated fifth in the Long-Term Climate Risk Index of countries most affected in the period 1999-2018[77]. Going forward, the negative effects of climate change are likely to result in extreme weather conditions that will have wide ranging impacts and will thus pose severe and negative impacts on the Project Zone's environment, economy and society.

In the last 50 years, the annual mean temperature in Pakistan has increased by roughly 0.5 °C. The number of heat wave days per year has increased nearly fivefold in the last 30 years. Annual precipitation has historically shown high variability but has slightly increased in the last 50 years and sea level along the

[77] https://www.germanwatch.org/sites/germanwatch.org/files/20-2-01e%20Global%20Climate%20Risk%20Index%202020_16.pdf (Page 9)

Indus Delta and Karachi coast has risen approximately 10 cm in the last 100 years[78]. By the end of this century, the annual mean temperature in Pakistan is expected to rise by 3 °C to 5 °C for a central global emissions scenario, while higher global emissions may yield a rise of 4 °C to 6 °C.

Average annual rainfall is not expected to have a significant long-term trend but is expected to exhibit large inter-annual variability. Sea level is expected to rise by a further 60 cm by 2099 [79]and will most likely affect the low-lying coastal areas south of Karachi toward Keti Bander and the Indus Delta.

To predict the impacts of these changes a Composite Vulnerability Index (CVI) has been developed for the Indus Delta area by Salik et al. (2015).[80] The CVI approach employs the IPCC definition of vulnerability (a function of exposure, sensitivity and adaptive capacity). The index consists of household parameters of all the three dimensions. Exposure is defined by 'natural disaster and climate variability', sensitivity by 'health', 'food', and 'water' and adaptive capability by 'sociodemographic profile', 'livelihood strategies', and 'social networks' (Pelling, 2011)[81]. This approach was applied to three future climate time periods (2010 to 2039), (2040 to 2069) and (2070 to 2099) with respect to the base climate time period (1961 to 1990). The analysis shows that the annual temperature will rise 1.15 °C, 2.4 °C and 4.19 °C by the F1, F2 and F3 time slices respectively, along with a declining trend in annual total precipitation. The detailed results on CVI are given in Appendix 14. Climate Change Vulnerability Assessment of Indus Delta.

Variability in temperature, frequency of extreme events and sea surface temperature – which is ranked high in the Project Zone – creates abrupt changes in exposure indicators and is categorised as moderate to highly sensitive and vulnerable by the study. This situation renders negative impacts on ecosystem functions, fish biodiversity and local livelihoods.

The scores of all sensitivity indicators for the Project Zone fall in the category of extremely sensitive and vulnerable and contribute to the community's sensitivity towards climate change, according to the report. Notably, the inadequate and unregulated release of freshwater flows from the Indus River (see Section 2.1.5) impacting agriculture and fisheries production, reflects a very high impact on the economy of community, which is largely dependent on fisheries.

The coping capacity of a community dealing with the climate change associated risks is highly dependent upon social factors like, social values, networks, customs as well as the social capital. In terms of coping potential in the Project Zone, consumption patterns, income diversification, dependency ratio, schooling or education level and infrastructure (access to basic facilities) are indicators which reflect low adaptive capacity/very high vulnerability.

[78] Chaudhry, Q. and U. Zaman. 2017 Climate Change profile of Pakistan Page IX

[79] Rabbani, I. and S. Tabrez. 2008. The Impact of Sea Level Rise on Pakistan's Coastal Zones – In A Climate Change Scenario, National Institute of Oceanography, Page 4

[80] Salik, K.M., S. Jahangir, W.Z. Zahdi, and S. Hasson. 2015 Climate change vulnerability and adaptation options for the coastal communities of Pakistan. *Ocean and Coastal Management* 112: 61-73.

[81] Pelling, M. 2011. Adaptation to Climate Change, From Resilience to Transfortmaton, Routledge, New York

There are several reasons behind these circumstances, but low or nearly insignificant literacy rate (worst amongst the fishing community), lack of access to basic facilities, low diversified and intervallic sources of income and inadequate Government investment are the most significant reasons behind this low adaptive capacity.

3.4.2 Climate Change Impacts (GL1.2)

Current or anticipated climate changes are having or are likely to have an impact on the following in the Project Zone and surrounding regions:

Community well-being Impacts

Community well-being will be reduced due to loss of human lives and greater injuries, morbidity and diseases due to higher temperatures, extreme weather events, and greater occurrence of floods, droughts, disease pathogens, insects, pests and bites by dangerous and poisonous animals; loss of productive assets like crop lands; loss of crops and livestock due to greater floods damages, droughts, diseases, etc.; loss of income and livelihoods earning opportunities; loss of infrastructure and access to various services; increased cost of living due to greater cost involved in access to various services and inflation; displacements and migration necessitated by floods, droughts, etc.

Biodiversity Impacts

Biodiversity conservation status in the Project Zone and surrounding regions will be negatively affected as explained below:

- Loss and fragmentation of coastal and marine habitats, including loss of food and shelter sources, due to sea level rise, loss of vegetation, shoreline erosion, increased salinity, greater temperatures on the surface of land and ocean and ocean acidification, etc.
- Loss of species and genetic diversity, particularly of endemic, rare and sensitive species which are not adapted to the new climatic situation and its greater variability
- Increased chances of poaching due to wildlife getting exposed and people capturing wildlife to meet their income and livelihoods needs
- Greater prevalence of diseases and pathogens and onslaught of invasive and exotic species

There will also be diversion of funds by government agencies to cater to damages caused by climate change events instead of investing in wildlife and biodiversity conservation.

Listed below are some of the major climate change related concerns of the Project Zone and surrounding regions and country in the past, which have resulted from the current climate change scenario and some future vulnerability concerns to climate change related concerns and extreme events:

Table 27. Key extreme events in the past which have resulted from the present climate change scenario.

Type of disaster	Year	Severity	Project Zone areas most affected
Cyclone A2	1999	High	Keti Bandar, Shah Bandar, Kharochan, Jati
Drought	1998-2002	High	Whole of district Thatta, Sujawal and Badin

Flood	2003	Medium	Whole of district Thatta and Sujawal
Tsunami	2005	High	Keti Bandar, Shah Bandar, Kharochan, Jati
Drought	2005	Low	Districts Thatta and Sujawal
Cyclone-Yemyin	2007	High	Districts Thatta and Sujawal
Flood	2010	Very high	Districts Thatta, Sujawal and Badin
Flood	2011	Very high	Districts Thatta, Sujawal and Badin

Future vulnerability concerns:

- Increased variability of monsoons
- Projected recession of Hindu Kush and Himalayas (HKH) glaciers threatening Indus River System (IRS) flows
- Increased risks of extreme events (floods, droughts, cyclones, extreme high / low temperatures)
- Water and heat stressed conditions in arid and semi-arid regions leading to reduced agricultural productivity
- Increase in deforestation, loss of biodiversity
- Increased intrusion of saline water in the Indus Delta due to sea level rise; risk to mangroves and breeding grounds of fish

The potential impacts that result from present and future vulnerabilities include devastation of mangroves, unavailability and low access to fuel wood, extinction of mangroves species due to increased salinity levels, degradation of agricultural lands due to seawater intrusion, decrease in freshwater flows, decreased access to clean drinking water and an almost absence of sanitation facilities, increased frequency and intensity of climatic disasters leading to a loss of livelihood sources and rising socio-economic costs.

3.4.3 Measures Needed and Designed for Adaptation (GL1.3)

Given the wide-ranging and anticipated negative consequences of climatic change for the social, economic and ecological systems in the Project Zone and its particularly adverse impacts on the poor and most vulnerable segments of the society, immediate and targeted actions are needed to deal with and adapt to the repercussions of climate change. In particular, the project has designed and will implement actions to support the following needed measures for climate change adaptation.

Table 28. Project activities and their climate change adaptation benefits.

Project activity	Sub-activity/ components	Adaptation benefits
Rehabilitation, restoration	Address primary threats to mangroves and wetlands Avoid deforestation and forest	Intact and well-managed mangroves and wetlands ecosystems provide a host of ecosystem services and benefits for human well-being. These include:

and sustainable management of mangroves	degradation of existing natural mangrove forests Mangrove planting Advocacy for ensuring adequate water supply for priority mangroves and wetlands areas Advocacy for improved water quality in coastal zones, rivers and lakes Advocacy for managing land-use change to protect Indus Delta mangroves and wetlands Encourage and promote sustainable use of mangroves and other wetland resources through preparation and implementation of Indus Delta Mangroves and Wetlands Management Plan and keeping the precautionary principle in view Address issues of climate change and natural disasters affecting mangroves and coastal ecosystems as well as coastal communities	Provisioning Services and their associated climate change adaptation related benefits: Fishes, shrimps and other marine products; timber and wood; fuelwood; fodder; biochemicals, medicinal and pharmaceutical products; food products; genetic resources; ornamental resources; transport infrastructure; water purification. Regulating Services and their associated climate change adaptation related benefits: Air quality maintenance; buffering against extreme events; Noise abatement; carbon sequestration and climate regulations; protection from floods and tsunamis; storms and erosion control; prevention of saltwater intrusion; pollination of agricultural and horticultural crops; reducing pests and diseases. Supporting Services and their associated climate change adaptation related benefits: Food security through primary production; nutrient cycling; habitat provision such as provision of spawning sites for nursery habitat for numerous fishes, shrimps and other marine species; and biodiversity conservation. Informational, Recreational and Cultural Services and their associated climate change adaptation related benefits: Knowledge systems for tackling the adverse effects of climate change; inspiration and therapeutic services in times of distress; formation of iconic landscapes and seascapes that guard against the vagaries of climate change; spiritual and religious values; sense of place; and association. As a result of the various measures taken by DBC-1 to protect, rehabilitate, restore and sustainably manage the mangroves and wetlands ecosystem, the realisation of above services and benefits in support of climate change adaptation will be increased thereby enhancing resilience to potential climate change impacts (environmental, economic, social and institutional).

Participatory village development planning	Short-term and long-term village development plans keeping in view the predicted climate changes and their impacts Advocacy and networking for integration of village development plans with the higher-level taluka/tehsil, district and provincial level development plans	The project's activities related to climate-smart village level development planning will create a basis for and help to integrate and mainstream climate change and environment into the long-term development process of the coastal areas in the Indus Delta. This among other things includes the potential need for climate change risks to be reflected in infrastructure and other village development plants, and the creation of management and monitoring systems to evaluate the need to implement climate change adaptation measures.
Provincial and district level climate change mitigation and adaptation planning	Technical inputs into the preparation of provincial and district level climate change mitigation and adaptation plans	The project has substantial climate change related expertise. The technical experts of the project will provide technical inputs into the preparation of provincial and district level climate change mitigation and adaptation plans. These plans when implemented will yield climate change adaptation benefits and their proper monitoring and evaluation.
Community-based business development and micro-finance related linkages development	Training and capacity building in small-business development advice and support Imparting of knowledge and skills for the development of alternative livelihoods Training and capacity building in support of sustainable production and harvesting of fisheries, forestry, agriculture, livestock and other products including their value chain promotion and diversification Linkage development to micro-finance providing organisations and services	The project implements comprehensive and needs-based technical support through training and capacity building for enhancing and developing alternative livelihoods. This includes support for improved fisheries/aquaculture, agriculture, forestry, livestock and other products-based business development, as well as value chain promotion and diversification away from the traditional natural-resource based economy. These business development activities ensure to consider, factor in and incorporate long-term climate change related risks and their anticipated impacts into their development plans. In addition, communities will have improved access to insurance services and credit facilities because of linkages development to various micro-finance organisations. These project interventions will ensure resilience of the existing livelihood sources as well as the availability of alternative livelihood opportunities and sources in the case of affected businesses, industries and sectors.
Improved public health and sanitation services	Improved access to affordable, clean, safe and sustainable drinking water facilities	The project works with local communities to improve the provision of drinking water facilities, hygiene and sanitation services and other public health care services.

	Improved access to hygiene and sanitation services Improved access to public health care services	This improved access to clean drinking water, hygiene and sanitation and public health care services reduces their vulnerability to various diseases and also better prepares them for dealing and coping with the negative impacts of climate change. Thus, their climate change adaptive capacity is increased.
Improved access to education services	Improved access to formal educational services Improved access to informal educational services	The project has provisions for and works with local communities to increase their access to both formal and informal education services. Because of this increased access to education services the communities will have better understanding of as well as capacity to deal with climate change and its impacts.
Improved access to affordable and sustainable energy sources	Development of renewable and sustainable local energy sources such as solar energy	The project works with local communities to make greater use of locally available renewable energy sources such as solar energy. This increases their reliance on local renewable and affordable energy sources. This switch to alternative and local energy sources enhances their resilience to potential climate change impacts which may affect the supply and provision of energy from traditional and grid sources.
Improved biodiversity conservation	Improved coastal and marine biodiversity conservation	To avert serious stress, threats and damage to coastal and marine life and biodiversity, the DBC-1 project will help biodiversity adapt to the changing climate through boosting the resilience of coastal and marine ecosystems. It will do this through the establishment and adaptive management of Marine Protected Areas (MPAs) in the Project Area/Project Zone. DBC-1 will employ nature-based tools and solutions such as the use of green infrastructure, conserving and building/expanding climate resilient mangrove ecosystem which are better adapted to high salinity, increased temperatures, and other extreme weather events. The Project Area includes areas where mangroves will grow due to climate-induced sea level rise. Protecting these areas through the project activities will help biodiversity to adapt to climate change. DBC-1 will maintain and increase ecological resilience through appropriate species and planting sites selection as well as employing appropriate planting methods in its restoration work, which will help in conserving and

		maintaining resilient ecosystems and compensate for any lost ecosystems due to sea level rise and shoreline/coastal erosion on the landward side. Furthermore, DBC-1 will facilitate rehabilitation and repair damages to already over-exploited and lost coastal and marine ecosystems through undertaking compensatory measures in the inter-tidal zones that are newly formed due to sea level rise.

4 COMMUNITY

4.1 Without-Project Community Scenario

4.1.1 Descriptions of Communities at Project Start (CM1.1)

The DBC-1 Project Zone is home to 60 villages with a total population of 42,483 in 4,911 households. The majority of settlements (42) lie on the fringes of the Project Zone boundary and are located within close proximity to one of the 17 major creeks that flow inland from the coast. There are also 18 smaller settlements of fishing communities that are permanently located within the creek system (see Figure 29 and Figure 30).

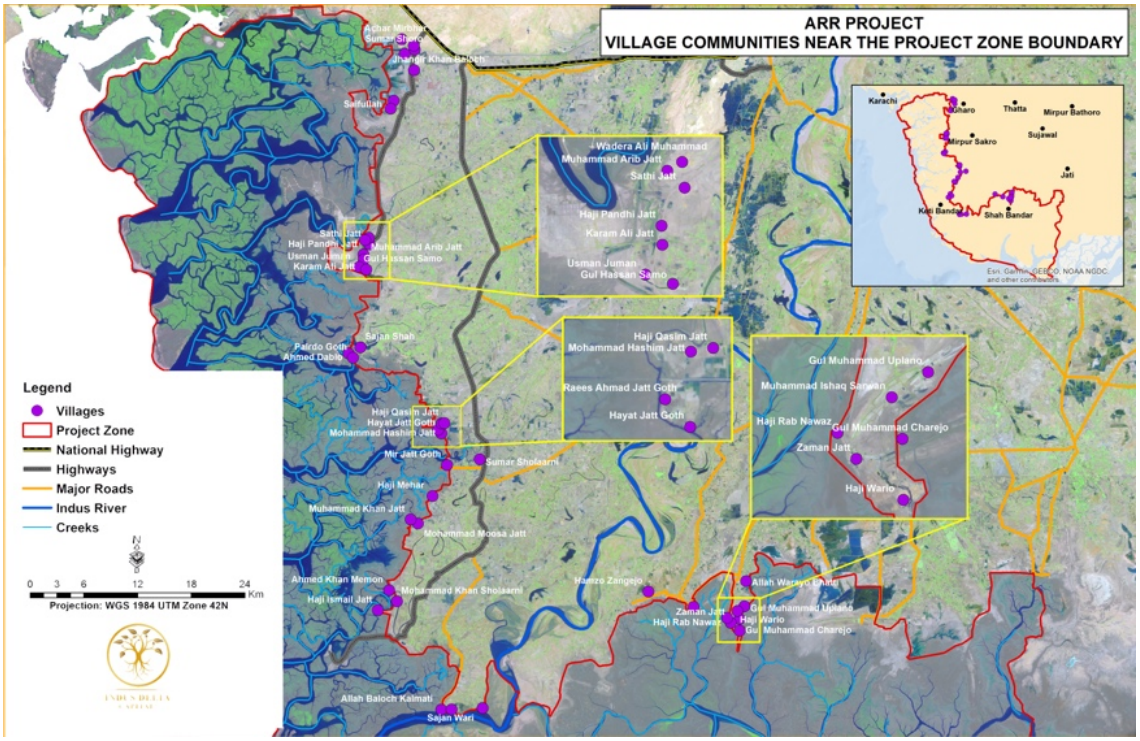


Figure 29. Villages near Project Zone boundary.

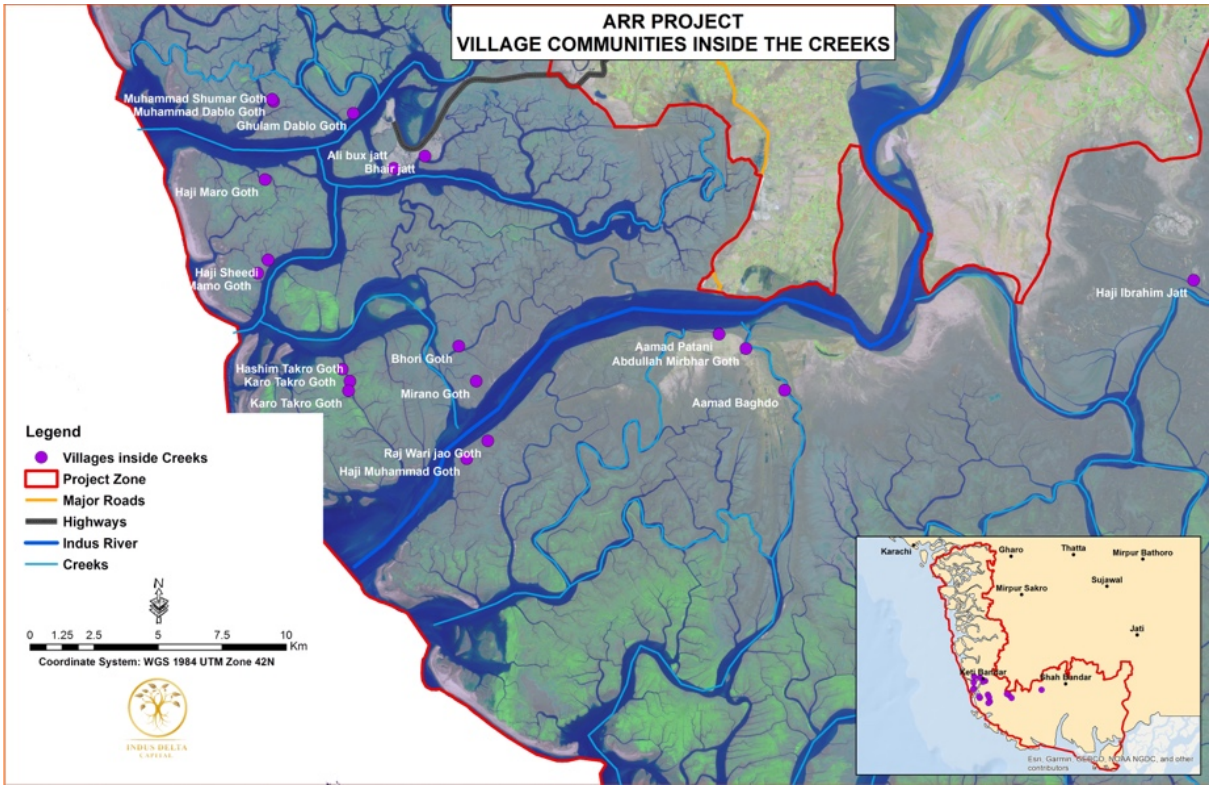


Figure 30. Villages and settlements in the creek system.

Well-being

To accurately determine the baseline conditions the proponent carried out a set of comprehensive Participatory Rural Appraisals and household surveys with community members in all of the villages in the Project Zone, as well as the SBIA workshops as detailed in Section 2.1.8.

Findings from these studies revealed that communities and households in the Project Zone live in an unpredictable economic and social environment where the majority are facing increasing poverty and environmental degradation traps.

Livelihoods and income sources for these communities are mostly natural-resources based, with the majority of households reliant on fishing. Due to this narrow non-diversified economic base, there are few other employment and income earning opportunities. As a result, more than 70% of the coastal population of Sujawal, Thatta and Badin live below the poverty line[82].

[82] OPHI. 2017. Report on multidimensional poverty in Pakistan (p45) https://www.ophi.org.uk/wp-content/uploads/Multidimensional-Poverty-in-Pakistan.pdf



Figure 31. Communities in the Project Zone live in basic housing and have limited access to education.

Because of its geographically isolated location, the cost of living in the region is already higher due to the added costs involved in transporting goods. Most villages lack road access and are usually approached by boat or motorcycle. Very little work has been carried out on infrastructure in the area in the recent past and there is neither the money and capacity, nor organisation within the communities for them to proactively take steps independently to improve conditions.

Access to formal credit facilities through banks is limited for most of the population due to collateral requirements. Hence communities – particularly fishermen dealing with rising costs of technology and an increase in demand for fish – are increasingly dependent on informal sources of borrowing money through money lenders who charge exorbitant interest rates.

As a result, many are caught in a debt cycle and are abandoning traditional methods of fishing in favour of environmentally unfriendly practices such as the use of illegal gillnets to increase their catch to service debt. Lack of available credit facilities is also a hindrance to potential new businesses as capital requirement costs cannot be met because very few villagers have any savings. Any money they earn is spent entirely on subsistence living. Over the years many families have been forced to migrate to the nearby cities of Karachi and Hyderabad in search of work to escape poverty. Environmental degradation due to sea intrusion – turning once cultivable land into barren patches – is also driving this trend forcing more families to leave the area in search of work. The general health of the population is very poor. One of the main causes of ill-health is lack of clean drinking water available in the area and prolonged consumption of saline water. The majority of people either travel large distances to collect potable water from wells, ponds, canals or depressions or purchase water cans at high prices. Collecting the water is the responsibility of women and children. There are five large government-built reverse osmosis (RO) plants that serve the Project Zone (Ahmed Dablo, Muhammad Khan Jatt and Haji Wario Goth villages). However, all are non-functional due to neglect and inadequate investment. Due to the scarcity of clean water, hygiene conditions in all villages are extremely poor. All but one village in the area has no sanitation facilities. Solid waste management is non-existent and infectious and water-borne diseases are widespread such as typhoid, cholera, dysentery, and hepatitis.

Communities in the region also lack access to reliable health and education facilities, due to inadequate infrastructure, staff and operational funds availability. There are only three basic health care units/ dispensaries that serve the region, and they are underfunded and ill-equipped. Literacy rates amongst the population are very low, particularly in women, and education is not seen as a priority. The area is home to 23 schools, but only 11 are functional providing a very basic education.

More than 90% of houses in the Project Zone villages are crude wooden or mud structures constructed by the householders themselves. They have no direct connection for electricity or gas.



Figure 32. Women make up 49% of the population but have a limited role in local economies.

Most housing units have open air kitchens in which firewood is the main source of fuel. Smoke causes serious health problems and food waste results in additional sanitation issues.

Population growth is fuelling further poverty and applying added pressure to available natural resources leading to accelerated environmental degradation. In the absence of infrastructure and disposable income, people are compelled to heavily depend on the renewable resources around them. This increased competition and stress on the ecosystem is also causing a narrowing of livelihood opportunities, increased cost of living and growing human-wildlife conflict.

Climate change impacts have also wreaked havoc on the region in recent years with the communities ill-prepared to cope with the shocks of prolonged heat waves, frequent tropical cyclones, recurring flooding and persistent drought.

Cultural Heritage

The DBC-1 Project Zone is located in Thatta and Sujawal Districts which have cultural, heritage and recreational sites that are of outstanding universal value.

The region once formed a part of the ancient Indus Civilisation which lasted from 3300 BC to around 1800 BC. Together with ancient Egypt and Mesopotamia, it was one of three early civilisations of the Near East and South Asia, and of the three, the most widespread.

Its cities were noted for their urban planning, baked brick houses, elaborate drainage systems, water supply systems, clusters of large non-residential buildings, and new techniques in handicraft (carnelian products, seal carving) and metallurgy (copper, bronze, lead, and tin). The Indus civilisation's economy appears to have depended significantly on trade, which was facilitated by major advances in transport technology. It may have been the first civilisation to use wheeled transport.

However, by 1800 BC, this advanced culture had abandoned their cities, moving instead to smaller villages further north. A study from the Woods Hole Oceanographic Institution (WHOI) found evidence that climate change likely drove the people to resettle far away from the floodplains of the Indus[83].

More recently, Thatta was the medieval capital of Sindh, and served as the seat of power for three successive dynasties. Thatta's historic significance has yielded several monuments in and around the city. Thatta's Makli Necropolis, a UNESCO World Heritage Site, is one of the world's largest cemeteries and has numerous monumental tombs built between the 14th and 18th centuries designed in a syncretic funerary style characteristic of lower Sindh. The city's 17th century Shah Jahan Mosque is richly embellished with decorative tiles and is considered to have the most elaborate display of tile work in South Asia.

On the very fringe of the Project Zone sits Banbhore, an ancient city dating back to the 1st century Scytho-Parthian-era. It was later controlled by the early Islamic empire from 8th to 13th century after which it was abandoned. Remains of one of the earliest known mosques in the region dating back to 727 AD are still preserved in the city. In 2004, the Department of Archaeology and Museums Pakistan submitted the site for UNESCO World Heritage status. The museum at Banbhore contains relics relating to the site, which covers several periods including Parthian, Hindu-Buddhist and Islamic. The exhibits include pottery shards, metal work, ornaments and utensils.

Within the Project Area lies the mysterious ruins at Jhaki Bandar. Thought to have been occupied during the middle ages, the red brick fort consists of an outer city wall and a citadel. It was thought to once have been an important port, but now lies largely neglected and unstudied.

[83] https://www.whoi.edu/press-room/news-release/climate-change-led-to-collapse-of-ancient-indus-civilization-study-finds/



Figure 33. Left, the remains of Banbhore Fort and right, the fort ruins at Jhaki Bandar, located in the Project Area.

Community Characteristics

In general, most of the communities included in the Project Zone are relatively homogenous fishing communities. However, there is diversity within communities based on cultural/ethnicity, economic (wealth), and social (gender and age) factors. Three major ethnic groups are present in the area: Sindhi, Balochi and Muhajirs (people who migrated from India after partition in 1947). All are Muslim and the dominant language spoken in the area is Sindhi. Other ethnic groups present in the Project Zone include Baghda, Baloch, Bhatti, Charejo, Dabla, Jatt, Kalmati, Lashari, Machi, Mallah, Memon (Kuchi), Mirbahar, Patani, Sarawan, Sholanri, Shoro, Syed, Uplano, and Zangejo. The geographical distribution of these ethnic groups is given in Appendix 1. Stakeholder Identification Table.

Communities are organised in '*dehs*'. A deh is the smallest administrative unit in rural Sindh and the term deh literally means 'village' in the administrative vocabulary. Several villages and small settlements make up a deh and some dehs make up a Union Council, which is the smallest unit of political representation in local government.



Figure 34. The majority of the population in the Project Zone rely on fishing as their main livelihood source.

Settlements, known as *goths*, are smaller entities which have only notional linkages with the deh. It is often but not always the case that the largest settlement in a deh will share its name with the deh. Actual villages or goths are often divided into sub-clusters called 'para', which are almost always populated by extended families belonging to one caste or a kinship group[84]. Academics such as Feroze Ahmed (1984) [85] describe Sindh's traditional village or raj, socially arrayed around dominant landowning families and kinship groups. One of the few post-colonial village studies in the province was conducted by Honigmann (1960)[86] who also described Sindh's villages as virtually defined by patrilineal kinship groups.

It is common that big multi-caste villages often break up due to several social and environmental changes as well as disputes among caste and kinship groups. Even big villages with a single caste break up in small settlements of over 8 to 10 households due to disputes over social, economic and political "entitlements".

[84] Bux Mallah, H.. 2009. Social Inequality and Environmental Threats in Indus Delta Villages: Palistan, Bielefeld: COMCAD (Working Papers – Centre on Migration, Citizenship and Development; 118)

[85] Ahmed, F. 1984. "Agrarian Change and Class Formation in Sindh." *Economic and Political Weekly* 19(39): 149-164.

[86] Honigmann, J. J. 1960."A Case Study of Community Development in Pakistan", *Economic Development and Cultural Change 8*(3): 288-303.

The livelihoods of Project Zone communities revolve around three areas: fishing, agriculture, and raising livestock. Other than the farming community, a large number of the landless own and manage livestock and work in non-farm employment. Most of the other workers are engaged in casual labour. Agro-based industries are also operational in the area and a source of employment for some, particularly the sugar and rice industries.

Amongst the fishermen, agriculturists and livestock rearing communities there are two distinct groups. There are the "fish lords" (owning large fish boats and have the financial capital to engage labour), landlords (who own agricultural lands) and those with large flocks of animals as opposed to the artisanal fishermen, landless tenants and people who own a few livestock for their subsistence living.

Apart from agriculture, sewing and embroidery are the predominant non-farm activities for females. Women are also primary collectors of timber and engaged in activities such as processing/sorting of fish/shrimps.

Surveys of household in the Project Zone found the following breakdown in livelihood sources for the communities in the Project Zone:

- 84% Fishing
- 9% Daily paid labourers/employment
- 4% Livestock rearing and farming
- 2% Transportation
- 1% Pensioners

Caste and kinship, sometimes defined in ethnic terms, are significant markers of identity, solidarity and conflict among indigenous people and there are conspicuous differences between various community groups based on wealth and access to assets, education, gender and age.

Syeds are landowners and comparatively more educated and wealthier than other groups and have a higher social status. Memons are mostly businessmen and traders. They too are socio-economically well-off, compared to the other ethnic groups.

However, the vast majority of the population in the Project Zone carve out a meagre living by fishing and are engaged in low-skilled manual labour during off season. Mallahs is the name for traditional seafaring communities. They are divided into rich Mallahs (those owning large boats and having access to Karachi fish markets) and poor Mallahs who own only artisanal boats and their weekly catch of fish is low (around 15 kg), barely enough for subsistence living.

Women make up 49% of the population but do not hold any assets (such as boats or land); all economic activities are controlled by men and the inheritors of assets are also always men. Women are the most vulnerable and marginalised where kinship identity remains integral through patrilineal descent.

Other economic stakeholders such as businessmen, traders and money lenders are allied with economic elites in their economic relations to the landless and poor fishermen. The social and economic interactions between the economically and socially well-off community groups and the poor and marginal groups is not egalitarian and work to the disadvantage of the latter groups. Thus, stakeholders in the area fall into two categories – those who benefit from the status quo and those who lose out.

Due to high population growth rate, majority of the population in Sindh Province and coastal districts is relatively young with more than 62% of the population below the age of 25 years. Elderly people who are 65 years or more account for around 2% of the population.[87]

4.1.2 Interactions between Communities and Community Groups (CM1.1)

There were two categories of community groups identified as key stakeholders in the SBIA workshops (see Sections 2.1.9.2 and 2.1.9.3). Firstly, there are those directly benefiting from the over exploitation of forests, fisheries and other natural resources including poachers, livestock grazers and fuelwood collectors. Other groups in this category are those that indirectly benefit by taking advantage of the situation, including exploitative employers paying low wages, middlemen and micro-lenders lending at exorbitant interest rates.

Secondly, there are those who stand to lose due to the activities by groups in the first category. They include artisanal fishers and the community in general losing access to or suffering diminished quality of many ecosystem goods and services – now or in the future. Other groups included in this category are women and children, who are particularly marginalised with no real access to income earning opportunities or education.

The unsustainable use of mangroves, fisheries, biodiversity and other coastal and marine resources by the first category of community groups (such as 'fish lords', open range livestock grazers, fuelwood gatherers, and other coastal marine resource abusers as well as upland dwellers who divert fresh water flows from the delta) and the exploitative practices adopted by employers, middlemen and money lenders work together to the disadvantage of the second category of poor and marginal community groups (artisanal fishermen, poor community members and daily wage earners, women, elderly, youth and children).

The individual and collective actions of the first category of community groups is leading to resources and environmental degradation on which the subsistence income and livelihoods of the poor and marginal groups depend and add to the poverty of these people by reducing their income and livelihood earning opportunities and increasing the cost of living for them.

There are a number of obstacles to more equitable interactions between communities and groups in the Project Zone. Some of these obstacles are personal, while others are organisational and cultural. Personal obstacles to greater community interaction include low self-esteem and perceived lack of knowledge and skills to interact with other groups, people's comfort in their existing relationships, the perceived lack of time and resources for such interaction, and the multiple ways in which fears are forming barriers to interacting with those who are perceived of having different social and economic status.

Organisational obstacles include the lack of or non-functioning of formal and informal organisations such as village development committees, women organisations, which can provide appropriate platforms for such interactions.

[87] https://fas.org/sgp/crs/row/sindh.pdf

Cultural barriers include ethnocentrism, inertia and lack of initiative in the culture to take steps to avail and build opportunities finding common grounds with others, and over-all lack of motivation for people to acknowledge and value interaction.

The state of conflicting stakes, interests, rights, relationships and interactions between the two sets of community groups (the haves and the have nots), which is existing in the baseline scenario, while may be producing short-term gains for the first category of community groups, is not in the long-term interest of both groups and is therefore not sustainable.

Potential sources of conflict in the communities and their mitigation strategies are given in Appendix 4. Stakeholder Analysis.

4.1.3 High Conservation Values (CM1.2)

High Conservation Values (HCVs) are the critical biological, ecological, social, economic and cultural values in ecosystems and landscapes that are the key values which need to be conserved in the management of natural systems. HCV 4,5 and 6 relate to the community. The status of various HCVs are as follows:

Table 29. Status of community related HCVs.

HCV	Qualifying Attribute	Focal Area
HCV 4 Environmental services	The Project Zone is part of a landscape that is important for the provision of water and prevention of floods	Communities living inside the creeks or those very close to mangrove areas depend on this environmental service
	The Project Zone hold areas important for the prevention of erosion and sedimentation	This ecosystem service is especially important for land owning communities and communities living on the fringes of creeks
	The Project Area is a part of landscapes that function as a natural break to saltwater intrusion	All mangroves in the Project Zone are important from the perspective of provision of regulating and supporting ecosystem services
HCV 5 Natural areas critical for meeting the basic needs of local people	The Project Zone plays an important role for meeting the basic needs of local fishing communities as the mangrove forests serve as nurseries and habitats for many fish and shrimp species in their initial stages of life	The whole of the Project Zone caters to the provisioning ecosystem services

HCV 6 Areas critical for maintaining the cultural identity of local communities	The Project Zone contains areas critical for maintaining the cultural identity of local communities, as detailed in Section 4.1.1.	The whole of the Project Zone supports the provision of cultural ecosystem services

4.1.4 Without-Project Scenario: Community (CM1.3)

Under the without-project scenario, the majority of the local communities and various community groups, particularly the poor and most vulnerable groups will be made worse off over time. For a description of the characteristics of the communities in the non-project scenario, see Sections 2.1.9 and 4.1.1.

During the SBIA community workshops (Section 2.1.6), after stakeholders had identified and prioritised the focal issues, they were then analysed further to establish the causal logic leading to the problems and a Problem Flow Diagram (PFD) for each of the focal issues was produced (Figure 35, Figure 36 and Figure 37).

A PFD is a situation analysis of the issue that represents stakeholders' understanding of what drives the existence of the focal issue. It aims to identify economic, political, institutional, social and/or cultural factors that contribute to existence of the issue.

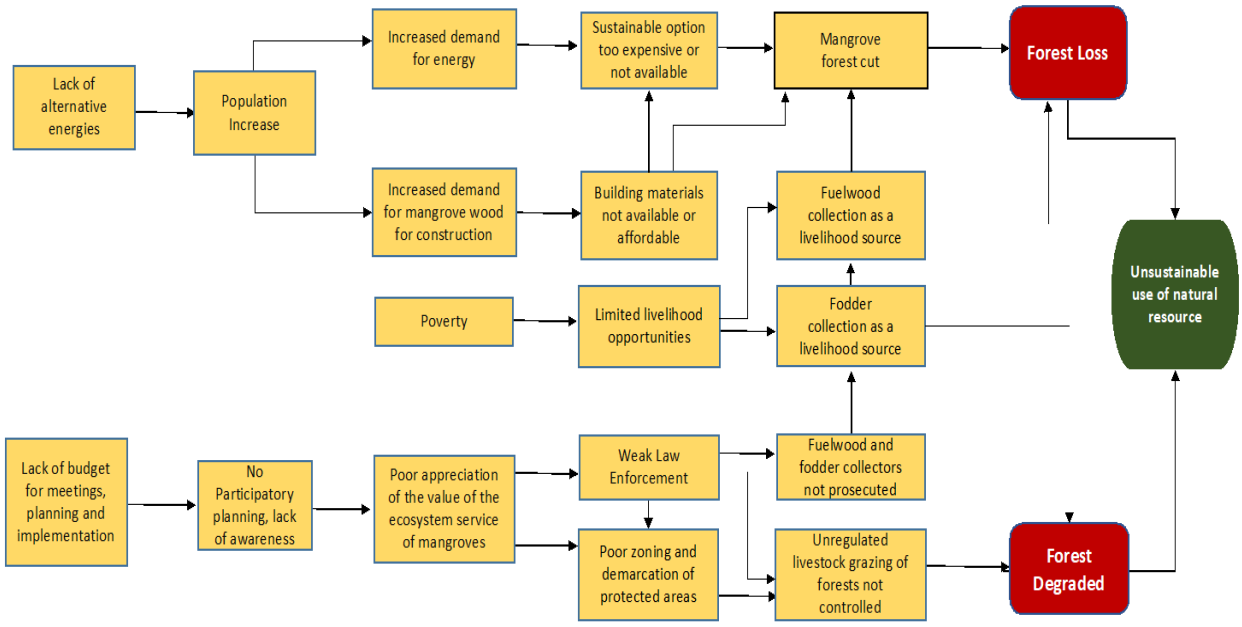




Figure 35. Mangrove forest degradation due to unregulated and unsustainable use.

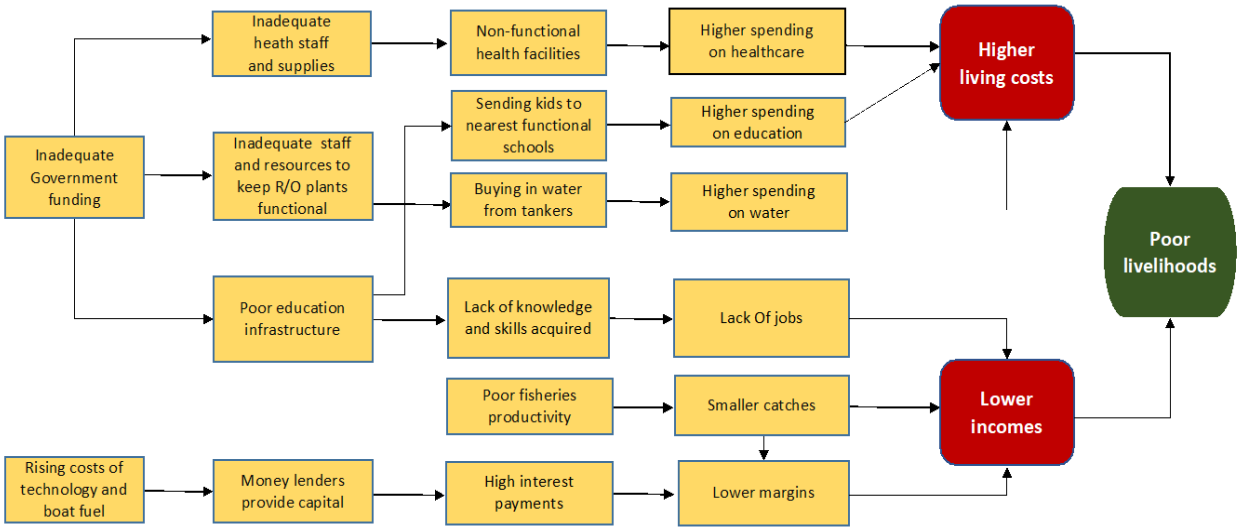


Figure 36. Poverty and impoverished community well-being.

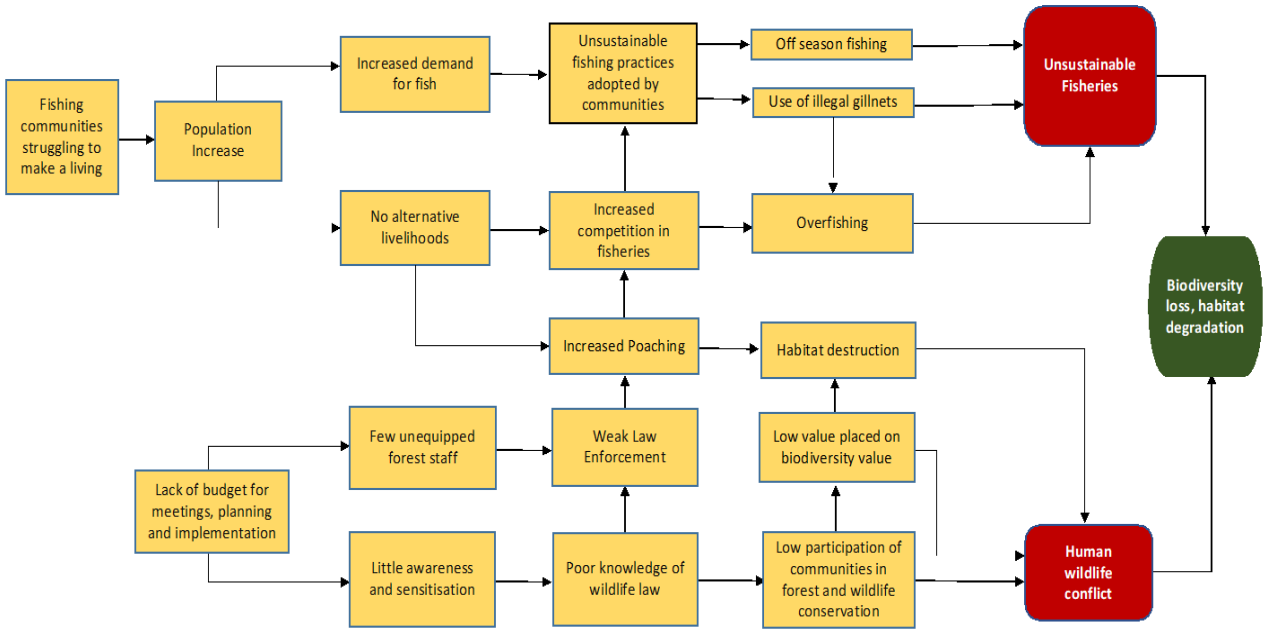


Figure 37. Continued and accelerated wildlife and habitat loss and fisheries degradation.

Next, work groups projected what would happen with the major direct threats (in red on the PFDs) identified for each focal issue in the short-to-medium term (5-10 years) in the absence of the ARR project.

Table 30. Mangrove forest degradation due to unregulated and unsustainable use.

Focal issue aspect	5-10 years	What will drive the change?
Forest loss	Worsen	• No alternative supply of fuel as uptake of solar or a sustainable alternative is too expensive for poor communities • No government intervention to improve infrastructure and provide direct services connections to homes • Greater demand for fuelwood due to population growth • Fuelwood collection becomes a viable livelihood source as prices increase with demand • No new construction techniques adopted and reliance on wood as a building material increases • No introduction of new technologies for cooking and heating so continued inefficient use of resource
Forest degradation	Worsen	• Increase in livestock as population increase • Continued unregulated grazing • Poor law enforcement • Fodder collection becomes viable livelihood source

Table 31. Poverty and impoverished community well-being.

Focal issue aspect	5-10 years	What will drive the change?
High living cost	Remain unchanged	• No accessible health facilities so people need to seek health care services at distant bigger towns, with travel and accommodation adding to their expenses • Few schools in the area remain functional so children need to be transported to far off locations to attend increasing the financial burden on parents • Lack of available clean water. People remain reliant

		on expensive water sold in cans trucked in on tankers from the cities
Low income	Remain unchanged	• Lack of education and skill – with no education, villagers are not qualified to take better paid jobs • Lack of access to affordable credit is a barrier to setting up a family business • Population pressure – increased competition for the same resources

Table 32. Continued and accelerated wildlife and habitat loss and fisheries degradation.

Focal issue aspect	5-10 years	What will drive the change?
Inability to restore degraded mangroves and wetland areas	Worsen	• Lack of funds and other resources will continue to contribute to inability to restore degraded mangroves and wetland areas • Due to inadequate advocacy work there will be continued lack of environmental water flows and sediment supply into the delta area and thus the underlying soil and hydrological requirements of the mangroves will not be met • Sea level rise will continue to erode seaward side mangroves and the non-establishment of mangroves on the newly formed inter-tidal areas landward side will continue to lead to shrinkage in the area of mangrove ecosystem
Unsustainable fisheries	Worsen	• Rising costs will push fishing communities into further debt forcing them to work year-round in a bid to improve catch numbers • Fishermen will be forced to abandon traditional methods and use environmentally unfriendly nets to increase catch. Poor law enforcement will allow the practice to continue • Increased population will increase demand for fish and numbers of people fishing will increase, putting excessive pressure on limited resources

Human wildlife conflict	Worsen	• Population growth and loss of habitat will make human-wildlife conflict more likely • Low levels of community awareness and lack of engagement in wildlife and biodiversity conservation • Poverty will mean poaching is seen as a lucrative activity • Poor law enforcement means wildlife law will not be enforced and offenders not prosecuted

4.2 Net Positive Community Impacts

4.2.1 Expected Community Impacts (CM2.1)

The major project activities can be grouped into the following ten areas (see details in Section 2.1.11). All the community-focused activities which the project plans to implement were identified during SBIA community workshops described earlier (see Section 2.1.8).

Most of these are designed to help create greater awareness, capacity and financial security in the communities, reducing the need to undertake unsustainable resource extraction from the Project Area. They include:

1) Direct employment, and job creation through upscaled ARR

2) Support for fishing communities and sustainable fisheries

3) Participatory land-use planning and awareness raising

4) Access to education for all

5) Access to safe drinking water and healthcare

6) Improved protection and law enforcement

7) Community based sustainable business development and access to microfinance

8) Sustainable energy development

9) Training of Sindh Wildlife and Forest Department

10) Promotion of various gender development and income generating activities for women

Theory of Change Statements

Based on the experience of the project proponent, a literature review, and information obtained from the SBIA workshop and various stakeholder consultations, a theory of change approach was applied to substantiate the DBC-1 project rationale and to produce indicators for a CCB monitoring plan.

Interventions would mainly address the issues or factors projected in the preceding section as likely to get worse in the absence of the project. These would thus constitute the project activities that if implemented would follow the theory of change logic outlined below to lead to the desired outcomes.

- **Focal issue 1 – Mangrove forest degradation due to unregulated and unsustainable use**: IF Alternative sources of energy are made available to communities, IF authorities control unregulated free-range grazing, IF communities become engaged in alternative livelihoods that are not destructive to the forest, IF communities are employed to protect forests through Mangrove Stewardship Agreements, THEN mangrove forests will be saved from deforestation and further degradation and will be enhanced and preserved for future generations
- **Focal issue 2 – Poverty and impoverished community well-being**: IF there are adequate and functional health facilities, IF education is improved through better facilities and access through bursary schemes, IF there is improved access to safe drinking water, IF large numbers of community members are employed directly by the project to carry out restoration work, IF cheap microfinance is made available for communities to pursue various business opportunities, IF women are facilitated to play a full role in local economies, THEN people will have a lower cost of living, higher incomes and improved livelihoods.
- **Focal Issue 3 – Continued and accelerated wildlife and habitat loss and fisheries degradation**: IF funds for restoration of degraded and de-vegetated mangroves and wetlands areas are made available, IF advocacy work is done for restoring environmental water flows and sediments inflows into the delta area, IF mangrove ecosystems lost due to sea level rise are compensated through establishment of mangroves in the newly formed inter-tidal areas, IF fishermen and fishing communities in the Project Zone are organised into well-functioning Fisheries Stewardship Committees (FSCs), IF appropriate and pragmatic Standards for Sustainable Fishing are developed in collaboration with these FSCs and adhered to, IF fishing communities are facilitated in alternative income earning sources and sources of credit, IF sensitisation and awareness-raising is conducted with local communities, IF security and law enforcement are strengthened, IF communities are mobilised to play an active role in the conservation and restoration of ecosystems through ARR, THEN vast areas of degraded wetlands will be restored, poaching and habitat loss will decline leading to improved wildlife populations and it will be possible to control illegal, unregulated, unreported and unsustainable fishing

Table 33. Expected community Impacts.

Community group	Community in general
Impact(s)	Enhanced ecosystem goods and services and improved livelihoods through better education, health, access to clean water and direct employment
Type of benefit/cost/risk	Predicted direct benefit
Change in well-being	Major improvement in livelihoods including education, health, food security and employment

Community group	Government and local authorities
Impact(s)	Better execution of their mandate through improved training, equipment, revenue collection and improved relations with communities

Type of benefit/cost/risk	Predicted direct benefit
Change in well-being	Moderate gains in revenue but major gains in community relations

Community group	Youth and women
Impact(s)	Availability of jobs, alternative livelihoods
Type of benefit/cost/risk	Predicted direct benefit
Change in well-being	Major impact on youth and women

Community group	Borrowers and debtors
Impact(s)	Direct access to affordable credit and gains in profits through payment of low interest rates on borrowed money
Type of benefit/cost/risk	Predicted direct benefit
Change in well-being	Major impact

Community group	Fishermen
Impact(s)	Direct access to affordable credit and gains in profits through adoption of new technologies that promote sustainable fishing practices
Type of benefit/cost/risk	Predicted direct benefit
Change in well-being	Major impact

Community group	Daily wage paid labour
Impact(s)	Availability of jobs, alternative livelihoods and reduced cost of living
Type of benefit/cost/risk	Predicted direct benefit
Change in well-being	Major impact on daily wage paid labour

Community group	Traders and middlemen (including employers and lenders)
Impact(s)	Reduced profits due to increased costs of goods or services and shrinking of customer base
Type of benefit/cost/risk	Predicted indirect cost

Change in Well-being	Potentially minor to moderate reduction in profits in the short term

Community group	Poachers, fuelwood collectors, fodder collectors
Impact(s)	Reduced income
Type of benefit/cost/risk	Predicted direct cost
Change in well-being	Potentially significant loss of livelihood sources in the short term

Community group	Upstream dwellers
Impact(s)	Reduced income
Type of benefit/cost/risk	Predicted direct cost
Change in well-being	Potential reduction in livelihood sources in the short term.

4.2.2 Negative Community Impact Mitigation (CM2.2)

Three main community groups are predicted to suffer potential costs from implementation of project activities. The DCB-1 will mitigate for these negative impacts as follows:

- *Poachers, fuelwood collectors and illegal livestock grazers*: although these are illegal activities, those undertaking them for basic livelihood support will be considered for direct employment in project restoration work. Regardless, they will have access to other general community benefits like improved ecosystem services, access to clean water and better education and health facilities. Further details regarding the mitigation strategies for this group can be found in Section 4.5.3.
- *Traders, middlemen and employers*: this group will see diminished profits in the short-term, however, they should enjoy greater stability in the long-term from conducting legitimate business, leading to reduced conflicts with the law, employees and community. They will also benefit in the long term from sustainable ecosystem goods and services.
- *Upstream dwellers:* This group is expected to see reduced income in the short-run. This, however, will be offset by the implementation of water sector development schemes, particularly irrigation efficiency increasing projects. These will be funded from carbon revenues which will accrue, and which the Sindh Government intends to spend on infrastructure development, especially in the irrigation sector throughout Sindh Province.

4.2.3 Net Positive Community Well-Being (CM2.3, GL1.4)

Focal issue 1 – Mangrove forest degradation due to unregulated and unsustainable use: The direct threats to forest destruction and degradation are: i) forest clearing for fuelwood and fodder, ii) uncontrolled and unregulated livestock grazing, and iii) poor law enforcement. In the absence of the project, these are expected to worsen and thereby leading to forest loss and diminishment of associated ecosystem services

to the communities. The Result Chain Diagram (Section 2.1.11) details the theory of change logic and depicts how DCB-1 aims to curb forest loss and degradation.

Focal issue 2 – Poverty and impoverished community well-being: The direct threats to poor community livelihoods were shown to be: i) rising living costs, and ii) low income. In the absence of the project, these are expected to worsen and thereby increase poverty and livelihood vulnerability. The Result Chain Diagram (Section 2.1.11) details the theory of change logic and depicts how DBC-1 aims to reduce poverty and improve overall livelihoods over the project's lifetime.

Focal issue 3 – Continued and accelerated wildlife and habitat loss and fisheries degradation: The direct threats to wildlife and its habitat are i) Greater human-wildlife conflict ii) increased poaching iii) poor law enforcement iv) continued unsustainable fishing and v) inability to restore degraded and de-vegetated mangrove ecosystems. In the absence of the project, these are expected to worsen and thereby lead to wildlife declines. The Result Chain Diagram (Section 2.1.11) details the theory of change logic and depicts how DBC-1 aims to reduce these pressures leading to improved habitat and wildlife populations.

The main aim of the community development component of the project is to enhance the well-being and livelihoods of the local communities and households through increasing their capabilities and reducing their vulnerabilities so that they can sustain their livelihoods both now and in the future. Under the with-project scenario, most of the direct and indirect causal factors of poverty and resource degradation will be addressed through the various project interventions. The Project Zone plays a critical role in maintaining regulatory and supporting ecosystem services provided by the mangrove forests. These services among others include hydrological services, flood and tsunamis, cyclones and floods damages control, pollination of agricultural crops, shoreline stabilisation and soil erosion control, and prevention of saltwater intrusion into productive agricultural lands.

The mangrove forests of the Project Zone also provide various provisioning services to the local communities. These are traditionally used by Project Zone communities for the provision of numerous ecosystem goods and services, such as spawning sites for fish and shrimps on which the livelihoods of fishing communities in the Project Area depend. The communities also benefit from the clean air and other genetic resources and biodiversity of the Project Zone.



Figure 38. Project Zone mangrove forests and their associated ecosystem service will be protected and enhanced.

The project has been conceived as a triple bottom-line project that is simultaneously working on climate change mitigation, community development and biodiversity conservation in this particularly vulnerable region of Pakistan.

Under the project scenario, the vast natural capital of the Project Zone will be safeguarded and further enhanced. As a result of project interventions, more than 226,000 ha of de-vegetated mangrove areas will be reforested and covered with mangrove vegetation. Moreover, Project Zone communities will be assisted to develop ways that ensure sustainable use of the natural resources found in the area and a system of resource use in which the benefits are retained locally.

With the increase in forest cover in the Project Zone, the access of all 42,000 plus local community members in the 60 villages to various natural resources (fishes, shrimps, fibre, water, air, soil and genetic resources) will be improved throughout the Project Zone of 350,000 ha. The Gold Level climate change adaptation benefits of the project regarding community well-being are outlined in Section 3.4. Consequently, everybody in the community is better-off under the with-project scenario due to increased income earning and livelihoods making opportunities on a sustainable basis.

The opposite of this net positive community well-being in the project scenario is the baseline scenario under which all Project Zone community groups will suffer in the long run, as any short-term gains from over-exploitation of natural resources are counterbalanced due to the severe degradation and the irreversible loss of natural capital.

4.2.4 High Conservation Values Protected (CM2.4)

As described below, none of the HCVs related to community well-being will be negatively affected by the project.

HCV4 – Conservation of areas with critical ecosystem services – regulating and supporting services: The project will support planting and/or assisted natural regeneration over 226,000 ha for maintaining the various ecosystem services of mangrove forests.

HCV5 – Conservation of areas critical for meeting basic community needs – provisioning services: As above, the project will re-vegetate 226,000 ha of de-vegetated mangrove areas for their various ecosystem services including those meeting the basic needs of local communities. The sustainable fisheries initiatives of the project will also ensure that this vital livelihood will meet community needs into the future.

HCV6 – Conservation of areas critical for traditional identity of communities – cultural, information and recreational services: The project will facilitate the local communities in availing the various cultural, information and recreational services of mangrove forests. The economic values of the cultural, information and tourism values of mangrove forests have been estimated under studies.[88] Thus, under the with-project

[88] Himes-Cornell, A. 2018. Mangrove Ecosystem Service Values and Methodological Approaches to Valuation: Where do we stand? *Frontiers in Marine Science* 5: 376.

scenario, areas identified as culturally important and/or having touristic values which will be protected and developed for the purpose.

4.3 Other Stakeholder Impacts

4.3.1 Impacts on Other Stakeholders (CM3.1)

The project is not anticipated to negatively impact any stakeholders other than to those outlined in Section 4.2.2, for which mitigation strategies are planned. During the design phase of the project potential offsite groups were identified and include other Government Departments, private sector service providers and NGOs. None are considered likely to be significantly impacted by the project because the Project Zone itself was designed to incorporate all those groups who are likely to be significantly affected. Positive impacts that the project activities are likely to cause on the well-being of other stakeholders include:

- Increased capacity of these stakeholders to engage and interact with Project Zone communities in relation to services provision, conflict resolution, participatory forest and wildlife and fisheries conservation, village land use planning, conservation agriculture, improved livestock management and environmental education
- Increased awareness on issues ranging from forest conservation, agriculture, land tenure and improving village governance as a result of awareness raising activities
- Enhanced funds availability from government share of carbon credits revenue and revenue from other Payments for Ecosystem Services (PES) by the Government of Sindh and an understanding of the concepts of PES by these other stakeholders

4.3.2 Mitigation of Negative Impacts on Other Stakeholders (CM3.2)

There are no negative impacts on other stakeholders, and therefore no mitigation strategies are required. This section is not applicable.

4.3.3 Net Impacts on Other Stakeholders (CM3.3)

As there are no negative impacts on other stakeholders, the positive impacts described in Section 4.3.1 are the net impacts on other stakeholders.

4.4 Community Impact Monitoring

4.4.1 Community Monitoring Plan (CM4.1, CM4.2, GL1.4, GL2.2, GL2.3, GL2.5)

A community monitoring plan has been prepared and is available as Appendix 15. CCB Community Monitoring Plan. The community monitoring plan is meant to achieve the project's objectives for over-all communities and specific community groups, and is in congruence with the project's theory of change statement and causal chain model as given in Section 2.1.11. The various community-related interventions aim at increasing income and lowering cost of living and contributing to their over-all improved living conditions and well-being. Towards these ends, the project is providing support in large-scale restoration of degraded mangrove land for increased income and employment opportunities and access to various

ecosystem services of restored mangrove forests; business development and access to micro-finance; funding for healthcare and education; access to clean water and better sanitation; support for fishing communities, women, poor and other vulnerable groups; support for alternative income and livelihood sources; support for renewable energy sources; and conservation of historical and heritage sites and cultural artefacts, etc.

This community monitoring plan has the following specific components, provisions and indicators. It identifies communities, community groups and other stakeholders to be monitored, variables to be monitored, types of measurements and sampling methods, and the frequency of monitoring and reporting for each type and method. It is based on variables directly linked to the project's objectives for communities and community groups and to predicted outputs, outcomes and impacts identified in the project's causal model related to the well-being of communities. It assesses differentiated impacts for each of the community groups and include an evaluation by the affected community groups. It also assesses the effectiveness of measures taken to maintain or enhance all identified HCVs related to community well-being. Besides it includes indicators of well-being impacts and risks for small holder/community members and impacts on women as well as has indicators for adaptation benefits for communities.

To ensure efficient and effective implementation of the community monitoring plan, the project has prepared detailed policy and SOPs for implementation of this plan. The policy and procedures documents provide details of the implementation mechanisms as well as experts and field team personnel who will carry out and oversee the implementation of the plan.

The project theory of change (see Section 2.1.11) provides the basis for the selection of project interventions/activities, outputs, objectives/outcomes, impacts, the underlying assumptions and the selection of indicators to use for long term community monitoring.

The adopted monitoring plan is compatible and in line with the main parameters discussed in Section 4.2.1 about the assessment of the current status, without-project baseline scenario, and the with-project scenario. These parameters will provide insights into the project's effects on the major community well-being related parameters, community related HCV related parameters and the Gold Standard Related Exceptional criteria related parameters.

DBC-1 shall use two major data sources for the selected indicators: Internal reporting systems and household and village level surveys. In addition, Focal Group Discussions with Village Development Committees will be used to validate findings and obtain any further information/clarification, while Government departments will be visited for secondary data and general community statistics.

4.4.2 Monitoring Plan Dissemination (CM4.3)

Dissemination of the monitoring plan for community benefits will follow what is described in Sections 2.3.2 and 3.3.4 on the dissemination of project summary documents and of the climate monitoring plan.

4.5 Optional Criterion: Exceptional Community Benefits

4.5.1 Exceptional Community Criteria (GL2.1)

Pakistan is a medium human development country but more than 70% of Project Zone households live below the national poverty line[89]. Thus, the Project Zone qualifies as a rural area with a high concentration of the population living under the national poverty line.

4.5.2 Short-term and Long-term Community Benefits (GL2.2)

All community members in the Project Zone are dependent on mangrove resources and are thus benefiting from their restoration, protection and sustainable management. Where this management prevents previous livelihood activities, the project has put in place actions to mitigate any negative effects. Through this mangrove management, DBC-1 is providing exceptional community benefits to the entire population (more than 42,000 people) of the Project Zone. These community benefits among others include the following:

- **Livelihood and income earning benefits**: Mangroves provide spawning sites and nursery habitats for fishes and shrimps on which the entire fishing community in the Project Zone depend for their livelihoods and income earning
- **Coastal protection benefits:** The whole of the Project Zone communities is getting increased protection from tsunamis and floods damages
- **Climate change adaptation benefits:** The entire coastal community is benefiting from the climate change adaptation benefits of mangroves (see Section 3.4)
- **Pollution prevention and control benefits**: Mangroves act as filters against sea water pollution from which the whole community benefits
- **Erosion control and shoreline stabilisation:** Due to their wave dampening action, mangroves prevent and control coastal land erosion and thus help ensure shoreline stabilisation. All the coastal communities are beneficiary of this ecosystem function of mangroves
- **Control of saltwater intrusion into adjoining lands:** Saltwater intrusion has become a big issue in coastal areas on account of sea level rise due to climate change and global warming. Mangroves help in controlling intrusion of salt water into adjoining agricultural lands. This helps the farming community in particular in the Project Zone
- **Increase of agricultural and livestock productivity**: The introduction of climate-smart agricultural practices and improved livestock health and over-all herd management practices will lead to increase in agricultural and livestock productivity. In addition, the insects living in the adjoining mangrove forests help in the pollination of agricultural and horticultural crops thereby increasing the production of these crops and thus increasing productivity of their agricultural lands

[89] UNDP, (2015) Multidimensional Poverty In Pakistan, P45

The project is also generating short-term and long-term community benefits through opportunities creation, security and reduction of vulnerabilities to various types of shocks (economic, environmental, and social), empowerment, and employment generation, which are supportive of the various Sustainable Development Goals (SDGs) including poverty reduction, income and food security, and climate resilience (see Section 2.1.12). The expected short- and long-term benefits regarding these net positive impacts are described in Section 4.2.1. Other project interventions include:

- **Water and sanitation**: DBC-1 will improve the human capital in the Project Zone by investing in safe and affordable drinking water supply and bringing about improvements in hygiene facilities. Under the project, five non-functional Reverse Osmosis (RO) plants located in the Project Zone will be made functional. To improve sanitation and access to drinking water, the project will make investments in the provision and management of freshwater and sanitation facilities on a local level in the area.
- **Health:** DBC-1 is paying special attention to and working on resolving the various community health related issues in the Project Zone such as the prevalence of communicable, non-communicable and preventable diseases, malnutrition and under-nourishment, proper coverage by Expanded Immunisation Program (EIP), and ensuring improved environmental health. It will achieve this through improving the access of local communities to all the seven Basic Health Units (BHUs) located in the Project Zone. DBC-1 will also invest in upgrading facilities and providing equipment at these locations, as well as constructing satellite health units in the most inaccessible regions. In addition to these measures there are a number of women and mother and child specific health services that are part and parcel of project interventions. These include trainings in: Antenatal Care; CBHE: Community Based Health Education; CBHTP: Community Based Health Training Program; Contraceptive Devices including IUCD: Intrauterine Contraceptive Device; MCH: Maternal and Child Health; PAB: Prevention at Birth; PMTCT: Prevention of Mother to Child Transmission; and PNC: Postnatal Care.
- **Education:** There are a total of 22 schools in the Project Zone of which only 10 are functional. The project will make at least 8 of the non-functional schools functional again.
- **Community participation:** Under the project, the local communities will not only become more cohesive units but also more inclusive in terms of the involvement of marginal groups and women in the planning, design, implementation, monitoring as well as decision making. It is anticipated that a total of 80 village organisations, 40 male and 40 female organisations will be established in the Project Zone.
- **Fisheries, agriculture and livestock**: DBC-1 will liaise with Fisheries, Agriculture and Livestock Departments to improve the provision of extension with regard to sustainable fish harvesting, access to Microfinance, practice of climate-smart and saline agriculture, and increasing the productivity of livestock sector through vaccination of their animals and adoption of proper herd management, feeding and breeding practices.
- **Employment opportunities**: Due to the implementation of various labour-intensive activities in the Project Area, all of which are providing employment opportunities for the local communities on their doorstep, the project has substantially enhanced income earning opportunities. Local community members are being engaged in various NRM related activities such as watch and ward of existing

mangrove forests and newly planted areas under Mangroves Stewardship Agreements, seeds and propagules collection of the various mangrove species, mangroves nurseries raising and planting of seeds and propagules.

- **Women:** The activities for the female population in the Project Zone are meant to address the issue of patriarchal culture by enhancing the socio-economic status of women through specially targeted interventions. Due to awareness creation and the organisation of female population into women organisations, the Project Zone female population will now have a forum of their own for addressing social and development problems. Planned training of 6,000 women in various crafts will increase their income earning opportunities. Training areas inter alia include crab farming; anchovies fisheries identification/ sorting, grading and processing; kitchen gardening; handicrafts making; sewing and embroidery training; hygiene and sanitation and midwifery.

The above human capital development interventions of the project will be available to the whole population of the total Project Area (more than 42,000 people) and therefore the total of the coastal communities will benefit from these measures.

4.5.3 Community Participation Risks (GL2.3)

Sixty meetings have been held with community members throughout the Project Area to discuss the risks for communities to participate in the project. These discussions focused on how the project would affect the income, livelihoods and overall well-being of the communities, and what will be the roles and responsibilities of communities for them to be eligible as project partners and getting support in terms of various community development activities. Based on these discussions, the following risks related to community participation have been highlighted:

Table 34. Risks related to community participation.

Community income, livelihood and over-all well-being related area	Anticipated risk	Risk mitigation strategy
Reduced access to mangrove forests for fuelwood collection by the communities living inside the creeks	Some coastal communities particularly those living inside creeks may feel that they have been deprived of their energy sources and thus may get aggrieved.	• Development of energy plantations • Promotion of fuel-efficient cooking stoves • Facilitation in provision of alternative energy sources
Reduced access to mangrove forests for fodder collection by the communities	Some coastal communities particularly those living inside creeks may feel that they have been deprived of their fodder sources and thus may get aggrieved.	• Promotion of fodder collection practices that are not harmful to mangrove forests • Promotion of alternative

		fodders
Reduced access to mangrove forests for their use as open range grazing area for their livestock	Some coastal communities particularly those living inside creeks may feel that they have been deprived of their free-range grazing areas and thus may get aggrieved	• Promotion of rotational grazing systems
More vigilant controls and restrictions on certain types of land uses in the Project Area	Some coastal communities may feel aggrieved with effective law enforcement	• Awareness raising • Training and capacity building • Provision of facilities for increased patrolling
Reduced income in the short-term for adoption of sustainable fish harvesting practices	Some coastal communities may feel aggrieved with effective law enforcement.	• Promotion of value chain in fisheries products • Promotion of increased access to cheap and institutional credit sources • Facilitation in fair weighing system for fish products • Facilitation in ensuring fair market prices for fish produce • Promotion of alternative livelihood sources

4.5.4 Marginalised and/or Vulnerable Community Groups (GL2.4)

Table 35. Net impacts on marginalised communities.

Community group 1	Coastal fishing communities
Net positive impacts	• Increased fisheries resources in the long-run due to protection of existing mangrove forests and planting of new forest areas • Better protection of damages resulting from tsunamis/cyclones and floods • Increased income opportunities • Access to credit facilities at easy and favourable terms and

	conditions • Increased employment opportunities • Better livelihood opportunities • Improved access to safe and affordable drinking water facilities • Better and expanded access to sanitation and hygiene facilities • Improved access to educational facilities • Better medical care and health facilities • Improved and expanded access to physical capital • Improved and expanded access to HCVs areas • Social capital development and enhanced empowerment • Improved linkages with other communities and other stakeholders and service providers • Improved access to information, and enhanced knowledge and skills levels • Clean ambient air • Reduced exposure to various types of hazards • Greater involvement in community development activities
Benefit access	• Easier, expanded and more secure access to all of the above benefits
Negative impacts	• Negative impacts not anticipated. Only short-term reduction in fish catch which will be compensated through better weighing practices, better price and alternative income and livelihood opportunities.
Community group 2	Coastal communities engaged in agriculture and crop husbandry
Net positive impacts	• Increased agricultural produce production due to productivity enhancement, soil erosion prevention, prevention and control of sea intrusion, pollination of agricultural crops by insects residing in mangrove forests, etc. • Better protection of damages resulting from tsunamis/cyclones and floods • Increased income opportunities • Access to credit facilities at easy and favourable terms and

	conditions • Increased employment opportunities • Better livelihood opportunities • Improved access to safe and affordable drinking water facilities • Better and expanded access to sanitation and hygiene facilities • Improved access to educational facilities • Better medical care and health facilities • Improved and expanded access to physical capital • Improved and expanded access to HCVs areas • Social capital development and enhanced empowerment • Improved linkages with other communities and other stakeholders and service providers • Improved access to information, and enhanced knowledge and skills levels • Clean ambient air • Reduced exposure to various types of hazards • Greater involvement in community development activities
Benefit access	• Easier, expanded and more secure access to all of the above benefits
Negative impacts	• Negative impacts not anticipated
Community group 3	Coastal communities engaged in livestock raising
Net positive impacts	• Increased access to livestock health and vaccination program and training in improved livestock herd, feeding and breeding management • Better protection of damages resulting from tsunamis/cyclones and floods • Increased income opportunities • Access to credit facilities at easy and favourable terms and conditions • Increased employment opportunities

	• Better livelihood opportunities • Improved access to safe and affordable drinking water facilities • Better and expanded access to sanitation and hygiene facilities • Improved access to educational facilities • Better medical care and health facilities • Improved and expanded access to physical capital • Improved and expanded access to HCVs areas • Social capital development and enhanced empowerment • Improved linkages with other communities and other stakeholders and service providers • Improved access to information, and enhanced knowledge and skills levels • Clean ambient air • Reduced exposure to various types of hazards • Greater involvement in community development activities
Benefit access	• Easier, expanded and more secure access to all of the above benefits
Negative impacts	• Negative impacts not anticipated. Only short-term reduction in income from reduced access to mangrove fodder and use of mangroves as open-range grazing areas. These will be compensated through improved livestock health and vaccination and improvements in livestock herd management, feeding and breeding practices as well as alternative income and livelihood opportunities.
Community group 4	Coastal communities engaged in daily wage labour
Net positive impacts	• Increased income opportunities from work in coastal tourism activities • Better protection of damages resulting from tsunamis/cyclones and floods • Increased income opportunities • Access to credit facilities at easy and favourable terms and conditions

	• Increased employment opportunities • Better livelihood opportunities • Improved access to safe and affordable drinking water facilities • Better and expanded access to sanitation and hygiene facilities • Improved access to educational facilities • Better medical care and health facilities • Improved and expanded access to physical capital • Improved and expanded access to HCVs areas • Social capital development and enhanced empowerment • Improved linkages with other communities and other stakeholders and service providers • Improved access to information, and enhanced knowledge and skills levels • Clean ambient air • Reduced exposure to various types of hazards • Greater involvement in community development activities
Benefit access	• Easier, expanded and more secure access to all of the above benefits
Negative impacts	• Negative impacts not anticipated.
Community group 5	Women
Net positive impacts	• Increased income opportunities from work in in various employment opportunities created under the project • Better protection of damages resulting from tsunamis/cyclones and floods • Increased income opportunities • Access to credit facilities at easy and favourable terms and conditions • Increased employment opportunities • Better livelihood opportunities • Improved access to safe and affordable drinking water facilities

	• Better and expanded access to sanitation and hygiene facilities • Improved access to educational facilities • Better medical care and health facilities • Improved and expanded access to physical capital • Improved and expanded access to HCVs areas • Social capital development and enhanced empowerment through participation in Women Organisations • Improved linkages with other communities and other stakeholders and service providers • Improved access to information, and enhanced knowledge and skills levels • Clean ambient air • Reduced exposure to various types of hazards • Greater involvement in community development activities
Benefit access	• Easier, expanded and more secure access to all of the above benefits
Negative impacts	• Negative impacts not anticipated.
Community group 6	Landless poor and other marginal groups
Net positive impacts	• Increased income opportunities from work in various employment opportunities created by the project • Better protection of damages resulting from tsunamis/cyclones and floods • Increased income opportunities • Access to credit facilities at easy and favourable terms and conditions • Increased employment opportunities • Better livelihood opportunities • Improved access to safe and affordable drinking water facilities • Better and expanded access to sanitation and hygiene facilities • Improved access to educational facilities

	• Better medical care and health facilities • Improved and expanded access to physical capital • Improved and expanded access to HCVs areas • Social capital development and enhanced empowerment through participation in Village Development Committees • Improved linkages with other communities and other stakeholders and service providers • Improved access to information, and enhanced knowledge and skills levels • Clean ambient air • Reduced exposure to various types of hazards • Greater involvement in community development activities
Benefit access	• Easier, expanded and more secure access to all of the above benefits • To ensure that marginalised and/or vulnerable smallholder/community members have access to project benefits, the following measures are being and will be taken: ○ <u>Addressing the problem of elite capture of benefits</u> The whole communities will be informed of the various project benefits and information related to various project benefits will be shared in community meetings which will be held in open sessions. ○ <u>Dealing with the problem of exclusion</u> The representation of small holders and marginal groups in various village level bodies such as village development committees, women organisations, MSAs, FSAs, etc. will be ensured. ○ <u>Dedicated project interventions for smallholders and marginal groups</u> A number of project interventions have been specifically designed for poverty reduction and well-being improvement of small holders and marginal groups. These among others include specific project activities (such as provision of solar system to small and poor communities living inside creeks), inclusion in MSAs, inclusion in FSAs, business

	support and facilitation to marginal groups and women, provision of loans and access to other financial resources, networking, etc. ○ Lack of access to information and knowledge and skills Special modules and programs have been designed for awareness raising, training and capacity building of small holders and marginal groups as well as women. ○ Dealing with problem of exploitation To deal with the problem of exploitation by lenders, purchasers, middlemen, employers and other agents, the following measures will be taken: ○ Linking to institutional credit providers such as Akhuwat ○ Provision of direct credit through the project mechanism ○ Facilitation in provision of cold storage facilities for small scale fishers ○ Facilitation in market access ○ Engagement in various project activities ○ Skills and capacity building to negotiate with middlemen and employer for fair return and wages
Negative impacts	• Negative impacts not anticipated.

4.5.5 Net Impacts on Women (GL2.5)

Besides the positive impacts of the project derived by the whole community in the Project Zone, there are several benefits aimed specifically at women to improve their incomes, livelihoods and overall well-being.

These project activities include awareness raising, training and capacity building, social mobilisation and social organisation, creation of employment and business opportunities, and giving them a role in decision making processes.

In addition to ensure that the project generates net positive impacts on the well-being of women and that women participate in or influence decision making, the project is already taking and will further scale up the following measures:

Addressing the problem of men capture of benefits

Exclusive information meetings will be held with women whereby they will be informed of the various project benefits.

Dealing with the problem of exclusion

To address the problem of women exclusion, women organisations have been and will be established throughout the Project Zone and women will be given representation in various forums established under the project.

Dedicated project interventions for smallholders and marginal groups

A number of project interventions have been specifically designed for poverty reduction and well-being improvement of women.

These among others include women health related interventions, focus on girls' education and adult literacy programs for women, special bursary schemes for girls, special business employment and opportunities for women in poultry farming, livestock rearing, kitchen gardening, Sindhi handicrafts making, crab farming, etc., provision of loans and access to other financial resources, networking, etc.

Lack of access to information and knowledge and skills

Special modules and programs have been designed for awareness raising, training and capacity building of women.

Dealing with problem of exploitation

To deal with the problem of exploitation by lenders, purchasers, middlemen, employers and other agents, the following measures will be taken:

- Linking to institutional credit providers such as Akhuwat specifically for women
- Provision of direct credit through the project mechanism targeted for women
- Facilitation in provision of facilities for business by women
- Facilitation in market access such as Design Houses in larger markets
- Engagement in various project activities
- Skills and capacity building to negotiate with middlemen and employer for fair return and wages

These various project interventions are all meant to increase the economic and social mobility of women. As a result of increased participation in social and economic activities, women will be in a better position to influence decisions affecting their lives. All these changes will positively affect the majority of women in the Project Zone. There are no foreseen negative impacts on women associated with the project.

4.5.6 Benefit Sharing Mechanisms (GL2.6)

The project has been designed and fundamentally set-up to generate benefits that reach the intended beneficiaries, which are the local communities, vulnerable and marginalised groups, women and other stakeholders, such as various service providers, members of civil society organisations, etc.

It has therefore a benefit sharing and incentives allocations system in place that gives voice and concern to all members of the community through a classic participatory and representative governing structure.

For this purpose, the local communities have been organised into village development committees and women organisations which decide on the benefit distribution and cost sharing arrangement under the project.

These village level organisations are socially inclusive and have representation of the marginal and vulnerable groups. Therefore, these traditionally left-out groups have a say in decisions pertaining to various aspects of the project including costs and benefits sharing. The implementation of the benefit sharing will be consolidated upon commercialisation of VCUs.

4.5.7 Benefits, Costs, and Risks Communication (GL2.7)

Development and ARR projects have benefits, costs and potentially risks associated with them. These need to be communicated to the local communities and other stakeholders in a truthful manner so as to obtain their Free, Prior and Informed Consent at the design and planning stage, implementation stage, and later on in monitoring and evaluation stage. To achieve this communication, the following steps are being undertaken by the project:

- Develop proper understanding of the benefits, costs and potential risks of the project in close consultation with communities and other stakeholder groups
- Categorise the community groups and stakeholder groups who would be the project beneficiaries, bearing direct or indirect costs related to the project and potential risks associated with the project
- Train and build capacity of relevant project staff to fully comprehend the benefits, costs, and potential risks associated with the project and the community and stakeholder groups who would be impacted
- Develop a mitigation plan for addressing the negative impacts and potential risks of the project
- Develop a communication strategy for the dissemination of various aspects of the project including its benefits, costs and potential risks and the groups of community and stakeholders who would be positively or potentially negatively impacted
- Develop proper institutional arrangements and make the necessary budgetary provisions for the dissemination of project information in timely manner to the concerned groups
- Have proper mechanisms and procedures in place to effectively address the risks and communication of the information pertaining to the project's benefits, costs and potential risks
- Hold necessary consultative meetings with the communities and stakeholders to share with and agree on the identified benefits, costs and mitigation strategies for addressing the risks with the concerned quarters
- Encourage the communities and stakeholders to establish a relevant forum at their level to tackle these issues
- Document the consultative meeting process regarding the benefits, costs and risks communication
- Implement the risk mitigation plan and monitor the results
- Document any lessons learnt

- Adapt the mitigation plan in light of the lessons learnt

4.5.8 Governance and Implementation Structures (GL2.8)

To implement the community development component of the project, proper governance and implementation structures are needed at the project level as well as the community level. Therefore, the project has established a Community Development, Extension and Gender Development Directorate in its organisational set-up.

This directorate is staffed by qualified professionals, both male and female, who specialise in community development, extension and gender development. The experts from this directorate regularly undertake field visits and coordinate with the local communities and other stakeholders with respect to the proper implementation of the community development component of the project.

The directorate staff has also identified key informants and focal persons amongst the community members and stakeholders to give them regular feedback.

At the community level, 40 village development committees and 40 women organisations have already been established to represent their particular villages and interact with the directorate staff of the project to discuss and agree on various community development related interventions designing, planning, implementation and participatory monitoring.

These village level organisations comprise of from 6-15 village representatives elected/selected by the respective village. These village organisations are socially inclusive and include representative from various ethnic and socio-economic groups within the community.

Regular meetings are held with these village organisations in a culturally appropriate manner at designated places, times and with already agreed meeting agendas. The proceedings of these consultative meetings are properly documented and circulated.

Decisions taken in these meetings are implemented through appropriate entities to which responsibility for implementation was assigned. The project also has put in place a robust feedback and grievance redress mechanism (Section 2.3.12).

4.5.9 Smallholders/Community Members Capacity Development (GL2.9)

The stakeholder groups in the Project Zone include fishing communities, farming and livestock owning communities, women, youth, daily wage earners, business community, local level organisations, Forest, Wildlife and Fisheries Department staff and staff of other government departments and service providers.

Based on meetings and discussions held with these stakeholders, the awareness raising and training and capacity building needs of community members and stakeholders' groups have been identified and assessed by the proponent.

To cater to the identified needs, a number of awareness raising and training and capacity building sessions are being designed, organised and implemented in the following thematic areas:

- Basic understanding of the Indus Delta area and its coastal and marine environment and coastal and marine resources of the area

- Coastal and marine ecosystems and their ecosystem services and values including High Conservation Values areas in the Indus Delta
- Threats to and main drivers of degradation of coastal and marine ecosystems and their services
- Climate change and its impacts in the Delta Area including sea level rise, saltwater intrusion, coastal erosion, droughts, flooding and other climate-related disasters
- Disasters and disasters risk reduction and management
- Basic understanding about blue carbon and ARR/RWE and AUWD projects
- Focal areas of DBC-1 project, its theory of change and project interventions logic
- Social and biodiversity impact assessment of DBC-1 project interventions
- Participatory socio-economic survey methods and techniques
- Participatory biodiversity assessment methods and techniques
- Stakeholder engagement and free, prior and informed consent
- Marginal groups and their social and economic empowerment
- Potential risks and risks mitigation and minimisation strategies for blue carbon projects
- Blue carbon benefits and benefits distribution system
- Feedback and grievances redress mechanism of DBC-1 project
- Negotiations and conflict resolution mechanisms
- Integrated and participatory coastal and marine resources planning, implementation, monitoring and management
- Voluntary guidelines, standards and code of conduct for sustainable fishing and other marine resources
- Fish Stewardship Committees and their role in sustainable fishing and other marine resources
- Mangrove Stewardship Agreements and their role in mangroves conservation and sustainable management
- Biodiversity Conservation Committees and their role in biodiversity conservation and sustainable management
- Microfinance and institutional credit and how to access it
- Development of common institutional platforms for integrated and coordinated work in pursuit of biodiversity conservation and sustainable management
- The need for action research and greater knowledge generation and dissemination on coastal and marine resources conservation and sustainable management
- Environmental water flows and their role in sustaining the delta and marine resource

- Improved planning, policies and governance mechanisms coastal and marine resources conservation and sustainable management
- Local partnerships development for enhanced and upscaled actions for coastal and marine conservation
- Marine Protected Areas and their role in coastal and marine resources conservation and sustainable management
- Nature-based solutions and their role in climate change mitigation and adaption and biodiversity conservation
- Energy conservation and the role of renewable energy sources in mangrove conservation

5 BIODIVERSITY

5.1 Without-Project Biodiversity Scenario

5.1.1 Existing Conditions (B1.1)

Location and general description

The DBC-1 Project Zone is located in the Indus Ecoregion, identified by the WWF's Global 200 as a biodiversity hotspot[90]. Located in a semi-arid environment, the Ecoregion is composed of riverine forests along the Indus River, mangrove forests and tidal wetlands in the coastal areas, while desert ecosystems occupy the periphery. The area, which covers around 65% of the Sindh Province, is regarded as the 40th most biologically rich in the Asia-Pacific region.

[90] Olsen, D.M. and E. Dinerstein. 2002. The Global 200: Priority Ecoregions for global conservation. *Annals of the Missouri Botanical Garden* 199-224.

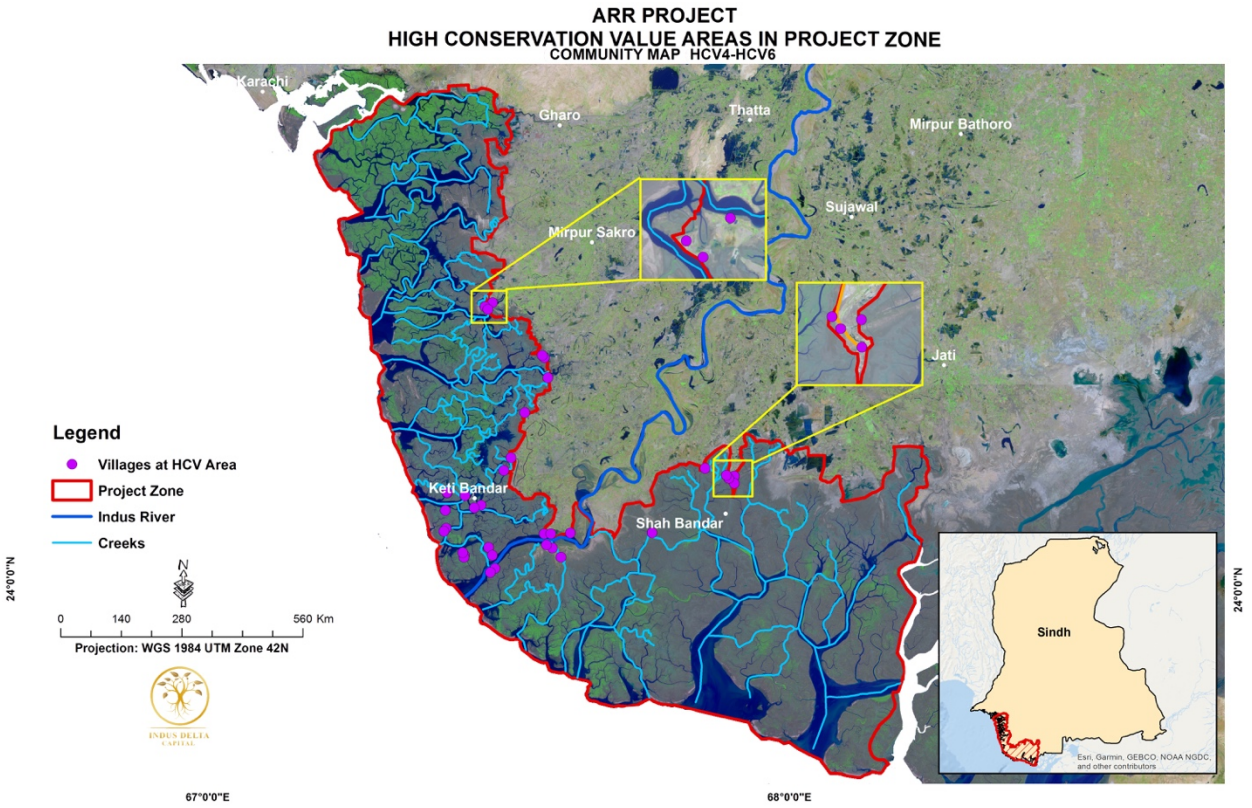


Figure 39. Location of vulnerable, endangered and near threatened species within the Project Zone.

The fan-shaped Indus Delta sits at the south of the Indus Ecoregion and is the world's fifth largest delta. It is a vast complex of multiple tidal river channels and 17 major creeks, low-lying sandy islands, mangrove forests and intertidal lands stretching from near Korangi Creek in the west to Sir Creek near the Indian border on the east. Wetlands including mangrove forests cover an area of about 600,000 ha and constitute an important ecosystem in the coastal deltaic region (Saifullah, 1997)[91]. The Indus Delta was designated a Ramsar Site in November 2002.

The area is rich in biodiversity and natural resources including mangrove forests, croplands, fisheries, wetlands, coastal creek systems and rare fauna as well as sights of cultural and historical heritage.

[91] S.M. Saifullah. 1997. Management of the Indus Delta Mangroves in B.U.Haq et al. (eds.), Coastal Zone Management Imperatives for Maritime Developing Nations, 333-346. Kluwer Academic Publishers.

However, despite its global ecological significance and local socio-economic importance (being home to marginal coastal and fishing communities), the delta has been facing numerous threats for several decades which have led to massive degradation and now threaten its future existence.

Unsustainable resource use coupled with a decrease in freshwater and sediment supply have taken a devastating toll on the ecology of the delta. Resource dependence of coastal communities and ineffective policies have resulted in vast areas of mangrove forest, and their goods and services, being overexploited.

This has been further compounded by low freshwater discharge from the Kotri Barrage. Before 1930, the Kotri Barrage discharge was 126 x 10^9 m^3, which was reduced in the 1960s to 72 x 10^9 m^3. This discharge was then further reduced to a record low of 10 x 10^9 m^3 in 2001-2[92].

Sea level rise is also having adverse effects on the delta. The rising level of seawater has already engulfed vast stretches of dry land and has intruded into once rich fertile lands. Salinity levels are as high as 40,000-45,000 ppm in some areas. As a result, the soils have turned saline and there have been heavy setbacks to ecosystems, habitats and species diversity.

Biodiversity features

To accurately assess the existing situation with respect to biodiversity in the Project Zone a baseline assessment survey was carried out at four strategic locations (Keti Bandar, Shah Bandar, Karo Chaan and Korangi) within the Project Zone (Figure 39). The full results of this study are given in Appendix 18. Biodiversity Survey.

Coastal vegetation

Compared to the de-vegetated and degraded mangrove areas in the Project Area, which have not only lost mangrove vegetation and associated biodiversity but also other important structural, compositional, ecological and functional features of intact wetlands, the intact parts of the Project Zone support a wide variety of vegetation including mangroves, herbs, shrubs, seaweeds and various grasses. These remaining intact areas are a stunning example of a natural wetland type consisting of a main river, punctuated with irrigation canals, reservoirs, ponds, lakes, marshes, creeks, sand flats, mudflats and mangrove forests. These forests are the largest arid mangrove forests in the world[93]. Eight species of mangroves have historically been reported in the Project Zone (see Table 35), but only four remain today. These are, *Avicennia marina, Rhizophora mucronata, Ceriops tagal,* and *Aegiceras corniculate*.

Table 36. List and distribution of mangrove species in Pakistan

Species	Distribution	Status

[92] https://foreverindus.org/pdf/180808annual_report_2007

[93] S.M. Saifullah. 1997. Management of the Indus Delta Mangroves in B.U.Haq et al. (eds.), Coastal Zone Management Imperatives for Maritime Developing Nations, 333-346. Kluwer Academic Publishers.

Bruguiera gymnorhiza	Karachi and Indus delta. Estuary of Indus (Murray, Hassan)	Extinct
Ceriops tagal	Karachi and coast of Sindh. Mouth of Indus and 'saltwater creek' (Stocks, Murray)	Existing
Ceriops decandra	Sindh tidal zone; existence considered doubtful	Extinct
Rhizophora apiculata	Tidal marshes at the mouth of Indus, Mina Hor, (Las Bella)	Extinct
Rhizophora mucronata	Mouth of Indus on muddy shores and tidal creeks (Henslow; Las Bella and Makran), coast (Burkill)	Existing
Aegiceras corniculatum	Mangrove swamps at mouth of the Indus (Stocks, Ritchie), Karachi, Mina Hor, (Jafri)	Existing
Avicennia marina	Tidal mangrove swamp, (Stern) China Creek, etc. (Jafri), Kalmat Hor	Existing
Sonneratia caseolaris	Mouth of Indus and tidal zone (Murray)	Extinct

The percentage proportion of the four species at the project start was: *Avicenna marina* (90%), *Rhizophora mucronata* (8%), *Aegiceras corniculatum* (1.5%) and *Ceriops tagal* (0.5%) (Sindh Forest Department, 2014)[94]. *Avicennia marina* occurs as an almost monotypic stand throughout the delta. Both *Rhizophora mucronata* and *Ceriops tagal* are mainly present because of the afforestation and re-forestation efforts of Sindh Forest Department and the DBC project. Inland areas have mostly halophytic vegetation including Chenopods, *Suaeda, various Tamarix* species *Salvadora persica*, and *Prosopis juliflora*. A full list of endemic species found in Sindh Province and in the Project Area is given in Appendix 17. List of Endemic Plant Species Found in Sindh Province.

A salient feature of arid mangroves in the Project Zone is that there is no understorey of shrubs, herbs and grasses mainly due to high saline conditions and lack of fresh water. However, the natural regeneration of *Avicennia marina* does occupy the gaps found in between other species like *Rhizophora mucronata* and *Ceriops tagal*. Vertically, the three major strata observed along the tidal creeks are: supratidal, intertidal, and subtidal. There is a unique assemblage of organisms associated with the mangrove vegetative structures in each of these three vertical strata.

The upper or supratidal stratum includes the arboreal portions of the mangrove forests. This stratum is occupied by birds, reptiles, crabs, snails, insects, and spiders. The middle or intertidal stratum extends from the high to low water tidal heights and encompasses the aerial root systems of the mangroves. Major organisms inhabiting this zone (barnacles, isopods, crabs, oysters, amphipods, snails, and algae)

[94] Official website Sindh Forest Department, Government of Sindh. https://sindhforests.gov.pk/page-mangroves

experience periodic submergence by the tides. The lower or subtidal stratum occurs below the low water mark where the mangrove roots provide substrate for organisms adapted to constant submergence (algae, sponges, tunicates, anemones, octocorals, shrimp, polychaetes, brittlestars, nudibranchs and jellyfish).

Terrestrial and supratidal biodiversity

The Project Zone is home to at least 11 species on the IUCN Red List. Seventy-five birds, ten mammals, and eight reptile species were recorded during the baseline faunal biodiversity survey conducted by the project from sampling locations of Keti Bander, Kharochaan, Shah Bander and the Korangi Creek.

Other studies (WWF 2007-08)[95] have reported that 75 bird species including 28 resident and 47 migratory species, 21 species of reptiles, two species of amphibians, 63 species of fish and 24 species of shellfish in the region. The Indus River, which runs through the heart of the Project Area is the main migration route for thousands of birds, which cross over the Himalayas to spend the winter either in Pakistan or further south. Out of the seven recognised major flyways in the world the Indus Flyway, Number 4, is also known as Green Route and is one of the most important[96] flyovers for migratory birds from Siberia. Migratory birds that visit the region include pelicans, herons and egrets, waders and raptors.

Historically the delta has been an important area for resident and migratory waterfowl, crane, teals, pintails, mallards. It is also home to a wide variety of species of ducks, geese, eagles, falcons and the Hobart bustard. Among mammals, wild boar, the Indian jackal, the Bengal fox, the fishing cat, cetaceans (humpback dolphin and bottle-nosed dolphin) and the endangered Indian Pangolin were recorded. Sea snakes are the most common reptiles in the Project Area.

Since the persistent sun and lack of freshwater in the mangrove forests create harsh environments for insects, only a few species of insects are active during the day. Nocturnal and endophytic feeding are common features among many of the mangrove-associated insect species.

Termites and ants (*Formicidae*) are ubiquitous and are clearly the most abundant terrestrial animals in these mangroves. It is estimated that may species of ants live in direct association with the mangroves, utilising hollow twigs and branches as nest sites[97].

The saltwater surface and mudflats on mangrove islands provide habitats for aquatic and semiaquatic insects, including species representing several families of *Diptera*, *Hemiptera*, *Odonata*, and *Coleoptera*. The shore-fly family *Ephydridae* is particularly species-rich in mangrove habitats. Most species in this family are detritivores. They live on decaying vegetation along the shore. Mangrove vegetation in the Project Area provides numerous supratidal habitats for herbivorous insects, along with their parasites and predators.

Intertidal and subtidal biodiversity

[95] https://foreverindus.org/pdf/180808annual_report_2007

[96] http://www.wildlifeofpakistan.com/PakistanBirdClub/birdcomeflyingin.html

[97] Feller, I.C. and M. Sitnik, 1996. Mangrove Ecology Workshop Manual. Smithsonian Institution, Washington, D.C.

In addition to the mangrove trees, other primary producers in mangrove communities and adjacent areas include microscopic and macroscopic algae. Microscopic algae are found in the plankton (phytoplankton), on mangrove roots (periphyton) and other substrates (epibenthic), and within the tissues of sea anemones, ascidians, sponges, and other animals (endobionts).

The distribution of macroscopic algae, commonly called seaweeds, is determined by substrate availability, light and nutrient levels, salinity, competition, and herbivory. Characteristic assemblages of seaweeds occur on mangrove roots (epiphytes), mangrove soils and surrounding substrates. Zooplankton are heterotrophic organisms (protozoans and animals) that are unable to maintain their distribution against the movement of water masses. Zooplankton in the Project Area are generally divided into two major groups depending on their size. Micro-zooplankton range from 20 to 200µm in size and include the larger protozoans and small invertebrate eggs and larvae. Macro-zooplankton above 200µm in length include a wide variety of invertebrate and fish larvae[98]. Both salinity and tidal regime affect the abundance and diversity of the zooplankton in coastal communities. Accumulated detritus also plays a key role from a trophic perspective. Organisms of the zooplankton are partially responsible for the success of mangrove systems as a nursery for higher species.

A total of 38 finfish species, 21 shellfish (shrimps, gastropods and bivalves) were identified during the survey at various project locations. *Liza subviridis* of the family *Mugilidae*, was found to be the dominant species making 14.36% of the total, whereas two other species of the family *Sciaenidae*, *Johnius carouna* and *Otolithes ruber*, were at 9.41% and 9.94%, respectively.

Current situation in the Project Area

The Project Area covers regions of highly degraded mangroves. The remaining vegetation in the Project Area is extremely sparse. In places, individual mangrove trees may be found, but the majority of the area is either barren land or covered with a scattering of seasonal, low salt tolerant *Oryza coarctata* grass.

At the time of validation, a total of 75,504 hectares of mangroves have been restored by the project.

Threats to biodiversity

The main threat to the biodiversity in the Project Zone is habitat reduction through mangrove degradation and deforestation. Besides loss of forest which leads to habitat loss and fragmentation for some water-dependent species, other factors causing loss of habitat and wetland degradation include:

- Excessive and indiscriminate harvesting of fisheries and other coastal resources beyond their regenerative capacities
- Inadequate engagement of key stakeholder groups to participate in resources conservation and development
- A general lack of awareness and capacity amongst stakeholders to sustainably manage wetlands,

[98] Jacobs, N.D. 1996. Zooplankton of Coastal Lagoons with Emphasis on the Mangrove Environment *In* Feller, I.C. and M. Sitnik. Mangrove Ecology: A Manual for a Field Course A Field Manual Focused on the Biocomplexity on Mangrove Ecosystems.

their ecosystems, resources and their ecosystem services

- Poor law enforcement due to lack of investment into mangrove forests protection, conservation, regeneration, and coastal areas conservation and rehabilitation
- Human-wildlife conflict
- Sea level rise
- A decline in freshwater flows due to upstream activities. This increases the salinity level in the wetlands areas and also leads to sea intrusion into various terrestrial areas including fertile crop lands in the nearby vicinities
- Inadequate supply of sediments into the wetlands causing the delta front to be eroded

5.1.2 High Conservation Values (B1.2)

The entirety of the ARR/RWE Project Area is of High Conservation Value based both on area as well as species parameters.

Area-based significance: The Indus Delta coastal ecosystem is one of the largest and the most important arid-zone coastal ecosystem in Asia. It is:

Globally significant – The Project Area is one of the largest and one of the most important sites globally for the species listed and arid zone mangrove ecosystem

Regionally significant – The Project Area is within one of the approximately five most important sites in South Asia and Asia Regions for the species listed

Nationally significant –The Project Area is the most important of the two coastal sites for the listed species in Pakistan

Species-based significance: The Project Area also has great ecological significance and is the wintering ground of many species of water birds. Migratory birds particularly shorebirds, egrets and herons, gulls and terns, pelicans and flamingos use these wetlands for feeding, resting and roosting purposes. The Project Area contains or provides potential habitat for the country's species which are endangered, vulnerable or threatened and are included in the IUCN Red Listing as tabulated below.

Table 37. High Priority IUCN Red Listed species found within the Project Zone.

Species Name	IUCN Red Listing	CITES Appendix
Fishing cat *(Prionailurus viverrinus)*	VU	II
Indian pangolin (*Manis crassicaudata)*	EN	II
The Indus River dolphin (*Platanista gangetica)*	EN	II
The Indian humpback dolphin *(Sousa plumbea)*	EN	I
Painted stork (*Mycteria leucocephala)*	NT	

Dalmatian pelican (*Pelecanus oncrotalus)*	NT	
Egyptian vulture (*Neophron percnopterus)*	EN	I
Cinerous vulture (*Aegypius monachus)*	NT	II
Black- tailed godwit (*Limosa limosa)*	NT	II
Bar-tailed godwit (*Limosa lapponica)*	NT	II
Eurasian curlew (*Numenius arquata)*	NT	I

Table 38. Qualifying attributes of the Project Area for High Conservation Values (HCVs) 1, 2 and 3 are detailed in the tables below.

High Conservation Value	**HCV 1: Species diversity**
Qualifying attributes	• Concentrations of biological diversity including endemic species, and rare, threatened or endangered species, that are significant at global, regional or national levels. • The Project Area is a part of landscapes containing populations of arid zone mangrove species • It forms part of the habitat for the endangered Indus River dolphin and the Indian humpback dolphin which have global significance • Other unique aquatic biota in the area include the Indus baril (*Barilius modestus*), Indus garua (*Clupisoma naziri*), rita catfish (*Rita rita*) and a number of snakehead fish including the giant snakehead, *Channa marulius*[99]. • The Project Area is the habitat of the endangered Indian pangolin • The Project Area has 32 of the 147 fish species found in the region that are endemic to Pakistan (Amir, Siddiqui, Masroor, 2016)[100] • The Project Area is used as a temporary place/habitat by a number of migratory bird species

[99] Miththapala, S. 2008. Mangroves. Coastal Ecosystems Series Volume 2: Ecosystems and Livelihoods Group Asia, IUCN.

[100] Amir, Siddiqui, Masroor, 2016, Finfish diversity and seasonal abundance in the largest arid mangrove forest of the Indus Delta, Northern Arabian Sea, Senckenberg Gesellschaft für Naturforschung and Springer-Verlag Berlin Heidelberg 2016

Focal area	Mangroves forests and degraded lands in the Project Area – it is necessary to carry out restoration activities and conserve the current mangrove area in order to maintain species diversity.
High Conservation Value	**HCV 2: Landscape-level ecosystems and mosaics**
Qualifying attributes	Large landscape-level ecosystems and ecosystem mosaics that are significant at global, regional or national levels, and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance. • The Project Area forms part of a large wetlands landscape which extends to over 600,000 hectares • The Project Zone is a part of landscape that contains mangrove ecosystems as well as mudflats ecosystems and is thus constituting landscapes that contain two or more contiguous ecosystems • The Project Zone is a part of landscapes containing populations of arid zone mangrove species
Focal area	Mangroves forests and degraded lands in the Project Area – it is necessary to carry out restoration activities and conserve the current mangrove area in order to maintain the project area's landscape level ecosystems and mosaics.
High Conservation Value	**HCV 3: Ecosystems and habitats**
Qualifying attributes	Rare, threatened, or endangered ecosystems, habitats or refugia. • The Project Zone is one of the largest zones of arid mangroves regionally, nationally and globally • The Project Zone is used as a temporary place/habitat by a number of migratory bird species
Focal area	Mangroves forests and degraded lands in the Project Area – it is necessary to carry out restoration activities and conserve the current mangrove area in order to maintain the project area's ecosystems and habitats.

5.1.3 Without-project Scenario: Biodiversity (B1.3)

Biodiversity impact assessment related meetings and discussions have been held with various stakeholder groups by the proponents to develop the DBC-1 Project Area biodiversity baseline, without-project and with-project land-use and biodiversity scenario. These meetings include the various SBIA Workshops held with stakeholders (see Section 2.1.9). The groups involved in this process included local communities with close knowledge of the area and representatives from the provincial government's Forest Department and

Wildlife Department, the Federal Government's Quality Control and Standards Authority, and various NGOs including inputs from the IUCN and WWF Pakistan. All participants at these meetings had some prior knowledge and experience of implementing biodiversity and conservation related activities within the DBC Project Zone.

Unsustainable use of mangrove forests

In discussions, an evaluation of historical conditions identified the direct and indirect drivers of biodiversity and HCVs degradation in the Project Area. All stakeholders were in agreement that the core issue driving degradation was a poor appreciation of biodiversity value, both at the institutional and community levels**.** Historically, existing forests and natural resources have been valued only for tangible benefits like timber, fuelwood and fodder by these actors.

Furthermore, community groups and authorities have not been properly sensitised to the benefits (economic, social and environmental) of conservation and restoration of wetlands. This has been largely due to capacity and knowledge gaps within local institutions, which are poorly developed and underfunded, leading to low levels of community engagement and participation in conservation and restoration activities.

Consequently, there is no perceived economic or environmental incentive for better or alternative land-use planning and vast areas of these once fertile croplands and wetlands – which were formerly farmed for red rice – have been left abandoned and allowed to degrade over time in the DBC Project Zone. Currently, increased population pressure and poverty is exacerbating the problem and putting further pressure on existing resources leading to further biodiversity degradation and wildlife habitat loss.

Human-wildlife conflict

Human-wildlife conflict is projected to increase under a without project scenario due to increased population and competition for resources. As outlined above, the majority of Project Zone communities are not sensitised to wildlife, its positive role and ecological importance in ecosystems and their services maintenance. Therefore killing, hunting and trapping of wild animals is often observed in the Project Zone as detailed below.

- Various reptile species (snakes and lizards) that are considered poisonous or otherwise dangerous by the local population are routinely killed as 'precautionary measures'
- Some wildlife species such as jackals and jungle cats, prey upon poultry and are considered 'problem species'. Many locals shoot or lay traps for them to avoid losses
- There is increased human and wildlife conflict on account of losses caused by some animals to crops and other property. This particularly holds true in the case of wild boar, which locals will target
- Increasing number of feral dogs are having a negative impact on wild animals in the Project Area. These canines are major food competitors for most of the carnivore species and are given refuge and shelter by some communities in the Project Zone. Their numbers are likely to increase with the passage of time
- Particular community groups like Jogies, Bar and the Bheel, who mostly come from outside the Project Zone, collect some reptiles and pangolins illegally to sell to the traders based in larger towns. Weak wildlife law enforcement and lack of convictions for offenders is a driver for this activity

In a without project scenario these activities will persist and worsen over time without the necessary interventions and the application of stricter law enforcement.

Unsustainable fisheries

The majority of the population in the Project Zone rely on fishing for their livelihoods and increasingly fisherman are adopting unsustainable harvesting practices to keep pace with demand and to make ends meet. Traditional fishing methods were environmentally friendly, where nets made of silk (*resham*) or a cotton variety (*latha*) were used for stationary fishing and had a sufficiently wide mesh to release small fry.

However, over recent times environmentally harmful nets have been introduced in an effort to increase fish catches[101]. These are made of nylon, have a fine mesh, and also catch non-target species. A combination of technology upgrades and rising costs have also made fisherman increasingly dependent on loans to finance their capital expenditures. In the absence of readily available institutional credit, the fisherman's only recourse is an informal and often exploitative credit system. As a result, efforts to maintain livelihoods in the face of declining catches and increasing debt appear to be forcing an increasing number into adopting unsustainable harvesting practices, further degrading biodiversity in the DBC-1 Project Area.

A seasonal ban on fishing (June–August) to protect spawning fish coincides with the monsoon squalls that make fishing difficult. In this case, nature to some extent comes to the aid of policy. But while the ban applies to sea-going vessels, it does not prevent shore fishing by locals, including in the shrimp breeding grounds[102]. Authorities, due to lack of budgetary provisions and low staff levels, also find it difficult to enforce the ban effectively.

Under a without-project scenario all of the above direct and indirect drivers will continue to exert negative pressures, leading to increased and accelerated biodiversity exploitation, reduction, degradation and fragmentation.

To ensure the project's success, key biodiversity related factors need to be addressed. These can be broadly categorised as focal issues. These priority focal issues – as determined by stakeholders – and their drivers are given in the tables below.

Table 39. Focal issues driving biodiversity loss and degradation within the Project Zone.

Focal issue 1	Drivers

[101] Shahid, U. 2013. Making a sustainable living from fishing in the Indus Delta

[102] Khan S.R. and S.R. Khan. 2011. Fishery degradation in Pakistan: a poverty–environment nexus? Canadian Journal of Development Studies/Revue canadienne d'études du développement, 32:1: 32-47.

Unsustainable use of resources	• Demand for and cutting of mangroves for fuelwood purposes and as a source of energy • Demand for and practice of open range grazing of camels and other livestock in mangrove forests • Cutting of branches, leaves and propagules as a fodder for livestock • Human and livestock population increase • Clearance of mangroves for aquaculture • Increased demand for fish and shrimp species • Unsustainable fishing practices • Expansion of settlements inside the creeks • Lack of alternative sustainable supply of fuelwood
Focal issue 2	Drivers
Ineffective law enforcement	• Lack of budgetary provisions and funds for enforcement of forest, wildlife and fisheries laws • Lack of training and capacity for forest, wildlife and fisheries law enforcement • Low staff numbers leading to fewer forest and adjoining marine and land areas patrols for apprehending forest, wildlife and fisheries laws offenders • Lengthy and cumbersome judicial process for adjudication of natural resources offence cases
Focal issue 3	Drivers
Low awareness of biodiversity value	• Lack of awareness on the part of communities and other stakeholders about the ecosystem services values of mangrove forests, wildlife and biodiversity • Low levels of community engagement in mangrove forest, wildlife and biodiversity, and fish resources protection • Human-wildlife conflict • Lack of needed investment funds for restoration work • Lack of incentives to communities for promoting sustainable management of forests, biodiversity, fisheries and other natural and environmental resources

	• Lack of alternative livelihood for communities

Stakeholders projected what would happen with regards to each focal issue in the short-to-medium term in the absence of the project. A worsening situation is expected with respect to each of the focal issues and their contributing factors leading to:

- A reduction of mangrove forests and disappearance of their ecosystem services
- Increased vulnerability of biodiversity and threatened species in the area due to lack of habitat and ongoing habitat destruction

5.2 Net Positive Biodiversity Impacts

5.2.1 Expected Biodiversity Changes (B2.1)

Project interventions

Net positive biodiversity impacts of the project include better protection and conservation of endemic, rare, vulnerable and threatened species; conservation of landscape level ecosystems and mosaics; and conservation and sustainable management of rare, threatened or endangered ecosystems, habitats and refugia through various project interventions that address the root causes and drivers of biodiversity and habitats loss.

Based on the identified Focal Issues listed in Table 38, entry points, management interventions and engagement strategies have been developed by stakeholders. These are seen as the most likely actions and activities to address the root causes and drivers of biodiversity degradation in the DBC-1 Project Zone.

These constitute project activities that if implemented would follow the theory of change logic developed in the Results Chain (see Figure B2) to lead to desired outcomes of restoration of wetlands and conservation and enhancement of biodiversity values. Accordingly, they are:

- **Wetland restoration and habitat improvement:** This will be achieved by rehabilitating and restoring 247,112 hectares of degraded and de-vegetated mangrove lands through planting of mangrove propagules and various assisted natural regeneration activities to create further and enhanced habitat for wildlife and restore mangrove forest ecosystems
- **Habitat security enhancement and effective enforcement of laws:** This will be accomplished through increasing number, capacity and welfare of law enforcement agencies via appropriate

training and allocation of resources to assist in institutional development and organisational strengthening

- **Ensuring sustainable resource use levels:** This focal area will be tackled through preventing and controlling unauthorised, un-regulated and unsustainable resource use of mangroves and fisheries, provision of alternatives to reduce pressure on existing resources and increasing resource use efficiency
- **Improved awareness raising and advocacy**: This will focus on ensuring better access to knowledge via dissemination and supporting its application, properly organising stakeholder groups for coordinated efforts, and doing advocacy work on issues of concern in particular unsustainable fishing practices and activities upstream that may disrupt freshwater flows into the delta

Theory of Change Statements

Based on the experience of the project proponent in working on biodiversity conservation and community projects in the landscape, a literature review, and information obtained from the SBIA workshop and various stakeholder consultations, a theory of change approach was applied to substantiate the DBC-1 project rationale and to produce indicators for a CCB monitoring plan.

A theory of change is a hypothesis about how a project intends to achieve its stated objectives, or a roadmap of how it plans to get from project activities to project impacts[103]. Interventions would mainly address the issues or factors projected in the preceding section as likely to get worse in the absence of the DBC-1 project. These would thus constitute the project activities that if implemented would follow the theory of change logic outlined below to lead to the desired outcomes.

Activity area 1: Habitat improvement and restoration of degraded and de-vegetated wetlands: IF funds for restoration work are made available, IF local communities are organised to play a role in mangrove restoration work, IF mangrove restoration work is implemented under ecological principles, IF communities are engaged in the protection of restored areas through Mangrove Stewardship Agreements THEN vast degraded and de-vegetated mangrove lands in the Project Area can be restored and protected.

Activity area 2: Habitat security enhancement and effective enforcement of laws: IF funds for laws enforcement are made available, IF local communities and concerned departments are trained, capacitated and facilitated in implementing forest, wildlife and fisheries laws, IF communities are engaged in the protection of restored areas through Mangrove Stewardship Agreements and Fisheries Stewardship Agreements, IF there are more patrols by well-motivated and equipped Forest Department staff as well as custodian communities under the Stewardship Agreements, THEN there will be improvements in offences prevention, detection, apprehension, prosecution, and adjudication and more effective enforcement of laws leading to reduced levels of destructive forest, wildlife and fisheries related use

[103] Richards, M. and S.N. Panfil. 2011. Social and Biodiversity Impact Assessment (SBIA) Manual for REDD+ Projects: Part 1 – Core Guidance for Project Proponents. Climate, Community & Biodiversity Alliance, Forest Trends (p59), Fauna & Flora International, and Rainforest Alliance. Washington, DC.

Activity area 3: Species and habitats conservation control of unsustainable levels of resource use: IF communities are provided with alternative sources of employment and income earning, IF local communities are provided with alternative energy sources, IF free-range livestock grazing is controlled, IF local communities are organised to play a role in resources protection, IF fishermen are educated and facilitated to use sustainable harvesting practices, THEN unsustainable levels of resource use (mangroves, wildlife, and fisheries) will be brought under control

Activity area 4: Improved awareness raising and advocacy: IF awareness raising and advocacy campaigns are properly designed, implemented and upscaled, IF the various stakeholders are properly motivated, trained, involved and engaged in resources planning, management and monitoring, IF there is increased knowledge and appreciation of biodiversity amongst local communities, IF there is greater involvement of communities and other stakeholders in resources conservation, restoration and sustainable management, THEN biodiversity habitat and HCVs will be conserved and enhanced in the Project Area
Anticipated changes in biodiversity resulting from project activities is given in the tables below.

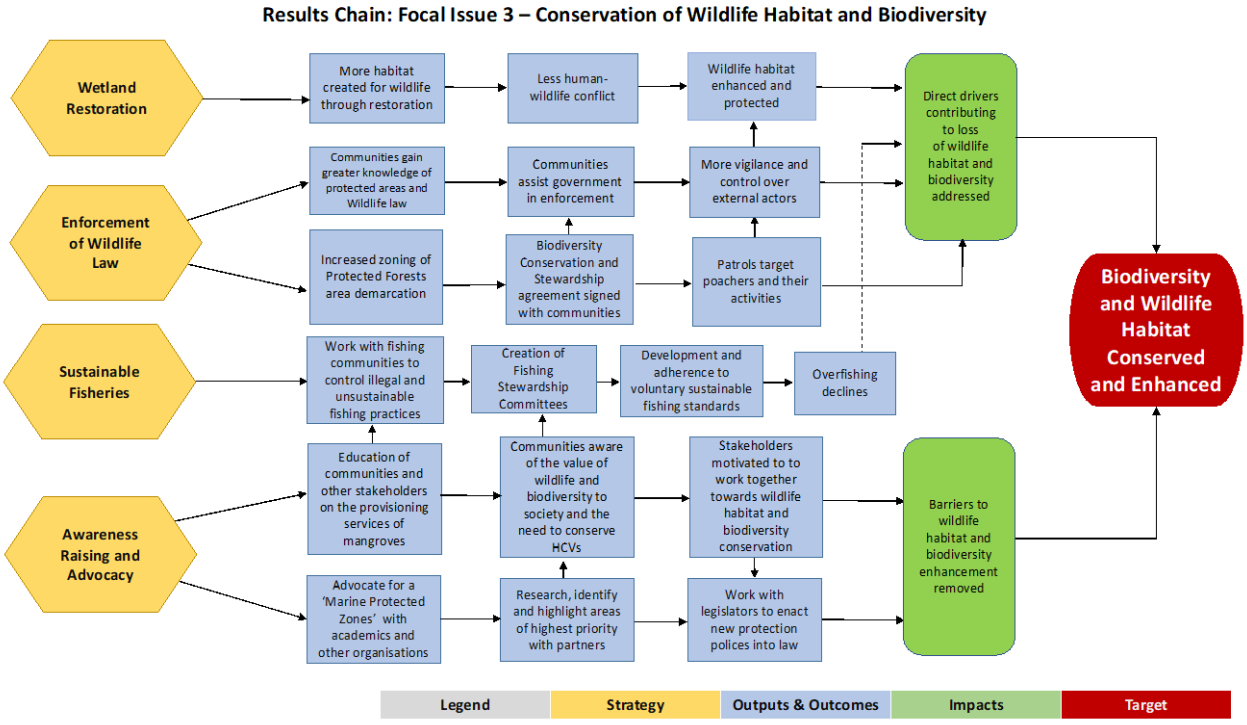


Figure 40. Results chain for project activities that aim to conserve wildlife habitat and biodiversity.

Table 40. Overall biodiversity changes due to project activities.

Biodiversity element	Flora
Estimated change	Positive

Justification of change	The project consists of the restoration and conservation of tidal wetland mangrove forests in the Project Area. Project interventions will be implemented via sustainable landscape management tools, which will contribute to the maintenance of the ecological structure and composition of the ecosystem. This will guarantee the availability of ecosystem services and the conservation of species of flora that are under threat. The methods used to estimate these changes are detailed in the monitoring plan (see Appendix 16. CCB Biodiversity Monitoring Plan) and SOPs.

Biodiversity element	Fauna
Estimated change	Positive
Justification of change	A good vegetation cover will ensure an adequate habitat for faunal species. Mangrove forests in the Project Zone are the habitat of a great variety of local and migratory birds, mammals and reptiles, which obtain food from them and use them as places of refuge and nesting. Marine and estuarine species will also find the necessary conditions for their reproduction, growth and permanence. The methods used to estimate these changes are detailed in the monitoring plan (see Appendix 16. CCB Biodiversity Monitoring Plan) and SOPs.

5.2.2 Mitigation Measures (B2.3)

None of the implemented or proposed project activities are expected to have any negative impacts on biodiversity, including any of the areas HCVs. Interventions are specifically designed to restore mangrove forests and thus improve habitat, as well as reduce any direct threats to wildlife and biodiversity. The level of uncertainty and risk associated with the project activities is very low, given the project's success to date. Hence, the need for explicit application of the precautionary principle does not arises.

5.2.3 Net Positive Biodiversity Impacts (B2.2, GL1.4)

Based on comparison of without-project scenario (Section 5.1) and with-project scenario (Section 5.2), most of the direct factors across the focal areas are projected as being likely to worsen in the absence of the ARR project. These, among others, include:

- Availability of funding support
- Fuelwood demand
- Fodder demand and demand for open range grazing in mangrove forests
- Demand for fisheries and other environmental resources
- Lack of zoning and Protected Areas demarcation
- Limited forest, wildlife, fisheries and other environmental laws enforcement

- Minimal risk of being prosecuted for various natural resources related offences
- Lack of awareness, understanding and motivation to show appreciation for biodiversity values
- Lack of knowledge, skills and capacity for biodiversity conservation

Thus, project activities planned and being implemented under Section 5.2 will result in clear environmental, biodiversity and HCVs benefits compared to the without-project scenario. Also, the project has no negative biodiversity impacts anticipated, either on-site or off-site. The Project Zone includes areas where mangroves will grow due to climate induced sea-level rise. Protecting these areas through the project activities will help biodiversity to adapt to climate change.

5.2.4 High Conservation Values Protected (B2.4).

Special attention will be paid to the protection and conservation of High Conservation Values 1,2, and 3 as identified in Section 5.1.2. These will be protected and conserved as per HCV Resource Network Common Guidance for the Management and Monitoring of High Conservation Values and the criteria and indicators of the CCB Standards Third Edition.

5.2.5 Species Used (B2.5)

The project will undertake restoration of degraded and de-vegetated mangrove areas within the project area. This will include planting of mangrove tree species combined with assisted natural regeneration that occurs in these planted areas. Species used or intended to be used in such replanting are *Avicennia marina, Rhizophora mucronate, Ceriops tagal,* and *Aegiceras corniculatum*. In the agroforestry program, the project will use local and native species such as *Acacia nilotica*.

All species used in the restoration work or natural forest replanting or agroforestry program under the project are native to the coastal areas of Sindh Province and non-invasive in these mangrove forest habitats. The project is limited in its capacity to improve plant species diversity with the current freshwater inflows and sediment regime. No non-native species will be used in the Project Area. All the natural mudflats in the landscape have been excised from the Project Area *a priori*.

5.2.6 Invasive Species (B2.5)

No invasive species, either floral or faunal, are being used by the project.

5.2.7 Impacts of Non-native Species (B2.6)

The project is not using any non-native invasive and alien species in its ARR program. Only native species are used.

5.2.8 GMO Exclusion (B2.7)

No Genetically Modified Organisms (GMOs) are being or will be used in the Project Area.

5.2.9 Inputs Justification (B2.8)

The use of various agro-chemicals like insecticides, weedicides, pesticides, fertilisers or other environmentally undesirable inputs is neither anticipated nor will be used under the project.

5.2.10 Waste Products (B2.9)

The main waste anticipated from implementation of this project are from construction/renovation activities (health centre construction, civic centre construction) and other infrastructure. For any such activity, the project will adhere to the Provincial Environmental Law provisions and guidelines, as stipulated under the established Environmental Impact Assessment process in the applicable environmental law.

5.3 Offsite Biodiversity Impacts

5.3.1 Negative Offsite Biodiversity Impacts (B3.1) and Mitigation Measures (B3.2)

Given the fact that all project activities are designed, planned and implemented to deliver positive biodiversity impacts, no negative impacts are anticipated, either onsite or offsite. There is very little possibility that the restoration of mangrove forests on degraded or de-vegetated areas will lead to displacement of activities offsite.

This is because the sources of threat to biodiversity are mainly local and they are unlikely to be transferred outside the Project Zone. There are no commercial threats to biodiversity in the area. This, however, will be very closely and carefully monitored and any resulting impacts will be assessed, quantified and mitigated on an immediate basis. As no negative off-site impacts are anticipated, no additional mitigation strategy is required at this point in time other than the actions proposed above.

5.3.2 5.3.2 Net Offsite Biodiversity Benefits (B3.3)

As there are no anticipated negative offsite impacts to biodiversity, an evaluation of unmitigated offsite impacts is not applicable.

5.4 Biodiversity Impact Monitoring

5.4.1 Biodiversity Monitoring Plan (B4.1, B4.2, GL1.4, GL3.4)

The biodiversity monitoring plan of the project, as given in Appendix 16. CCB Biodiversity Monitoring Plan, has been developed keeping in view project's causal model related to biodiversity. It aims at addressing the underlying causes of biodiversity loss by mainstreaming biodiversity conservation across its various project interventions; reducing direct pressures on biodiversity and promoting its sustainable use; improving the status of Indus Delta wetlands biodiversity by safeguarding ecosystems, species and genetic diversity; enhancing the benefits to local communities and other stakeholders from biodiversity conservation; and enhancing implementation of biodiversity conservation and sustainable management measures through participatory planning, knowledge sharing and capacity building.

More specifically, the biodiversity monitoring plan includes the biodiversity-related variables to be monitored, which are not only in line with, but which are also directly linked to the project's biodiversity objectives and to predicted outputs, outcomes and impacts identified in the project's causal model related to biodiversity. The monitoring plan and the protocol for its implementation have identified and given the areas to be monitored and also give the types of measurements, the sampling methods, and the frequency of monitoring and reporting to be used.

To ensure the implementation of biodiversity monitoring plan, the project has a team of experts and field teams with the requisite competencies, clear job descriptions and responsibilities with regard to the monitoring plan implementation and they have been organised in an organisational structure which is meant to deliver results on the ground.

The project has also developed a detailed policies and procedures document (given separately) that details policies for oversight and accountability of biodiversity monitoring activities as well as procedures for handling non-conformances with the validated monitoring plan. Provided therein is also the project's organisational structure and personnel for implementation of the plan.

The theory of change logic in the Result Chain Diagrams (Section 5.2.1) was used as the basis for selecting indicators for biodiversity monitoring, along with the best sampling methods to collect these data to acceptable levels of accuracy, precision and cost effectiveness whilst retaining transparency and simplicity. The Appendix 16 (CCB Biodiversity Monitoring Plan) and SOPs guide data collection.

Furthermore, the indicators will be analysed based on the pressure-state-response framework, which also relies on a causal-chain logic. Wildlife surveys and monitoring for all species – with a focus on HCVs – will be done using several methods: patrols, camera traps and information from any independent research projects in the area.

Vegetation and land-cover: Monitoring of land cover and land cover changes and vegetation development over time is an integral part of the biodiversity monitoring plan. For this purpose, among others the project would make use of remote sensing (based on LANDSAT imagery) and GIS techniques (see Section 3.3.3) with appropriate ground truthing as well as establish permanent sample plots for vegetation and vegetation change monitoring.

5.4.2 Biodiversity Monitoring Plan Dissemination (B4.3)

Dissemination of the monitoring plan for biodiversity will follow the guidelines described in Sections 2.3.2 and 3.3.4 on the dissemination of project summary documents.

5.5 Optional Criterion: Exceptional Biodiversity Benefits

The project is seeking Exceptional Biodiversity Benefits based on the presence of HCVs 1,2 and 3, IUCN Red List species and critical ecological functions.

5.5.1 High Biodiversity Conservation Priority Status (GL3.1)

The project is expected to generate exceptional biodiversity benefits based on achievement of multiple criteria defined in the Key Biodiversity Areas (KBAs) and the CCB Standards Third Edition – vulnerability and irreplaceability.

The Project Area forms part of the Indus eco-region, which is identified and classified as amongst the 40 globally biodiversity rich eco-regions. The arid zone mangroves in the Indus Delta area contain biodiversity sites that are contributing significantly to the global persistence of biodiversity and these sites meet one or more of the 11 criteria of the KBAs.

5.5.2 Trigger Species Population Trends (GL3.2, GL3.3)

There have not been systematic and thorough assessments of biodiversity-related High Conservation Values in the Indus Delta Project Zone landscape. This makes it difficult at present to provide either current numbers or estimates for the end of the project.

However, given the current poor or limited levels of law enforcement across the landscape, coupled with extreme poverty, minimal livelihood and job opportunities for the local communities, loss of critical mangrove forests and wetlands habitats including HCVs is likely to continue without the Indus Delta ARR project interventions.

This is likely to lead to a reduction in most, if not all, of the threatened and vulnerable trigger species. Given this likely scenario, the proposed activities under the project's theory of change (Section 5.2.1) will lead to an improved status for most of the threatened and vulnerable species as given in Table 40 and Table 41 below.

Table 41. Trends in trigger species populations – key threatened mammal species.

Trigger species	Indus River dolphin ((*Platanista minor*) and the Indian Ocean humpback dolphin (*Sousa plumbea*)
Conservation status	Endangered
Population trend at start of project	Both these mammals are endemic to the Indus eco-region and there were several sightings of the *Sousa plumbea* during our biodiversity survey (see Appendix 18. Biodiversity Survey). Both are considered endangered species and their IUCN Red Listing indicates that populations at the start of the project are declining.
Without-project scenario	In the without-project scenario, it is highly likely that population of both species would be negatively affected in the Project Zone due to lack of awareness of their global significance and further degradation of their habitat.
With-project scenario	Under the with-project scenario, both species are expected to maintain or increase from their current population density due to the improved habitat provided by the project interventions and increased awareness creation about the species and the need to conserve the species.
Trigger species	Indian pangolin (*Manis crassicaudata*)

Conservation status	Endangered
Population trend at start of project	The Indian pangolin is a nocturnal mammal and relies heavily on its sense of smell to detect its food. It can climb up the trees and curls up its body when threatened. Normally solitary, it spends daytime in underground chambers. The animal is at risk due to poaching pressure from Jogies, Bellies and other community groups who are engaged in its illegal trade. The population trend of the species at the start of the project is therefore likely declining.
Without-project scenario	In the without-project scenario, its population will likely further decline due to poor law enforcement.
With-project scenario	Under the project scenario, measures will be taken to curb the illegal trade in the species, meaning the population is expected to be maintained or increased. This will be done through stricter enforcement of the law, awareness creation, training and capacity building, improvements in governance, and allocation of needed resources (human, technical, material and financial) for its conservation.
Trigger species	Fishing cat (*Prionailurus viverrinus*)
Conservation status	Vulnerable
Population trend at start of project	The fishing cat mainly feeds on fish but also preys on waterfowl and frogs. Due to habitat degradation and increased food competition in the Project Area, the population of the species is decreasing. Therefore, population trend of the species at the start of the project is considered to be declining.
Without-project scenario	In the without-project scenario, the population of the fishing cat is highly likely to decline because the animals and biodiversity on which it preys are both in decline.
With-project scenario	Under the with-project scenario, the population of the fishing cat is very likely to increase due to the fact that both the direct and indirect threats to the species will be addressed. With better and increased mangrove forest cover the animal, which lives near water in protected dens and is seldom seen in the open during daytime, will have an improved habitat for their reproduction, growth and permanence. The project will also create awareness amongst the communities about the biodiversity significance of the species.

Table 42. Trends in trigger species populations – key threatened bird species.

Trigger species	Egyptian vulture (*Neophron percnopterus)*
Conservation status	Endangered
Population trend at start of project	This endangered bird was spotted in the Project Area during a biodiversity survey (see Appendix 18. Biodiversity Survey). Its IUCN Red Listing indicates a decreasing trend in population globally.
Without-project scenario	In the without-project scenario this declining population trend of the species is likely to continue regionally too due to further habitat degradation.
With-project scenario	With the project populations of this vulture species are likely to be maintained or increase from their current density due to the improved habitat provided by the project interventions.

APPENDICES

Appendix 1. Stakeholder Identification Table

Table A1.1. Communities included in the Project Zone for DBC-1, with their dependency on mangroves.

No.	Name of village	Population	Main ethnic groups	Dependence on mangroves			
				Fuelwood [kg]	Fodder [kg]	Fisheries [kg]	# of families
1	Saleh Muhammad Baloch	1,050	Mallah, Baloch, Minorities	-	-	600	120
2	Sumar Shoro	425	Shoro	-	-	3,000	40
3	Achar Mirbahar Goth	55	Mirbahar	-	-	45	10
4	Natho Goth	55	Sodhai	-	-	-	12
5	Saifullah Goth	375	Sodhai, Machi	-	-	-	45
6	Jahangir Khan Baloch	113	Kalmati	-	-	-	25
7	Muhammad Hashim Mirbahar	1,500	Mirbahar	60,000	-	600	200
8	Sathi Jatt Goth	900	Kalmati	-	-	3000	100
9	Wadera Ali Muhammad	1,250	Jatt	-	-	100	300
10	Haji Pandhi Jatt	500	Jatt	-	-	160	51
11	Karam Ali Jatt	425	Jatt	19,800	-	400	45
12	Usman Juman Goth	500	Jatt	48,000	-	600	40
13	Arab Jatt	2,000	Jatt	-	-	800	200
14	Sajan Shah	110	Mallah, Syed	-	-	200	17
15	Ahmed Dablo	2,000	Dabla	-	-	80,000	200
16	Palrdo Goth	350	Dabla	9,000	-	400	
17	Hayat Jatt Goth	300	Jatt	11,200	-	300	40
18	Raees Ahmed Jatt Goth	300	Jatt	-	-	40,000	50
19	Muhammad Hashim Jatt	600	Jatt	10,000	-	12,000	50

	Goth						
20	Haji Qasim Jatt	150	Jatt	-	-	5,000	24
21	Mir Jatt Goth	1,000	Jatt	-	2,000	1,500	150
22	Haji Mehar Goth	1,000	Lashari	-	-	-	100
23	Sumar Sholari	45	Sholaarni	-	-	-	7
24	Muhammad Musa Jatt	2,620	Mallah, Jatt	-	-	1,600	70
25	Muhammad Khan Jatt	1,000	Jatt	-	320	3,000	300
26	Ahmed Khan Memon	1,000	Memon	-	-	-	100
27	Muhammad Khan Sholaarni	600	Mallah, Syed, Sholaarni	6,000	-	24,000	100
28	Haji Ismail Jatt	2,500	Jatt	-	-	6,000	80
29	Bhair Jatt	2,500	Jatt	-	-	20,000	40
30	Ali Bux Jatt	1,000	Jatt	-	-	-	20
31	Bhori Goth	2,000	Sodani Jatt	40,000	-	-	200
32	Mirano Goth	100	Wangai Jatt	24,000	-	480	30
33	Raj Wari Jao Goth	50	Jatt	3,000	-	80	45
34	Haji Muhammad Goth	250	Jatt	-	-	2,000	20
35	Haji Maro Goth	250	Dabla	3,920	-	1,000	14
36	Muhammad Shumar Goth	150	Dabla	10,500	-	600	25
37	Muhammad Dablo Goth	100	Dabla	8,100	-	20	30
38	Ghulam Dablo Goth	100	Dabla	16,000	-	160	40
39	Allah Baloch Kalmati Goth	100	Kalmati Baloch	-	-	-	6
40	Kareem Bakhsh Baloch	150	Murgur Baloch	-	-	2,000	30

41	Sajan Wari Goth	700	Mallah	-	-	1,200	150
42	Abdullah Mirbahar Goth	400	Mirbahar	-	-	480	50
43	Ahmad Baghdo	250	Baghda	-	-	280	20
44	Ahmad Pattani	30	Patani	-	-	30	12
45	Haji Sheedi	40	Dabla	3,840	-	200	12
46	Haji Mamo Goth	40	Dabla	1,800	-	3600	15
47	Hashim Takro Goth	80	Dabla	5,250	-	200	35
48	Karo Takro Goth-1	20	Pulwani Dabla	30	-	500	6
49	Karo Takro Goth-2	20	Dabla	750	-	600	6
50	Allah Warayo Bhatti	530	Bhatti	3,400	-	20	85
51	Gul Muhammad Uplano	1,000	Uplano	-	-	3,750	300
52	Gul Muhammad Charejo	150	Chareja	800	-	600	20
53	Goth Umar Jatt	4,000	Jatt	48,000	-	4,000	400
54	Hamzo Zangejo	2,000	Zangejo	-	-	24,000	500
55	Haji Wario Goth	500	Jatt Pakirani	33,600	-	5,000	70
56	Zaman Jatt	1,000	Jatt	4,000	-	800	50
57	Haji Ibrahim Jatt	300	Jatt	2,400	-	16,000	60
58	Haji Rabnawaz	250	Mallah	3,600	-	7,500	45
59	Muhammad Ishaq Sarwan	100	Sarwan	-	-	-	30
60	Haji Gul Hassan Samoo	1600	Samon, Khaskheli, Mallah	-	-	-	250

Appendix 2. Socio-Economic Characteristics of Project Zone Communities

Table A2.1. Socio-economic characteristics of Project Zone communities.

Vil No.	Village name	Literacy rate	Percent income fishing	House holds	Drinking water facilities	Road transport	Road access	No. of community members engaged in fishing	Time devoted to fishing [days]	Trend/ change in fish catch	No. of live-stock	No. of schools	No. of revers osmos (RO) plant
1	Saleh Muhammad Baloch	6.95%	20	120	No	No	Yes - Metaled road	10	180	Not significant	0	1	0
2	Sumar Shoro	10%	20	40	No	No	Yes - Metaled road	45	365	No data	200	0	0
3	Achar Mirbahar Goth	20%	80	10	Yes	Yes	Yes - Metaled road	7	240	significant	0	0	0
4	Natho Goth	1.81%	0	12	No	Yes	Yes - Unpaved			Null	0	0	0
5	Saifullah Goth	0.66%	0	45	Yes	Yes	Yes - Unpaved			Null	0	0	0
6	Jhangir Khan Baloch	7%	0	25	Lake	Yes	Yes - Metaled road			Null	22	0	0

7	Mohammad Hashim Mirbahar	67.7%	80	200	KD Irrigation channel	Yes	Yes - Metaled road	85	365	significant	0	1	0
8	Sathi Jatt Goth	3.8%	50	100	No	No	Yes - Metaled road	300	300	significant	0	2	0
9	Wadera Ali Muhammad	0%	50	300	No	Yes	Yes - Metaled road	250	240	Not significant	0	1	0
10	Haji Pandhi Jatt	1.6%	73.72	51	RO plant	No	Yes - Metaled road	120	365	Not significant	45	1	1
11	Karam Ali Jatt	0.94%	100	45	Lake boring	No	Yes - Metaled road	200	300	Not significant	0	0	0
12	Usman Juman Goth	0%	100	40	No	Yes	Yes - Metaled road	20	365	Not significant	25	1	0
13	Mohammad Arab Jatt	12.3%	100	200	No	Yes	Yes - Metaled road	300	84	Not significant	100	1	0
14	Sajan Shah	7.2%	6.8	17	No	No	Yes - Unpaved	18	84	Not significant	17	1	0
15	Ahmed Dablo	0.5%	100	200	RO plant	No	Yes - Unpaved	800	360	Not significant	90	1	1
16	Palrdo Goth	0%	100	100	No	No	Yes - Unpaved	70	365	No data	22	0	0

17	Hayat Jatt Goth	2%	50	40	No	No	Yes - Unpaved	50	365	Not significant	2	0	0
18	Raees Ahmad Jatt Goth	10%	95	50	No	No	Yes - Unpaved	100	365	Not significant	25	1	0
19	Mohammad Hashim Jat Goth	1.33%	99	50	No	No	Yes - Unpaved	250	365	Not significant	37	0	0
20	Haji Qasim Jatt	29.33%	100	24	No	Yes	Yes - Unpaved	40	365	Not significant	15	1	0
21	Mir Jatt Goth	1.5%	100	150	No	No	Yes - Unpaved	200	120	Not significant	200	1	0
22	Haji Mehar Goth	15%	0	100	No	No	Yes - Unpaved			Null	27	1	0
23	Sumar Sholaarni	11.11%	70	7	No	No	Yes - Unpaved	7	365	Not significant	15	0	0
24	Mohammad Moosa Jatt	0.26%	100	70	No	No	Yes - Unpaved	500	144	Not significant	55	0	0
25	Muhammad Khan Jatt	0.7%	100	300	RO plant	No	Yes - Unpaved	250	120	Not significant	6	0	1
26	Ahmed Khan Memon	50%	10	100	Yes	Yes	Yes - Unpaved		365	Not significant	50	1	0
27	Muhammad Khan Sholaarni	0%	100	100	No	Yes	Yes - Unpaved	200	240	Not significant	15	1	0
28	Haji Ismail	2.68%	100	80	No	No	Yes -	800	180	Not	25	2	0

	Jatt						Unpaved			significant			
29	Bhair Jatt	0.8%	100	40	No	No	Yes - Unpaved	200	365	Not significant	2	0	0
30	Ali Bux Jatt	8.2%	100	20	No	Yes	Yes - Unpaved	300	252	Not significant	0	1	0
31	Bhori Goth	0%	100	200	No	No	Yes - By Boat	800	365	Not significant	0	0	0
32	Mirano Goth	0%	100	30		No	Yes - By Boat	25	365	Not significant	75	0	0
33	Raj Wari Jao Goth	2%	100	15	No	No	Yes - By Boat	20	365	Not significant	10	0	0
34	Haji Muhammad Goth	0%	100	20	No	No	Yes - By Boat	75	365	Not significant	22	0	0
35	Haji Maro Goth	0%	100	14	No	No	Yes - By Boat	50	365	Not significant	3	0	0
36	Muhammad Shumar Goth	0.66%	100	25	No	No	Yes - Metaled road	80	365	Not significant	0	0	0
37	Muhammad Dablo Goth	0%	100	30	No	No	Yes - By Boat	50	365	Not significant	0	0	0
38	Ghulam Dablo Goth	0%	100	40	No	No	Yes - By Boat	40	365	Not significant	0	0	0
39	Allah Baloch Kalmati Goth	2%	0	6	No	No	Yes - Unpaved			Null	8	0	0
40	Kareem Buksh Baloch	1.33%	16	30	No	No	Yes - Unpaved	20	183	Not significant	30	0	0

41	Sajan Wari Goth	0%	100	150	No	Yes	Yes - Unpaved	200	183	Not significant	0	2	0
42	Abdullah Mirbahar Goth	2.5%	100	50	No	No	Yes - By Boat	80	365	Not significant	9	0	0
43	Ahmad Baghdo	0%	100	20	No	No	Yes - By Boat	50	365	Not significant	2	0	0
44	Ahmad Patani	0%	100	12	No	No	Yes - By Boat	13	365	Not significant	10	0	0
45	Haji Sheedi	0%	100	12	No	No	Yes - By Boat	12	365	Not significant	7	0	0
46	Haji Mamo Goth	0%	100	15	No	No	Yes - By Boat	20	365	Not significant	0	0	0
47	Hashim Takro Goth	0%	100	35	No	No	Yes - By Boat	30	365	Not significant	15	0	0
48	Karo Takro Goth	0%	100	6	No	No	Yes - By Boat	6	365	Not significant	3	0	0
49	Karo Takro Goth	0%	100	6	No	No	Yes - By Boat	8	365	Not significant	0	0	0
50	Allah Warayo Bhatti	17.9%	5	85		No	Yes - Unpaved	50	240	No data	25	1	0
51	Gul Muhammad Uplano	15%	100	300	No	Yes	Yes - Metaled road	400	240	Not significant	65	1	0
52	Gul Muhammad Charejo	2%	100	20	No	No	Yes - Metaled road	50	144	Not significant	0	0	0
53	Goth Umar	4.05%	100	400	No	Yes	Yes -	500	365	Not	92	1	0

	Jatt						Metaled road			significant			
54	Hamzo Zangejo	2%	100	500	No	Yes	Yes - Unpaved	700	365	Not significant	12	1	0
55	Haji Wario Goth	20%	100	70	RO plant	No	Yes - Metaled road	250	365	Not significant	240	0	1
56	Zaman Jatt	0.6%	100	50	No	Yes	Yes - Metaled road	400	365	Not significant	12	0	0
57	Haji Ibrahim Jatt	6.6%	100	60	No	Yes	Yes - By Boat	100	240	Not significant	110	0	0
58	Haji Rab Nawaz	0%	99	45	No	Yes	Yes - Metaled road	25	96	significant	15	0	0
59	Muhammad Ishaq Sarwan	8%	18	29	No	Yes	Yes - Metaled road	25	300	Not significant	10	0	0
60	Haji Gul Hassan Samon	3.12%		250	No	Yes	Yes - Metaled road				30	1	0

Appendix 3. PRAs and FPIC Meetings

Table A3.1. PRAs and FPIC meetings.

Date	Village	Meeting Objectives/ Purpose	Confirmation/ Re-confirmation of FPIC	Participants
5-12-18	Saleh Muhammad Baloch	Getting FPIC and collection of socio-economic data	Villagers affirmed their FPIC for the project and its various interventions	Abdullah Mallah, Gul Hassan Mallah, Mukhtiar Mallah, Achar Mirbhar
5-12-18	Sumar Shoro	Getting FPIC and collection of socio-economic data	-do-	Zulfiqar, Muhammad Yousif
5-12-18	Achar Mirbahar Goth	Getting FPIC and collection of socio-economic data	-do-	Shabir, Ghulam Nabi Mirbhar, Ghulam Hussain, Sadam Hussain Mirbhar
7-12-18	Natho	Getting FPIC and collection of socio-economic data	-do-	Gul Hassan, Bhagul, Shaher Bano
7-12-18	Saifullah Goth	Getting FPIC and collection of socio-economic data	-do-	Wazir Ali Sodhai, Bashir Ahmed, Zeenat
7-12-18	Jahangir Khan Baloch	Getting FPIC and collection of socio-economic data	-do-	Mohammad Usman Kalmati, Raza Muhammad, Gul Mohammad Kalmati, Mubarak Kalmati, Abdul Majeed Kalmati
7-12-18	Muhammad Hashim Mirbahar	Getting FPIC and collection of socio-economic data	-do-	Abdul Rehman Mirbhar, Nawaz Ali, Rafeeq, Mehmood, Yousuf, Ghulam Haider
10-12-18	Sathi Jatt Goth	Getting FPIC and collection of socio-economic data	-do-	Haji Jatt
10-12-18	Wadera Ali Muhammad Jatt Goth	Getting FPIC and collection of socio-economic	-do-	Ghulam Jatt, Mohammad Amin Jatt, Abdul Aziz

		data		
10-12-18	Haji Pandhi Jatt	Getting FPIC and collection of socio-economic data	-do-	Hamzo Jatt, Noor Muhammad Jatt, Halo Jatt
10-12-18	Karam Ali Jatt Goth	Getting FPIC and collection of socio-economic data	-do-	Ali Akbar, Abdul Hamid Jatt
12-12-18	Usman Juman Goth	Getting FPIC and collection of socio-economic data	-do-	Muhammad Jumman, Meer Mohammad
12-12-18	Muhammad Arib Jatt	Getting FPIC and collection of socio-economic data	-do-	Ayoub Jatt Baloch, Jamoon Jatt, Hakim Ali Jatt, Akbar Jatt
14-12-18	Sajjan Shah	Getting FPIC and collection of socio-economic data	-do-	Abdul Sattar Ali Shah, Madad Ali Shah, Pir Mohammad Shah, Ajmal Sanijoh, Aijaz Shahid
14-12-18	Ahmed Dablo	Getting FPIC and collection of socio-economic data	-do-	Abdul Shakoor, Mohammd Idrees, Umar
14-12-18	Palrdo	Getting FPIC and collection of socio-economic data	-do-	Mumtaz, Majeed Mirbhar, Ibrahim Mirbhar
18-12-18	Hayat Jatt Goth	Getting FPIC and collection of socio-economic data	-do-	Ghulam Jatt, Abdul Rahim, Ameer Ahmed, Yamin Jatt
18-12-18	Ahmed Ali Jatt	Getting FPIC and collection of socio-economic data	-do-	Mohammad Qasim, Abdul Ghani, Ameer Ahmed
18-12-18	Muhammad Hashim Jatt	Getting FPIC and collection of socio-economic data	-do-	Pasayo Jatt, Mohammad Ibrahim Jatt, Ameer Ahmed Jatt
18-12-18	Haji Qasim Jatt	Getting FPIC and collection of socio-economic	-do-	Ghulam Rasool, Ahmed Khan, Muhammad Anwar Jatt, Akbar Jatt, Muhammad Ismail Jatt

		data		
19-12-18	Mir Jatt Goth	Getting FPIC and collection of socio-economic data	-do-	Muhammad Issa Jatt, Abu Bakar, Sufan, Kareem Baksh, Muhammad Jatt
19-12-18	Haji Mehar Baloch	Getting FPIC and collection of socio-economic data	-do-	Abdul Sattar Lashari, Ummeed Ali Lashari, Khan Mohammad, Muhammad Jabbar, Ghani, Farooq
19-12-18	Sumar Sholarni	Getting FPIC and collection of socio-economic data	-do-	Mamoon Baloch, Mohammad Haroon, Alu Sholarni
21-12-18	Muhammad Moosa Jatt	Getting FPIC and collection of socio-economic data	-do-	Gul Muhammad Jatt, Chanesar, Zahid, Hajan, Hakim Ali Jatt, Juman Jatt
21-12-18	Muhammad Jatt Goth	Getting FPIC and collection of socio-economic data	-do-	Sofan Jatt, Abdul Sattar, Javed, Rasool Baksh Jatt,Saleem Jatt, Ghulam Hussain Jatt, Misri Jatt, Noor Muhammad, Ghazi Jatt, Wahid Baksh
21-12-18	Ahmed khan Memon	Getting FPIC and collection of socio-economic data	-do-	Muhammad Hussain Memon, Muhammad Siddique, Shah Jahan Memon
26-12-18	Muhammad Khan Sholarni	Getting FPIC and collection of socio-economic data	-do-	Mashooq Sholani, Karam Ali Sholani, Manzoor Ahmed Sholani, Muhammad Rafeeq Sholani. Hasib Ali, Abdullah
26-12-18	Haji Ismail Jatt	Getting FPIC and collection of socio-economic data	-do-	Abdul Majeed Jatt, Fakeer Muhammad Jatt, Ali Hassan Jatt, Rahimdad Jatt, Ghulam Nabi Jatt, Hamzo Jatt, Muhammad ayoub Jatt, Abdur Rahim Jatt, Qamar-uz-zaman Jatt
26-12-18	Bhair Jatt	Getting FPIC and collection of socio-economic data	-do-	Hashim Jatt, Habibullah Ahmed Jatt, Laddo, Mamoon Jatt
26-12-18	Ali Baksh Jatt	Getting FPIC and collection of socio-economic data	-do-	Ghulam Qadir Jatt, Muhammad Ali Jatt, Muhammad Saleem Jatt

27-12-18	Bhori Goth	Getting FPIC and collection of socio-economic data	-do-	Hashim, Hamza Jatt, Ahmad Jatt, Somaar Jatt, Gul Sher Jatt
27-12-18	Mirano Jatt	Getting FPIC and collection of socio-economic data	-do-	Muhammad Hanif Jatt, Noor Muhammad Jatt, Nawaz Ali Jatt
27-12-18	Raj Wari Jao	Getting FPIC and collection of socio-economic data	-do-	Gul Hassan Jatt, Aalam Jatt
27-12-18	Haji Muhammad	Getting FPIC and collection of socio-economic data	-do-	Ahmad Jatt, Umar, Ghulam Mustafa Jatt, Ramzan, Aalam
28-12-18	Hajamro	Getting FPIC and collection of socio-economic data	-do-	Rizwan Dablo, Sajjad, Ayoub, Bilal, Ahmad
28-12-18	Muhammad Shumar Goth	Getting FPIC and collection of socio-economic data	-do-	Shabbir Ahmed Dablo, Muhammad Siddiq Dablo, Ali Dablo, Umer, Mithu Dablo, Nazeer Dablo, Ghulam Hussain
28-12-18	Goth Muhammad Dablo	Getting FPIC and collection of socio-economic data	-do-	Karmi Dablo, Agario Dablo, Ahmed
28-12-18	Ghulam Dablo Goth	Getting FPIC and collection of socio-economic data	-do-	Somaar Dablo, Fatah Dablo, Muhammad Younis Dablo, Mumtaz Ali Dablo, Umer Dablo, Ayoub Dablo, Ismail Dablo
1-1-19	Allah Baloch Kalmati goth	Getting FPIC and collection of socio-economic data	-do-	Ishaq, Ahayo Baroch, Basar Mar Ghor Baloch, Yousif Baloch
1-1-19	Karim Baksh Baloch	Getting FPIC and collection of socio-economic data	-do-	Zahid Hussain Baloch, Gul Sher, Ghulam akbar Baloch, Notak Baloch, Sawan Baloch, Loung Baloch, Abdul Majeed Baloch, Wassand, Dost Ali Baloch, Rab Nawaz
1-1-19	Sajan wari goth	Getting FPIC and collection of	-do-	Ahmed Malha, Muhammad Somar Mirbhar, Eidhan, Rahim

		socio-economic data		Baksh, Majeed, Muhammad Ars, Jazo, Muhammad Moosa Mirbhar
1-1-19	Goth Abdullah Mirbahar	Getting FPIC and collection of socio-economic data	-do-	Noor Muhammad, Ali Nawaz Mirbhar. Muhammad Ibrahim, Ghulam Abbas Mirbhar, Asif Mirbhar, Riaz Mirbhar, Afzal Mirbhar, Shahid Hussain Mirbhar, Sualleh Muhammad Mirbhar
2-1-19	Ahmed Baghdo	Getting FPIC and collection of socio-economic data	-do-	Zakaria mirbhar, asghar. Abdul razzaq baghdo, Nadeem, Ibrahim Patani, Ghulam Qadir, Muhammad Ali Baghdo,
2-1-19	Ahmed Patani	Getting FPIC and collection of socio-economic data	-do-	Jummah, Zubaida, Suleman Mirbahar
2-1-19	Haji Sheedi	Getting FPIC and collection of socio-economic data	-do-	Mohammad Ibrahim Dablo, Abu Baqar Dablo, Muhammad Usman Dablo, Hassin Dablo, Ahmed Mirbhar Yousif
3-1-19	Haji Mamo Goth	Getting FPIC and collection of socio-economic data	-do-	Hussain, Yaqoob, Ibrahim Dablo, Ghani dablo, Hashim
3-1-19	Hashim Takro Goth	Getting FPIC and collection of socio-economic data	-do-	Yousif Sholani, Akram, Muhammad Hassan Sholari, Mamu, Ismail, Juman sholari
3-1-19	Karo Takro 1	Getting FPIC and collection of socio-economic data	-do-	Mariam, Ahmed Dablo
3-1-19	Karo Takro 2	Getting FPIC and collection of socio-economic data	-do-	Usman, Mubarak, Hassan, Yousif Dablo, Moosa
14-1-19	Haji Allah Warayo Bhatti	Getting FPIC and collection of socio-economic data	-do-	Mehar Ali, Muhammad Hashim, Ghulam Ali Bhatti, Muhammad Sharif, Abdul Rehman, Muhammad Arsh Bhatti
14-1-19	Gul Muhammad Uplano	Getting FPIC and collection of socio-economic data	-do-	Noor Hassan Uplano, Noor Muhammad Uplano, Mirlo Uplano, Noor Muhammad Uplano, Lal Muhammad Uplano, Abdul Sattar Uplano, Muhammad Moosa

				Uplano, Sohib Dino Uplano, Rafique Ahmed Uplano
14-1-19	Gul Muhammad Charejo	Getting FPIC and collection of socio-economic data	-do-	Ghulam Nabi Charejo, Iqbal Charejo, Azeem, Muhammad Umar Uplano, Ghulam Muhammad Charejo, Muhammad Charejo
17-1-19	Muhammad Umar Jatt	Getting FPIC and collection of socio-economic data	-do-	Ahmed Khan, Daru Mirbhar, Muhammad Siddique Jatt, Ibrahim Jatt, Bachal Jatt, Abdul Razzaq Jatt, Muhammad
17-1-19	Hamzo Zangejo	Getting FPIC and collection of socio-economic data	-do-	Ali Asghar, Hassan Zangejo, Abbas Ali, Muhammad Usman Zangejo, Qasim Ali Zangejo, Muhammad khan Zangejo
17-1-19	Haji Warayo	Getting FPIC and collection of socio-economic data	-do-	Judio Jatt Muhammad Hassan Jatt, Bachu, Suleman Jatt
17-1-19	Zaman Jatt	Getting FPIC and collection of socio-economic data	-do-	Abbas Jatt, Ghulam Mustafa, Jan Muhammad Jatt, Abdul Majeed Jatt, Abdul rehman, Ismail Jatt, Ganwar Jatt
24-1-19	Haji Ibrahim Jatt	Getting FPIC and collection of socio-economic data	-do-	Ayub Jatt, Ismail Jatt, Abdul Hassan Jatt, Shah Dino Jatt, Arif Jatt
24-1-19	Haji Rab Nawaz	Getting FPIC and collection of socio-economic data	-do-	Azam Mirbhar, Noor Muhammad Mallah, Ghulam Qadir Mallah, Ghulam Mirbhar, Qurban Mirbhar, Muhammad Arib Mallah, Shako Mirbhar
24-1-19	Muhammad Ishaq Sarwan	Getting FPIC and collection of socio-economic data	-do-	Nasirullah Sarwan, Mir Umar, Ali Nawaz, Abdul Ghafoor, Abdul Hassan Sarwan, Muhammad Raheem
24-4-19	Haji Gul Hassan Samon	Getting FPIC and collection of socio-economic data	-do-	Abdul Razzaq, Muhammad Suleman, Muhammad Saleem, Asif, Abdul Waheed

Appendix 4. Stakeholder Analysis

Table A4.1. Stakeholder analysis.

Stakeholder or stakeholder sub-group	Current activities and impact on the landscape	Project strategy and effect of project on their activities	Relationship with other stakeholders (partnership/conflict)
Subsistence users of coastal resources and owners of adjoining lands: Long- term de facto use of mangroves and other coastal resources	Their use may be regulated to avoid overharvesting, but they would not have been expected to negatively impact forests. They may be among the most effective at monitoring status.	Identification of individual users is difficult, and changes over time. Not a well-organised grouping and power to enforce is likely limited. They therefore would be organised into Village Development Committees (VDCs) and Women Organisations (WOs) so as to work with them as cohesive bodies instead of individuals.	If they try to establish any right with respect to land or any other coastal resource, they will be asked to produce ownership certificates of the lands that they owned prior to the land getting planted with mangroves under DBC-1. However, this will likely not be the case as the entire Project Area is state owned property.
Individual households: Possible to provide household forest protection contracts that clearly define rights and responsibilities under Mangrove Stewardship Agreements	Monitoring responsibilities can be clearly defined and targeted. Likely to be the most cost effective because engaging them in Mangrove Stewardship Agreements (MSAs) and targeting payments to individuals as part of MSAs is possible	Enforcement would have to rely on government. Measures will be taken that the Mangrove Stewardship Agreements are implemented in their letter and spirit	Illegal extraction of mangroves wood, fodder and other resources like over-fishing or use of fishing nets with illegal mesh size and types. Households may think that they have lost their subsistence living or income earning opportunities. Therefore, there is potential of conflict between the concerned department and individual households if they resort to activities that are prohibited. These potential sources of

			conflict will be dealt with through awareness raising, training and capacity building in various types of alternative livelihoods earning opportunities. For youth and women there will be special targeted programmes so as to enhance economic opportunities for them
Coastal Villages: Lack explicit rights, but proximity means they can influence management, likely overlap with subsistence users	Best suited to enforce and make rules over resource use, if supported through co-management arrangements	Currently not organised into village organisations (VOs) or community organisations (COs). These coastal villages do not have any legal rights to mangroves which are state property and declared as Protected Forests under the Forest Act. The project will ensure that there is no elite capture of any project benefits to the village. Their support for DBC-1 will be through communal infrastructure development projects	The same as for individual households. They will also be organised into village organisations ore community organisations. Males will be organised into village development organisations (VDOs) and females into Women Organisations (WOs). They will be motivated to get involved in the implementation of various project activities both as staff, labour and as suppliers of inputs. Communities will be linked to microfinance organisations
Coastal and Marine Fisheries Department Authorities: Coastal authorities and Marine Fisheries Department authorities make	Decide on allocation of land and rights to fisheries resources and implementation of their respective policies and laws for various purposes and therefore have management rights and responsibilities. Coastal authorities allocate contracts for coal,	These authorities may have some interest in DBC-1 activities which are related to matters that fall within their mandate. DBC-1 will do advocacy work with them to bring them on board as their activities have an impact on DBC-1 and local communities with which DBC-1 is working	Close linkages will have to be developed with them so that they are motivated to provide better services to DBC-1 communities

decisions with regard to various aspects of coastal areas including enforcement of fisheries laws and monitoring of the areas. Fisheries Department also owns some of the Reverse Osmosis (RO) plants in the area.	gas and oil pipelines. Marine Fisheries Department enforces fisheries related laws and policies. Have some monitoring ability		
Full Surrounding Communities: Have rights over the area through de facto usages and tacit political support	Limited impact beyond the coastal villages	Too many people with too little direct impact on the service. Main intervention would be awareness raising about DBC-1 and its positive impacts on the communities and the ecosystems and their services	Awareness raising and provision of employment opportunities in project activities
Fishing Communities: Directly adjacent to mangrove areas and may have some fish harvesting and use certificates in and around mangrove areas.	If fishermen have rights over-fishing in neighbouring mangrove forests, they could be paid to forego those rights to ensure sustainable fishing over time, as in a conservation easement. They may be paid to forego their rights to restore fisheries and mangroves in the area	Fishing rights have been assigned in recent years. Fishing communities need to be made aware of two important aspects: the role of mangroves as fish spawning sites and therefore playing a role in their conservation and area increase; and the need for sustainable fish harvesting so that their livelihoods can be sustained and improved over time	Skills building in aquaculture, crab farming, fish processing, marketing and value additions. Also, they will be made aware of the impact of their over-harvesting fishing practices and use of illegal net types and nets mesh sizes on over-all fish population, fish species diversity and consequences of these practices for their sustainable livelihood outcomes over the long-term
Provincial Governments:	Implement policy and legal frameworks. But usually face	Sindh Forest Department is the lead agency in implementation of DBC-1. It had financial and	Training and capacity building of the various

Establish rules around mangrove protection and administer and finance enforcement	constraints in implementing their mandates.	technical problems in restoring mangrove forests without this project. Therefore, this project has been developed so that the revenue from carbon credit sales could be used for financing investment in mangrove forests restoration and development	Government departments for better services provision to the communities in light of their given mandates

Appendix 5. Training and Capacity Building

Table A5.1. Training and capacity building.

Topic	Target	Description	Outcome	Duration
Data and information management	Project employees and selected community members	Provide training on data collection, storage and analysis	Data and information properly managed and easily accessed	One-day training and hands on experiences
Project boundary establishment	Project employees and selected community members	Provide training on boundary establishment on maps and in the field	Project boundaries easily established, and their relevant information collected, archived and stored for future access	One-week training and hands on experiences
Participatory planning, monitoring and evaluation	Project Zone communities, relevant government agencies such as Forest Department, and employees	Training on participatory land-use mapping and village planning, monitoring and evaluation	Community maps digitised, and village plans endorsed by the local governments and communities	One-week training and hands on experience
Socio-economic survey methods	Employees and Project Zone communities	Field based training on socio-economic surveys, survey instruments development, instruments administration, data recording and analysis and report preparation	Socio-economic survey team established, and activities run	One-week training and hands on experiences
Biodiversity survey methods	Employees and Project Zone communities	Field based training on flora and fauna survey, survey instruments development, phenology, identification and	Biodiversity survey team established, and activities run	One-week training and hands on experiences

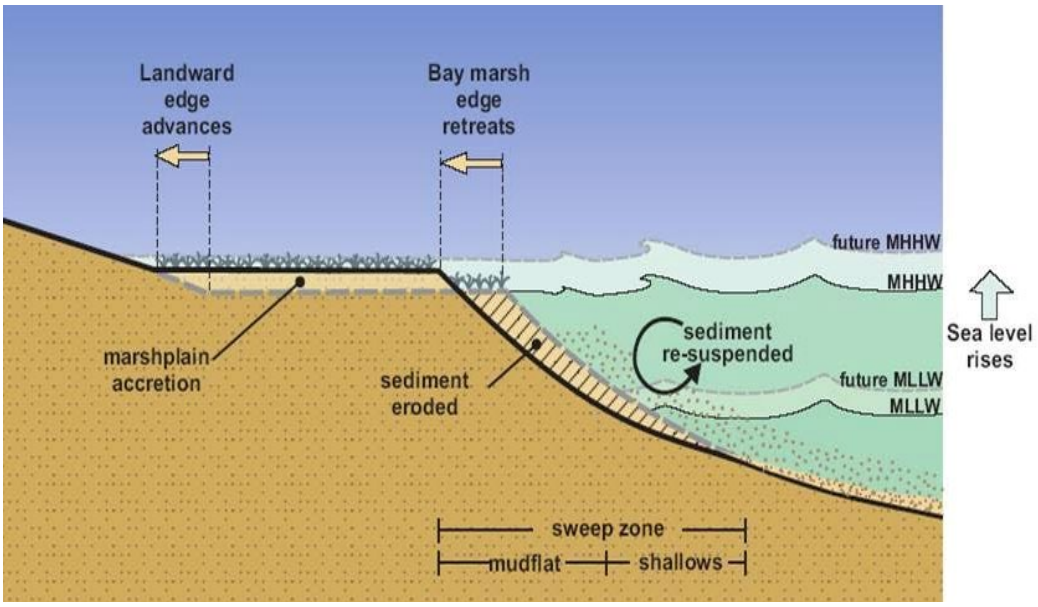
		data recording and analysis and report preparation		
Mangroves propagules collection and nurseries raising activities	Project Zone communities, employees	Field based training on propagules collection, nursery establishment and operation and maintenance	Nursery facilities developed and operational	Two-days training and hands on experience
Mangroves planting activities	Communities	Mangrove planting techniques and maintenance of the planted areas	Tree planting underway at planting season time	One-day training and hands on experience
Carbon MRV	Project Zone communities, employees	Field and classroom based. Provide training and equipment for the measurement, monitoring and reporting of biomass and soil organic carbon	MRV teams formed, and necessary equipment and facilities provided	One-week training and hands on experience
Community development related MRV	Project Zone communities, employees	Field and classroom based. Provide training and equipment for the measurement, monitoring and reporting of community development activities	Community development related MRV teams formed, and necessary equipment and facilities provided	One-week training and hands on experience
Biodiversity related MRV	Project Zone communities, employees	Field and classroom based. Provide training and equipment or the measurement, monitoring and reporting of biodiversity both floral and faunal	Biodiversity related MRV team formed, and necessary equipment and facilities provided	One-week training and hands-on experience
Basic Skills in various Income generating activities relating to all aspects including production, processing, marketing and value	Project Zone communities, employees	Classroom and on-the-job training on various income generating activities	Entrepreneurs established, and kits for certain income generating activities	Three-days training and hands-on experience

addition-aquaculture/crab culture, agriculture, livestock, handicrafts, ecotourism			provided	
Controlled grazing measures	Project Zone communities	Field based training on controlled grazing techniques	Effective measures for controlled grazing in place	One-day training and hands on experience
Conflict mediation	Project Zone communities, local governments, employees	Classroom and on-the-job training provide training on formal conflict mitigation and resolution processes	Conflict resolution mechanism in place and understood by community stakeholders	One-day training

Appendix 6. Coastal Wetland Soil Carbon Stock Accounting Tool

Rationale

The purpose of this simple geometric calculation tool is to explore changes in tidal wetland (marsh or mangrove) soil volume and carbon stock in response to sea level rise and erosion under a range of geomorphic parameters that influence wetland resilience (Figure A6.1).



Source: Environmental Science Associates

Figure A6.1. Conceptualisation of tidal wetland landward transgression with sea level rise.

Model construct

The tool is based on a model of a 1 m strip through a tidal wetland surface (B2-B3) width, set at model initiation (Figure A6.2). This wetland is bounded by an upland (A1-A2) and a mudflat (A4-A5), each with a definable slope. Tidal range and initial soil depth are definable parameters. Wetland surface is assumed to be at Mean High Water Spring Elevation (e.g., half the tidal range). The seaward edge of the wetland can be ascribed a cliff edge of zero or greater (B3 to B4). Soil depth (B3-A3) can be defined based on reference site conditions or set to a common reference depth of 1 m.

The tool calculates annual time steps for a 100-year period change in soil volume, responding to wetland accretion capacity (set by a non-dynamic variable[104]), landward transgression (calculated from wetland surface elevation gain and upland slope), and wetland edge retreat.

Changes in soil carbon stock are based upon changes in soil volume and a carbon density variable. The fate of eroded carbon can also be set. For instance, an assumption could be made that 80% of eroded soil carbon is remineralised in well-oxygenated and energetic nearshore settings, or lower percentage for depositional sinks.

Wetland resilience to sea level rise and sensitivity to 'elevation capital'[105] can be explored by varying tidal range (which sets wetland elevation above mean tides [and assumes drowning elevation]), as well as definable wetland accretion and sea level rise parameters.

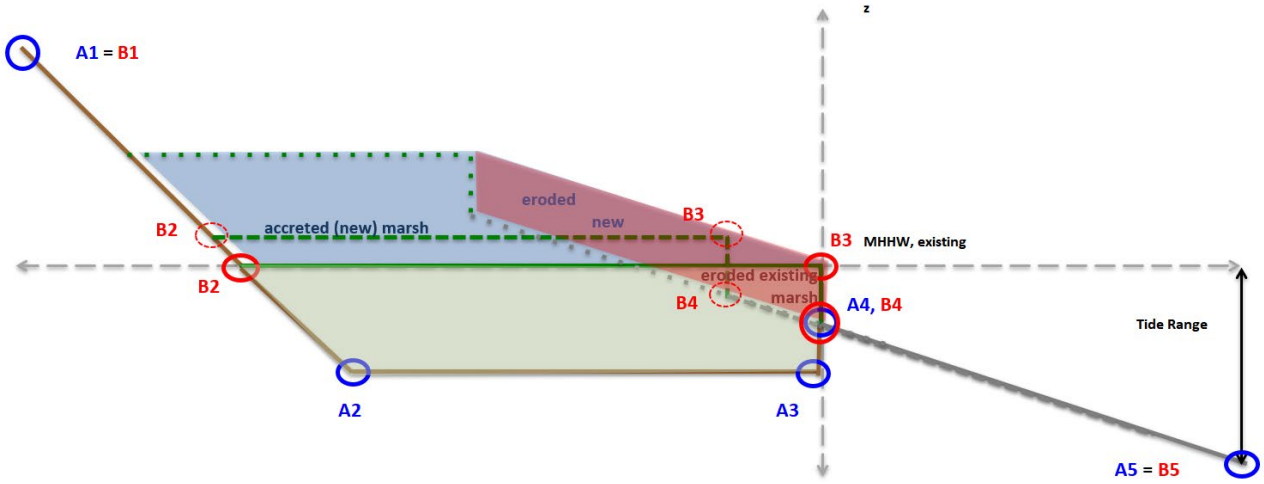


Figure A6.2. Model schematic.

Outputs

The tool provides visual and tabular outputs in annual timesteps (Figure A6.3) for:

- Tidal wetland profile evolution – calculating location relative to initial condition back of the wetland, wetland edge as well as wetland width (extent of wetland from the water's edge to the upland).
- Tidal wetland volume – calculating net change based on surface accretion and edge erosion and

[104] The current version of the tool does not represent suspended sediment delivery specifically but through a prescribed wetland accretion rate of 10 mm yr^{-1}. This is a simplification of a process known to be non-linear. The accretion rate value would be considered high in other locations but for the highly muddy coastline of the Guianas, this value is likely conservatively low. Future versions of the tool may include variable accretion based upon wetland surface elevation relative to tidal frame and sediment concentration.

[105] Elevation capital reflects the height of a tidal wetland surface above the drowning elevation of the vegetation, and as such reflects the amount of sea level rise a wetland can accommodate before vegetation drowns.

landwards migration.

- Tidal wetland soil carbon stock (per metre segment of wetland for a given width) based on changes in soil volume and a soil carbon density input.

Wetland edge erosion rate and distance may be set based upon:

- The rate of sea level rise and the slope of a mudflat (e.g., to analyse geomorphic settings where mudflat elevation is in dynamic equilibrium with sediment supply and wave energy, and sediment supply is sufficient to maintain mudflat building with sea level rise).
- A defined rate of lateral retreat (e.g., to analyse settings where either the slope is not defining the rate of wetland loss such as sheltered locations or a constructed intervention has been placed to protect the edge from erosion).
- A combination of sea level rise and a defined lateral retreat (addition of one and two).

Three IPCC (AR5) eustatic sea level rise projections have been selected to bracket a range of low (RCP2.6 mean), medium (RCP8.5 mean) and high (RCP8.5 max) scenarios (Table A6.1; IPCC 2014).

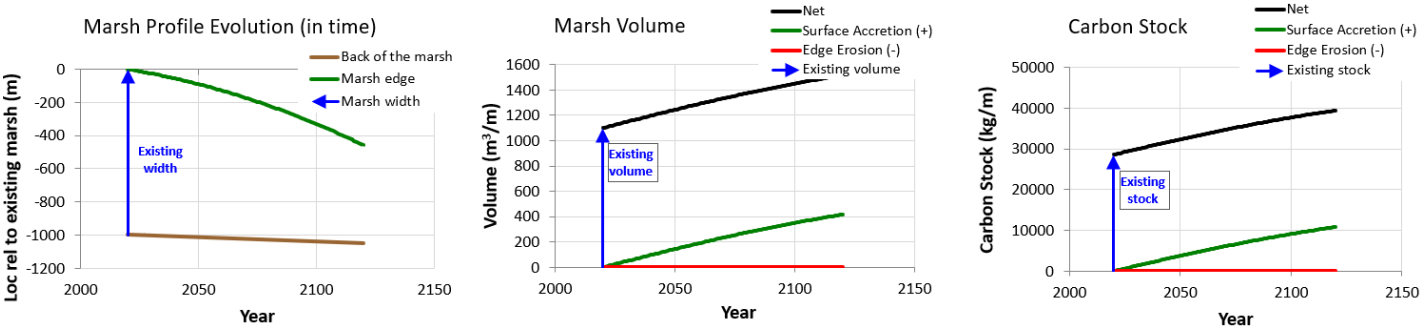


Figure A6.3. Model outputs.

Table A6.1. Projected change in global mean surface temperature and global mean sea level rise for the mid- and late 21st century, relative to 1995-2005 period (IPCC, 2014).

		2046–2065		2081–2100	
	Scenario	**Mean**	***Likely* range** [c]	**Mean**	***Likely* range** [c]
Global Mean Surface Temperature Change (°C) [a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	**Mean**	***Likely* range** [d]	**Mean**	***Likely* range** [d]
Global Mean Sea Level Rise (m) [b]	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Notes:

[a] Based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) ensemble; changes calculated with respect to the 1986–2005 period. Using Hadley Centre Climatic Research Unit Gridded Surface Temperature Data Set 4 (HadCRUT4) and its uncertainty estimate (5 to 95% confidence interval), the observed warming from 1850–1900 to the reference period 1986–2005 is 0.61 [0.55 to 0.67] °C. *Likely* ranges have not been assessed here with respect to earlier reference periods because methods are not generally available in the literature for combining the uncertainties in models and observations. Adding projected and observed changes does not account for potential effects of model biases compared to observations, and for natural internal variability during the observational reference period. *{WGI 2.4.3, 11.2.2, 12.4.1, Table 12.2, Table 12.3}*

[b] Based on 21 CMIP5 models; changes calculated with respect to the 1986–2005 period. Based on current understanding (from observations, physical understanding and modelling), only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st century. There is *medium confidence* that this additional contribution would not exceed several tenths of a meter of sea level rise during the 21st century.

[c] Calculated from projections as 5 to 95% model ranges. These ranges are then assessed to be *likely* ranges after accounting for additional uncertainties or different levels of confidence in models. For projections of global mean surface temperature change in 2046–2065, *confidence* is *medium*, because the relative importance of natural internal variability, and uncertainty in non-greenhouse gas forcing and response, are larger than for the 2081–2100 period. The *likely* ranges for 2046–2065 do not take into account the possible influence of factors that lead to the assessed range for near term (2016–2035) change in global mean surface temperature that is lower than the 5 to 95% model range, because the influence of these factors on longer term projections has not been quantified due to insufficient scientific understanding. *{WGI 11.3.1}*

[d] Calculated from projections as 5 to 95% model ranges. These ranges are then assessed to be *likely* ranges after accounting for additional uncertainties or different levels of confidence in models. For projections of global mean sea level rise *confidence* is *medium* for both time horizons.

Source: IPCC 2014

Closing

The inputs to the tool are uncalibrated but based upon best judgement to represent the coastal conditions and to test sensitivity to a high rate of sea level rise. Calibration can be improved with data on shoreline topography and bathymetry, time averaged surface water suspended sediment concentrations and regional sea level rise rates.

For additional information on geomorphic modelling for coastal systems, see:

Deng, Junjie & Woodroffe, Colin & Rogers, Kerrylee & Harff, Jan. (2017). Morphogenetic modelling of coastal and estuarine evolution. Earth-Science Reviews. 171. 254-271. 10.1016/j.earscirev.2017.05.011.

Whitehouse, R.J.S, Cooper, N., Pethick, J., Spearman, J., Townend, I.H. and Fox, D. Dealing with geomorphological concepts and broad scale approaches for estuaries. In: 40th Defra Flood and Coastal Management Conference, 5 - 7 July 2005, York, UK. http://eprints.hrwallingford.co.uk/75/

Appendix 7. Application of the Coastal Wetland SOC Accounting Tool in the Indus Delta

An application of the Coastal Wetland Soil Carbon Stock Accounting Tool (CWSCSAT) to a hypothetical shore profile on the Indus Delta is explored below. Though the model is uncalibrated, it is possible through explicated assumptions and available information to investigate the sensitivity of the shoreline and mangroves to sea level rise and erosion. Key parameters that drive sensitivity to sea level rise and erosion are explored.

Model setup

Fixed variables:

- Vertical land movement (0)
- SLR curve (High – AR5 RPC8.5 max)
- C density (0.026 g cm^{-3})
- Oxidised fraction of remobilised C (80%)

Erosion mechanism: (scenario 3 based upon specified erosion and sea level rise rate)

Additional information: Mean Spring Tide Range set conservative at 3 m.

Tested scenarios

A base model setup is provided in Figure A7.1. The model is parameterised to begin in 2015 and end in 2075, which represent the project's start and end date. For the basis of comparison, an assumed width of 20 km (20,000 m) is applied, which encompasses current dense and sparse mangroves, plantations, and degraded/de-vegetated areas. The mangrove/degraded area is assumed to transition to open mudflat at a 1 m cliff. The slope of adjacent upland is 1:500 and mudflat 1:500. Sea level rise is assumed to rise at a high rate and attain 0.54 m above present levels by the year 2075 to test sensitivity to greatest extent of sea level change over the project's duration. Initial elevation of the mangrove surface is set at 1 m above mean sea level.

Observations from model

- With an accretion rate of 3 mm yr^{-1}, the mangrove likely has meaningful elevation capital to maintain the forest against sea level rise over the coming decades. The average elevation of the mangrove soil surface is not known. Applying an assumption that much of this surface is at least 1 m above mean sea level, and that the mangrove has a minimal capacity to build soil at 10 mm yr^{-1} would keep the mangrove above drowning elevation through 2120. Even with retreat of the mangrove edge (243 m over 100 years), the mangrove – coastal forest will be a net sink of carbon both over a crediting period of 20-50 years and over the 100-year timeframe.
- Figure A7.2 illustrates the implications of sea level rise if the mangrove has 50 cm of elevation capital rather than 100 cm. Under both conditions, the mangrove would not drown within the 100-year time frame. Gain of soil carbon across the mangrove surface would exceed losses at the eroding edge.
- The scale of existing intact coastal forest along much of the NBS-LME coastline is a benefit to potential carbon management. Reducing mangrove width to 500 m from 3,000 m, a gradual carbon accumulation is calculated that declines towards zero at the end of the century and carbon loss with erosion from the mangrove edge exceeds carbon accumulation on the surface (Figure A7.3). Nevertheless, under modelled conditions, a 500 m width of mangrove would not be a net source of soil carbon over the 100-

year timeframe.

- Figure A7.4 explores the sensitivity of the carbon stock losses to assumptions about the morphology of the mangrove edge and mudflat slope. The base model assumes a 100 cm high slope break at the edge of the mangrove. The morphology of the slope break can vary considerably depending upon tidal range, wave exposure, capacity of the mangrove to build and maintain an edge in an erosional environment and the mudflat dynamics in response to increased wave energy. In this case, differences in carbon stock change trajectories are insignificant.
- Figure A7.5 illustrates the sensitivity of carbon stock calculations associated with assumptions about dominant slope of intertidal mudflat. Shallowing the intertidal slope from to 0.002 (1:500) from 0.005 (1:200) and maintaining sea level using the high RCP 8.5 max scenario trajectory results in a retreat of the mangrove edge by 609 m compared with 243 m for a wide carbon stock. There is minimal difference in net soil carbon stock over the long term driven (220,968 versus 209,486 tonne C per unit width of mangrove) driven by assumptions of mangrove capacity to build with sea level rise even as the edge retreats.

INPUTS	
visualizer on or off	on
Planning horizon and SLR	
Start year	2015
End year	2075
SLR curve (None/Low/Med/High)	High
Year to plot in graph to the right	2015
Vertical land movement (mm/yr)	0
SLR (m, 2015 - 2075)	0.54
Vertical land movement (m)	0.00
Relative SLR (m)	0.54
Profile parameters	
Slope of mudflat (unitless)	0.002
Slope at landward edge (unitless	0.002
Marshplain width (m)	20000
Height of eroding face (m)	1
Depth of marsh sediments (m)	3
Tide range (m)	3
Width of mudflat (m)	3000
Erosion/accretion parameters	
Marsh edge erosion rate (m/yr)	17
Erosion scen(1, 2, 3 - see read-me	3
Maximum accretion rate (mm/yr)	3
Carbon parameters	
Soil carbon density (g/cm^3)	0.026
Oxidized frac of remobilized C (%)	80%
Soil carbon density (kg/m^3)	26
Error messages:	

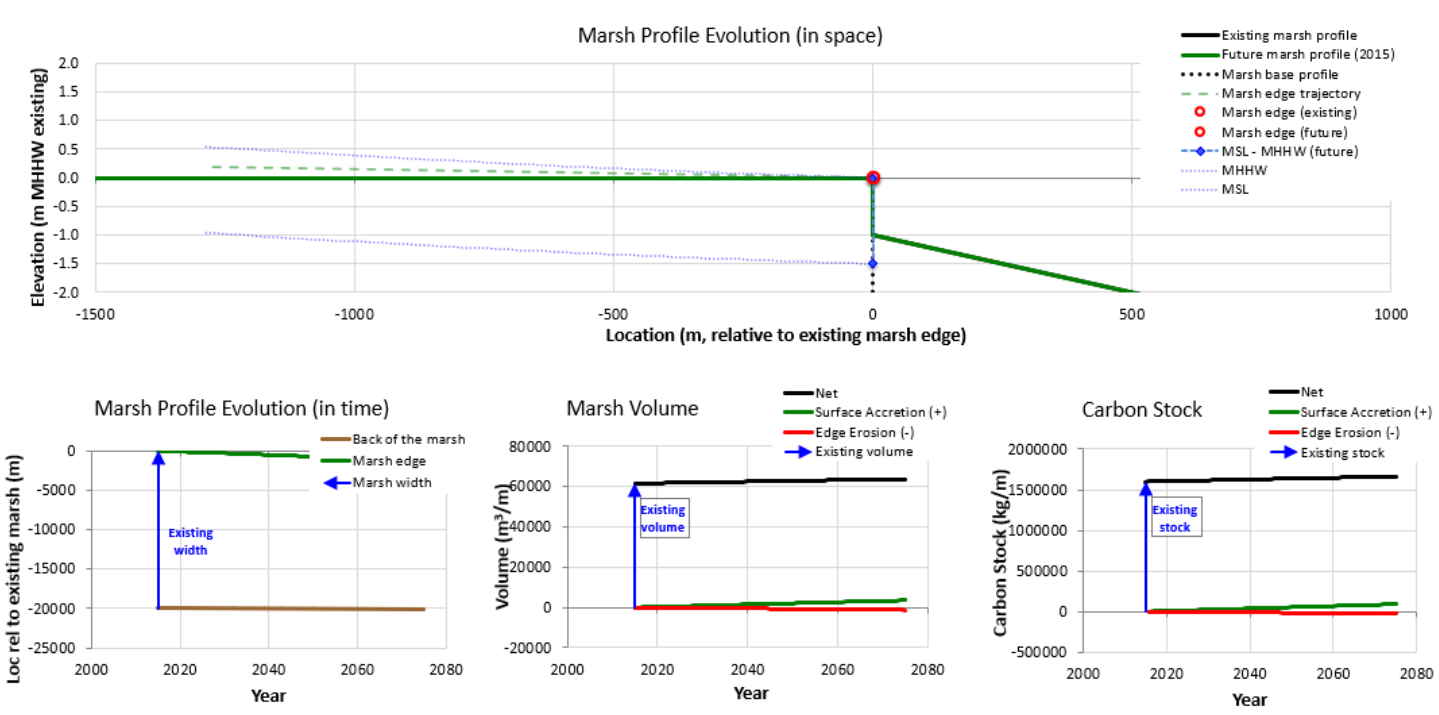


Figure A7.1: Illustration of the model setup. Within the model, initial mangrove surface elevation (and hence elevation capital) is set by adjusting tidal range. Here the mangrove surface is 1 mMSL (m above mean sea level) and an accretion rate of 10 mm yr^{-1} maintains vegetation at or just above the mangrove drowning elevation by year 2075. Retreat of a 1 m high cliff mangrove edge by 1.3 km with erosion and sea level rise over the project duration leads to release of soil carbon, 80% of which is assumed to be mineralised.

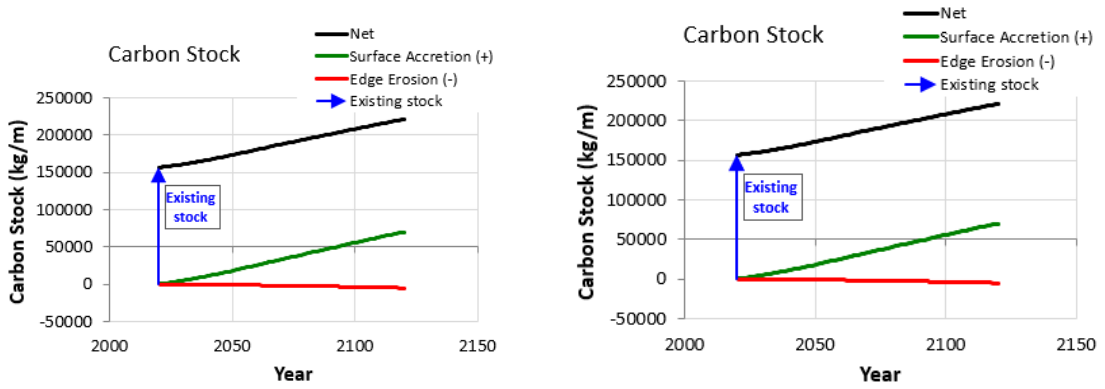


Figure A7.2. Model estimates of mangrove soil C stock change over 100 years: mangrove width = 3,000 m, with (left) elevation capital = 1 m and (right) elevation capital = 0.5 m.

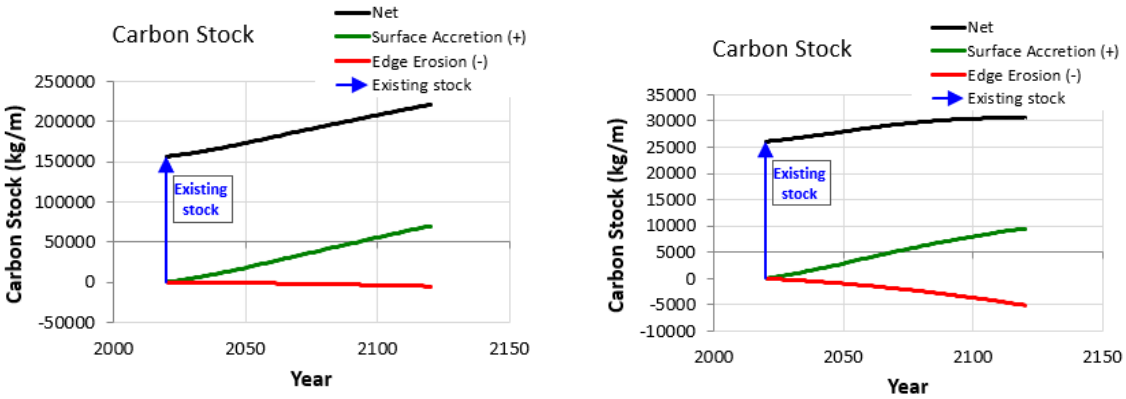


Figure A7.3. Model estimates of mangrove soil C stock change over 100 years: elevation capital 1 m, with (left) mangrove width = 3,000 m and (right) mangrove width = 500 m.

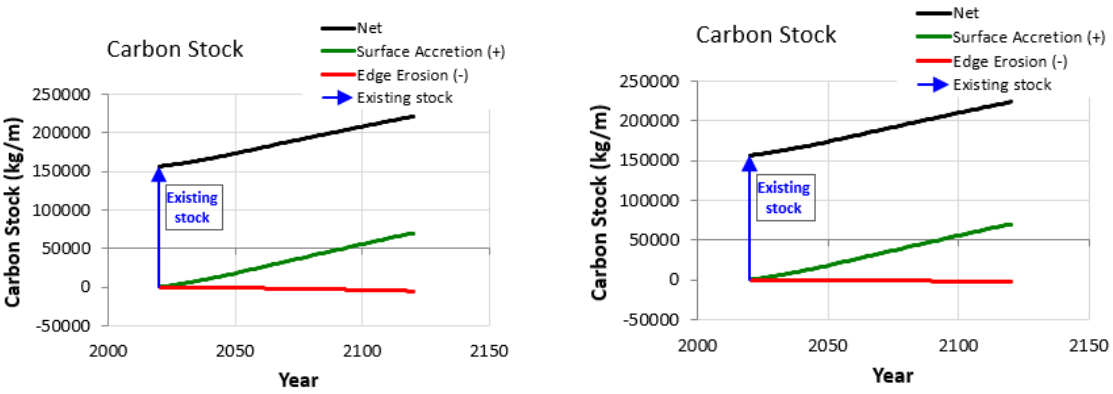


Figure A7.4. Model estimates of mangrove soil C stock change over 100 years: elevation capital = 1 m and mangrove width = 3,000 m, with an edge cliff reduced in height from (left) 0.5 m to (right) 0 m.

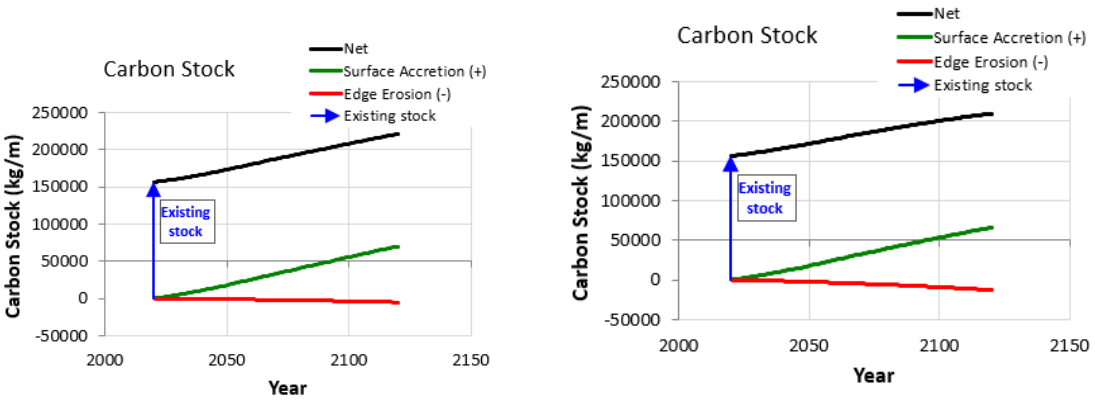


Figure A7.5. Model estimates of mangrove soil C stock change over 100 years: elevation capital = 1 m and mangrove width = 3,000 m; the mudflat slope decreases from (left) 1:200 to (right) 1:500 with a cliff edge height increased to 1 m.

Literature cited

IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Appendix 8. Statement Showing the Estimated Areas Under Red Rice Cultivation in Indus Delta

Table A8.1. Estimated areas under red rice cultivation in Indus Delta.

Sr.No	District	Taluka	Name of deh	Estimated area in red rice (acres)
1	Thatta	Keti Bundar	Juho	5,500
2	Thatta	Keti Bundar	Bery	4,523
3	Thatta	Keti Bundar	Sokhi	2,790
4	Thatta	Keti Bundar	Shahpur Dakhin wari	2,270
5	Thatta	Keti Bundar	Keti Hashim	2,190
6	Thatta	Keti Bundar	Bangar	1,320
7	Thatta	Keti Bundar	Kheersar Dakhin wari	2,760
8	Thatta	Keti Bundar	Khede wah	3,680
9	Thatta	Keti Bundar	Hameed wari	1,459
10	Thatta	Keti Bundar	Nighe wari	3,120
11	Thatta	Keti Bundar	Keti Bundar	2,100
12	Thatta	Keti Bundar	Kharium	2,900
13	Thatta	Keti Bundar	Hambas	1,060
14	Thatta	Keti Bundar	Kathichuka	2,140
15	Thatta	Keti Bundar	Munara	2,300
16	Thatta	Keti Bundar	Mir wah	4,100
17	Thatta	Keti Bundar	Miani	2,790
18	Thatta	Keti Bundar	Takro kari waro	2,880
19	Thatta	Keti Bundar	Takro Kharun	2,100
20	Thatta	Keti Bundar	Takro Hashim	3,170
21	Thatta	Keti Bundar	Keti Pir Ali Bux	4,202
			Total Keti Bundar	59,354
22	Sujawal	Kharochan	Keenjar	5,200
23	Sujawal	Kharochan	Eracho	2,504
24	Sujawal	Kharochan	Sultanpur	1,800
25	Sujawal	Kharochan	Tango	1,908
26	Sujawal	Kharochan	Takro Farid khan	4,810
27	Sujawal	Kharochan	Garho	4,370
28	Sujawal	Kharochan	Miran	4,520
29	Sujawal	Kharochan	Lakho Ghot	16,894

30	Sujawal	Kharochan	Adiari	1,800
31	Sujawal	Kharochan	Pakhiaro	2,200
32	Sujawal	Kharochan	Ghorar	2,100
33	Sujawal	Kharochan	wariasio	2,091
34	Sujawal	Kharochan	Adiari	4,200
35	Sujawal	Kharochan	Kun	3,900
36	Sujawal	Kharochan	Tikyo	3,490
			Total Kharo Chan	61,787
37	Sujawal	Shah Bundar	Shah Bunder	2,184
38	Sujawal	Shah Bundar	Larh Sanhroo	3,880
39	Sujawal	Shah Bundar	Khanani	3,000
40	Sujawal	Shah Bundar	Bux Ali Kalhoro	600
41	Sujawal	Shah Bundar	Qasim Soomro	1,200
42	Sujawal	Shah Bundar	Lyari	21,029
43	Sujawal	Shah Bundar	Thul	6,420
44	Sujawal	Shah Bundar	Khan Bhatt Sukapur	4,900
	Sujawal	Shah Bundar	Part of Protected Forest/Wildlife Sanctuary	20,310
			Total Shah Bundar	63,523
				184,662 acres
			Grand Total	74,732 ha

Appendix 9. Projection of Future Conditions in the Baseline and Project Scenarios

The tables below list the key variables determining the future GHG emissions and refer to sections in this PD where results are further elaborated.

Relevant definitions in VMD0019

Types

Process Specific: Variations in the value of the variable are associated with specific actions, ongoing events, or global conditions, rather than with specific locations.

Location Specific: Variations in the value of a variable are tied to a specific location, and typically that the value of the variable changes across the landscape.

Categories

Controlled: Change in a variable is under the control of the project proponent.

Planned: Changes in the value of the variable are under the control of identified agents who are independent of the project proponent.

Systemic. The future value of the variable is systemic if changes in the variable depend primarily on one or more conditions whose future value is not subject to knowable plans, typically because they involve or depend on the actions and influences of unknown actors and/or large-scale systems outside of local control. For instance, cattle grazing intensities in the area may go down if there is a large drop in the price of beef.

Temporal character

Inherent. The variable is an inherent characteristic of the area or the natural processes affecting the area, and therefore the variable existed without human intervention or existed as a result of human actions over a very long period of time in the past (for instance, traditional landscape burning by indigenous peoples).

Caused. The variable is a characteristic which arose as a result of some specific human action at a known time, and therefore has a clear start (for instance, commencement of grazing of domestic sheep in an area).

Projected. The variable is a characteristic which will arise as a result of projected human activities at some time in the future under the baseline scenario (for instance, humans caused deforestation in an area which currently has never been deforested).

Intended. The variable is a characteristic which will arise as a result of the project activities under the project scenario (for instance, emissions from project activities).

Baseline scenario

Step 1: Define the geographic area(s) within which the variable is to be projected

- Project Area

Step 2: Identify the scenario under which the variable is to be projected

- Baseline scenario

Step 3: Determine the type and category of the variable being projected

- See Table A9.1

Step 4: Temporal character of the variable

- See Table A9.1

Step 5: Determination of the steps to be taken to project the future value of the variable

- See Table A9.1

Table A9.1. Type, category and temporal character of variables in the baseline scenario; steps for projections.

Variable	Type	Category	Temporal character	Relevant steps in module[106]
Sediment supply in the Indus Delta	Process specific	Systemic	Caused	Steps 1-6 Step 8-10 Step 13
Freshwater supply in the Indus Delta	Process specific	Systemic	Caused	Steps 1-6 Step 8-10 Step 13
Sea level rise and associated submergence and erosion	Process specific	Systemic	Inherent	Steps 1-6 Step 8-10 Step 13
Natural regeneration	Location specific	Systemic	Inherent	Steps 1-5 Steps 7-10 Step 14
Tree harvesting, grazing	Location specific	Planned	Projected	Steps 1-5 Step 7 Steps 9-10 Step 12

Step 6: Analysis of historic trends for process specific variables

- See Table A9.2

[106] Following Figure 1 in the module

Table A9.2. Historic trends for process specific variables in the baseline scenario.

Variable	Type	Summary and reference to section with elaborated results
Sediment supply in the Indus Delta	Process specific Systemic Caused	Section 2.1.1; 2.1.5 Extensive engineering works for irrigation purposes between the 1950s and 70s have reduced sediment load of the Indus River. This, together with the extreme levels of wave energy, has caused rapid wave reworking and transgression of the Indus Delta. The end product is a wave-dominated delta, characterised as a transgressive sand body, capped by extensive aeolian dune deposits. The reduced sediment supply has exacerbated the degradation of mangrove habitats.
Freshwater supply in the Indus Delta	Process specific Systemic Caused	Section 2.1.5 The Indus Delta receives its fresh water and sediment supply from the Indus River, which flows through the delta before reaching the Arabian Sea. The Indus Delta shelf is 150 km wide and receives minimal rainfall during the monsoon season. The reduced supply of freshwater has exacerbated the degradation of mangrove habitats.
Sea level rise and associated submergence and erosion	Process specific Systemic Inherent	Section 3.1.3.2.2 The historic trend is not relevant, as is has no predictive value for future sea level rise

Step 7: Analysis of historic trends for location specific variables

- See Table A9.3

Table A9.3. Historic trends for location specific variables in the baseline scenario.

Variable	Type	Summary and reference to section with elaborated results
Natural regeneration	Location specific Systemic Inherent	Section 3.1.4; 3.2.1.4 This variable is directly assessable through remote sensing. Remote sensing footage shows that due various reasons, natural regeneration of vegetation in the Indus Delta after mangrove habitat degradation is insignificant. There are ecological barriers that hinder the natural re-generation process in the Project Area. These include the non-availability/non-reaching of mangrove propagules to

		certain areas (particularly high lying areas or those without natural vegetation), flushing out of the propagules out of the site with tide water (especially those of *Avicennia marina* which have smaller propagules), and damage to the degenerated areas on account of biotic pressure in terms of grazing, fodder collection, etc..
Tree harvesting, grazing	Location specific Planned Projected	Section 2.1.1; 3.1.4 Over a number of decades, mangrove forests in the Indus Delta have experienced massive-scale deforestation and degradation due to a number of contributing factors. These include their use by the local communities as a source of fuelwood, fodder and open range grazing by livestock.

Step 8: Determine the drivers and agents influencing the variable

- See Table A9.4

Step 9: Reassess the category of variable being projected

- No changes

Step 10 Analysis of constraints to future values of the variable

- See Table A9.4

Table A9.4. Drivers and agents; constraints to future values of the variables in the baseline scenario.

Variable	Type	Step 8: Drivers and agents	Step 10: Constraints
Sediment supply in the Indus Delta	Process specific Systemic Caused	Section 2.1.1; 2.1.5 Upstream activities in the Indus River including construction works, irrigation, under government control.	The main constraint has occurred in the past and no future additional constraints are likely to occur
Freshwater supply in the Indus Delta	Process specific Systemic Caused	Section 2.1.5 Upstream activities in the Indus River including construction works, irrigation, under government control	The main constraint has occurred in the past and no future additional constraints are likely to occur
Sea level rise and associated submergence and erosion	Process specific Systemic Inherent	Section 3.1.3.2.2 Not relevant	No constraints
Natural regeneration	Location specific Systemic	Section 3.1.4	The driver is likely to continue in line with the historic trend

	Inherent	Ecological barriers including lack of mangrove propagules, and grazing and fodder collection	
Tree harvesting, grazing	Location specific Planned Projected	Section 2.1.1 Local communities using mangroves and its habitat as a source of fuelwood and fodder, and area for grazing by livestock	The driver is likely to continue in line with the historic trend

Step 11: Projection of controlled variables

- None

Step 12: Projection of planned variables

- See Table A9.5

Step 13: Projection of process specific systemic variables

- See Table A9.5

Step 14: Projection of location specific systemic variables

- See Table A9.5

Table A9.5. Projection of variables in the baseline scenario.

Variable	Type	Step	Results
Sediment supply in the Indus Delta	Process specific Systemic Caused	13	Section 2.1.1; 2.1.5 Sediment supply is likely to continue in line with the historic trend
Freshwater supply in the Indus Delta	Process specific Systemic Caused	13	Section 2.1.5 Freshwater supply is likely to continue in line with the historic trend
Sea level rise and associated submergence and erosion	Process specific Systemic Inherent	13	Section 3.1.3.2.2 According to IPCC scenario
Natural regeneration	Location specific Systemic Inherent	13	Section 3.1.4 Natural regeneration is likely to be thwarted completely, in line with the historic trend
Tree harvesting, grazing	Location specific Planned	12, 14	Section 2.1.1

	Projected		Tree harvesting and grazing are likely to continue in line with the historic trend

Project scenario

Step 1: Define the geographic area(s) within which the variable is to be projected

- Project Area

Step 2: Identify the scenario under which the variable is to be projected

- Project scenario

Step 3: Determine the type and category of the variable being projected

- See Table A9.6

Step 4: Temporal character of the variable

- See Table A9.6

Step 5: Determination of the steps to be taken to project the future value of the variable

- See Table A9.6

Table A9.6. Type, category and temporal character of variables in the project scenario; steps for projections.

Variable	Type	Category	Temporal nature	Relevant steps in module
Sediment supply in the Indus Delta	Process specific	Systemic	Caused	Steps 1-6 Step 8-10 Step 13
Freshwater supply in the Indus Delta	Process specific	Systemic	Caused	Steps 1-6 Step 8-10 Step 13
Sea level rise and associated submergence and erosion	Process specific	Systemic	Inherent	Steps 1-6 Step 8-10 Step 13
Vegetation development	Location specific	Controlled	Intended	Steps 1-5 Step 7-10 Step 11
Tree harvesting, grazing	Location specific	Controlled	Intended	Steps 1-5 Step 10

				Step 11

Step 6: Analysis of historic trends for process specific variables

- See Table A9.7

Table A9.7. Historic trends for process specific variables in the project scenario.

Variable	Type	Summary and reference to section with elaborated results
Sediment supply in the Indus Delta	Process specific Systemic Caused	See baseline scenario
Freshwater supply in the Indus Delta	Process specific Systemic Caused	See baseline scenario
Sea level rise and associated submergence and erosion	Process specific Systemic Inherent	See baseline scenario

Step 7: Analysis of historic trends for location specific variables

- See Table A9.8

Table A9.8. Historic trends for location specific variables in the project scenario.

Variable	Type	Summary and reference to section with elaborated results
Vegetation development	Location specific Controlled Intended	Sections 2.1.1; 3.1.3.2.1; 3.2.2.1; 3.2.2.4.1 This variable is directly assessable through remote sensing. Historic trends are not relevant for the project scenario. Natural regeneration of mangrove since the start of the ARR programme in 2015 is not part of the baseline scenario and will be included in the monitoring of the project scenario.
Tree harvesting, grazing	Location specific Controlled Intended	Section 2.1.1; 5.2.1

Step 8: Determine the drivers and agents influencing the variable

- See Table A9.9

Step 9: Reassess the category of variable being projected

- No changes

Step 10 Analysis of constraints to future values of the variable

- See Table A9.9

Table A9.9. Drivers and agents; constraints to future values of the variables in the project scenario.

Variable	Type	Step 8: Drivers and agents	Step 10: Constraints
Sediment supply in the Indus Delta	Process specific Systemic Caused	See baseline scenario	See baseline scenario
Freshwater supply in the Indus Delta	Process specific Systemic Caused	See baseline scenario	See baseline scenario
Sea level rise and associated submergence and erosion	Process specific Systemic Inherent	See baseline scenario	See baseline scenario
Vegetation development	Location specific Controlled Intended	Sections 2.1.1; 3.1.3.2.1; 3.2.2.1; 3.2.2.4.1 Project developer	Section 2.4.5; 2.1.20 No constraints other than sufficient funding
Tree harvesting, grazing	Location specific Controlled Intended	Section 5.2.1 Project developer	Section 4.2.1 No constraints to implementing the Mangrove Stewardship Agreement other than sufficient funding

Step 11: Projection of controlled variables

- See Table A9.10

Step 12: Projection of planned variables

- None

Step 13: Projection of process specific systemic variables

- See Table A9.10

Step 14: Projection of location specific systemic variables

- None

Table A9.10. Projection of variables in the project scenario.

Variable	Type	Step	Results
Sediment supply in the Indus Delta	Process specific Systemic Caused	13	See baseline scenario
Freshwater supply in the Indus Delta	Process specific Systemic Caused	13	See baseline scenario
Sea level rise and associated submergence and erosion	Process specific Systemic Inherent	13	See baseline scenario
Vegetation development	Location specific Controlled Intended	11	Section 3.2.2.1 Project developer projects the plantation of some 250,000 hectares of mangrove forest
Tree harvesting, grazing	Location specific Controlled Intended	11	Section 4.2.1 Project developer has Mangrove Stewardship Agreement with communities, which stops tree harvesting and grazing in the project scenario

Appendix 10. Pre-project Land Cover and Vegetation Development

Pre-project vegetation in the Project Area is almost absent. However, some mangrove tree vegetation does exist, in particular along creeks, see Figure A10.1, as a notable example.

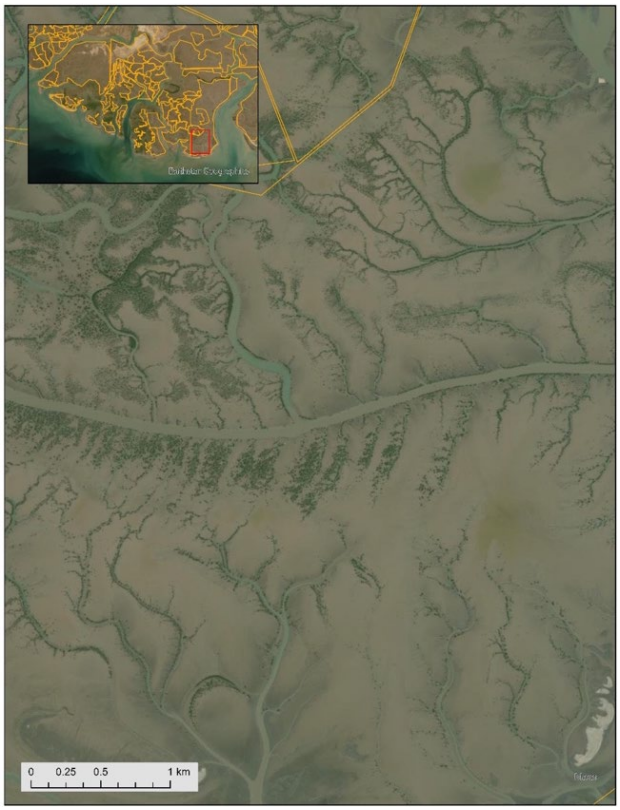


Figure A10.1. Example of pre-project (2014) presence of mangrove trees along creeks in Shah Bander area, within the Project Area.

To assess whether this vegetation would stock significant amounts of carbon in the baseline scenario, remote sensing imagery of year 2014 was analysed for presence of mangrove trees. In four areas (the one depicted above and three additional areas – see Figure A10.2 for their locations) a detailed assessment was performed to quantify the area covered.

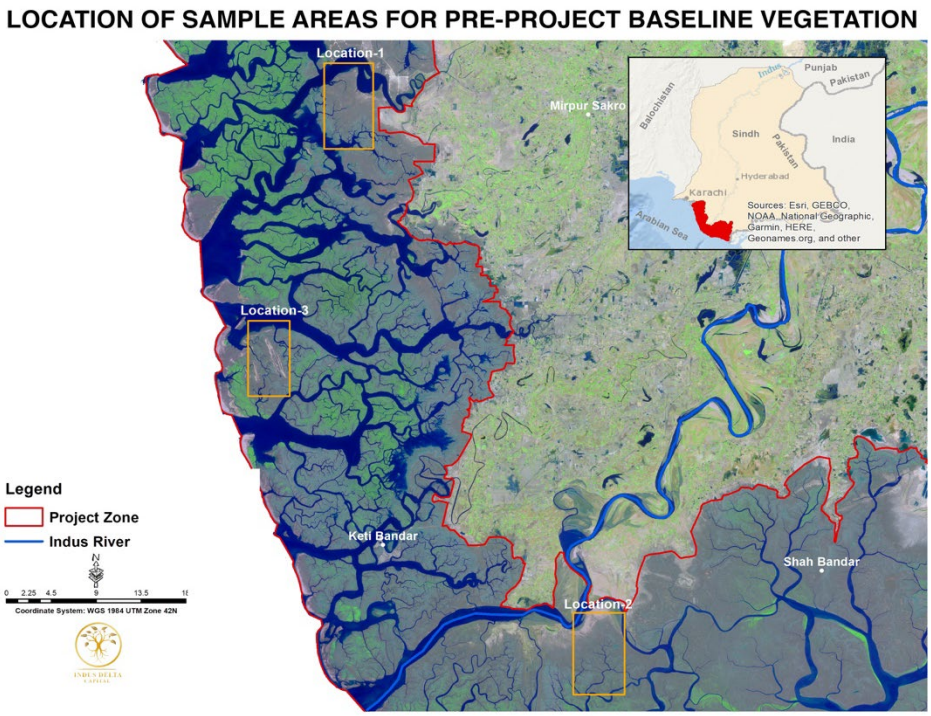
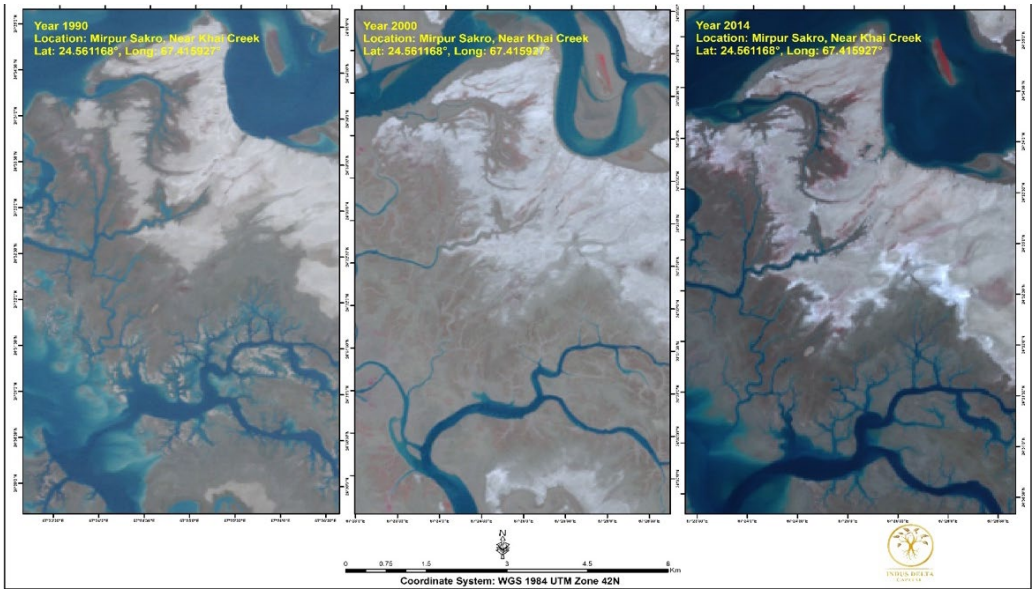


Figure A10.2. Location of three sample areas for baseline vegetation within the Project Area.

The times series in Figures A10.3 – A.10.5 show a very sparse presence of mangrove since 1990. The areas of mangrove vegetation, distinguishing sparse and dense, are provided in Table A10.1.



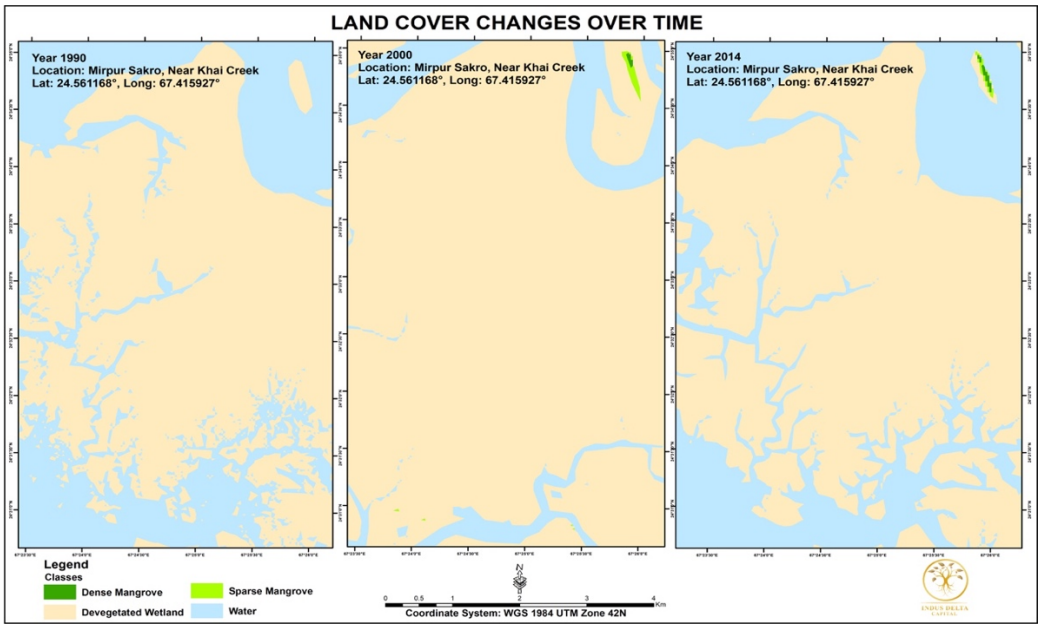
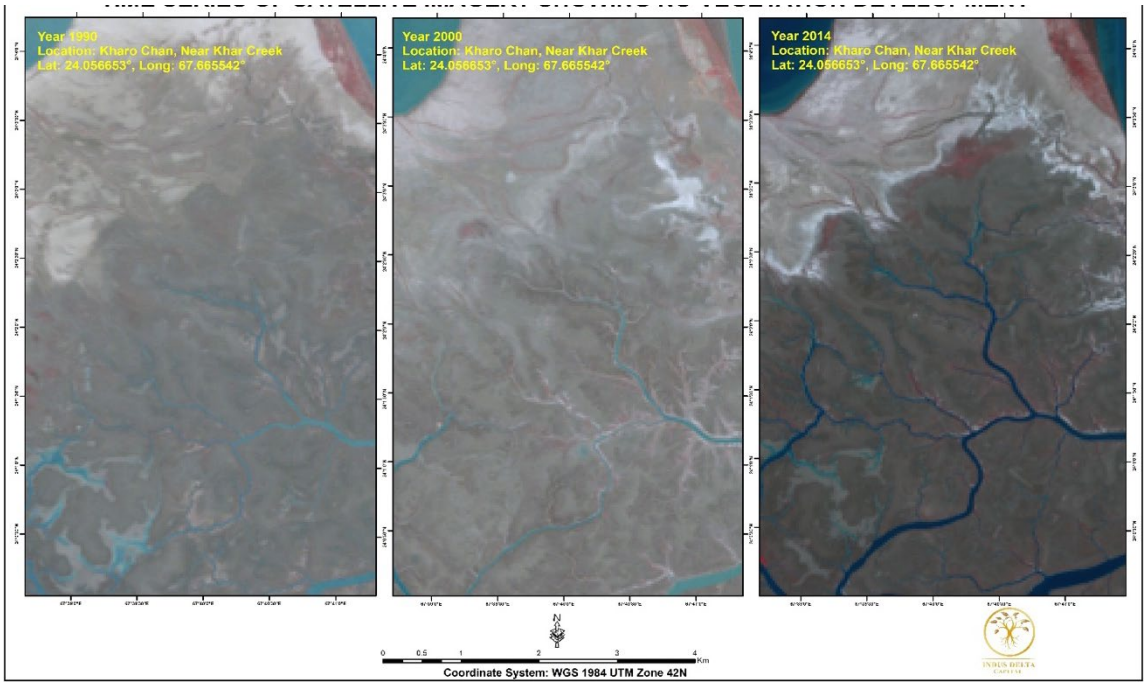


Figure A10.3. Time series of land cover during the period 2000-2014 in Mirpur Sakro.



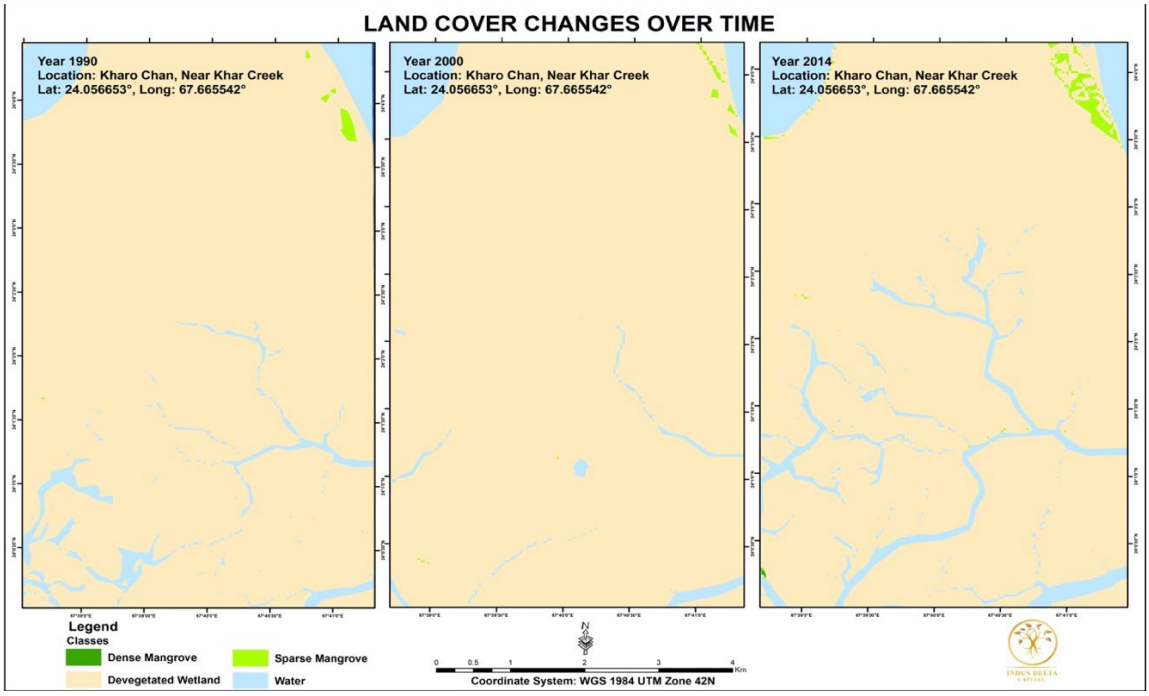
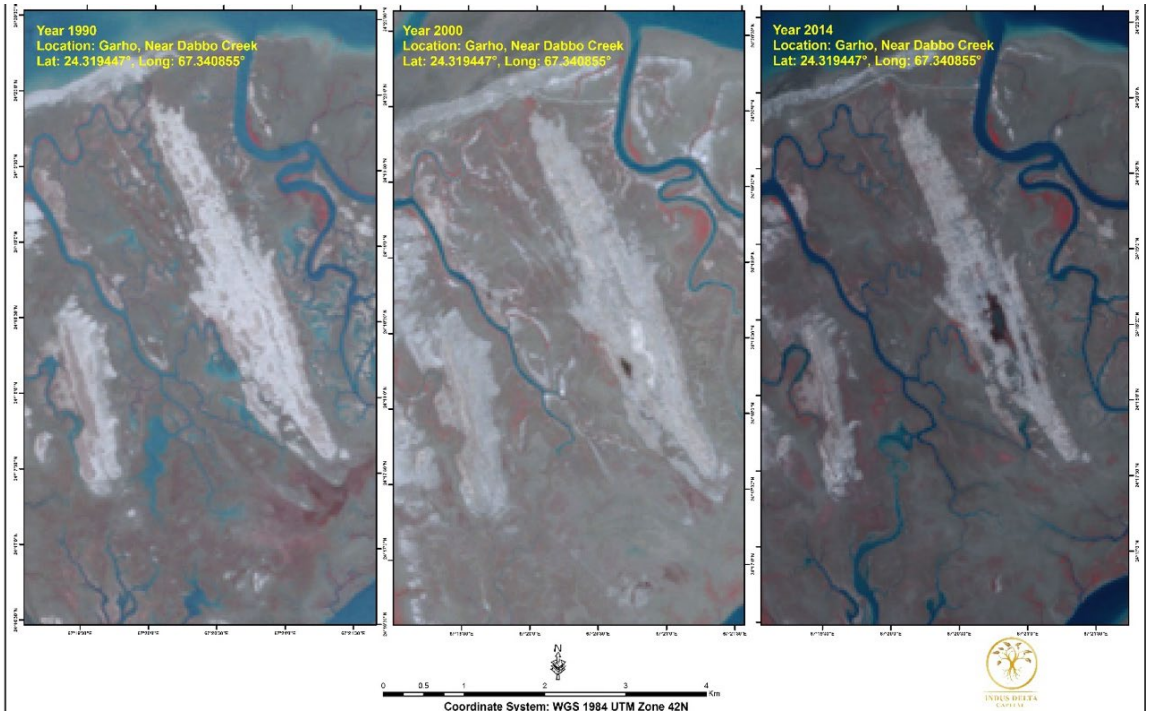
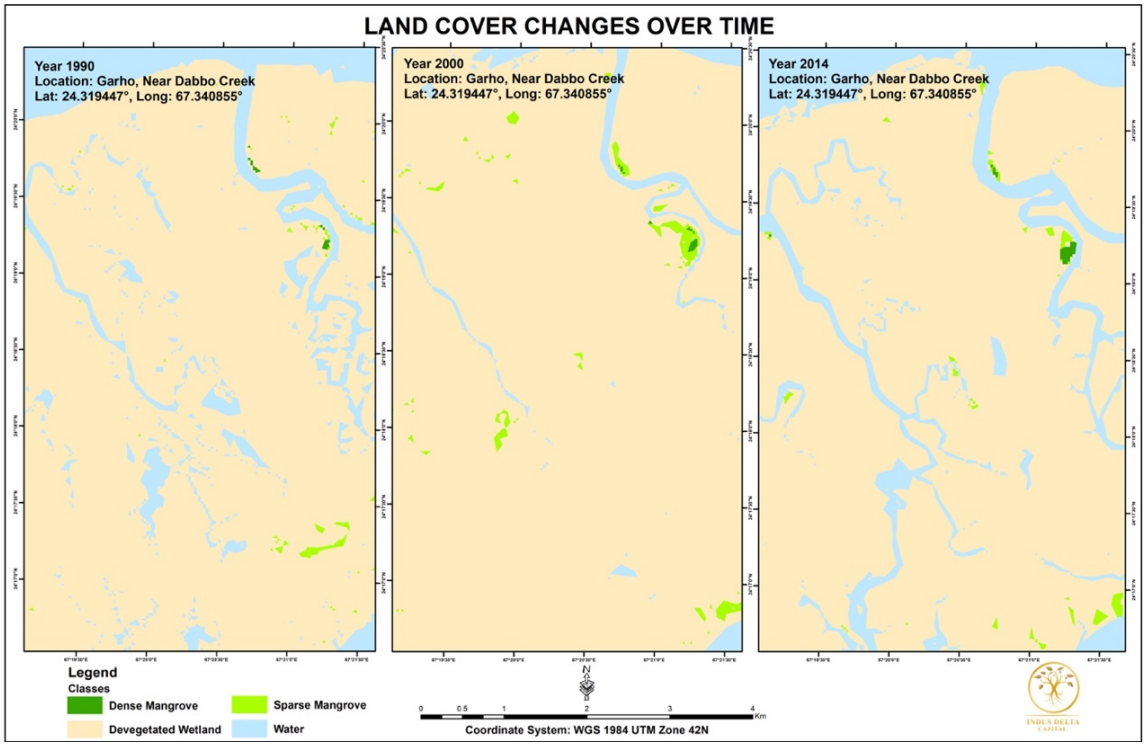
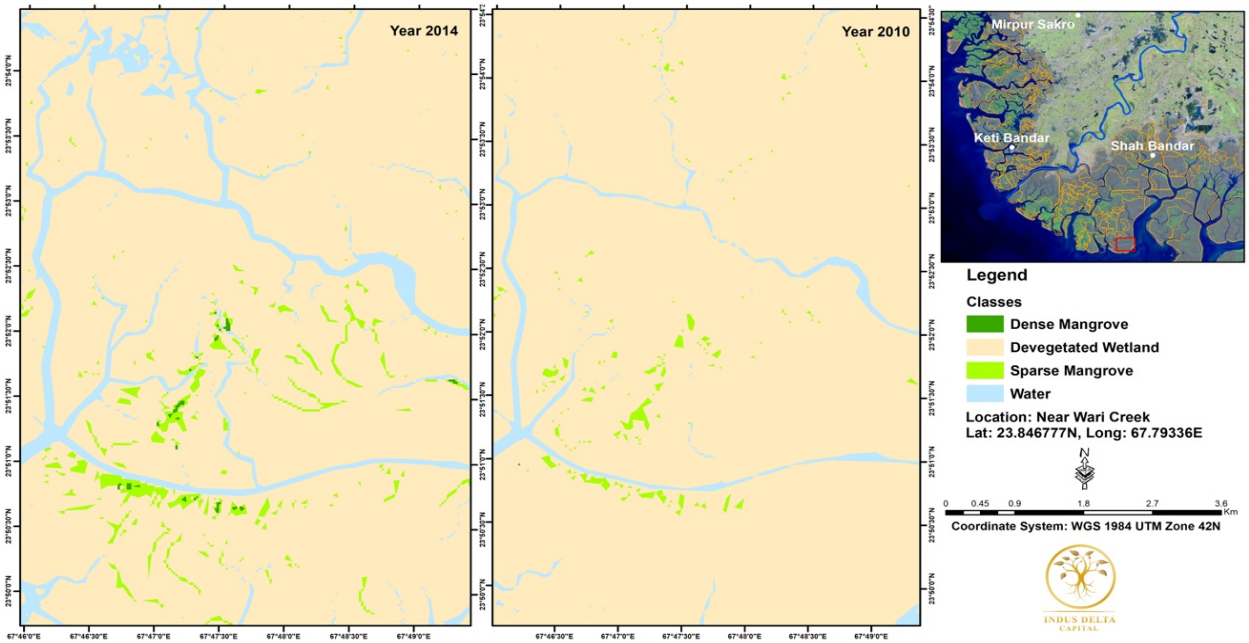


Figure A10.4. Time series of land cover during the period 2000-2014 in Kharo Chan.





FigureA10.5. Time series of land cover during the period 2000-2014 in Garho.



FigureA10.6. Time series of land cover during the period 2010-2014 in Shah Bander.

Table A10.1. Land cover in three sample areas in a time series before project start date.

Class/ Year	1990	2000	2014
Mirpur Sakro	Ha		
De-vegetated wetland	2,589	3,512	2,811
Dense mangrove	Nil	1	3
Sparse mangrove	Nil	7	3
Water	1,383	453	1,408
Kharo Chan			
De-vegetated wetland	3,691	3,533	3,465
Dense mangrove	Nil	Nil	0.4
Sparse mangrove	8	6	28
Water	253	179	388
Garho			
De-vegetated wetland	2,729	3,045	2,753
Dense mangrove	2	2	4
Sparse mangrove	11	31	16
Water	589	126	504

Table A10.2. Share of mangrove cover in year 2014.

Location	Latitude in degrees	Longitude in degrees	De-vegetated	Sparse mangrove	Dense mangroves	Total area
			ha			
Mirpur Sakro	24.56117	67.41593	2,811	3	3	2,817
			99.8%	**0.2%**		
Kharo Chan	24.05665	67.66554	3,465	28	0.4	3,493
			99.2%	**0.8%**		

Garho	24.31945	67.34086	2,753	16	4	2,773
			99.3%	**0.7%**		
Shah Bander	23.84677	67.79336	4,730	123	7	4,860
			97.3%	**2.7%**		

Using a similar approach as in CDM AR Tool 4 (see also Section 3.2.2.6) to assess the significance of pre-project mangrove vegetation, on the basis of the results in Table A10.2 it is concluded that these areas are below 5%, i.e., *de minimis*. However, to be conservative, GHG removals in the project scenario will be corrected for the presence of baseline mangrove vegetation by excluding a portion of the Project Area. This portion is quantified as the average of the percentage of the mangrove areas as provided in Table A10.2, i.e., 1.1%.

Appendix 11. Mangrove Canopy Cover Development

The project uses a default value for SOC accumulation in the *ex-ante* estimation of GHG removals. The default value applied is conditional on the vegetation cover, where for a vegetation with 50% or more cover the value van be applied without any reduction. For vegetation covers below 15% no default value can be used. Between 15% and 50% cover, a linear interpolation can be applied.

According to field observations, *Avicennia* plantations show a 50% or higher canopy cover after 5-7 years. *Rhizophora* plantations are quickly invaded by *Avicennia*, and thus show a similar rate of canopy development and after some 10 years they are fully covered.



Figure A11.1. 3-year old *Rhizophora* plantation with natural regeneration of *Avicennia*.



Figure A11.2. 7-year old *Rhizophora* plantation with natural regeneration of *Avicennia*.

Appendix 12. Risk Analysis

1. INTERNAL RISK

Project Management		
Risk Factor	**Risk Factor and/or Mitigation Description**	**Risk Rating**
a)	Species planted (where applicable) associated with more than 25% of the stocks on which GHG credits have previously been issued are not native or proven to be adapted to the same or similar agro-ecological zone(s) in which the project is located. Not applicable Justification and evidence: Species used or intended to be used in replanting are all native: *Avicennia marina, Rhizophora mucronate, Ceriops tagal,* and *Aegiceras corniculatum*. Section 5.2.5.	
b)	Ongoing enforcement to prevent encroachment by outside actors is required to protect more than 50% of stocks on which GHG credits have previously been issued. Justification and evidence: The baseline scenario is characterised a.o. by trampling of and damage to any newly emerging natural seedlings/natural regeneration by camels/other livestock and browsing by camels/other livestock, and lopping of branches of mangroves and mangrove propagules for fodder and fuelwood purposes. Section 3.1.4. Protection and law enforcement activities will continue to seek to prevent illegal exploitation of the Project Area for fuelwood cutting and illegal grazing of livestock as well as poaching and killing of wildlife species. Carbon funds will be used to substantially increase manpower used to enforce these measures. Section 2.1.11.	2
c)	Management team does not include individuals with significant experience in all skills necessary to successfully undertake all project activities (i.e., any area of required experience is not covered by at least one individual with at least 5 years' experience in the area). Not applicable Justification and evidence: There is a suite of key technical skills which are required to implement DBC-1. These include an understanding of the science and art of ecosystem restoration, forest and biodiversity conservation, geographic information systems and remote sensing, biomass sampling, coastal ecology and Greenhouse Gas Accounting. Sections 2.4.2 and 2.4.3.	

d)	Management team does not maintain a presence in the country or is located more than a day of travel from the project site, considering all parcels or polygons in the project area. Not applicable Justification and evidence: The core team is based in the project headquarters in Karachi and in field offices in Keti Bandar and Shah Bandar and maintains a presence throughout the Project Zone. Section 2.4.2.	
e)	Mitigation: Management team includes individuals with significant experience in AFOLU project design and implementation, carbon accounting and reporting (e.g., individuals who have successfully managed projects through validation, verification and issuance of GHG credits) under the VCS Program or other approved GHG programs. Justification: There are sufficient capacities at the organisation level with the proponents for over-all restoration programme management. The project team have the required capacities around various aspects of project management such as project integration management, scope management, cost management, schedule/time management, procurement management, resources management, logistics management, communications management, risk management, etc. Justification and evidence: See item c) above. Sections 2.4.2 and 2.4.3.	-2
f)	Mitigation: Adaptive management plan in place. Justification and evidence: Project activities are monitored and evaluated on a regular basis according to the project's monitoring plans and SOPs with respect to these various activities. The information becoming available as a result of these monitoring and evaluation activities and continued consultations with stakeholders will be fed into future actions and decision making so as to enable adaptive management of the project and its interventions. Section 2.3.8.	-2
Total Project Management (PM) [as applicable, (a + b + c + d + e + f)] Total may be less than zero.		**-2**

Financial Viability		
Risk Factor	**Risk Factor and/or Mitigation Description**	**Risk Rating**
a)	Project cash flow breakeven point is greater than 10 years from the current risk assessment.	

	Not applicable Justification and evidence: See item d) below.	
b)	Project cash flow breakeven point is greater than 7 and up to 10 years from the current risk assessment. Not applicable Justification and evidence: See item d) below.	
c)	Project cash flow breakeven point greater than 4 and up to 7 years from the current risk assessment. Not applicable Justification and evidence: See item d) below.	
d)	Project cash flow breakeven point is less than 4 years from the current risk assessment. Justification and evidence: Financial analysis provided separately	0
e)	Project has secured less than 15% of funding needed to cover the total cash out before the project reaches breakeven. Not applicable Justification and evidence: See item h) below.	
f)	Project has secured 15% to less than 40% of funding needed to cover the total cash out required before the project reaches breakeven. Not applicable Justification and evidence: See item h) below.	
g)	Project has secured 40% to less than 80% of funding needed to cover the total cash out required before the project reaches breakeven Not applicable Justification and evidence: See item h) below.	
h)	Project has secured 80% or more of funding needed to cover the total cash out before the project reaches breakeven. Justification and evidence: Financial analysis provided separately	0
i)	Mitigation: Project has available as callable financial resources at least 50% of total cash out before project reaches breakeven.	-2

	Justification: Funding and finance related risks such as non-availability of funds for project implementation, perceived risks, and high start-up costs and transactions costs are minimal. So are risks associated with low prices for carbon and other ecosystem services; low economic returns and insufficient revenues from ecosystem services to pay for opportunity costs, transactions costs and implementation costs visa-a-vis high risks; inflation and rising costs for project activities implementation; and extreme fluctuations in country currency exchange rates. The project is financially viable as the project benefits exceed the project costs. The various measures for assessing financial viability such as the Net Present Value (NPV), Benefit Cost Ratio and Internal Rate of Return (IRR) all show that it is a financially viable project. Evidence: Financial analysis provided separately	
Total Financial Viability (FV) [as applicable, ((a, b, c or d) + (e, f, g or h) + i)] Total may not be less than zero.		**0**

Opportunity Cost		
Risk Factor	**Risk Factor and/or Mitigation Description**	**Risk Rating**
a)	NPV from the most profitable alternative land use activity is expected to be at least 100% more than that associated with project activities; or where baseline activities are subsistence-driven, net positive community impacts are not demonstrated Not applicable Justification and evidence: See item f) below.	
b)	NPV from the most profitable alternative land use activity is expected to be between 50% and up to100% more than from project activities. Not applicable Justification and evidence: See item f) below.	
c)	NPV from the most profitable alternative land use activity is expected to be between 20% and up to 50% more than from project activities. Not applicable Justification and evidence: See item f) below.	

d)	NPV from the most profitable alternative land use activity is expected to be between 20% more than and up to 20% less than from project activities; or where baseline activities are subsistence-driven, net positive community impacts are demonstrated. Not applicable Justification and evidence: See item f) below.	
e)	NPV from project activities is expected to be between 20% and up to 50% more profitable than the most profitable alternative land use activity. Not applicable Justification and evidence: See item f) below.	
f)	NPV from project activities is expected to be at least 50% more profitable than the most profitable alternative land use activity Justification and evidence: Financial analysis provided separately	-4
g)	Mitigation: Project proponent is a non-profit organization. Not applicable Justification and evidence: Project proponent IDC is not a non-profit organisation. Sections 2.1.1, 2.1.20, 2.4.3.	
h)	Mitigation: Project is protected by legally binding commitment to continue management practices that protect the credited carbon stocks over the length of the project crediting period. Justification: DBC-1 is developed and managed by the Government of Sindh and Indus Delta Capital Limited, who have entered into public-private partnership arrangements through a 60-year agreement, renewable up to 100 years for the protection, conservation and ecosystem restoration of mangrove wetlands in the Sindh Indus Delta area. By collaborating with the project-area communities and partner organisations, Forest Department of Government of Sindh and Indus Delta Capital Limited take full responsibility to manage, finance and implement project activities for the duration of the project. Evidence: Section 2.4.1.	-2
i)	Mitigation: Project is protected by legally binding commitment to continue management practices that protect the credited carbon stocks over at least 100 years. Not applicable	

	Evidence: See item i) above.	
Total Opportunity Cost (OC) [as applicable, (a, b, c, d, e or f) + (g + h or i)] Total may be less than 0.		**-6**

Project Longevity		
a)	Without legal agreement or requirement to continue the management practice. Not applicable Evidence: See item b) below.	
b)	With legal agreement or requirement to continue the management practice Jutification: The project does not have a legally binding agreement that covers at least a 100-year period from the project start date, but 60 years and renewable; The project longevity is 60 years; Legal agreement or requirement to continue management practice are in place. Evidence: Section 2.4.1.	0
Total Project Longevity (PL) May not be less than zero		**0**

Internal Risk	
Total Internal Risk (PM + FV + OC + PL) Total may not be less than zero.	**0**

2. EXTERNAL RISK

Land Tenure and Resource Access/Impacts		
Risk Factor	**Risk Factor and/or Mitigation Description**	**Risk Rating**

a)	Ownership and resource access/use rights are held by same entity(s) Justification and evidence: DBC-1 is developed and managed by the Government of Sindh and Indus Delta Capital Limited, who have entered into public-private partnership arrangements through a 60-year agreement. Section 2.4.1. All lands in the Project Area are classified as Protected Forests and are state property. Therefore, their ownership vests in the Government of Sindh. Section 2.1.6.	0
b)	Ownership and resource access/use rights are held by various entity(s) (e.g., land is government owned and the project proponent holds a lease or concession). Not applicable Justification and evidence: See item a) above.	
c)	In more than 5% of the project area, there exist disputes over land tenure or ownership. Not applicable Justification and evidence: See item a) above.	
d)	There exist disputes over access/use rights (or overlapping rights). Not applicable Justification and evidence: See item a) above.	
e)	WRC projects unable to demonstrate that potential upstream and sea impacts that could undermine issued credits in the next 10 years are irrelevant or expected to be insignificant, or that there is a plan in place for effectively mitigating such impacts. Not applicable Justification and evidence: Water and sediment discharge to the delta have been drastically altered since the mid 1950s due to large-scale industrial activity. The present-day river and delta have been hugely impacted by; (1) dams constructed upstream, (2) barrages and their irrigation canals, (3) artificial flood levees, (4) sediment impoundment behind upstream reservoirs, and (5) inter-basin diversion. The effect of the engineered diversions is most alarming regarding the future conditions in the delta. The decrease in water and sediment discharge below the Kotri barrage, situated to the north of the Project Zone between Jamshoro and Hyderabad, has a number of environmental, social and economic consequences due to increases in the effect of	

	waves and tides, resulting in sea water intrusion and coastal erosion. Section 2.1.5. The project has conservatively estimated potential erosion based on a sea-level rise forecast and the related loss of carbon stored in soil and vegetation. Sections 3.1.3.2.2, 3.2.1.5.5, 3.2.2.5.1.5.	
f)	Mitigation: Project Area is protected by legally binding commitment (e.g., a conservation easement or protected area) to continue management practices that protect carbon stocks over the length of the project crediting period. Justification: Legally binding commitments to continue management practices that protect the credited carbon stocks over the length of the project crediting period are in place. Evidence: Section 2.4.1.	-2
g)	Mitigation: Where disputes over land tenure, ownership or access/use rights exist, documented evidence is provided that projects have implemented activities to resolve the disputes or clarify overlapping claims. Not applicable Justification and evidence: The Project Area is free of land grabbing, territorial displacement, or deprivation from access to resources. There have been only a few minor disputes amongst the communities of various villages or within communities of a village over land, territory or resources in the Project Zone during the last 20 years. Most of their disputes have been pertaining to migrant herders bringing camels for grazing into the delta area during the flood season. All such disputes are resolved through local mediation measures by the communities themselves and there is no resort to government or other official channels for dispute resolution. Also, the likelihood of disputes on land, territories and resources to occur in the future is low. Therefore, there is no potential for the project to prejudice any decision or outcome of a dispute through its activities. Using a precautionary approach, the project has a protocol for disputes resolution at the community level. Evidence: Section 2.5.6.	
Total Land Tenure (LT) [as applicable, ((a or b) + c + d + e + f + g)] Total may not be less than zero.		**0**

Community Engagement		
Risk Factor	**Risk Factor and/or Mitigation Description**	**Risk Rating**
a)	Less than 50 percent of households living within the project area who are reliant on the project area, have been consulted. Not applicable Justification and evidence: Social and Biodiversity Impact Assessment (SBIA) workshops were held in strategic locations in the Project Zone with key representatives of community groups. Participants consisted of representatives from all stakeholder groups including local administration, village elders, local community leaders, indigenous women and youth representatives. See Section 2.1.6. In total for the FPIC process and other project related activities, more than 45 meetings have been held since 2013 which have been attended by hundreds of community members from the Project Zone. See Section 2.3.7.	
b)	Less than 20 percent of households living within 20 km of the project boundary outside the project area, and who are reliant on the project area, have been consulted. Not applicable Justification and evidence: See item a) above.	
c)	Mitigation: The project generates net positive impacts on the social and economic well-being of the local communities who derive livelihoods from the project area. Justification: The project is providing community benefits to the entire population (more than 42,000 people) of the Project Zone. These community benefits are listed in various sections of this PD. Evidence: Sections 4.5.2, 4.5.4.	-5
Total Community Engagement (CE) [where applicable, (a + b + c)] Total may be less than zero.		**-5**

Political Risk		
Risk Factor	**Risk Factor and/or Mitigation Description**	**Risk Rating**

a)	Governance score of less than -0.79 Justification: The country's calculated governance score is -0.99. The resulting risk tool score is 0.79 (risk tool). Evidence: The Worldwide Governance Indicators, 2020 Update. The Worldwide Governance Indicators (WGI) are a research dataset summarising the views on the quality of governance provided by a large number of enterprise, citizen and expert survey respondents in industrial and developing countries. These data are gathered from a number of survey institutes, think tanks, non-governmental organisations, international organisations, and private sector firms. The six aggregate indicators are based on over 30 underlying data sources reporting the perceptions of governance of a large number of survey respondents and expert assessments worldwide. http://info.worldbank.org/governance/wgi/	6
b)	Governance score of -0.79 to less than -0.32. Not applicable Justification and evidence: See item a) above.	
c)	Governance score of -0.32 to less than 0.19. Not applicable Justification and evidence: See item a) above.	
d)	Governance score of 0.19 to less than 0.82. Not applicable Justification and evidence: See item a) above.	
e)	Governance score of 0.82 or higher. Not applicable Justification and evidence: See item a) above.	
f)	Mitigation: Country is implementing REDD+ Readiness or other activities. Justification: The country is receiving REDD+ Readiness Funding from the FCPF and is implementing REDD+ Readiness as well as a Social and Environmental Safeguards System. Evidence: Pakistan is in the list of countries that is receiving FCPF funding as shown on the website of FCPF in the Asia-Pacific Group. Website of Pakistan National REDD+ Office http//www.redd-	-2

	pakistan.org has various documents related to various FCPF and Safeguards system related documents.	
Total Political (PC) [as applicable ((a, b, c, d or e) + f)] Total may not be less than zero.		**4**

External Risk	
Total External Risk (LT + CE + PC) Total may not be less than zero.	0

3. NATURAL RISK

Fire (F)	
Significance	Risk is not applicable to project area Justification and evidence: The Indus Delta region is not susceptible to severe natural destructive events. The area is subject to very little geological activity and as a native ecosystem the risks from disease and pests are minimal. The risk of fire is negligible due to regular inundation and high humidity under the forest canopy and in the whole of the intertidal zone. Also, government has standing orders with respect to forest fires prevention, suppression and reporting. In the event a forest fire, it has to be reported on immediate basis and a fire damage report prepared. This fire damage report among others needs to have details with respect to the date and time the fire occurred, how it occurred, specific location of the fire, extent/area affected, and damages caused by the fire. No such fire damage incidents in the Indus Delta mangrove forests have been reported over the past more than two decades. See Section .2.1.18.
Likelihood	Not relevant
Score (LS)	0
Mitigation	Not relevant

Pest and Disease Outbreaks (PD)

Significance	Risk is not applicable to project area Justification and evidence: See item Fire, above.
Likelihood	Not relevant
Score (LS)	0
Mitigation	Not relevant

Extreme Weather (W)	
Significance	Insignificant (less than 5% loss of carbon stocks) or transient (full recovery of lost carbon stocks expected within 10 years of any event) Evidence: Sections 3.4.1, 3.4.2.
Likelihood	Less than every 10 years
Score (LS)	2
Mitigation	1.0 Justification: No prevention measures applicable to the risk factor are implemented; Project proponent has no history of containing natural risk.

Geological Risk (G)	
Significance	Risk is not applicable to project area Justification and evidence: See item Fire, above
Likelihood	Not relevant
Score (LS)	0
Mitigation	Not relevant

Score for each natural risk applicable to the project (Determined by (LS × M)	
Fire (F)	0

Pest and Disease Outbreaks (PD)	0
Extreme Weather (W)	2
Geological Risk (G)	0
Other natural risk (ON)	0
Total Natural Risk (as applicable, F + PD + W + G + ON)	2

4. OVERALL NON-PERMANENCE RISK RATING AND BUFFER DETERMINATION

4.1 Overall Risk Rating

Risk Category	Rating
Internal Risk	0
External Risk	0
Natural Risk	2
Overall Risk Rating (a + b + c)	

4.2 Calculation of Total VCUs

The cumulative buffer withholding and resulting VCUs are provided in Table 23 in Section 3.2.4.

Appendix 13: Mangrove Growth Curve for *Ex-ante* Calculations

Ex-ante estimates of carbon sequestration in mangrove plantations are based on the annual areas of tree planting and a general growth model for mangrove forest with *Avicennia* and *Rhizophora*. Having separate growth models for these two species has no foundation in the situation in the plantations, as often a mixture is planted and *Avicennia* often quickly invades *Rhizophora* stands.

On the basis of a chronosequence of mangrove plantations in and in the vicinity of the Project Area, a general growth curve was developed. Plot coordinates are shown in Figure A13.1. The ages of 16 sampled plantations ranged from a 1-5 year class to over 30 years. Plantations established prior to the project start date originate from a previous planting programme by the Sindh Forest Department, IUCN-Pakistan and WWF-Pakistan. The management and protection of these plantations outside the Project Area varies considerably, as do carbon stocks as a consequence. Therefore, plot selection outside the Project Area was based on a visual observation of (lack of) disturbance.

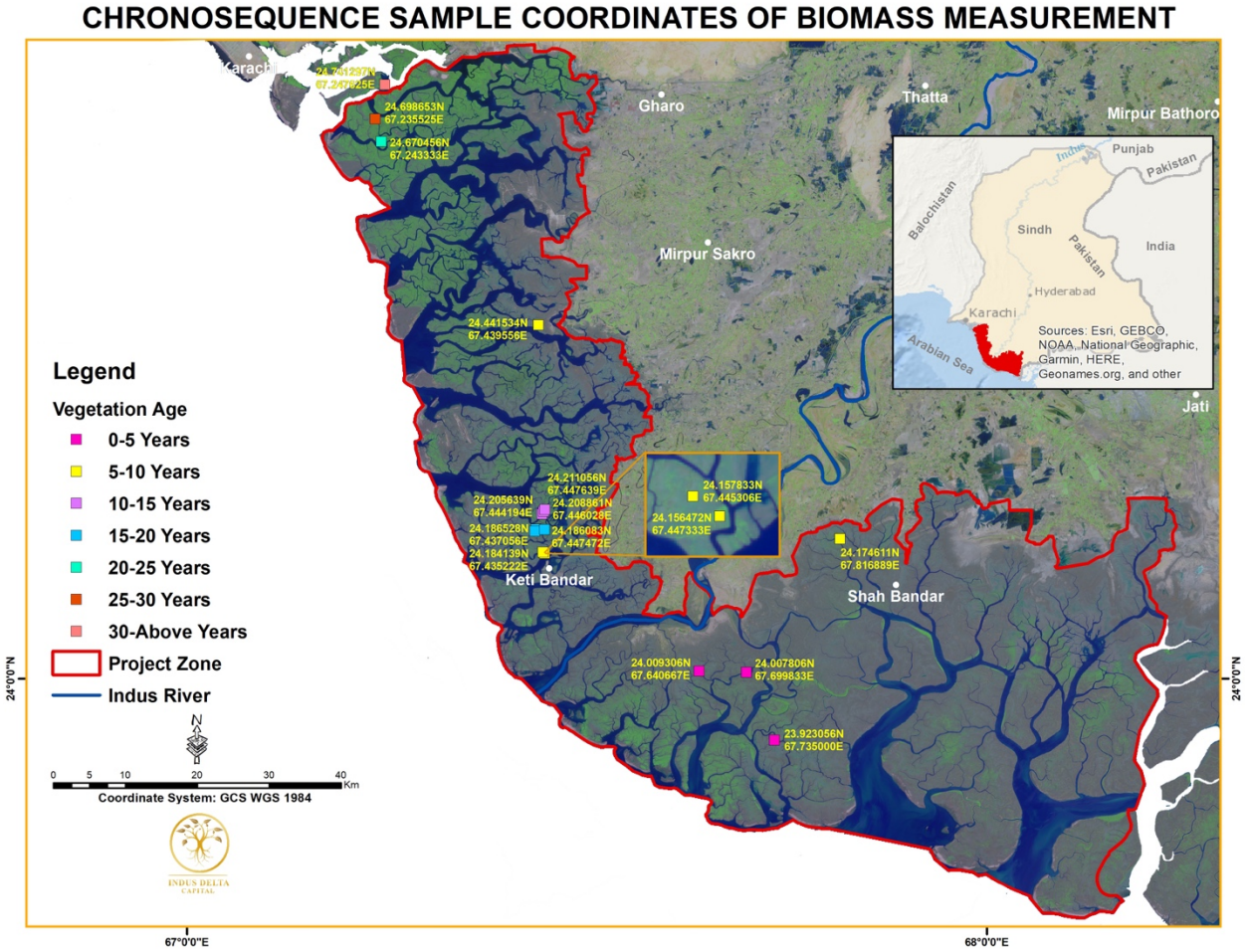


Figure A13.1. Map with coordinates of the biomass chronosequence plots.

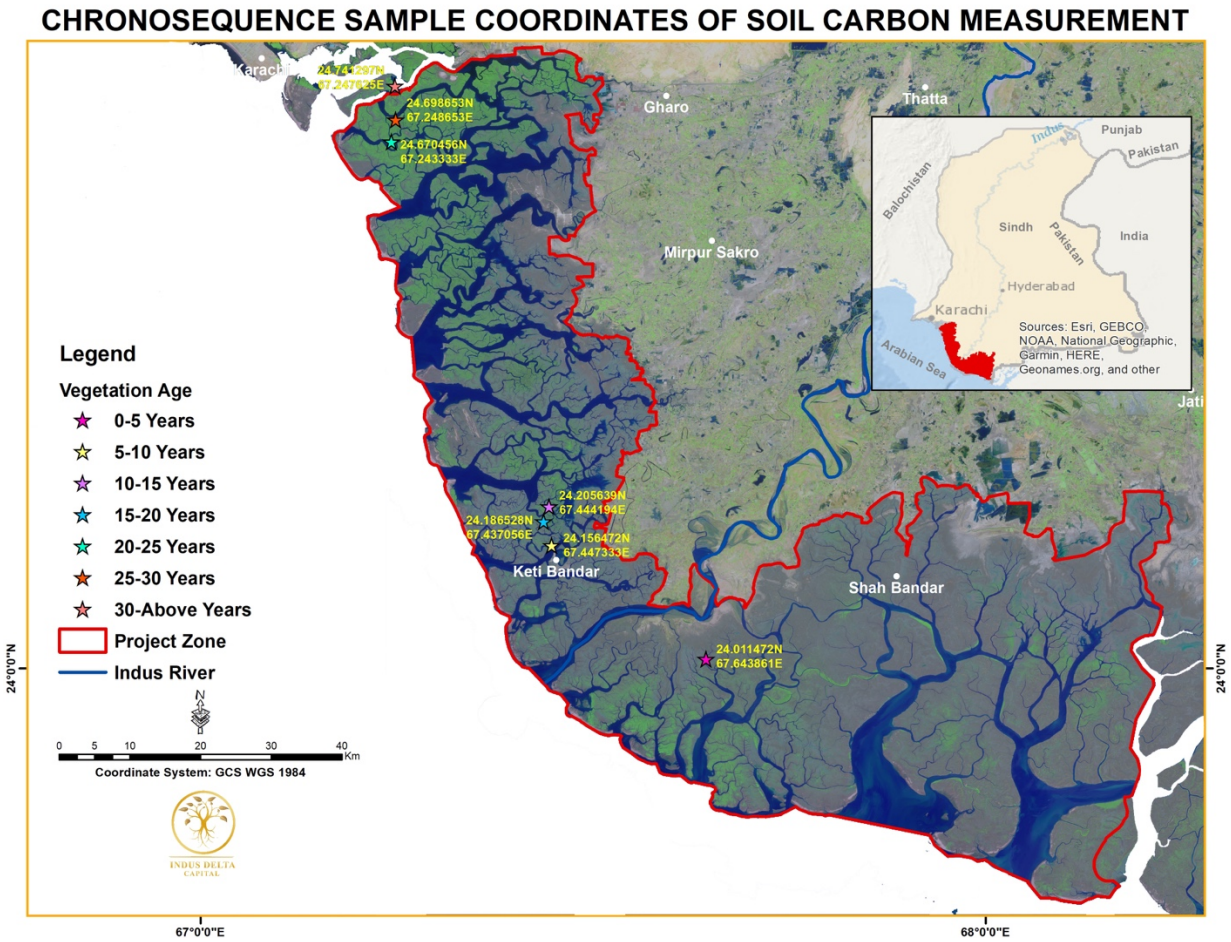


Figure A13.2. Map with coordinates of the soil chronosequence plots.

Note that the soil sample points depicted in Figure A13.2 were used for the tentative assessment of a SOC accumulation rate following mangrove reforestation, see Sections 3.2.2.5.1.2 and 3.3.3.4.

The resulting mangrove biomass growth model is shown in Figure A13.3. The curve was manually fitted using the following equation, modelling an S-shaped curve[107]:

$$TotalC = Cmax((1 - exp(-bt))^{\frac{1}{c}}$$

Where:

TotalC Carbon stored in aboveground and belowground mangrove biomass (t C ha^{-1})

Cmax Asymptotic value of the curve (t C ha^{-1})

[107] Similar to nonlinear mathematical models such as Weibull and Richard's models, see Fekedulegn et al 1999: Parameter estimation of nonlinear growth models in forestry, Silva Fennica, vol. 33, no. 4, pp. 327-336

b Controls the maximum growth rate

c Controls the form of the tail

Table A13.1. Parameters of the mangrove biomass growth model.

Parameter	Value
Cmax	200 t C ha^{-1}
b	0.1
c	0.45

The asymptotic value of 200 t C ha^{-1} was roughly based on the stock in the oldest plantation measured, suggesting that there is at least this potential. IPCC[108] default values for aboveground biomass in mangroves in tropical wet and tropical dry environments are 192 and 92 t d.m. ha^{-1}, respectively (Table 4.3 IPCC). Using IPCC default values for R/S ratios (Table 4.5 IPCC) and carbon fraction (Table 4.2 IPCC), these biomass values translate to carbon stocks of 129 and 54 t C ha^{-1}. These values are below the stocks seen in older plantations in the Indus Delta, but the range provided for tropical wet is 8.7–384 t d.m. ha^{-1}, or 5.1–223 t C ha^{-1}. While the Indus Delta region has a relatively dry climate, the growth conditions for mangroves are seen to mimic tropical wet conditions more closely[109].

Parameters *b* and *c* were manually fitted to obtain minimal residuals.

The model gives a relatively modest carbon sequestration rate in the first decade (19 t C ha^{-1} after 5 years and 64 t C ha^{-1} after 10 years), compared to the default linear increase suggested by the IPCC for tropical wet conditions (9.9 t d.m. ha^{-1} y^{-1}, corresponding with 33 t C ha^{-1} after 5 years and 67 t C ha^{-1} after 10 years).

[108] 2013 Supplement to the 2006 Guidelines: Wetlands

[109] There are a number of abiotic and biotic factors affecting mangrove seedling and over-all mangrove establishment, survival and growth rate. These factors, among many others, include salinity and nutrient availability. Being usually the main reason behind abiotic stress, high and low salinity generally limits mangrove growth. In mangroves, growth rate as a function of salinity displays a peculiar pattern; it is maximum when salinity levels are intermediate but gets substantially reduced in both fresh water as well as more saline conditions.

In the Indus Delta, salinity and nutrient availability vary across the intertidal zone, generating a continuum of conditions for survival and growth rate. These factors are also different compared to neighbouring regions, such as Oman, Iran and UAE. The neighbouring regions have a characteristic marine environment, opposed to the Indus Delta's mix of fluvic and marine conditions. Salinity levels and nutrients availability are comparatively better in the Indus Delta area due to the inflow of fresh water and sediments.

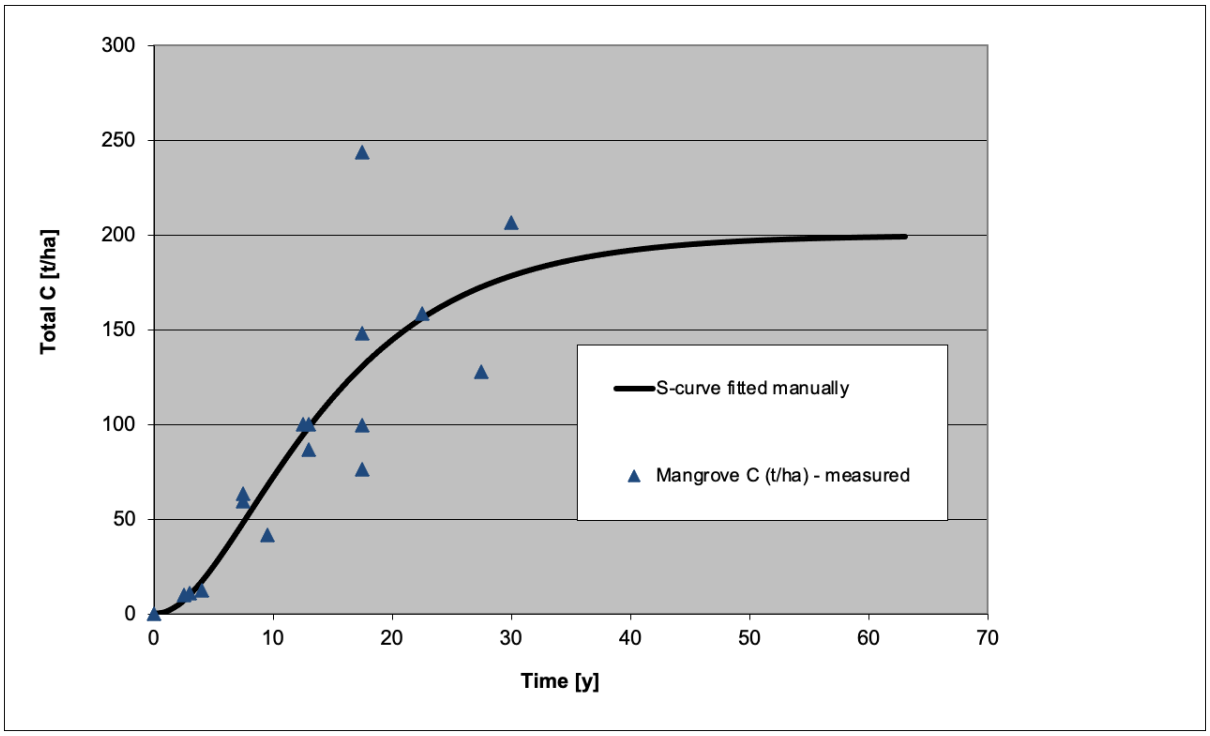


Figure A13.3. General growth model for mangrove plantations in the Indus Delta.

Appendix 14. Climate Change Vulnerability Assessment of Indus Delta

Table A14.1. Categorisation of vulnerability levels.

Index value scale	Exposure/ Vulnerability	Sensitivity/ Vulnerability	Adaptive capacity/ Vulnerability	Cumulative Vulnerability Index (CVI)
0.00≤CVI≤0.30	Low/Low	Low/Low	Low/High	Low
0.31≤CVI≤0.50	Medium/Medium	Medium/Medium	Medium/High	Medium
0.51≤CVI≤0.70	High/High	High/High	High/Medium	High
0.71≤CVI≤1.00	Very high/Very high	Very high/Very high	Very high/Low	Very high

Source: Salik, K.M., S. Jahangir, W.Z. Zahdi and S.H. Hasson. 2015. Climate change vulnerability and adaptation options for the coastal communities of Pakistan. Ocean and Coastal Management 112 (2015) 61-73.

Table A14.2. Sub-indices of CVI assessment, their indicators, related variables and their computed values. Based on structured interview of 60 respondents in the Keti Bandar of Indus Delta conducted during April 2013.

Sub-indices and their indicators	Variable	Variable description	Index over-all	Index for agriculture	Index for fisheries
Exposure (E)			**0.521**	**0.521**	**0.521**
Air temperature	E1	Monthly variability of temperatures during 1951-2010	0.677	0.677	0.677
	E2	Monthly average diurnal temperature range	0.549	0.549	0.549
	E5	Frequency of extreme hot months (above 30 ^{0}C)	0.410	0.410	0.410
	E6	Frequency of extreme cold months (below -10 ^{0}C)			
Precipitation (P)	E7	No. of extreme dry days: spring (P < 5 mm) summer (P = 0 mm)	0.555	0.555	0.555
	E3	Monthly variability of total precipitation	0.394	0.394	0.394
Sea surface temperature	E4	Monthly variability of sea surface temp. during 1951-2010	0.542	0.542	0.542
Sensitivity (S)			**0.652**	**0.638**	**0.669**
Mangrove forests	S1	Sensitivity of mangroves in Keti Bandar	0.808	0.845	0.769
	S2	Accessibility to mangroves	0.371	0.269	0.444
	S3	Mangroves used per month as fuel	0.024	0.001	0.050

Water and sanitation	S4	Share of households relying on unprotected water sources	0.908	0.787	0.758
	S5	Population deprived of sanitation facility	0.967	0.938	1.000
Fresh water flows	S6	Change in freshwater flows	0.815	0.742	0.913
	S7	Effect of unavailability of fresh water on agriculture	0.804	0.935	-
	S8	Effect of unavailability of freshwater on fish	0.848	-	1.000
	S9	Frequency of sea intrusion or inundation	0.649	0.610	0.692
Climatic disasters	S10	Frequency of natural climatic disasters	0.959	0.924	1.000
	S11	Intensity of natural climatic disasters	0.881	0.903	0.857
	S12	Estimated per capita economic costs of these disasters	0.062	0.066	0.058
	S13	Percentage of population financially aided by various agencies	0.817	0.781	0.857
Lack of adaptive capacity (1-A)			**0.564**	**0.581**	**0.546**
Consumption patterns	A1	Household consumption per capita	0.081	0.057	0.105
Income diversification	A2	Herfindahl index of income diversification (higher value, more diversification)	0.141	0.161	0.122
Dependency ratio	A3	Ratio of total number of people and number of people earning in a family	0.214	0.236	0.189
Education level	A4	People educated above secondary level	0.017	0.031	0.000
	A5	Percentage share of literate people	0.195	0.307	0.067
Infrastructure	A6	Access to basic services	0.196	0.234	0.152
Assets	A7	Nature of dwellings	0.850	0.875	0.821
	A8	Number of the assets owned by the community members	0.650	0.453	0.875
Family networks	A9	Level of cooperation within the family network within the village	0.983	0.969	1.000

	A10	Level of cooperation within the family network outside the village	0.883	0.844	0.929
Migrations	A11	Extent of migration due to natural disasters	0.800	0.844	0.750
	A12	Extent of migration because of material reasons	0.783	0.719	0.857
CVI			**0.580**	**0.579**	**0.580**

Source: Salik, K.M., S. Jahangir, W.Z. Zahdi and S.H. Hasson. 2015. Climate change vulnerability and adaptation options for the coastal communities of Pakistan. Ocean and Coastal Management 112 (2015) 61-73.

Appendix 15. CCB Community Monitoring Plan

Activity area – Community livelihoods and well-being								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Decrease in living costs, improved community health and education	By 2027, 100% of community members with direct livelihood and well-being benefits from DBC-1	SIA001	# schools constructed, repaired or equipped	Output	Internal report	Community outreach team	Annually	Project Zone
		SIA002	# teachers employed	Outcome	Internal report	Community outreach team	Annually	Project Zone
		SIA003	# functional schools in the Project Zone	Outcome	Internal report	Community outreach team	Annually	Project Zone
		SIA004	# students benefiting from bursary	Impact	Household surveys / PRAs / internal	Community outreach	Annually	Project Zone

CCB v3.0, VCS v3.3

			schemes/ better access to education		report	team		
		SIA005	# health facilities built or equipped	Output	Internal report	Community outreach team	Annually	Project Zone
		SIA006	# of functional health facilities in Project Zone	Outcome	Internal report	Community outreach team	Annually	Project Zone
		SIA007	% community members benefiting from DBC-1 related health schemes	Impact	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA008	# Reverse osmosis (RO) plants made functional through repair and operation and maintenance	Output	Internal report	Community outreach team	Annually	Project Zone
		SIA009	# people with easy access to clean drinking water	Impact	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA010	# Hygiene facilities provided/	Output	Internal report	Community outreach	Annually	Project Zone

			rehabilitated			team		
		SIA011	# communal meeting facilities provided / rehabilitated	Output	Internal report	Community outreach team	Annually	Project Zone
Higher income levels	By 2025, 10% of community members earning direct income from DBC-1 and associated activities	SIA012	# of people directly employed by the DBC-1	Impact	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA013 / BIA015	# of Mangrove Stewardship Agreements signed with communities	Outcome	Internal report	Community outreach team	Annually	Project Zone
		SIA014	# community members who have accessed microfinance schemes	Outcome	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA015	# community members trained in alternative livelihoods	Output	Communications and meetings records,	Community outreach team	Annually	Project Zone

					Internal progress reports			
		SIA016	# Households reporting increased income	Impact	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone

Activity area – Wetland restoration and conservation								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Wetlands restored	By 2027, 226,378 hectares of degraded wetlands under restoration	SIA017	# of hectares brought under mangroves plantations	Output	Copies of agreements, Internal progress reports	Field operations and GIS teams	Annually	Project Area
		SIA018	# of hectares within the landscape restored or protected for their ecological importance	Output	Internal progress reports	Field operations and GIS teams	Annually	Project Zone
		SIA019	# of hectares within target landscape	Output	Internal progress reports	Field operations	Annually	Project Zone

			brought under improved practices			and GIS teams		
		SIA020	Ten further indicators in Biodiversity Monitoring Plan (BIA001-BIA010)					
Mangrove forests protected and conserved	By 2025 the main drivers of forest degradation such as the practice of unregulated free-range grazing and fuelwood collection tackled and reduced, and mangroves management plan prepared and being implemented	SIA021	Nine indicators in Biodiversity Monitoring Plan (BIA27-BIA38)					
	By 2022 at least 50% of community members with a	SIA022	Three indicators in Biodiversity Monitoring Plan (BIA39-BIA44)					

	greater appreciation of biodiversity and HCVs conservation							

Activity area – Sustainable fisheries and marine diversity								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Sustainable fisheries	By 2025, 15 Fish Stewardship Committees (FSCs) of fisheries dependent communities and supporting institutions have been established throughout the Project Zone to work towards sustainable	SIA023	Participatory development of one set of guidelines and standards for sustainable fishing practices	Output	Communications and meetings records, Internal progress reports	Community outreach team Forest and Wildlife Department Department of Fisheries	Annually	Project Zone

	fisheries resource management, marine biodiversity conservation and improved livelihoods							
		SIA024	Development and implementation of a reporting system to ensure compliance with set guidelines and standards	Output	Communications and meetings records, Internal progress reports	Community outreach team Forest and Wildlife Department	Annually	Project Zone
		SIA025	# of awareness raising and training and capacity building sessions held about coastal and marine biodiversity conservation and adaptive management of Marine Protected	Output	Communications and meetings records, Internal progress reports	Community outreach team Forest and Wildlife Department	Annually	Project Zone

			Areas					
		SIA026	# FSCs adhering to agreed terms	Outcome	Surveys, communications and meetings records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA027	# of fishermen attending awareness raising held	Outcome	Communications and meetings records, Internal progress reports/ Internal report	Community outreach team	Annually	Project Zone
		SIA028	# of fishermen with a greater appreciation of sustainable fishing practices	Output	Surveys, communications and meetings records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA029	# of nets with proper mesh size distributed	Output	Internal report	Community outreach team	Annually	Project Zone
		SIA030	# of FSA's linked to	Output	Surveys,	Community	Annually	Project

			microfinance schemes		Communications and meetings records, Internal progress reports	outreach team		Zone
		SIA031	# of fishermen with decreased debt obligations	Outcome	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA032	# of fishermen able to access open market	Outcome	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA033	# of cold storage facilities in the Project Zone	Output	Internal report	Community outreach team	Annually	Project Zone
		SIA034	% of fishermen benefitting directly from DBC-1	Impact	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone
		SIA035	% fishermen reporting increased consistency in catch	Impact	Household surveys / PRAs / internal report	Community outreach team	Annually	Project Zone

Activity area – Women's empowerment and marginal groups								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Better livelihoods for women	By 2027, increased social and economic empowerment for women leading to better well-being for at least 80% of women in the Project Zone	SIA036	# women organisations (WO) formed	Output	Copies of agreements, Internal progress reports	Community outreach team	Annually	Project Area
		SIA037	# of women trained in mid-wifery and basic first aid	Output	Internal progress reports	Community outreach team	Annually	Project Zone
		SIA038	# of instances of infant and maternal mortality during childbirth	Outcome	Internal progress reports, Government records	Community outreach team	Annually	Project Zone
		SIA039	# of women reporting	Output	Household surveys,	Community	Annually	Project

			reduced health related issues		Internal reports	outreach team		Area
		SIA040	# of woman trained in various livelihood skills	Output	Household surveys, Internal reports	Community outreach team	Annually	Project Zone
		SIA041	# of women with access to microfinance	Output	Household surveys, Internal reports	Community outreach team	Annually	Project Zone
		SIA042	# of WOs linked to design houses for income earning opportunities in clothing manufacture and handicrafts	Output	Household surveys, Internal reports	Community outreach team	Annually	Project Zone
		SIA043	# of women joining adult literacy classes	Outcome	Internal progress reports	Community outreach team	Annually	Project Zone
		SIA044	# of women in employment through DBC-1 business linkages	Outcome	Household surveys, Internal reports	Community outreach team	Annually	Project Zone
		SIA045	# of women directly	Outcome	Household surveys,	Community	Annually	Project

			employed by the project		Internal reports	outreach team		Zone
		SIA046	# of women reporting increased social and economic empowerment	Outcome	Household surveys, Internal reports	Community outreach team	Before every verificati on	Project Zone
		SIA047	% of women directly benefitting from DBC-1	Impact	Household surveys, Internal reports	Community outreach team	Annually	Project Zone
Better livelihoods for communities engaged in agriculture	By 2027, up to 50% of the community associated with agriculture trained in climate smart agriculture that helps them prepare for negative impact and sustainable agriculture practices in the face of climate change	SIA048	# of trainings held	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone

		SIA049	# of participants at meetings	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA050	# of agriculturists facilitated with microfinance	Output	Household surveys, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA051	# of agriculturists adopting new practices	Outcome	Household surveys, Internal progress reports	Community outreach team	Before every verificati on	Project Zone
Better livelihoods for communities engaged in livestock	By 2027, 50% of this community group is trained for better livestock husbandry	SIA052	# of trainings held in livestock health	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA053	# of trainings held in herd management	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone

		SIA054	# of participants at meetings	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA055	# of livestock vaccinated	Output	Surveys, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA056	# of herders facilitated with Microfinance	Output	Household surveys, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA057	# of livestock owners deploying better livestock feeding practices	Outcome	Household surveys, Internal progress reports	Community outreach team	Before every verification	Project Zone
		SIA058	# of livestock owners practicing better herd management	Outcome	Household surveys, Internal progress reports	Community outreach team	Before every verification	Project Zone
		SIA059	% change in income from livestock and livestock products	Impact	Household surveys, Internal progress reports	Community outreach team	Before every verification	Project Zone

Better livelihoods for daily wage labourers and the landless poor	50% of these community groups have increased incomes and livelihood earning opportunities	SIA060	# of vocational trainings held	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA061	# of member attending vocational training	Output	Training session records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA062	# of people in employment	Outcome	Household surveys, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA063	# of people directly employed by the project	Output	Household surveys, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA065	% with enhanced and diversified income and livelihood sources	Impact	Household surveys, Internal progress reports	Community outreach team	Before every verificati on	Project Zone

Community engagement and participation in resource management	By 2025, at least 80 percent of the community in the Project Zone organised and trained for participatory coastal and marine resources management	SIA066	# of multistakeholder village development committees formed and trained	Output	Copies of agreements, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA067	# of Focal group discussion held with VDCs	Output	Meeting records, Internal progress reports	Community outreach team	Annually	Project Zone
		SIA068	# of VDCS demonstrating greater appreciation of coastal and marine ecosystems and their goods and service	Outcome	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone
		SIA069	# of VDCs directly benefiting from DBC-1	Impact	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone

Conservation of historical and heritage sites and cultural artefacts	By 2025, conservation plan for Jhaki Bander Island Fort developed in collaboration with relevant organisations leading to better awareness and increased site visits	SIA070	# of interactions with relevant organisations and site visits undertaken in connection with the preparation of site assessment and conservation plan	Output	Internal report	Community outreach team	Annually	Project Zone
		SIA071	# of promotional material and knowledge documents developed and available about Jhaki Bander Island Fort	Output	Internal report and promotional products and knowledge documents about Jhaki Bunder Island Fort	Community outreach team	Annually	Project Zone
		SIA072	Conservation plan/report on conservation of Jhaki Bander Island Fort	Outcome	Internal report and availability of site assessment and conservation plan	Community outreach team	Annually	Project Zone

		SIA073	# of Community members and other visitors aware about Project Zone cultural history and significance and visiting the conserved Island Fort Site	Impact	Internal report	Community outreach team	Every three years	Project Zone
Activity area – Adaptation benefits for communities								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Increase in adaptation benefits for communities	By 2027, 100 % of community members are reporting increased adaptation benefits	SIA074	Number of fishermen reporting increased and stable fisheries catch per unit of fishing effort	Impact	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone
		SIA075	Number of community members reporting reduction in number of hectares of shoreline eroded	Impact	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone

		SIA076	Number of community member reporting reduction in hectares of landscape damaged by flood or tidal water	Impact	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone
		SIA077	Number of community members reporting reduction in number of hectares of croplands affected by salt water intrusion	Impact	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone
		SIA078	Number of community members reporting reduction in number of people who are forced to migrate due to climate change impacts.	Impact	PRAs / Internal progress reports	Community outreach team	Annually	Project Zone

Appendix 16. CCB Biodiversity Monitoring Plan

Activity area 1 – Mangrove restoration / Habitat improvement								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Increase in habitat area	By 2027, restore 226,378 hectares of degraded and de-vegetated mangrove areas through ARR activities	BIA001	# of hectares of degraded and de-vegetated mangrove lands restored	Output	Satellite imagery analysis and field checking/verification, Internal progress and survey reports	GIS and field operations team	Annually	Project Area
		BIA002	# of hectares of restored forests through natural re-generation	Outcome	Satellite imagery analysis and field checking/verification, Internal progress and survey reports	GIS and field operations team	Annually	Project Area
		BIA003	Species coming in through natural re-generation	Outcome	Field flora surveys, Internal progress and survey reports	Field operations team	Annually	Project Area
		BIA004	# of hectares of	Outcome	Satellite imagery	GIS and field	Annually	Project

			restored forests with crown cover now reaching 50%		analysis and field checking/verification, Internal progress and survey reports	operations team		Area
		BIA005	List of key threatened species of mammals and birds as given in Table A18.2 and Table A18.5 in Appendix 18. Biodiversity Survey.	Outcome	Field checking and faunal surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Every three years	Project Area
		BIA006	# and abundance of plant species in restored forests	Outcome	Field checking and vegetation surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Every three years	Project Area
		BIA007	# of hectares of restored forests with signs of grazing	Outcome	Field checking and survey reports, Internal progress and survey reports	Field operations team	Annually	Project Area
		BIA008	# of hectares of restored forests with	Outcome	Field checking and survey reports,	Field operations	Annually	Project Area

			signs of damage to vegetation		Internal progress and survey reports	team		
		BIA009	# of hectares of forests with invasive and non-native species	Outcome	Field checking and surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Every three years	Project Area
		BIA010	Presence, abundance and distribution of key HCVs	Impact	Field checking and surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Every three years	Project Area
	By 2027, initiatives are undertaken in support of advocacy for release of environmental water flows into the Indus Delta	BIA011	# of advocacy initiatives undertaken to advocate for release of environmental water flows into the Indus Delta	Output	Field checking and surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Annually	Project Zone
		BIA012	# No. of advocacy initiatives undertaken to advocate to monitor and measure	Output	Field checking and surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Annually	Project Zone

			by concerned agencies for release of environmental water flows into the Indus Delta					
		BIA013	# of research studies undertaken to assess the economic, social and environmental consequences of reduced release of fresh water into the Indus Delta	Output	Field checking and surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Annually	Project Zone
		BIA014	# of advocacy initiatives undertaken to advocate for Environmental Fiscal Reforms in the Indus Delta	Output	Field checking and surveys, Internal progress and survey reports	Biodiversity Impact Assessment team	Annually	Project Zone

Activity area 2 – Habitat security enhancement / Effective enforcement of laws

Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Decrease in direct threats to mangroves, wildlife and fisheries	By 2027, at least 15 Mangrove Stewardship Agreements (MSAs) have been executed for all newly restored mangrove areas	BIA015	# of Mangrove Stewardship Agreements executed with the communities	Output	Copies of agreements, Internal progress reports	Field operations team	Annually	Project Zone
	By 2027, Biodiversity and HCVs Conservation Agreements (BHCAs) have been executed with the relevant communities	BIA016	# of BHCAs executed with local communities	Output	Copies of agreements, Internal progress reports	Field operations and biodiversity teams	Annually	Project Zone
	By 2027, working relationships have been	BIA017	# of meetings held	Output	Communications and meetings records,	Sindh Forest and Wildlife Department	Annually	Project Zone

	established by Sindh Forest and Wildlife Department with the Provincial Sindh Fisheries Department/ Marine Fisheries Department and local fishing communities for protecting fish biodiversity				Internal progress report of Sindh Forest and Wildlife Department			
	By 2027, initiatives undertaken in support of responsible and sustainable fishing	BIA018	18 indicators in Community Monitoring Plan (SIA022-SIA039)					
	By 2022, regular mangroves protection, biodiversity and	BIA019	# of patrols, discussion sessions and meetings held	Output	Patrols and discussion sessions records, Internal progress	Sindh Forest and Wildlife Department and	Annually	Project Zone

	HCVs conservation related patrols, discussions sessions held with local communities				report of Sindh Forest and Wildlife Department	Community outreach and Biodiversity Impact Assessment teams		
	By 2022, regular training and capacity building in effective laws enforcement held with Forest and Wildlife Department staff and local communities	BIA020	# of training and capacity building sessions and meetings held	Output	Training and capacity building sessions records, Internal progress report of Sindh Forest and Wildlife Department	Sindh Forest and Wildlife Department and Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone
	By 2027, at least 15 Fish Stewardship Agreements (FSAs) have been executed with communities	BIA021	# of FSAs executed with the communities	Output	Copies of agreements, Internal progress reports	Field operations team	Annually	Project Zone

		BIA22	# of offence cases of biodiversity and illegal, unregulated and unsustainable fishing apprehended	Outcome	Internal progress reports of concerned agencies	Field operations team	Annually	Project Zone
		BIA23	Development and maintenance of a database for data collection and management on biodiversity and sustainable fishing	Output	Internal progress reports of concerned agencies	Field operations team	Annually	Project Zone
	By 2027, at least 50 percent of the Personnel and 20 percent of community members trained in mangroves, biodiversity and HCVs conservation	BIA024	# of persons trained and capacitated	Outcome	Trainings and capacity buildings sessions records, Internal progress report of Sindh Forest and Wildlife Department	Sindh Forest and Wildlife Department and Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone
	By 2027, the	BIA025	% of Project Area	Output	Project Area	Sindh Forest	Annually	Project

	whole of the Project Area boundary is demarcated, protected and properly maintained		boundary with boundary pillars erected, maintained and protected		boundary pillars records register, Internal progress report of Sindh Forest and Wildlife Department	and Wildlife Department and Field operations team		Area
	By 2027, 100 % of the HCVs areas are brought under a proper management system	BIA026	% of HCVs Areas conserved and brought under a sustainable management system	Impact	Satellite imagery analysis and field checking/verification Internal progress reports, Biodiversity Impact Assessment study reports	Sindh Forest and Wildlife Department and Biodiversity Impact Assessment team	Annually	Project Area
	By 2027, Biodiversity and HCVs Conservation Agreements (BHCAs) have been executed with the relevant	BIA027	# of BHCAs executed with local communities	Output	Copies of agreements, Internal progress reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Zone

	communities							
	By 2027, working relationships have been established by Sindh Forest and Wildlife Department with the Provincial Sindh Fisheries Department/ Marine Fisheries Department and local fishing communities for protecting fish biodiversity	BIA028	# of meetings held	Output	Communications and meetings records, Internal progress report of Sindh Forest and Wildlife Department	Sindh Forest and Wildlife Department team	Annually	Project Zone

Activity area 3 – Species and habitat conservation / Controlling unsustainable use of resources								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Reduced	By 2022,	BIA029	# of families using	Output	Families and	Field	Annually	Project

incidences of unsustainable use of resources	unregulated open-range grazing practices are stopped		stall feeding for livestock		household surveys, Internal progress and families/ household surveys reports	operations team		Zone
		BIA030	% of mangrove forests with controlled and streamlined grazing practices	Outcome	Field checking and surveys, Internal progress and survey reports	Field operations team	Annually	Project Zone
	By 2022, at least 50% of the creek communities' households are using alternative sources of energy	BIA031	% of households using solar heaters for energy purposes	Output	Household surveys, Internal progress and surveys reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area
		BIA032	# of plants planted under agroforestry system to meet fuelwood demand	Output	Field checking and planting records, Internal progress and surveys reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area

		BIA033	% of households using fuel-efficient cooking stoves	Output	Household surveys, Internal progress and surveys reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area
	By 2027, 100% of the Project Area Mangrove Forests are managed under an approved management plan	BIA034	% of mangrove forests under approved forest management plan	Outcome	Record of preparation and approval of forest management, Internal progress reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area
	By 2022, a monitoring plan is developed and under implementation for monitoring of biological and ecological factors and recovery	BIA035	Analysis of data for signs of increasing trend in populations of rare, endemic, vulnerable, threatened and endangered species	Outcome	Field checking and surveys, Internal progress and survey reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area

	criteria (such as population, demographics, habitat existence and securement) of rare, endemic, vulnerable, threatened and endangered species found in the Project Area							
	By 2021, a monitoring plan is developed and under implementation for monitoring of biological and ecological factors and recovery criteria (such as population, demographics, habitat existence and securement)	BIA036	Analysis of data for signs of increasing trend in population of keystone and flagship species	Outcome	Field checking and surveys, Internal progress and survey reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area

	over-time trend of key threatened species							
	By 2027, there is at least 50% decrease in incidence of wildlife killing from 2021 levels	BIA037	# of rangers employed	Output	Field checking and surveys, Internal progress and survey reports	Field operations and Biodiversity Impact Assessment teams	Annually	Project Area
		BIA038	# of wildlife patrols undertaken	Outcome				
		BIA039	# of reported cases of Human-Wildlife conflict	Outcome				
		BIA040	% change in the incidence of wildlife killing	Impact				

Activity area 4 – Awareness raising and advocacy

Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Greater appreciation and awareness of wildlife and biodiversity benefits	By 2022, 50% of households demonstrate a greater appreciation for wildlife, biodiversity and HCVs conservation	BIA041	# of awareness and sensitisation meetings	Output	Proceedings of meetings held, Internal progress reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Area
		BIA042	# of community members attending awareness and sensitisation meetings	Output	Proceedings of meetings held, Internal progress reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Area
		BIA043	% of households with greater awareness about importance of conservation of biodiversity and HCVs	Impact	Household surveys conducted, Household surveys reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Area

CCB v3.0, VCS v3.3

Advocacy work in support of release of environmental water flows to the delta and declaration of Marine Protected Zone	Liaison and linkages development with academia and other organisations for advocacy regarding release of environmental water flows to the delta area	BIA044	# of communication events, meetings and discussion held	Output	Communications and meetings records, Proceedings of meetings held, Internal progress reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Area
	Liaison and linkages development with academia, other organisations, policy makers and legislatures held for declaration of Marine Protected Zone	BIA045	# of communication events, meetings and discussions held	Output	Communications and meetings records, Proceedings of meetings held, Internal progress reports	Sindh Forest and Wildlife Department	Annually	Project Zone

	By 2027 a declaration of Marine Protected Zone	BIA046	Declaration notification issued	Impact	Notification by competent authority as given in internal progress reports	Sindh Forest and Wildlife Department	Annually	Project Zone
Activity area 5 – Adaptation benefits for biodiversity								
Key results	SMART objective	Code	Indicator	Indicator type	Data collection method	Who?	When?	Where?
Increase in adaptation benefits for biodiversity	By 2027, 100 % of community members are reporting presence of or increased biodiversity adaptation benefits	BIA047	Number of community members in the Project Zone reporting presence or increased number of endemic, rare, vulnerable, threatened and endangered species	Impact	PRAs, Biodiversity Surveys and reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone
		BIA048	Number of community members in the Project Zone reporting presence or increased extent of landscape level	Impact	PRAs, Biodiversity Surveys and reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone

			ecosystems and mosaics that are characteristic of wetlands landscapes					
		BIA049	Number of community members in the Project Zone reporting presence or increased extent of rare, threatened or endangered ecosystems, habitats or refugia	Impact	PRAs, Biodiversity Surveys and reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone
		BIA050	Number of community members in the Project Zone reporting presence or increased extent of at least one dimension of Key Biodiversity Areas such as increased ecological integrity, biological processes or irreversibility	Impact	PRAs, Biodiversity Surveys and reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone

			dimension, etc.					
		BIA051	Number of community members in the Project Zone reporting presence or increased extent of trigger species, threatened or geographically restricted biodiversity or reduced threat status	Impact	PRAs, Biodiversity Surveys and reports	Community outreach and Biodiversity Impact Assessment teams	Annually	Project Zone

Appendix 17. List of Endemic Plant Species Found in Sindh Province

S.No.	Plant family and species	Distribution	Conservation status
1	*Acanthaceae – Justicia vahlii Scindica* (Malik & Ghafoor)	Karachi and Dadu District	Rare
2	*Asparagaceae – Asparagus deltae* (Blatter)	Thatta	Extinct
3	*Asparagaceae – Asparagus gharoensis* (Blatter)	Southern Sindh	Probably extinct
4	*Asparagaceae – Asparagus dumosus* (Baker)	Coastal areas of Sindh	Vulnerable
5	*Burseraceae – Commiphora stocksiana* (Engl)	Karachi Division, Thatta and Sanghar Districts	Rare
6	*Chenopodiaceae – Atriplex stocksii Boiss*	Coastal areas of Sindh	Fairly common
7	*Compositae – Pulicaria boisseri* (Hook F)	Sindh	Fairly common
8	*Convolvulaceae – Convolvulus scindicus* (Stocks)	Thatta and Dadu Districts	Rare
9	*Malvaceae – Abutilon alii* (Abedin)	Karachi Division	Critically endangered
10	*Malvaceae – Abutilon karachianum* (Husain& Baquar)	Karachi Division	Critically endangered
11	*Malvaceae – Abutilon sepalum* (Husain & Baquar)	Karachi Division and Thatta District	On the brink of extinction
12	*Malvaceae – Hibiscus scindicus* (Stocks)	Sindh	Rare
13	*Malvaceae – Pavonia glechomaefolia f.karachiensis* (Abedin)	Karachi	Rare

CCB v3.0, VCS v3.3

14	*Malvaceae – Sida spinosa kazmii var.* (Abedin)	Sindh	Rare
15	*Mimosaceae – Acacia nilotica hemispherica* (Ali & Faruqi)	Sindh	Fairly common
16	*Tamaricaceae – Tamarix alii* (Qaiser)	Southern Sindh	Fairly common
17	*Tamaricaceae – Tamarix salina* (Dyer)	Khairpur, Mirpurkhas, Sukkur, Karachi	Rare
18	*Tamaricaceae – Tamarix sarenensis* (Qaiser)	Tharparkar District, Keti Bundar, Keenjhar	Rare
19	*Tamaricaceae – Tamarix sultanii* (Qaiser)	Southern Sindh	Rare

Appendix 18. Biodiversity Survey

1. Methods

Sampling locations

Korangi Creek (KC): This site is located near Karachi and is heavily polluted. Its intertidal area was exposed 9 m and a poor structure of benthic communities was observed.

Hajmaro Creek: This creek is located near Keti Bander (KB) and its intertidal area was exposed vertically to about 10 m. A significant number of benthic communities were noticed, and this was a pollution-free site.

Karo Chaan (KoC): This location is about 30-40 km from Keti Bander, its intertidal area extends over 20 m.

Shah Bander (SB): Intertidal area of this location is very short – about 7-8 m – and faunal presence was found to be low.

Table A18.1. Sampling stations.

Korangi Creek sites	Name of stations	Coordinates
Station 1	Main Phitti Creek	0317977 N 2745001 E
Station 2	Phitti Creek	0319846 N 2741526 E
Station 3-1	Rato Kot	032880 N 2739056 E
Station 3-2	Rato Kot	0322180 N 2736423 E
Station 3-3	Rato Kot	0321331 N 2736670 E
Station 3-4	Rato Kot	0321256 N 2733486 E
Station 4	Khadero	0320007 N 2733486 E
Shah Bandar sites	Name of stations	Coordinates
Station 1	Shah Bandar Base Point	24103939N 7867532607E
Station 2-1	Cabin Wari Creek	2410132 N 6752147 E

Station 2-2	Cabin Wari Creek 2	2407582 N 6751061 E
Station 2-3	Cabin Wari Creek 3	2407582 N 6751061E
Station 3-1	Mehnoon Lal Creek	2404106 N 06748164 E
Station 3-2	Mehnoon Lal Creek	2404509N 6745099E
Station 4	Layaari Creek	2401265 N 67453106 E
Keti Bandar/ Karo Chaan sites	Name of stations	Coordinates
Station 1-1	Hajmaro Creek	2411297 N 06727003 E
Station 1-2	Hajmaro Creek	2409485 N 06726547 E
Station 2	Tango Creek	2411296 N 06727003 E

Benthic fauna using quadrate method

Assessment of benthic communities was observed using the quadrate method. Two horizontal and two vertical – plus one replicate quadrate – was applied to count benthic communities from the proposed locations.

Water quality analysis

Temperature, salinity oxygen and TDS from four sites were recorded using a HL-4 water quality analyser.

Data logging, analysis and interpretations

Fish and shellfish specimens were transported to the University of Karachi for further investigation such as identification and size. Frequency data was recorded for each individual. The data was logged in Excel sheets and analysis of diversity was estimated using Excel Spread Sheets and a multivariate analysis was done using Primer 5.0 software and SPSS ver.16.

Mammals watching and enumeration methods

Point count and line transect methods were used for survey of mammals. Incidental sightings from the boat were also taken into account.

Bird survey and scene shooting

Extensive field surveys and boat surveys were made to record the migratory, winter visitors, passage migrants and resident birds. Line transect method and point count methods were used for the survey of bird fauna in creek areas. Field equipment and field guides were used for identification.

Reptile identification and record

Methods used for the survey of reptiles included active searching and searching of fishermen's catch from mangrove areas. There are standard methods for the studies of amphibians and reptiles (Hayek and Martin, 1997). For recording the species, strip census technique has been used (Ahmed, 1988 and Khan et al, 2010).

Listing of various species under the international conventions and Red Data Book

The inclusion of various species in Red Data Book, Appendices of CITES and CMS has also been indicated in the listing of species.

2. Results

Fish and shellfish

Several surveys were conducted in December 2018 and January 2019 to collect fish specimens using gillnet operated by small boats in Hajmaro Creek, Sanheri Creek and Shah Bander areas. Fish specimens were also collected from Katra nets being operated in various creeks. Fishery trends were discussed with fishermen and experts from the designed sampling locations.

Among 38 finfish species *Liza subviridis* of the family *Mugilidae* comprised of 14.36% of the population sampled. Two species of family *Sciaenidae*, *Johnius carouna* and *Otolithes ruber,* had percentages of 9.41 and 9.94 respectively. However, 12 finfish species were found to be below 1%.

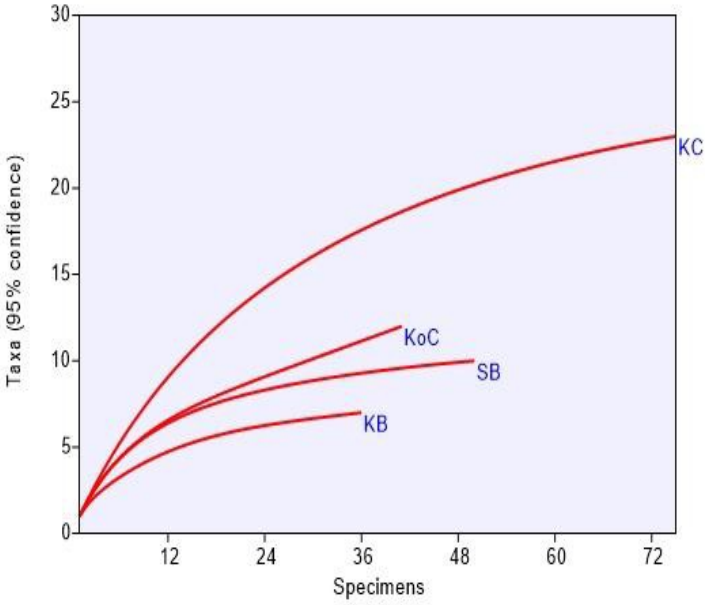


Figure A18.1. A rarefaction counter approach was applied to elucidate highest number of individuals encountered from the four locations. The highest number of individuals (fish)

sampled were from Karo Chaan (KC) followed by Shah Bander (SB) whereas Keti Bander found to be lowest in terms of the individual rarefaction.

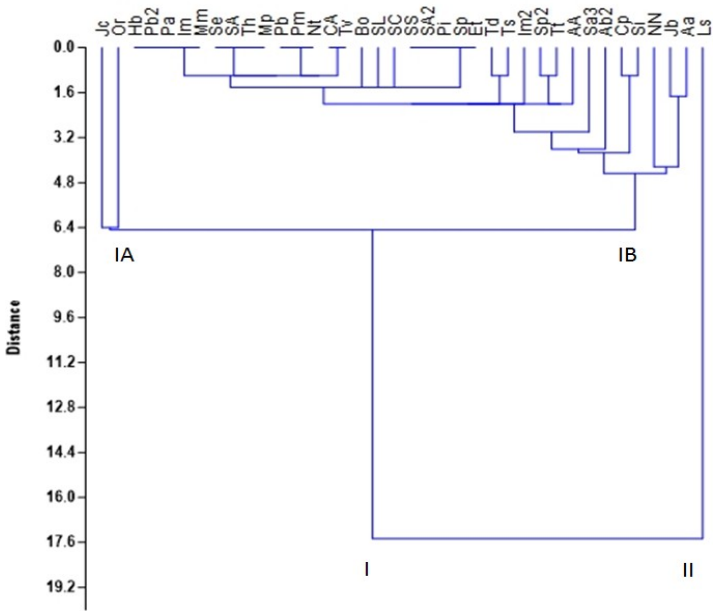


Figure A18.2. Similarity among species collected from four sites (Euclidean cluster approach).

A cluster analysis (Figure A18.2) grouped 2 major groups I and II. Group I was further divided into two subgroups IA and IB to elucidate distance in the finfish species. Species in group I and II shows the greatest difference whereas in subdivision of group I, i.e., IA and IB, species share some similarity. Group IA is lesser complex than the IB, as IA have 2 finfish species and IB have 36 species. Species in IA are *Johnius carouna* and *Otolithes ruber*. Species in IB are *Arius arius, Scomberoides commersonnianus, Scomber australasicus, Nematolosa nasus, Sardinella sindensis, Sardinella albella, Cynoglossus arel, Paraplagusia bilineata, Himantura bleekeri, Thryssa dayi, Thryssa hamiltonii, Thryssa setirostris, Trypauchaen vagina, Pomadasys maculatus, liza subviridis, Moolgarda perusii, Narcine timlei, Pisodonophis boro, Pseudorhombus arsius, Platycephalus indicus, Sarsogona prinonota, Eleutheronema tetradactylum, Ilisha megaloptera, Johnius dussumieri, Johnius borneensis,, Johinus borneensis, Scomber australasicus, Solea elongate, Brachirus orientalis, Acanthopagrus berda, Acanthopagrus arabicus, Sphyraena pinguis, Minous monodactylus, Terapon theraps,Nematolosa nasus, Sardinella sindensis, Sardinella albella, Cynoglossus arel, Paraplagusia bilineata, Himantura bleekeri, Thryssa dayi, Thryssa hamiltonii, Thryssa setirostris, Trypauchaen vagina, Pomadasys maculatus, Moolgarda perusii, Narcine timlei, Pisodonophis boro, Pseudorhombus arsius , Platycephalus indicus, Sarsogona prinonota, Eleutheronema tetradactylum, Ilisha megaloptera, Johnius dussumieri, Johnius carouna, Johnius borneensis, Scomber australasicus, Solea elongate, Brachirus orientalis, Acanthopagrus berda, Acanthopagrus arabicus, Sphyraena pinguis,*

Minous monodactylus, Terapon theraps. Group II includes *liza subviridis*. Significant differences were noted in species diversity, evenness and equitability among four study locations. The highest value of H-diversity represents more diverse in KC followed by KoC and SB while the lowest was in KB, where species richness was lowest. Margalef values signify high species richness in KC. Estimated equitability (i.e., Pileon's evenness index, J) with which species were numerically distributed was higher in KC and lowest in KB. The Chao-1 index estimated maximum of 8.0 species in KB, 25.1 in KC, 33.0 in KoC, and 10.3 in SB. Mean species richness validates that KoC and KC are the areas highest species richness (Table A18.1 and Figure A18.3).

Table A18.1. Summary of the diversity indices calculated for the pooled data of 38 fish species sampled in this study.

Diversity indices	KB	KC	KoC	SB
Dominance_D	0.35	0.07	0.16	0.15
Simpson_1-D	0.65	0.93	0.84	0.85
Shannon_H	1.43	2.88	2.09	2.04
Evenness_e^H/S	0.60	0.78	0.67	0.77
Brillouin	1.21	2.49	1.76	1.77
Menhinick	1.17	2.66	1.87	1.41
Margalef	1.67	5.10	2.96	2.30
Equitability_J	0.73	0.92	0.84	0.88
Fisher_alpha	2.59	11.3	5.71	3.76

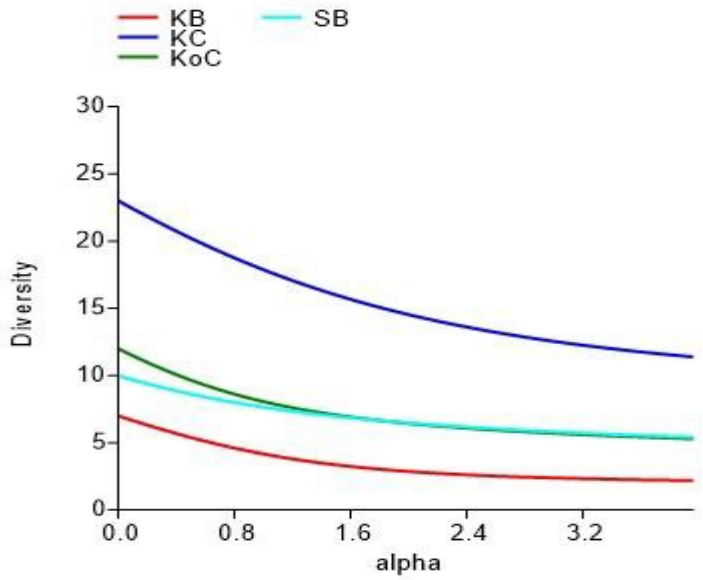


Figure A18.3. Comparative account of diversity estimated from four locations.

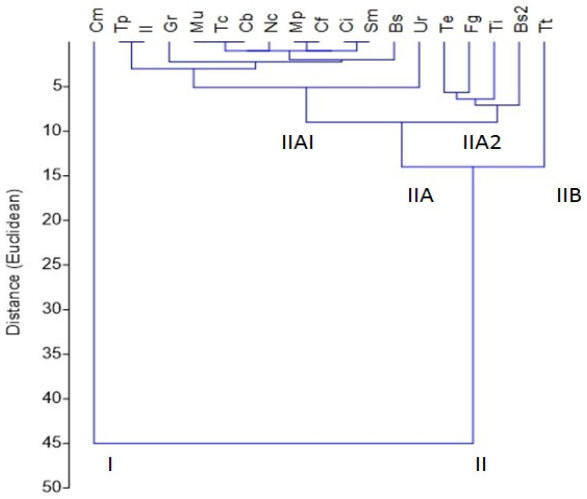


Figure A18.4. Similarity among species collected from four sites (Euclidean cluster approach).

The clustering in FigureA18.4 was established separately for shellfish species where assemblage I and II are completely separated from each other whereas in II it is subdivided as IIA and IIB. It shows a close relation with each other but few shellfish species in IIA show lower variation and are sub divided as IIAI and IIA2. Acronyms used are: Cm = *Cerithiummorus*, Tp = *Telescopium*, Gr = *Grapsid* sp., MU = *Murex*, Tc = *Thais carinifera*, Cb = *Charybdis feriatus*, Nc = *Neritacrepidularia*, Mp = *Matutaplanipes*, Cf = *Charybdis feriatus*, Ci = *Clibanarius infraspinatus*, Sm = *Squillamantis*, BS = *Bursa spinosa*, Ur = *Urothuthiseduli* Te = *Terebraliapalustris*, Fg = *Ficusgracilis*, Ti = *Tibiainsulaechorab curta*, Bs2 = *Babylonia spirata.*

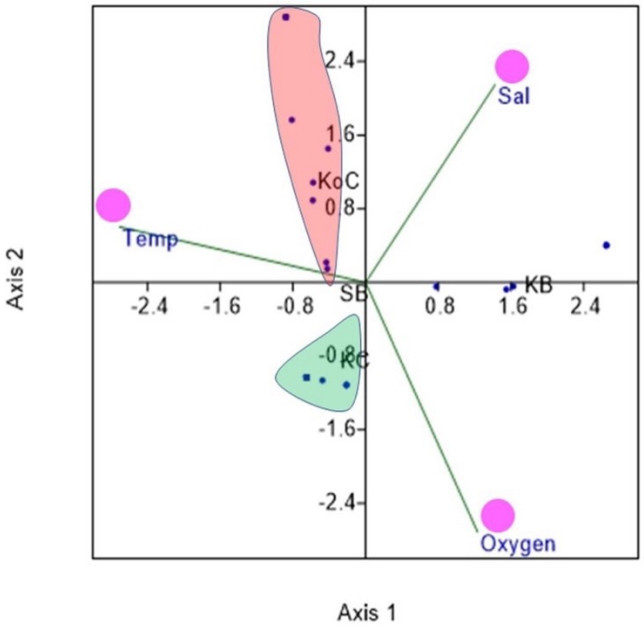


Figure A18.5. Bi-plot established for 38 cases where most important water quality parameters used (temperature, salinity and oxygen) in this study.

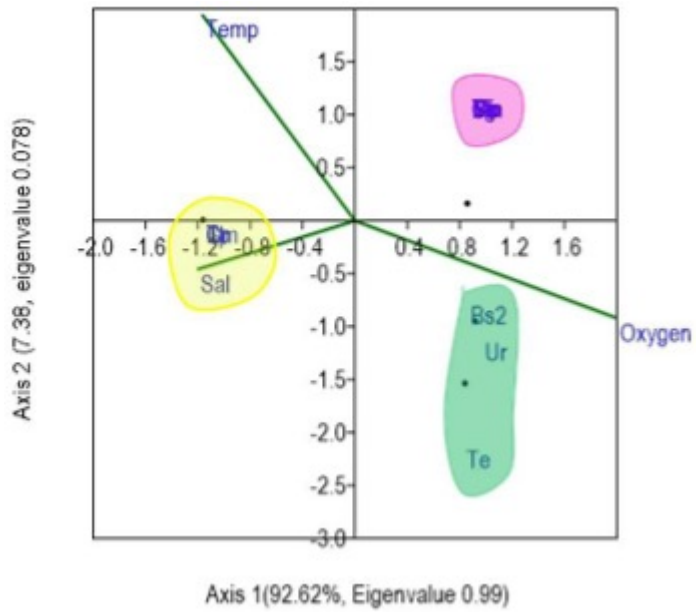


Figure A18.6. Bi-plot established for shellfish species where most important water quality parameters used (temperature, salinity and oxygen).

Canonical correspondence analysis was performed in relation to the three water quality parameters (temperature, salinity and oxygen). Axis 1 against axis 2 was significant at 60.61% with eigenvalue 0.63 and a permutation test was applied: P = 0.97. Overall assessment defines that temperature and oxygen has little influence on the distribution of the fish species, however, salinity influenced it (Figure A18.5). The bi-plot established for shellfish species is significantly varied than fish species. It defines that temperature and oxygen can influence distribution of the shellfish species, but salinity poorly impact them (Figure A18.6).

Mammals

During the study, 10 mammals were recorded from the mangrove area (Table A18.2). Among them, one mammal, the Indian Ocean humpback dolphin (*Sousa plumbea*), is recorded as endangered under the IUCN Red List. The fishing cat (*Prionailurus viverrinus*), also spotted, is recorded as vulnerable.

Table A18. 2 List of Mammals recorded from mangrove area.

	Order	Family	Scientific Name	Common Name	IUCN Red List	CITES	CMS
1	*Cetacea*	*Delphinidae*	*Sousa plumbea*	Indian Ocean humpback dolphin	EN	II	II
2	*Cetacea*	*Delphinidae*	*Tursiops truncates*	Bottlenose dolphin	LC	II	II
3	*Carnivora*	*Canidae*	*Canis aureus*	Indian jackal	LC	_	_
4	*Carnivora*	*Canidae*	*Prionailurus viverrinus*	Fishing cat	VU	_	_
5	*Carnivora*	*Herpestidae*	*Herpestes javanicus*	Indian mongoose	LC	_	_
6	*Artiodactyla*	*Suidae*	*Sus scorfa*	Wild boar	LC	_	_
7	*Chiroptera*	*Hipposideridae*	*Hipposideros fulvus*	Fulvus leaf-nosed bat	LC	_	_
8	*Chiroptera*	*Hipposideridae*	*Ascellia triderns*	Trident leaf-nosed bat	LC	_	_
9	*Chiroptera*	*Molossidae*	*Tadarida egyptiaca*	Egyptian free-tailed bat	LC	_	_
10	*Chiroptera*	*Vespertiloni dae*	*Scotophilus heathii*	Lesser house bat	LC	_	_

Table A18.3. Station wise composition and density (percentage) of various mammals at Shah Bander and Karo Chaan.

Scientific name	common name	Sta.1	Sta. 2-1	Sta. 2-2	Sta. 2-3	Sta. 3-1	Sta. 3-2	Sta. 4-1	Sta.5
		Shah Bandar Base	Cabin Wari Creek	Cabin Wari Creek 2	Cabin Wari Creek-3	Menhoon Lal Creek	Menhoon Creek	Layyari Creek	Kharo Chan
Canis aureus	Indian jackal			25			50		
Prionailurus viverrinus	Fishing cat			25					
Herpestes javanicus	Indian mongoose			25					
Sus scorfa	Wild boar			25					
Tadarida egyptiaca	Egyptian free-tailed bat	100							
Scotophilus heathii	Lesser house bat						50		

Composition of mammals in Keti Bander area

All 10 species of mammals were seen in highest numbers at Sta.1-2, including the Indian Ocean humpback, bottlenose dolphin, Indian mongoose, wild boar, fulvus leaf-nosed bat, trident leaf-nosed bat, Egyptian free-tailed bat and lesser house bat.

Table A18.4. Station-wise composition and density (percentage) of various mammals in the Keti Bander area.

	Common name	Scientific name	Sta. 1-1	Sta. 1-2	Sta. 2
			Hajamro Creek	Hajamro Creek	Tango Creek
1	Indian Ocean humpback dolphin	*Sousa plumbea*	25	25	50
2	Bottlenose dolphin	*Tursiops truncates*		12.5	
3	Indian jackal	*Canis aureus*	25		
4	Fishing cat	*Prionailurus iverrinus*	25		50
5	Indian mongoose	*Herpestes javanicus*		12.5	
6	Wild boar	*Sus scorfa*		12.5	
7	Fulvus leaf-nosed bat	*Hipposideros fulvus*		12.5	

8	Trident leaf-nosed bat	*Ascellia triderns*		12.5	
9	Egyptian free-tailed bat	*Tadarida egyptiaca*	25		
10	Lesser house bat	*Scotophilus heathii*		12.5	

Birds

During the study, 75 birds were recorded from the mangrove area (Table A18.5), 28 of which resident and 47 migratory. Seven birds are recorded as threatened or near threatened. They are Egyptian vulture (*Neophron percnopterus*) endangered, cinerous vulture (*Aegypius monachus*) near threatened, painted stork (*Myceteria leucocephala*) near threatened, Dalmatian pelican (*Pelecanus crispus*) near threatened, black-tailed godwit (*Limosa limosa*) near threatened, bar-tailed godwit (*Limosa lapponica*) near threatened and Eurasian curlew (*Numenius arquata*).

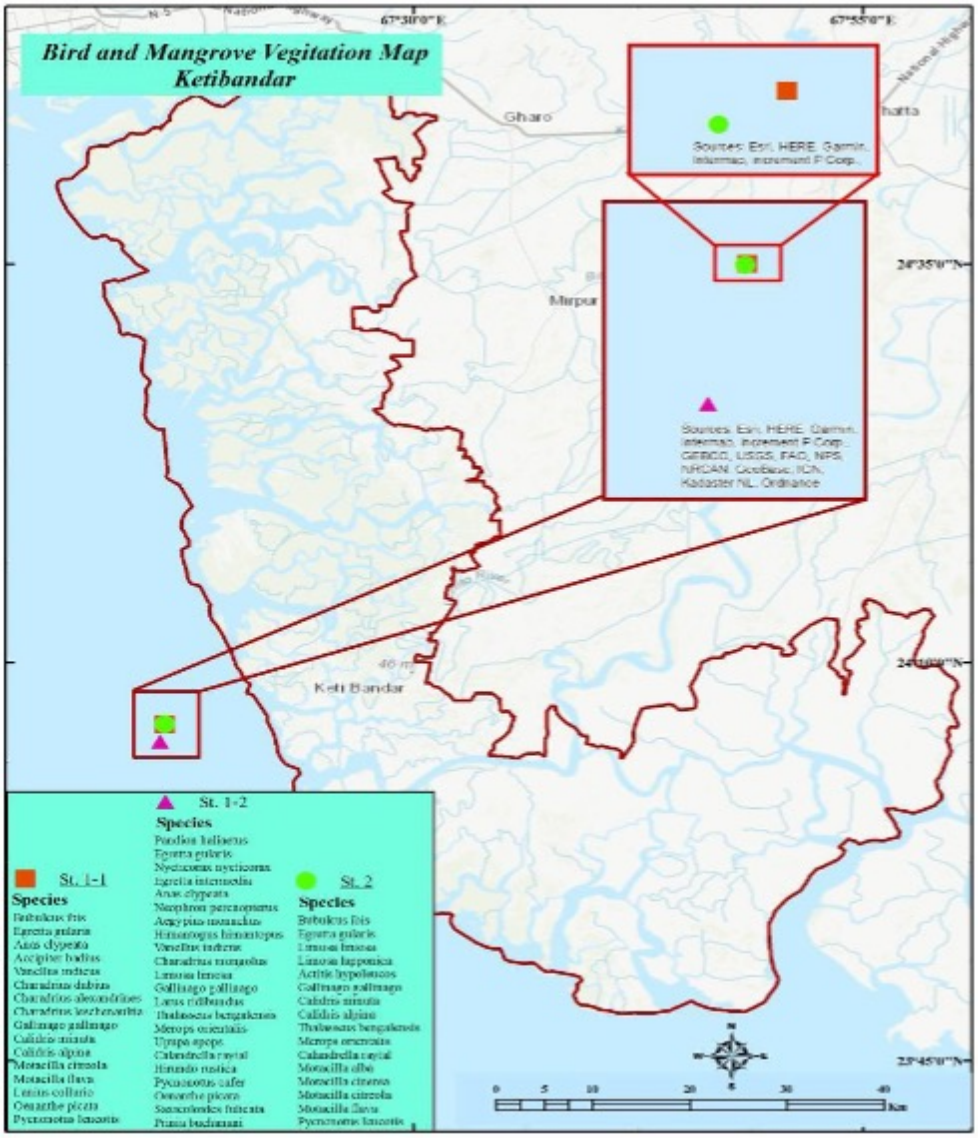


Figure A18.7. Site location and bird species at Kati Bandar.

Table A18.5. List of birds recorded from Project Area sites during the survey.

	Order	Family	Scientific Name	Common Name	Status	IUCN Red List
1	*Pelecaniformes*	*Phalacrocoracidae*	*Phalacroco rax niger*	Little cormorant	WV	LC
2	*Ciconiiformes*	*Ardeidae*	*Ardea cinerea*	Grey heron	R	LC
3	*Ciconiiformes*	*Ardeidae*	*Ardea purpurea*	Purple heron	R	LC

4	*Ciconiiformes*	*Ardeidae*	*Ardeola grayii*	Pond heron	R	LC
5	*Ciconiiformes*	*Ardeidae*	*Ardeola striatus*	Little green heron	R	LC
6	*Ciconiiformes*	*Ardeidae*	*Bubulcus ibis*	Cattle egret	R	LC
7	*Ciconiiformes*	*Ardeidae*	*Egretta gularis*	Reef heron	R	LC
8	*Ciconiiformes*	*Ardeidae*	*Nycticorax nycticorax*	Night heron	R	LC
9	*Ciconiiformes*	*Ardeidae*	*Egretta alba*	Large egret	R	LC
10	*Ciconiiformes*	*Ardeidae*	*Egretta intermedia*	Intermediate egret	R	LC
11	*Ciconiiformes*	*Ardeidae*	*Egretta garzetta*	Little egret	R	LC
12	*Ciconiiformes*	*Threskiornithidae*	*Platalea leucorodia*	Spoonbill	WV	LC
13	*Ciconiiformes*	*Ciconiidae*	*Myceteria leucocephala*	Painted stork	WV	NT
14	*Ciconiiformes*	*Phoenicopterida*	*Phoenicopterus Minor*	Lesser flamingo	R	LC
15	*Ciconiiformes*	*Phoenicopteridae*	*Phoenicopt erus ruber*	Greater flamingo	R	LC
16	*Pelecaniformes*	*Pelecanidae*	*Pelecanus crispus*	Dalmatian pelican	WV	NT
17	*Pelecaniformes*	*Pelecanidae*	*Pelecanus oncrotalus*	White pelican	WV	LC
18	*Anseriformes*	*Anatidae*	*Tadorna tadorna*	Shelduck	WV	LC
19	*Anseriformes*	*Anatidae*	*Anas clypeata*	Shoveler	WV	LC
20	*Anseriformes*	*Anatidae*	*Anas crecca*	Common teal	WV	LC
21	*Anseriformes*	*Anatidae*	*Anas latyrhynchos*	Mallard	WV	LC
22	*Anseriformes*	*Anatidae*	*Anas Penelope*	Wigeon	WV	LC
23	*Falconiformes*	*Accipitridae*	*Milvus migrans*	Common kite	R	LC
24	*Falconiformes*	*Accipitridae*	*Haliastur indus*	Brahminy kite	R	LC
25	*Falconiformes*	*Accipitridae*	*Buteo buteo*	Common buzzard	WV	LC
26	*Falconiformes*	*Accipitridae*	*Circus aeruginosus*	Marsh harrier	WV	LC
27	*Falconiformes*	*Accipitridae*	*Neophron percnopterus*	Egyptian vulture	WV	EN
28	*Falconiformes*	*Accipitridae*	*Aegypius monachus*	Cinerous vulture	WV	NT
29	*Falconiformes*	*Accipitridae*	*Accipiter badius*	Shikra	R	LC

30	*Falconiformes*	*Pandionidae*	*Pandion haliaetus*	Osprey	WV	LC
31	*Charadriiformes*	*Recurvirostridae*	*Himantopus himantopus*	Black-winged stilt	R	LC
32	*Charadriiformes*	*Charadriidae*	*Vanellus indicus*	Red-wattled lapwing	R	LC
33	*Charadriiformes*	*Charadriidae*	*Charadrius dubius*	Little ringed plover	WV	LC
34	*Charadriiformes*	*Charadriidae*	*Charadrius alexandrine s*	Kentish plover	WV	LC
35	*Charadriiformes*	*Charadriidae*	*Charadrius mongolus*	Lesser sand plover	WV	LC
36	*Charadriiformes*	*Charadriidae*	*Charadrius leschenaultia*	Greater sand plover	WV	LC
37	*Charadriiformes*	*Scolopacidae*	*Limosa limosa*	Black-tailed godwit	WV	NT
38	*Charadriiformes*	*Scolopacidae*	*Limosa lapponica*	Bar-tailed godwit	WV	NT
39	*Charadriiformes*	*Scolopacidae*	*Numenius phaeopus*	Whimbrel	WV	LC
40	*Charadriiformes*	*Scolopacidae*	*Numenius arquata*	Eurasian curlew	WV	NT
41	*Charadriiformes*	*Scolopacidae*	*Tringa erythropus*	Spotted redshank	WV	LC
42	*Charadriiformes*	*Scolopacidae*	*Tringa nebularia*	Greenshank	WV	LC
43	*Charadriiformes*	*Scolopacidae*	*Tringa*	Redshank	WV	LC
44	*Charadriiformes*	*Scolopacidae*	*Tringa stagnatilis*	Marsh sandpiper	WV	LC
45	*Charadriiformes*	*Scolopacidae*	*Actitis hypoleucos*	Common sandpiper	WV	LC
46	*Charadriiformes*	*Scolopacidae*	*Gallinago gallinago*	Fantail snipe	WV	LC
47	*Charadriiformes*	*Scolopacidae*	*Calidris minuta*	Little stint	WV	LC
48	*Charadriiformes*	*Scolopacidae*	*Larus argentatus*	Herring gull	WV	LC
49	*Charadriiformes*	*Scolopacidae*	*Larus genei*	Slender-billed gull	WV	LC
50	*Charadriiformes*	*Scolopacidae*	*Calidris alpine*	Dunlin	WV	LC
51	*Charadriiformes*	*Laridae*	*Larus ridibundus*	Black-headed gull	WV	LC
52	*Charadriiformes*	*Laridae*	*Thalasseus bengalensis*	Lesser crested tern	WV	LC
53	*Charadriiformes*	*Laridae*	*Sterna sandvicensis*	Sandwich tern	WV	LC
54	*Charadriiformes*	*Laridae*	*Hydroprogne caspia*	Caspian tern	WV	LC
55	*Charadriiformes*	*Laridae*	*Sterna hirundo*	Common tern	WV	LC

56	*Caprimulgiformes*	*Camprimulgidae*	*Caprimulgus europaeus*	Eurasian nightjar	SBV	LC
57	*Coraciiformes*	*Meropidae*	*Merops superciliosus*	Blue-cheeked bee-eater	R	LC
58	*Coraciiformes*	*Meropidae*	*Merops orientalis*	Little green bee-eater	R	LC
59	*Coraciiformes*	*Upupidae*	*Upupa epops*	Hoopoe	R/WV	LC
60	*Passeriformes*	*Alaudidae*	*Calandrell a raytal*	Indian sand lark	R	LC
61	*Passeriformes*	*Hirundinidae*	*Hirundo rustica*	Swallow	WV	LC
62	*Passeriformes*	*Motacillidae*	*Motacilla alba*	White wagtail	WV	LC
63	*Passeriformes*	*Motacillidae*	*Motacilla cinerea*	Grey wagtail	WV	LC
64	*Passeriformes*	*Motacillidae*	*Motacilla citreola*	Citrine wagtail	WV	LC
65	*Passeriformes*	*Motacillidae*	*Motacilla flava*	Yellow wagtail	WV	LC
66	*Passeriformes*	*Pycnotodidae*	*Pycnonotus cafer*	Red-vented bulbul	R	LC
67	*Passeriformes*	*Pycnotodidae*	*Pycnonotus leucogenys*	White-cheeked bulbul	R	LC
68	*Passeriformes*	*Laniidae*	*Lanius collurio*	Bay-backed shrike	WV	LC
69	*Passeriformes*	*Muscicapidae*	*Oenanthe picata*	Indian bush chat	WV	LC
70	*Passeriformes*	*Muscicapidae*	*Saxicoloides fulicata*	Indian robin	R	LC
71	*Passeriformes*	*Muscicapidae*	*Prinia buchanani*	Rufous-fronted prinia	R	LC
72	*Passeriformes*	*Nectariniidae*	*Nectarinia asiatica*	Purple sunbird	R	LC
73	*Passeriformes*	*Zosteropidae*	*Zosterops palpebrosa*	Oriental white-eye	R	LC
74	*Passeriformes*	*Ploceidae*	*Passer domesticus*	House sparrow	R	LC
75	*Passeriformes*	*Corvidae*	*Corvus splendens*	House crow	R	LC

Bird composition at Korangi Creek

In total 15 species were observed around the Korangi Creek area. Eleven species were migratory and only two were resident i.e. lesser flamingo, greater flamingo. Two species observed were near threatened (black-tailed godwit and bar-tailed godwit) IUCN (Table 6).



Figure A18.8. Site location and bird species at Korangi Creek.

Table A18.6. Percentage of bird species around Korangi Creek (Karachi coast).

No	Scientific name	Common Name	Sta. 1	Sta. 2	Sta. 3-1	Sta. 3-2	Sta. 3-3	Sta. 3-4	Sta. 4
			Main Phitti Creek	Phitti Creek	Rato Kot	Rato Kot	Rato Kot	Rato Kot	Khadero

1	*Pelecanus oncrotalus*	White pelican	32.26	48.00	3.13	27.78	26.92	32.00	11.76
2	*Phoenicopterus minor*	Lesser flamingo	22.58	4.00	18.75	11.11	3.85	0.00	0.00
3	*Phoenicopterus ruber*	Greater flamingo	0.00	0.00	21.88	0.00	3.85	0.00	0.00
4	*Anas clypeata*	Shelduck	0.00	8.00	0.00	0.00	0.00	0.00	0.00
5	*Anas crecca*	Shoveler	0.00	4.00	0.00	5.56	0.00	24.00	0.00
6	*Charadrius dubius*	Little ringed plover	0.00	4.00	9.38	16.67	15.38	0.00	17.65
7	*Charadrius alexandrines*	Kentrish plover	6.45	0.00	3.13	5.56	3.85	12.00	5.88
8	*Charadrius mongolus*	Lesser sand plover	6.45	0.00	6.25	11.11	7.69	8.00	11.76
9	*Charadrius leschenaultia*	Greater sand plover	3.23	20.00	25.00	0.00	0.00	0.00	5.88
10	*Limosa limosa*	Black-tailed godwit	12.90	0.00	0.00	0.00	3.85	0.00	5.88
11	*Limosa lapponica*	Bar-tailed godwit	3.23	0.00	0.00	0.00	3.85	4.00	5.88
12	*Numenius phaeopus*	Whimbril	3.23	0.00	0.00	11.11	0.00	12.00	5.88
13	*Numenius arquata*	Eurasian curlew	6.45	0.00	3.13	0.00	19.23	4.00	17.65
14	*Calidris minuta*	Little stint	3.23	8.00	9.38	0.00	11.54	4.00	11.76
15	*Platalea leucorodia*	Spoonbill	0.00	4.00	0.00	11.11	0.00	0.00	0.00

Bird composition at Shah Bandar and Karo Chaan

In total 38 species of birds were observed at Shah Bunder and Karo Chaan areas. Out of these, 19 were migratory species, including 18 winter visitors and one summer breeding visitors (Eurasian nightjar). Near-threatened species include the painted stork and Eurasian curlew which were seen with high density.

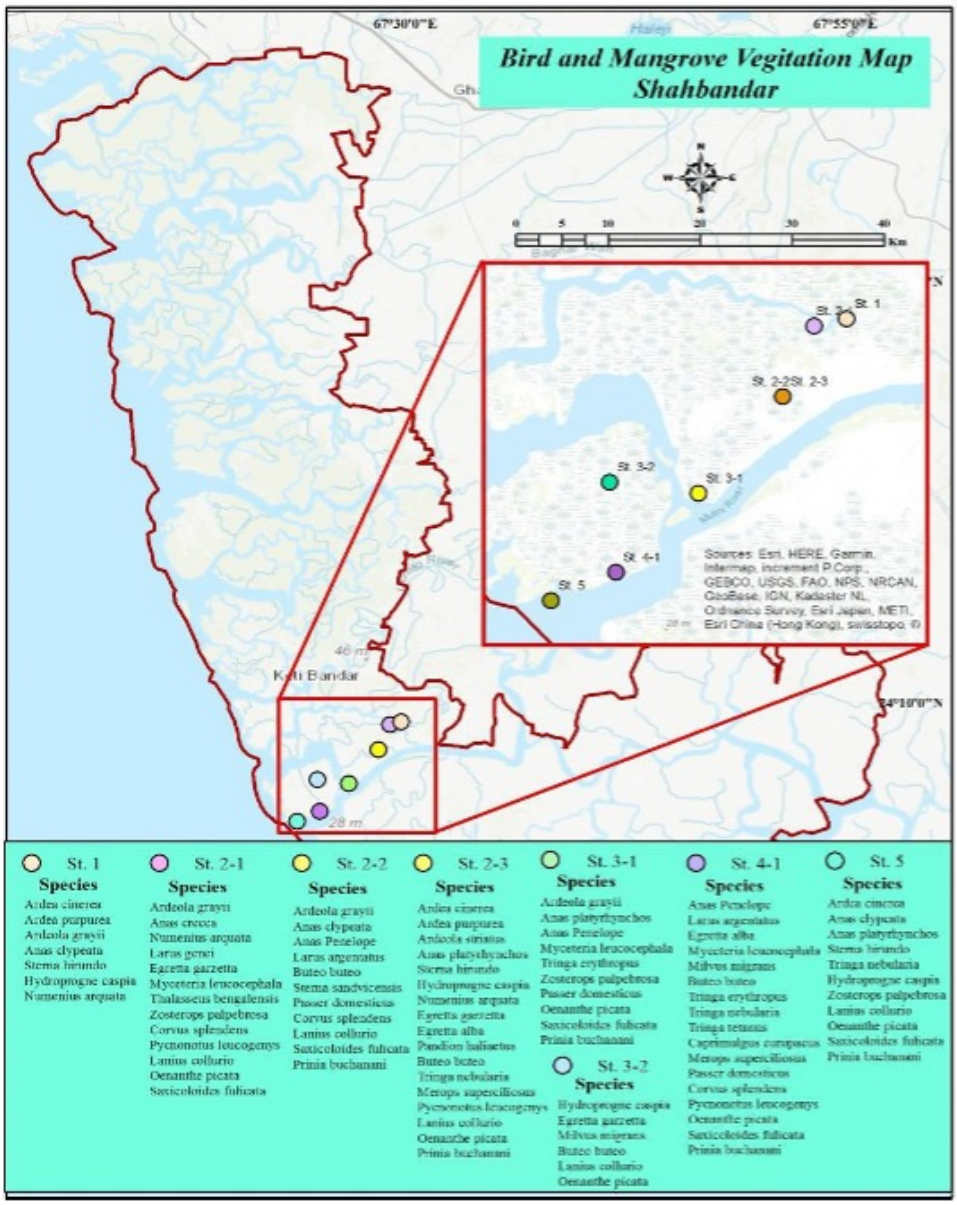


Figure A18.9. Site location and bird species at Shah Bander.

Table A18.7. Station-wise occurrence and density (percentage) of various bird species at Shah Bander.

No	Scientific name	Common name	Sta.1	Sta. 2-1	Sta. 2-2	Sta. 2-3
			Shah Bandar Base point	Cabin Wari Creek	Cabin Wari Creek 2	Cabin Wari Creek-3

1	*Ardea cinereal*	Grey heron	16.67	0.00		14.20
2	*Ardea purpurea*	Purple heron	12.50	0.00		4.94
3	*Ardeola grayii*	Pond heron	4.17	7.41	6.67	0.00
4	*Ardeola striatus*	Little green heron	0.00	0.00	0.00	0.62
5	*Anas clypeata*	Shoveler	4.17	0.00	13.33	0.00
6	*Anas crecca*	Common teal	0.00	14.81	0.00	0.00
7	*Anas platyrhynchos*	Mallard	0.00	0.00	0.00	4.94
8	*Anas Penelope*	Wigeon	0.00	0.00	6.67	0.00
9	*Sterna hirundo*	Common tern	25.00	0.00	0.00	7.41
10	*Hydroprogne caspia*	Caspian tern	33.33	0.00	0.00	25.93
11	*Numenius arquata*	Eurasian curlew	4.17	14.81	0.00	18.52
12	*Larus genei*	Slender-billed gull	0.00	7.41	0.00	0.00
13	*Larus argentatus*	Herring gull		0.00	6.67	0.00
14	*Egretta garzetta*	Little egret		3.70	0.00	4.94
15	*Egretta alba*	Large egret		0.00	0.00	7.41
16	*Pandion haliaetus*	Osprey		0.00	0.00	4.32
17	*Myceteria leucocephala*	Painted stork		25.93	0.00	0.00
18	*Milvus migrans*	Common kite		0.00	0.00	0.00
19	*Haliastur indus*	Brahminy kite		0.00	0.00	0.00
20	*Buteo buteo*	Common buzzard		0.00	13.33	0.62
21	*Circus aeruginosus*	Marsh harrier		0.00	0.00	0.00
22	*Tringa erythropus*	Spotted redshank		0.00	0.00	0.00
23	*Tringa nebularia*	Greenshank		0.00	0.00	0.62
24	*Tringa tetanus*	Redshank		0.00	0.00	0.00
25	*Thalasseus bengalensis*	Lesser crested tern		3.70	0.00	0.00
26	*Sterna sandvicensis*	Sandwich tern		0.00	6.67	0.00
27	*Hydroprogne caspia*	Caspian tern		0.00	0.00	0.00

28	*Caprimulgus europaeus*	Eurasian nightjar		0.00	0.00	0.00
29	*Merops superciliosus*	Blue-cheeked bee-eater		0.00	0.00	0.62
30	*Nectarinia asiatica*	Purple sunbird		0.00	0.00	0.00
31	*Zosterops palpebrosa*	Oriental white-eye		3.70	0.00	0.00
32	*Passer domesticus*	House sparrow		0.00	6.67	0.00
33	*Corvus splendens*	House crow		3.70	13.33	0.00
34	*Pycnonotus leucogenys*	White-cheeked bulbul		3.70	0.00	1.85
35	*Lanius collurio*	Bay-backed shrike		3.70	6.67	0.62
36	*Oenanthe picata*	Indian bush chat		3.70	0.00	1.23
37	*Saxicoloides fulicata*	Indian robin		3.70	13.33	0.00
38	*Prinia buchanani*	Rufous-fronted prinia		0.00	6.67	1.23

Table A18.8. Station-wise occurrence and density (percentage) of various bird species at Karo Chaan.

No	Scientific name	Common name	Sta. 3-1 Menhoon Lal Creek	Sta. 3-2 Menhoon Creek	Sta. 4-1 Layyari Creek	Sta.5 Karo Chaan
1	*Ardea cinereal*	Grey heron	0.00	0.00	0.00	3.23
2	*Ardea purpurea*	Purple heron	0.00	0.00	0.00	0.00
3	*Ardeola grayii*	Pond heron	4.55	0.00	0.00	0.00
4	*Ardeola striatus*	Little green heron	0.00	0.00	0.00	0.00
5	*Anas clypeata*	Shoveler	0.00	0.00	0.00	3.23
6	*Anas crecca*	Common teal	0.00	0.00	0.00	0.00
7	*Anas platyrhynchos*	Mallard	6.82	0.00	0.00	61.29
8	*Anas Penelope*	Wigeon	4.55	0.00	2.63	0.00
9	*Sterna hirundo*	Common tern	0.00	0.00	0.00	6.45
10	*Hydroprogne caspia*	Caspian tern	0.00	40.91	0.00	0.00

11	*Numenius arquata*	Eurasian curlew	0.00	0.00	0.00	0.00
12	*Larus genei*	Slender-billed gull	0.00	0.00	0.00	0.00
13	*Larus argentatus*	Herring gull	0.00	0.00	5.26	0.00
14	*Egretta garzetta*	Little egret	0.00	13.64	0.00	0.00
15	*Egretta alba*	Large egret	0.00	0.00	10.53	0.00
16	*Pandion haliaetus*	Osprey	0.00	0.00	0.00	0.00
17	*Myceteria leucocephala*	Painted stork	22.73	0.00	7.89	0.00
18	*Milvus migrans*	Common kite	0.00	27.27	15.79	0.00
19	*Haliastur indus*	Brahminy kite	0.00	0.00	0.00	0.00
20	*Buteo buteo*	Common buzzard	0.00	2.27	7.89	0.00
21	*Circus aeruginosus*	Marsh harrier	0.00	0.00	0.00	0.00
22	*Tringa erythropus*	Spotted redshank	13.64	0.00	2.63	0.00
23	*Tringa nebularia*	Greenshank	0.00	0.00	7.89	3.23
24	*Tringa tetanus*	Redshank	0.00	0.00	10.53	0.00
25	*Thalasseus bengalensis*	Lesser crested tern	0.00	0.00	0.00	0.00
26	*Sterna sandvicensis*	Sandwich tern	0.00	0.00	0.00	0.00
27	*Hydroprogne caspia*	Caspian tern	0.00	0.00	0.00	6.45
28	*Caprimulgus europaeus*	Eurasian nightjar	0.00	0.00	2.63	0.00
29	*Merops superciliosus*	Blue-cheeked bee-eater	0.00	0.00	5.26	0.00
30	*Nectarinia asiatica*	Purple sunbird	0.00	0.00	0.00	0.00
31	*Zosterops palpebrosa*	Oriental white-eye	4.55	0.00	0.00	3.23
32	*Passer domesticus*	House sparrow	2.27	0.00	2.63	0.00
33	*Corvus splendens*	House crow	0.00	0.00	2.63	0.00
34	*Pycnonotus leucogenys*	White-cheeked bulbul	0.00	0.00	7.89	0.00
35	*Lanius collurio*	Bay-backed shrike	0.00	2.27	0.00	3.23
36	*Oenanthe picata*	Indian bush chat	9.09	13.64	2.63	3.23
37	*Saxicoloides fulicata*	Indian robin	2.27	0.00	2.63	3.23
38	*Prinia buchanani*	Rufous-fronted prinia	2.27	0.00	2.63	3.23

Bird composition at Keti Bander

In total 38 species were sighted in the vicinity of Keti Bander, of which 27 were migratory species, 26 were winter visitors and one was resident/winter visitor (hoopoe).

The remaining 11 species were all resident species. Three near-threatened species were also recorded: cinerous vulture, black-tailed godwit and bar-tailed godwit (Table A18.9).

Table A18.9. Composition and percentage of bird species at various locations around Keti-Bander area.

No	Common name	Scientific name	Sta. 1-1	Sta. 1-2	Sta. 2
			Hajamro Creek	Hajamro Creek	Tango Creek
1	Osprey	*Pandion haliaetus*	0.00	10.64	0.00
2	Cattle egret	*Bubulcus ibis*	3.13	0.00	12.50
3	Reef heron	*Egretta gularis*	25.00	21.28	28.13
4	Night heron	*Nycticorax nycticorax*	0.00	4.26	0.00
5	Intermediate egret	*Egretta intermedia*	0.00	2.13	0.00
6	Shoveller	*Anas clypeata*	9.38	2.13	0.00
7	Egyptian vulture	*Neophron percnopterus*	0.00	2.13	0.00
8	Cinerous vulture	*Aegypius monachus*	0.00	2.13	0.00
9	Shikra	*Accipiter badius*	3.13	0.00	0.00
10	Black-winged stilt	*Himantopus imantopus*	0.00	4.26	0.00
11	Red-wattled lapwing	*Vanellus indicus*	3.13	6.38	0.00
12	Little ringed plover	*Charadrius dubius*	9.38	0.00	0.00
13	Kentrish plover	*Charadrius alexandrines*	3.13	0.00	0.00
14	Lesser sand plover	*Charadrius mongolus*	0.00	4.26	0.00
15	Greater sand plover	*Charadrius leschenaultia*	3.13	0.00	0.00
16	Black-tailed godwit	*Limosa limosa*	0.00	2.13	3.13
17	Bartailed godwit	*Limosa lapponica*	0.00	0.00	3.13
18	Marsh sandpiper	*Tringa stagnatilis*	0.00	0.00	0.00
19	Common sandpiper	*Actitis hypoleucos*	0.00	0.00	6.25

20	Fantail snipe	*Gallinago gallinago*	3.13	2.13	3.13
21	Little stint	*Calidris minuta*	3.13	0.00	6.25
22	Dunlin	*Calidris alpine*	3.13	0.00	6.25
23	Black headed gull	*Larus ridibundus*	0.00	4.26	0.00
24	Lesser crested tern	*Thalasseus bengalensis*	0.00	4.26	6.25
25	Little green bee- eater	*Merops orientalis*	0.00	2.13	3.13
26	Hoopoe	*Upupa epops*	0.00	2.13	0.00
27	Indian sand lark	*Calandrella raytal*	0.00	2.13	3.13
28	Swallow	*Hirundo rustica*	0.00	2.13	0.00
29	White wagtail	*Motacilla alba*	0.00	0.00	3.13
30	Grey wagtail	*Motacilla cinerea*	0.00	0.00	3.13
31	Citrine wagtail	*Motacilla citreola*	3.13	0.00	3.13
32	Yellow wagtail	*Motacilla flava*	6.25	0.00	3.13
33	Red-vented bulbul	*Pycnonotus cafer*	0.00	6.38	0.00
34	White-cheeked bulbul	*Pycnonotus leucogenys*	9.38	0.00	6.25
35	Bay-backed shrike	*Lanius collurio*	6.25	0.00	0.00
36	Indian bush chat	*Oenanthe picata*	6.25	4.26	0.00
37	Indian robin	*Saxicoloides fulicata*	0.00	4.26	0.00
38	Rufous-fronted prinia	*Prinia buchanani*	0.00	4.26	0.00

Reptiles

Six species of sea snakes were observed during the present study. None of them were listed as threatened (Table A18.10).

Table A18.10. Reptiles recorded from mangroves.

	Order	Family	Scientific name	Common name	Red Listing
1	*Squamata*	*Hydrophidae*	*Enhydrina schistose*	Beaked sea snake	LC
2	*Squamata*	*Hydrophidae*	*Hydrophis cyanocinctus*	Annulated sea snake	LC
3	*Squamata*	*Hydrophidae*	*Hydrophis spiralis*	Yellow sea snake	LC

4	*Squamata*	*Hydrophidae*	*Hydrophis caerulescens*	Blue-green sea snake	LC
5	*Squamata*	*Hydrophidae*	*Hydrophis fasciatus*	Small-headed sea snake	LC
6	*Squamata*	*Hydrophidae*	*Pelamis platurus*	Pelagic sea snake	LC

Table A18.11. Station-wise density (percentage) of reptiles (snakes) along Karachi coast (Korangi).

No	Scientific name	Common name	Sta. 1	Sta. 2	Sta. 3-1	Sta. 3-2	Sta. 3-3	Sta. 3-4	Sta. 4
			Main Phitti Creek	Phitti Creek	Rato Kot	Rato Kot	Rato Kot	Rato Kot	Khadero
1	*Enhydrina schistose*	Beaked sea snake			20				
2	*Hydrophis cyanocinctus*	Annulated sea snake			20				
3	*Hydrophis spiralis*	Yellow sea snake			20	50	100		
4	*Hydrophis caerulescens*	Blue-green sea snake				50			
5	*Hydrophis fasciatus*	Small-headed sea snake			20				
6	*Pelamis platurus*	Pelagic sea snake			20				

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