CAPACITY TRAINING WORKSHOP

CTCN TA for saline water purification technology at household level and low-cost durable housing technology for coastal areas of Bangladesh

Date: 12th – 13th November, 2018 | Venue: Seminar Hall-2, PKSF Bhaban, Agargaon, Dhaka.

CTCN CLIMATE TECHNOLOGY CENTRE & NETWORK

BUP BANGLADESH UNNAYAN PARISHAD

KICT

GTAT Glory And Technology

GTC 녹색기술센터 GREEN TECHNOLOGY CENTER

Table of Content

Workshop Agenda

Day 1 - 12th November, 2018

Time	Item / Session	Speaker
09:00 – 09:30	Registration	
Opening Session		
09:30 – 10:10	Recitation from the Holy Quaran	**Mr. Babul Hossain**, Imam, DoE
	Welcome Address	**Mr. Mirza Shawkat Ali** Director, CC&Int'l Conv., DoE
	Address by the Korean Representative	**Dr. Chang U CHAE**, KICT
	Address by Chairman BUP	**Dr. Rezaul Karim**
	Address by the Special Guest	**Dr. Nurul Quadir** Additional Secretary, MoEFCC
	Address by the Chief Guest	**Dr. Q K Ahmad, Chairman**, PKSF
	Address by the Chair	**Dr. Sultan Ahmed** Director General, DoE
	Vote of Thanks	Dr. Nilufar Banu, ED, BUP
10:10 – 10:30	Group Photo and Coffee Break	
(Session 1) Low cost domestic climate-resilient housing technology solutions Session Chair: **Dr. Rezaul Karim**, Moderated by **Engr. Shamim**, Director HBRI		
10:30 – 11:00	Field survey results of southern coastal areas in Bangladesh	**Dr. Chang U CHAE**, KICT & **Mr. Kazi Amdadul Hoque**, Friendship
11:00 – 11:30	Review of building materials and component alternatives for southern coastal housing	**Dr. Tae Hyeob SONG**, KICT
11:30 – 12:30	Design guideline for housing construction in southern coastal areas of Bangladesh	**Mr. Mohammad Abu Sadeque**, HBRI
12:30 – 13:00	Proposals of housing model for southern coastal areas of Bangladesh	**Dr. Chang U CHAE**, KICT & **Young Wan Kim**, BOF, Korea
13:00– 13:30	Open discussion	Moderated by **Engr. Shamim**, Director, HBRI
13:35– 14:30	Lunch	

(Session 2) Saline water purification technology solutions Session Chair: **Dr. Fazle Rabbi Sadeque Ahmed**, Moderated by Representative of DPHE		
14:30 – 15:00	General water purification techniques using membrane technologies	**Prof.Sangho Lee** Kookmin University
15:00 – 15:30	Investigation of local water use in the village of Satkhira, Bagerhat Region	**Dr. Dongjin Yang**, GATC
15:30 – 15:50	Coffee Break	
15:50 – 16:20	Implementation and technical part of managing desalination water treatment plant in south east coastal region of Bangladesh	**S.M Mahabub Alam** & **Sarder Ziauddin** NGF
16:20 – 17:00	Low-cost desalination applications to solve water problems in coastal areas of Bangladesh	**Dr. Yunchul Woo**, KICT
17:00 – 17:20	Open discussion	Moderated by Representative of DPHE
17:20 – 17:30	Closing	

Day 2 - 13th November, 2018

Time	Item / Session	Speaker
(Session 3) Identifying finance opportunities for the technology deployment Session Chair: **Abdul Karim**, Managing Director, PKSF		
10:00 – 10:40	Climate Technology Cooperation through CTCN and Korea's Technology Cooperation activities	**Mr. Chang Sun JANG**,GTC
10:40 – 11:00	Access to Climate Finance	**Ms. Rywon YANG**, GTC
11:00 – 11:20	Coffee break	
11:20 – 12:00	Technology cooperation and its potential linkage with carbon market	**Dr. Sue Kyung LEE**, GTC
12:00 – 12:30	Open discussion	
12:30 – 13:00	Closing remarks	**Mr. Chang Sun JANG**, GTC **Dr. Sultan Ahmed**, DG, DoE
13:00 – 14:00	Lunch	

Field survey result of southern coastal areas in Bangladesh

2018. 11. 12.

Chang-U Chae / Kazi Amdadul Hoque

KICT KOREA INSTITUTE of CIVIL ENGINEERING and BUILDING TECHNOLOGY

Friendship

Summary of field survey

CTCN Project

Output 3

Objective	Survey Contents	Output Contents
• **Survey on residential environment in the region**	• To investigate the climate conditions of the area and the status of the structures and materials of the present houses	• Review on the current situation of residence in the southern coastal areas of Bangladesh • Review on the types of building structure and materials of housing
	• To survey the patterns of the building sites and to analyze the major materials and structural types of the existing house	
	• To investigate the climate characteristics of the target area and data	• Review on defects and deterioration of housings and its examples
	• To analyze and reflect the housing requirements of residents in the existing area	• Review results on the requirements by residents

CTCN Project

Output 3

Objective	Survey Contents	Output Contents
• **Survey on the status of materials and production infrastructure**	• To investigate the current state of building infrastructures in residential construction	• Review on the current situation for the housing construction
	• To investigate tangible and intangible of local resources (timber, aggregate and other inorganic materials), as well as locally produced manufacturing industries of materials (cement, plywood, processing timber and aggregate processing facility)	
	• To investigate the utilization of construction machinery and the status of construction infrastructure	• Review on transportation
	• To suggest test methods etc. in consideration of local conditions for the housing construction	• Suggestion on appropriate building materials/ components
	• To suggest alternatives of possible building materials for local production and use	

CTCN Project

Output 3

Objective	Survey Contents	Output Contents
• **Survey of building standard and system**	• To investigate the current state of the infrastructure • To investigate the difference of housing standards and habitants behaviors between the central and the local government	• Analysis on the system for the technology and legislation for the housing construction
• **Suggestion on the appropriate housing and a plan for pilot applications**	• To suggest a prototype of housing • To suggest a plan for supply and use of building materials	• Suggestion on prototypes and a pilot plan
• **Capacity building**	• To provide lectures on building components and application for the low-income families	• Lectures
• **Final presentation**	• To provide final presentation and report	

Field Study

Purpose : Deriving alternatives through climate environment and current residence study

Item	Contents	Main Contents	Purpose of Field Study
Environment	Climate	- Humidity and Precipitation	- Derive appropriate architectural form
	Soil	- Salt concentration	- Analysis of construction material availability
	Water	- Salinity, pH	- Utilization of construction work
Resource	Aggregate and soil	- Rocks, Coarse aggregate, Fine aggregate, Clay etc	- Utilization of construction materials
	Wood and other	- Trees, reeds, etc.	- Utilization of construction materials
Residential Environment	Type of housing	- Main building materials (wall, roof, floor) - Structure type	- Set up on remodeling direction
	Ventilation	- Openings and windows - Cooking fuel and form	- Interior material composition
Accessibility and others	Infrastructure	- Road, Electricity, Manpower	- Set up on Construction Direction

Conditions for selecting site

1. Scale of the site	• Household unit: 50 ~ 100 households • Population standard: 200 ~ 500 ※ It is hard to identify the village structure on selected region, but it can be selected as the minimum unit of the village. However, the composition of the housing should be in the form of a resident village and the distance between houses must be close by to each others.
2. Location of site	• Three locations (three villages) on each regions (3 for Bagerhat, 3 for Satkhira) • Three villages must have different features of ground type (e.g. coastal wetland, flat land and hilly land) • Six villages at least in two regions.
3. Field survey contents	**(1) Town survey contents** • Survey of accessibility from main road to town (road type, road width, size of movable vehicles, etc.) • Road form and soil survey in the village • Measurement of chloride content for soil and underground water (Concrete chloride content measuring equipment - KICT equipment) • Measurement of pH and chloride contents for surrounding water and rivers (pH meter - KICT equipment) • Drainage (sewage) facility

Conditions for selecting site

3. Field survey contents	**(2) Housing survey contents** **a) Housing structure** • Main structure type of the house (wood, masonry, soil erection, etc.) • Analysis of major causes of aged housing (analysis of causes such as salt and weathering) • Analysis of aging type (size and shape of cracks, size and shape of exfoliations etc.) • Current status and maintenance of old structure • Current status of internal space division (average area and number of rooms) • Presence of floor and ceiling (ceiling finish) • Difference in height between the main building and the ground (presence of canopy) **b) Housing type** • Average number of residents (survey on family composition) • Fuel usage patterns for meals • Exhaust and ventilation methods • Configuration and materials of windows and doors • Sleeping type (floor, bed, etc.) • Indoor finishing (cement, soil, wood, tree branches, etc.) • Indoor floor finishing (soil, cement, wood, board, tile, etc.) • Indoor shoe usage **c) Residential facilities** • Use of water (water supply facilities or direct use of underground water) • Electricity supply (voltage and main use of electrical appliances) • Location and types of toilet (indoor, outdoor)

Conditions for selecting site

3. Field survey contents	**(3) Data Collection (aid of materials)** **a) Last 10 years of disaster on selected regions** • Data provided by the weather centre and other organizations • Damage status to housing due to the disasters (heavy rain / flood) • Disaster prevention plans by government **b) Major construction material supply systems and markets on selected region** • Supply system of materials for housing construction (self supply, purchase, etc.) • Major construction material production facilities near the selected region **c) Construction material price data** • Bangladesh's major construction material price data **d) Test organization status and contact information** • Organization which is capable of evaluating the performance of construction materials **e) Housing laws and regulations** • Housing construction regulations • Housing performance and construction standards • Earthquake resistance, fire resistance, flood prevention, durability standards and regulations • Local Construction Ordinances (regulation) **f) Previous performed status and research data** • Rural housing status data • Rural housing improvement activity data • Previous performed pilot project data • Rural housing design data

Field Study

Key questions on selection site

Questions	Detailed contents	Note
Construction method on house	① Self-construction (built by yourself) [ ] ② Communal sharing of labor (village or neighborhood's assistance [ ] ③ Home builder with license [ ] ④ Others [ ]	
Major structure of housing (main structure)	① Wood [ ] ② Cement block [ ] ③ Clay (unbaked) bricks [ ] ④ Baked bricks [ ] ⑤ Concrete [ ] ⑥ Others [ ]	
Main form of roof	① Thatched roof[ ] ② Tin roof [ ] ③ Slate(inorganic substance) roof [ ] ④ Wood [ ] ⑤ Tiled roof [ ] ⑥ Others [ ]	
Main configuration of wall	① Masonry (stone masonry) [ ] ② Board (wood) type [ ] ③ Weaving wood type [ ] ④ Tin board type [ ] ⑤ Stacking up soil (soil erection) [ ] ⑥ Others [ ]	

Field Study

Key questions on selection site

Questions	Detailed contents	Note
Main configuration type of indoor floor	① Soil/earth (stone masonry) [ ] ② Board [ ] ③ Vinyl Carpet [ ] ④ Cement concrete [ ] ⑤ Tile [ ] ⑥ Others [ ]	
Sleeping type	① Floor [ ] ② Bed [ ] ③ Others [ ]	
Fuel type to cook	① Wood [ ] ② Oil [ ] ③ Coal [ ] ④ Gas [ ] ⑤ Methane [ ] ⑥ Others [ ]	
Major Resources	① Forest resources (wood) [ ] ② Mineral resources such as stone [ ] ③ Sand [ ] ④ Pebbles [ ] ⑤ Others [ ]	

Field Study

Key questions on selection site

Questions	Detailed contents	Note
Accessibility	① Road Status [ ] - Asphalt pavement up to the village area, then off-roads(unpaved road) to the survey site (accessible by SUV vehicles) - Accessible truck size (1 ton, 2.5 ton, 5 ton, 10 ton etc.) ② Traffic Status [ ] - Explain the accessibility by public transportation	
Construction materials market formation	① Distance to the nearest city from survey site (the city which involves the construction material-related market) ② Minimum unit of construction material market	
Construction materials price data	① Data that can identify trends in prices of major housing construction materials ② Bangladesh price data or local price data	
Architectural law data	① Housing Construction Regulations ② Housing performance and construction standards ③ Earthquake resistance, fire resistance, flood prevention, durability standards and regulations ④ Local Construction Ordinances(regulation)	
Housing-related survey and research	① Rural housing status data ② Rural housing improvement activity data ③ previous performed pilot project data ④ Rural housing design data	

Field Survey

Field Survey - checklist

Housing Condition Checklist			
A : Village unit			
Location	□ Bagerhat □ Satkhira (Detail name on site :)		
Number of households		Total number of dwellers (population)	
Mobile Accessibility	□ Yes □ No	Distance from main road	m
Road pavement on village	□ Yes □ No	Average width of the main road	m
Soil chloride content	kg/m³	PH concentration of domestic water	
B : Structure and Damage			
Structure type	□ Timber □ Bricks □ Soil □ etc. ( ) □ Corrugated galvanized iron (CGI) sheets		
Total housing area	m²	Number of rooms	
Ceiling height	m	Ceiling Finish	□ Yes □ No
Height of the building from the ground	m	Entrance canopy	□ Yes □ No
Number of windows		Total areas of windows	m²
Crack in wall & floor	□ No □ Yes (Total length of cracks: cm, Total number of cracks :)		
Major cause of deterioration	□ Weathering □ Salt attack □ Aging □ Material failure □ etc. ( )		
C : Use and Materials			
Number of residents		Location on kitchen	□ Inside □ Outside
Fuel type to cook		Exhaust / ventilation method	□ Chimney □ Fan □ None
Main entrance area	m²	Material type of main entrance	
Main material of window		Switch method of window	
Sleep type	□ Floor □ Bed □etc. ()	Indoor floor finish	□ Soil □ Cement □ Plate□ Tile □ wood □ etc. ()
Indoor wall finish	□ Soil □ Cement □ Tile □ wood □ etc. ( )	Indoor shoe usage	□ Using shoes □ Slippers or barefoot
D : Residential facilities			
Water for drinking	□ Individual ground water □ Joint water supply (manual carriage) □ etc.( )		
Water for living (shower, flush)	□ Individual ground water □ Joint water supply (manual carriage) □ etc .()		
Availability of electricity	□ Yes□ No	Lighting method	□ electricity □ etc .()
Location of toilet	□ Inside □ Outside	Type of toilet	
E : Others			
Registered to government office	□ Yes □ No	Building permission and management	□ Yes □ No
Contract type for construction	□ Individual □ Cooperative construction □ Professional contractor (or installer)		

Field Trip

Field study – schedule/method

Field Trip Schedule

Schedule

Day 1: 09th September'2018 (Sunday)

Time Schedule:

1.	Arrival at Hazrat Shah Jalal International Airport, Dhaka	: 12:10 hrs. (ETA)
2.	Arrival and reporting at Domestic Airport	: 15:30 hrs. (ETA)
3.	Departure from Dhaka to Jessore Domestic Airport by Biman Flights	: 16:30 hrs. (ETD)
4.	Arrival at Jessore Domestic Airport	: 17:15 hrs.
5.	Departure from Airport to Khulna by Microbus *(Need 2:30h traveling by road- 70km)*	: 17:45 hrs. (ETD)
6.	Arrival at Hotel and Check-in to hotel (khulan) **(Hotel: Castle Salam, Khulna)**	: 20:15 hrs. (ETA)
7.	Dinner at Hotel & Night Stay	: 20:30 hrs.

End of the day activities

Day 02: 10th September 2018 (Monday)

Time Schedule

1.	Breakfast at Hotel	: 08:00 hrs.
2.	Departure from Hotel to Mongla, Bagerhat by Microbus *(Need 1.5h traveling by road-48km)*	: 09:00 hrs. (ETD)
3.	Arrival at Hotel Pashur Mongla	: 10:30 hrs. (ETA)
4.	Refreshment at Hotel Pashur Mongla	: 10:35 hrs.
5.	Departure from Ghat to villages by Speed Boat *(Need 20-30min one way traveling by river)*	: 11:00 hrs.
6.	Arrival and visit villages (Village Kaya bunia under Chadpai union, Mongla Upazila, Bagerhat)	: 11:45 hrs.
7.	Departure to another village by Speed Boat	: 12:30 hrs.
8.	Arrival and visit villages (Village Kamal kathi under Padmapukur union, Mongla Upazila, Bagerhat)	: 13:00 hrs.
9.	Departure to Hotel Pashur Mongla	: 14:00 hrs. (ETA)
10.	Arrival at Hotel Pashur Mongla	: 14:30 hrs. (ETA)
11.	Lunch at Hotel Pashur Mongla	: 14:30 hrs.
12.	Departure to Village by Microbus	: 15:30 hrs.
13.	Arrival and visiting villages	: 16:00 hrs.
14.	Departure to Hotel at Khula by Microbus	: 17:30 hrs.
15.	Arrival at Hotel	: 19:00 hrs.
16.	Dinner at Hotel & Night Stay	: 20:30 hrs.

Day 03: 11th September 2018 (Tuesday)

Time Schedule

1.	Breakfast at Hotel & Hotel Check out	: 08:00 hrs.
2.	Departure to Khulna Division office by Microbus	: 08:45 hrs.
3.	Arrival and Meeting with DoE at Khulna Division office	: 09:00 hrs.
4.	Departure to Shyamnagor by Microbus	: 11:00 hrs.
5.	Arrival at Friendship Hospital Shyamnagar	: 13:30 hrs.
6.	Lunch at Friendship Hospital Shyamnagar	: 13:35 hrs.
7.	Departure to Villages by Microbus & boat (Need 25minutes by car & 20 minutes by boat)	: 14:10 hrs. (ETD)
8.	Arrival and visiting Village *(Village Kamal kathi under pabmapukur Union of Shyamnagar Upazila)*	: 15:00 hrs.
9.	Departure to Village by Motorbike	: 15:30 hrs.
10.	Arrival and visiting Village *(Village Noth Jhapa under pabmapukur Union of Shyamnagar Upazila)*	
11.	Departure Island to village by Boat	: 16:20 hrs. (ETD)
12.	Arrival and visiting Village *(Village Durgabati under Burigoalini Union of Shyamnagar Upazila of Satkhira)*	: 16:45 hrs.
13.	Departure to Hotel at Symnagar by Microbus	: 17:30 hrs.
14.	Arrival at Hotel (**Borsha Guest House, Symnagar, Satkhira**)	: 18: 45 hrs.
15.	Dinner at Hotel & Night Stay ***End of the day activities***	: 20 :00 hrs.

Day 04: 12th September 2018 (Wednesday)

Time Schedule

1.	Breakfast at Hotel	: 07:30 hrs.
2.	Hotel check out in Symnagar, Satkhira	: 08:00 hrs.
3.	Departure to Satkhira District Office by Microbus	: 08:15 hrs.
4.	Arrival and meeting with Meeting with local stakeholders	: 10:00 hrs.
5.	Departure to Jessore Domestic Airport by Offices Car	: 13:00 hrs.
6.	Lunch at Chuknagar during travel roadside restaurant	: 13:45 hrs.
7.	Arrival at Jessore Domestic Airport	: 15:30 hrs.
8.	Departure to Dhaka Domestic Airport	: 17:40 hrs.
9.	Arrival at Dhaka Domestic Airport	: 18:25 hrs.
10.	Departure to Hotel by Offices Car	: 18:45 hrs.
11.	Arrival at Hotel	: 19:30 hrs.
12.	Dinner at Hotel	: 20:00 hrs.
13.	Night Stay at Hotel	: 21:30 hrs.

Methodology

Methodology

- The feasibility study is a quantitative techniques and for better triangul ation qualitative technique has been used in some cases.

- The feasibility study has carried out based on a review of Housing guid eline, data and observations gathered during field visits and interviews with villagers as well as relevant personnel from Government and othe r agencies.

- The data gathered through different methods including survey, focuse d group discussions, in-depth interviews, document and program com ponent review.

Field Trip

Bagrahat Mongla region

#1 : Kaya bunia,

#2 : Shalabunia,

#3 : Kamal Kathi)

Field Trip

Field trip - Begrahat

Visit Bagrahat Mongla region- #1: Kaya bunia, #2 : Shalabunia, #3 : Kamal Kathi)

- #1: Kaya bunia village -






Field Trip

Field trip - Begrahat

Visit Bagrahat Mongla region- #1: Kaya bunia, #2 : Shalabunia, #3 : Kamal Kathi)

- #2 : Shalabunia village -






Field Trip

Field trip - Begrahat

Visit Bagrahat Mongla region- #1: Kaya bunia, #2 : Shalabunia, #3 : Kamal Kathi)

- #3 : Kamal Kathi village -






Field Trip

Satkhira Shyamnagar region

#1 : Kamal kathi,

#2 : Noth Jhapa,

#3 : Durgabati)

Field Trip

Field trip - Satkhira

Visit Satkhira Shyamnagar region- (#1: Kamal kathi, #2 : Noth Jhapa, #3 : Durgabati)

- #1: Kamal kathi village -






Field Trip

Field trip - Satkhira

Visit Satkhira Shyamnagar region- (#1: Kamal kathi, #2 : Noth Jhapa, #3 : Durgabati)

- #2 : Noth Jhapa village -






Field Trip

Field trip - Satkhira

Visit Satkhira Shyamnagar region- (#1: Kamal kathi, #2 : Noth Jhapa, #3 : Durgabati)

- #3 : Durgabati village -



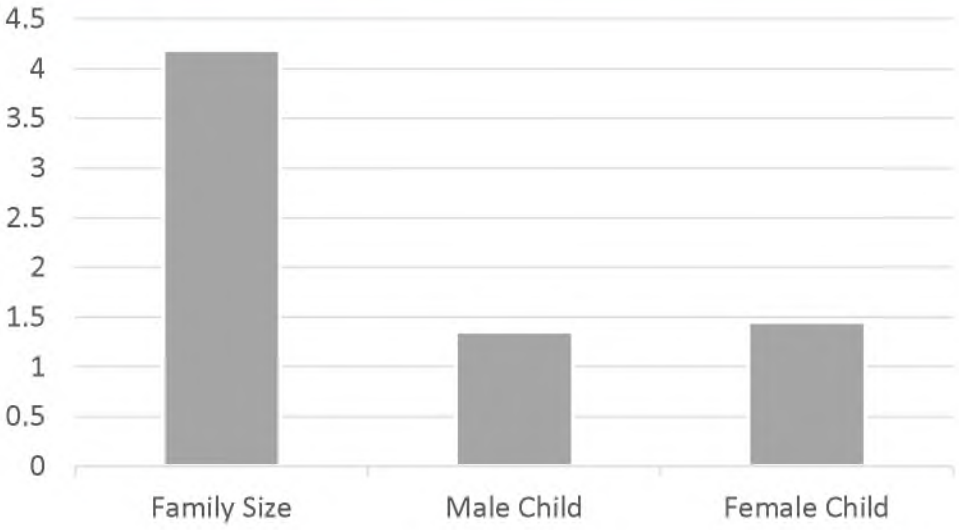



Field survey result

Field Survey Result

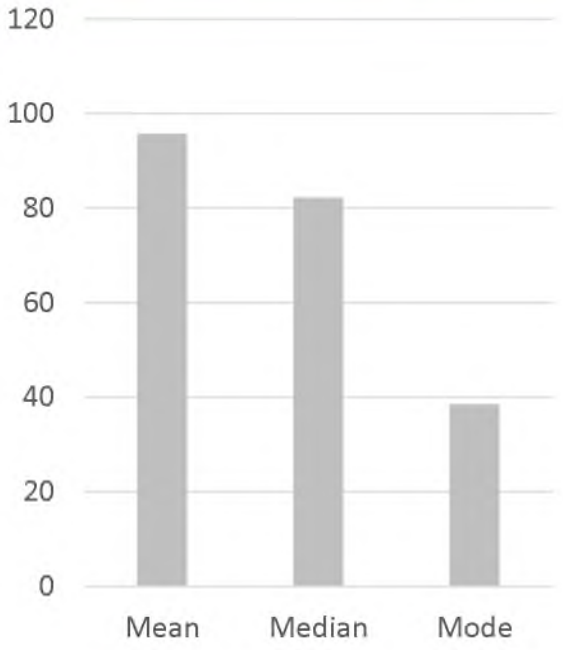
Family profile

Profile	Average	Maximum	Minimum
Family Size	4.19	10	1
Male child	1.35	7	1
Female child	1.45	5	1
Yearly Income	82,556 BDT	180,000	3,600



Housing Area

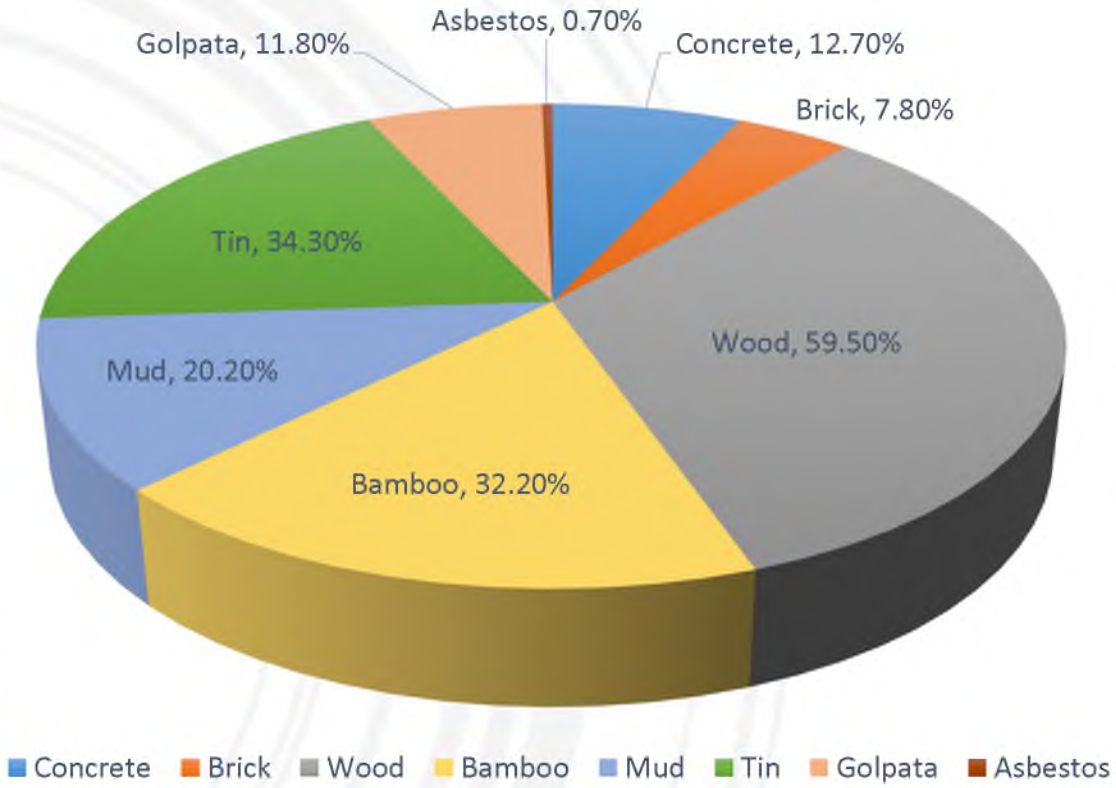
Housing Area (Square Meter)	
Mean	95.75
Median	82.11
Mode	38.40



Field Survey Result

House Structure Type (multiple responses considered

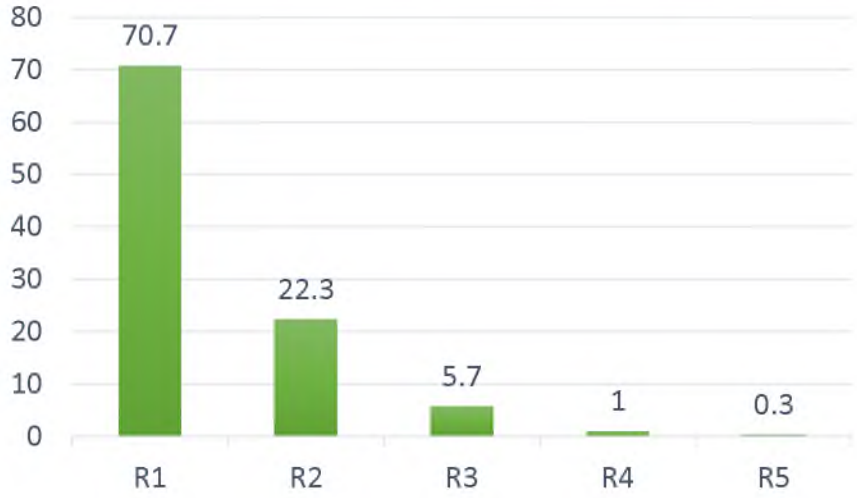
	Responses	Percent
	Number	
Concrete	76	12.7%
Brick	47	7.8%
Wood	357	59.5%
Bamboo	193	32.2%
Mud	121	20.2%
Tin	206	34.3%
Golpata	71	11.8%
Asbestos	4	0.7%



Field Survey Result

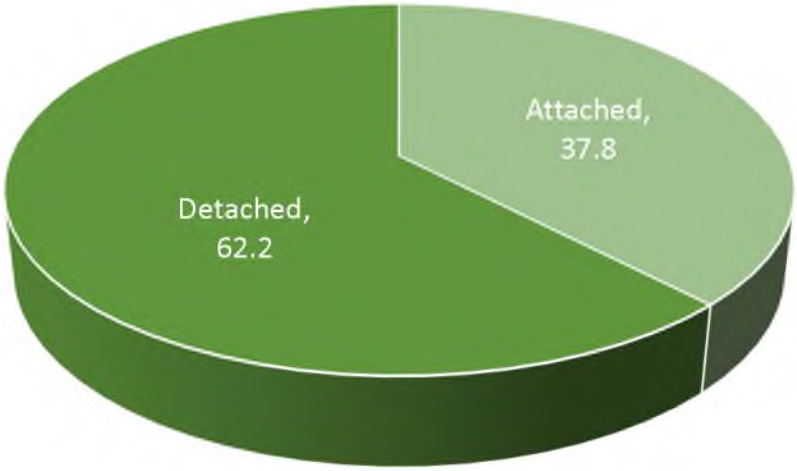
Room number excluding the kitchen

Room Number	Frequency	Percent
1	424	70.7
2	134	22.3
3	34	5.7
4	6	1.0
5	2	0.3
Total	600	100.0



Position of Kitchen

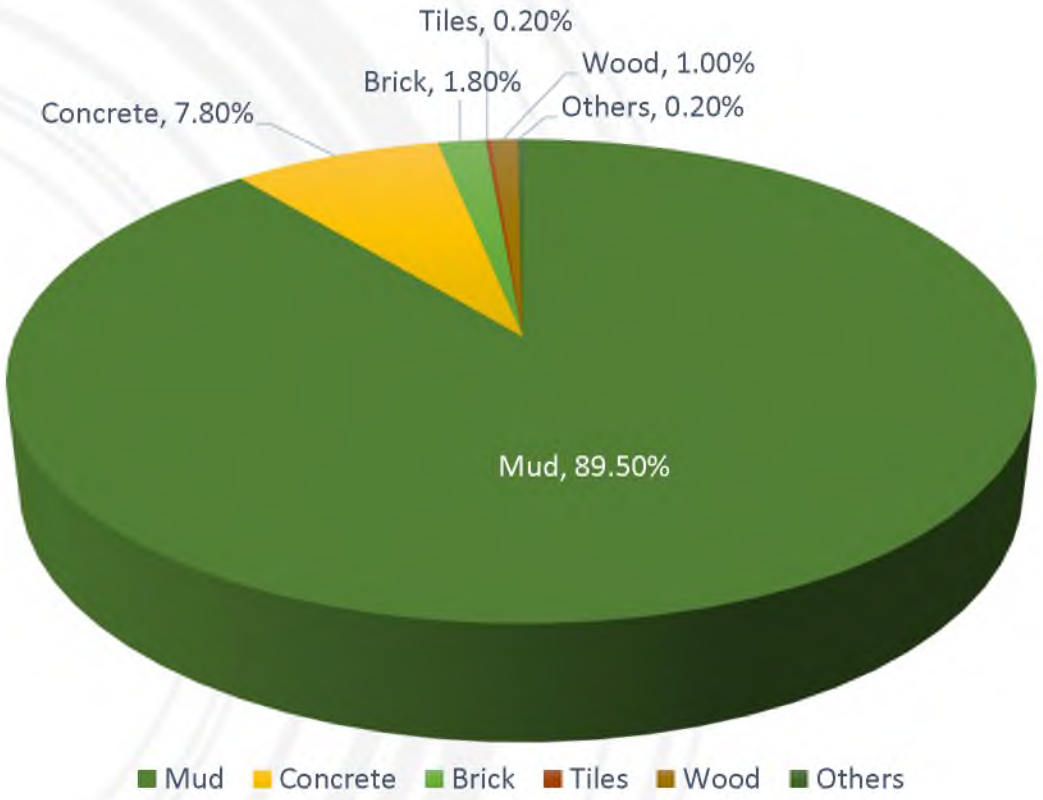
Position	Frequency	Percent
Attached	227	37.8
Detached	373	62.2
Total	600	100.0



Field Survey Result

Floor materials (multiple responses consider

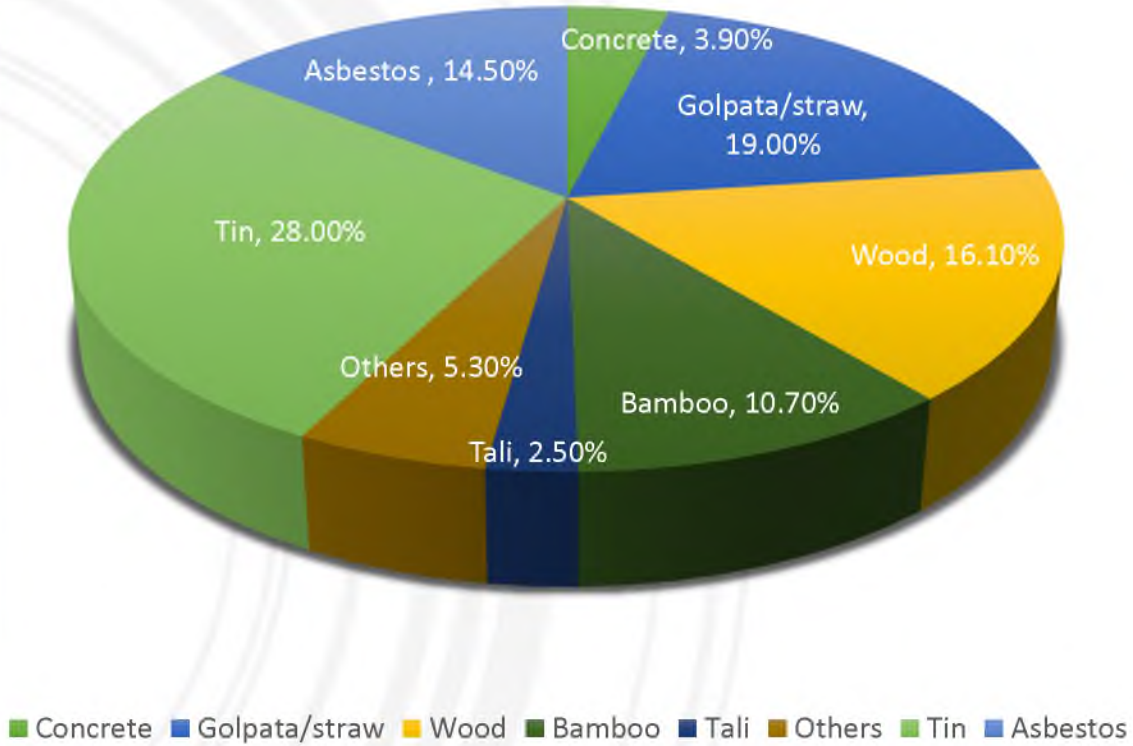
Material	Responses	
	N= 600	Percent
Mud	537	89.5%
Concrete	47	7.8%
Brick	11	1.8%
Tiles	1	0.2%
Wood	6	1.0%
Others	1	0.2%



Field Survey Result

Ceiling materials (multiple responses consid

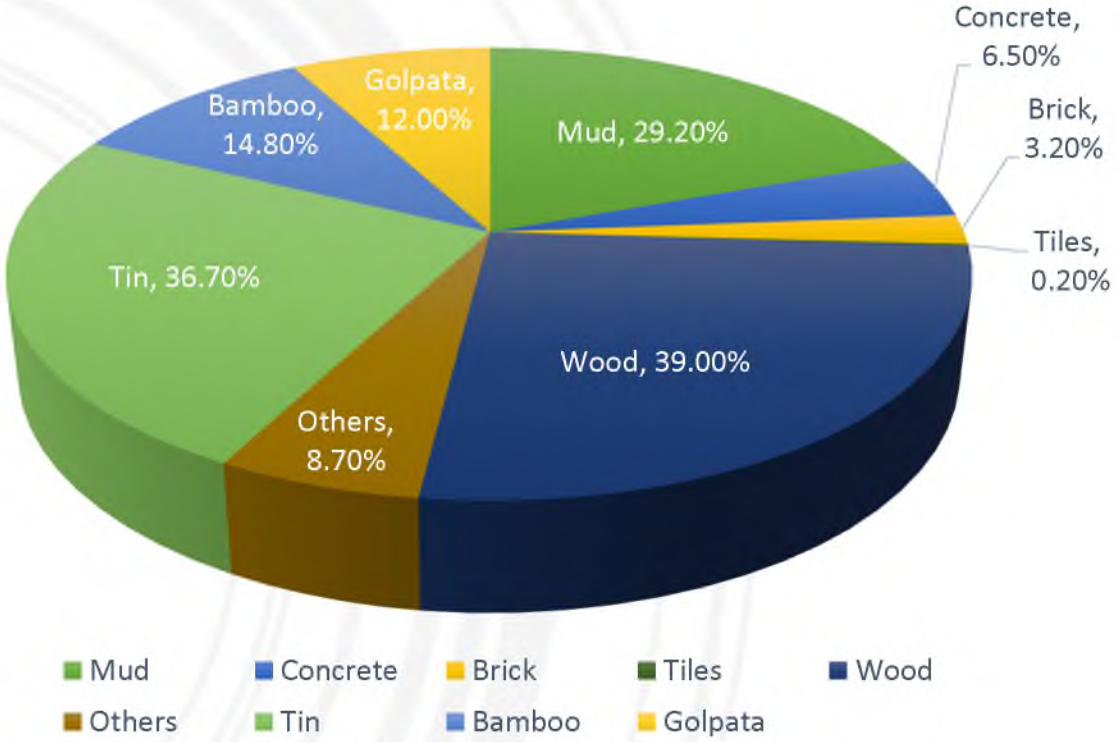
Materials	Responses	
	N	Percent
Concrete	35	3.9%
Golpata/straw	170	19.0%
Wood	144	16.1%
Bamboo	96	10.7%
Tali	22	2.5%
Others	47	5.3%
Tin	250	28.0%
Asbestos	130	14.5%
Total	600	100.0%



Field Survey Result

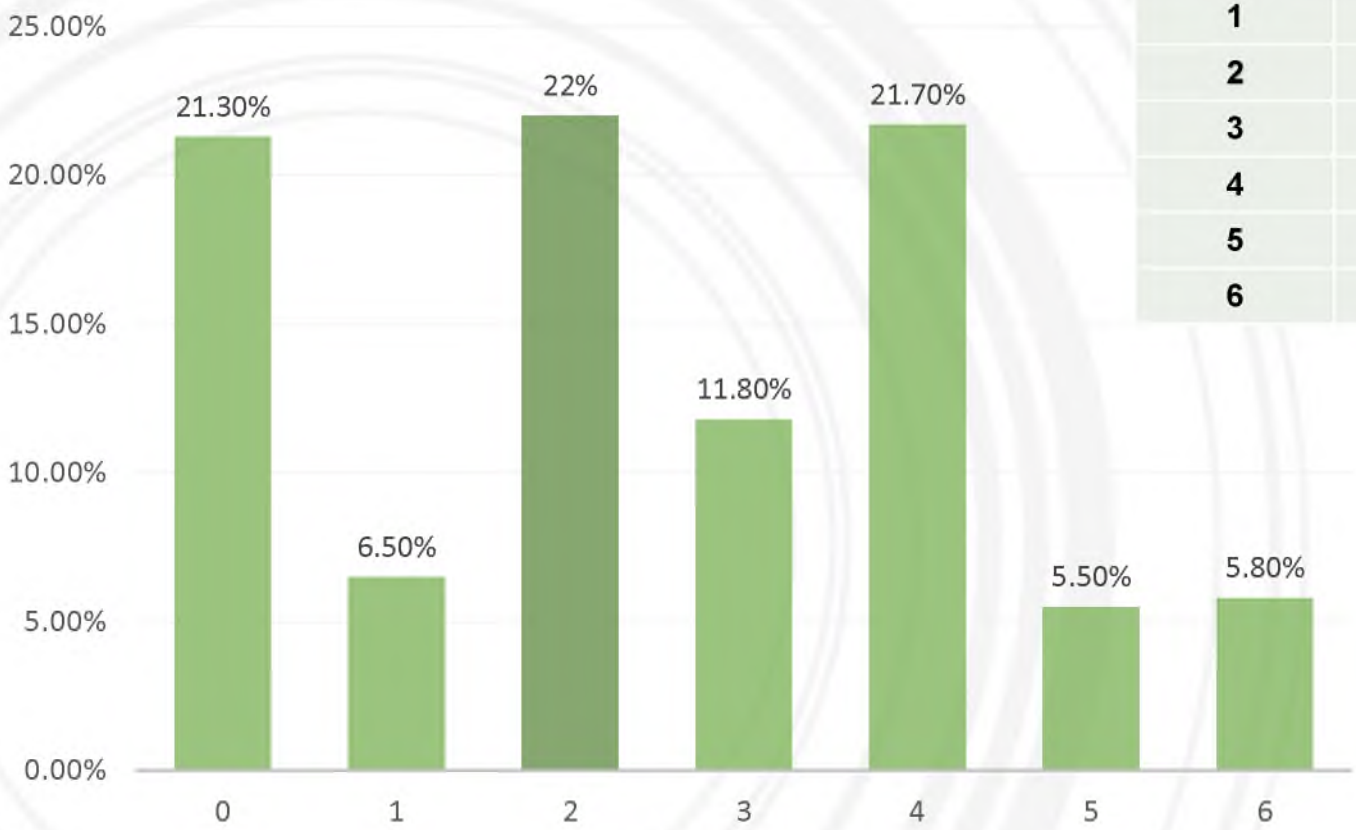
House inside wall material (multiple response

Material	Responses	
	N= 600	Percent
Mud	175	29.2%
Concrete	39	6.5%
Brick	19	3.2%
Tiles	1	0.2%
Wood	234	39.0%
Others	52	8.7%
Tin	220	36.7%
Bamboo	89	14.8%
Golpata	72	12.0%



Field Survey Result

Number of windows in the house

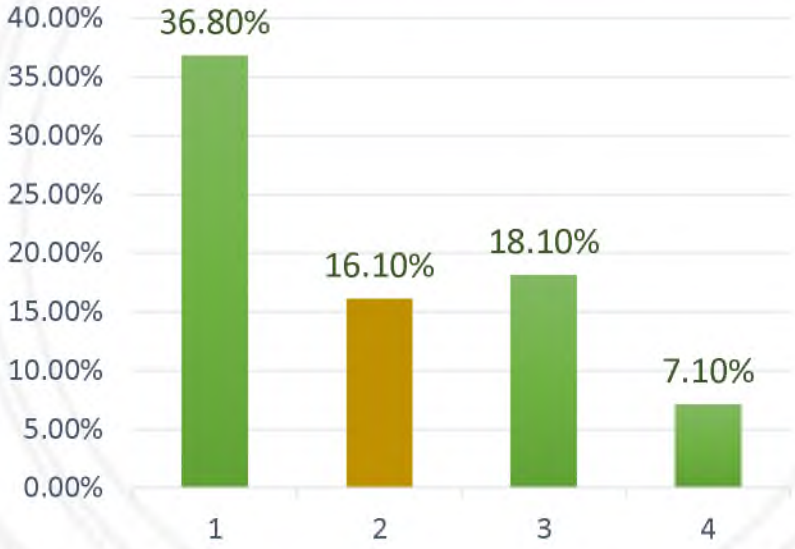


Number	Frequency	Percent
0	128	21.3
1	39	6.5
2	132	22.0
3	71	11.8
4	130	21.7
5	33	5.5
6	35	5.8

Field Survey Result

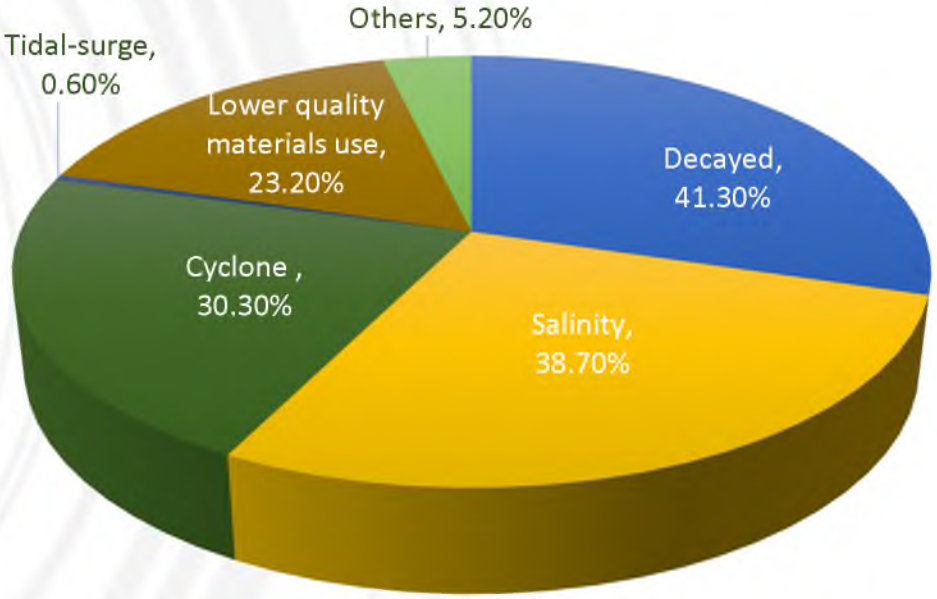
Number of cracks in roof

A number of cracks in roof		
Number of Cracks	N=155	Percent
1	57	36.8
2	25	16.1
3	28	18.1
4	11	7.1



Reason for roof crack

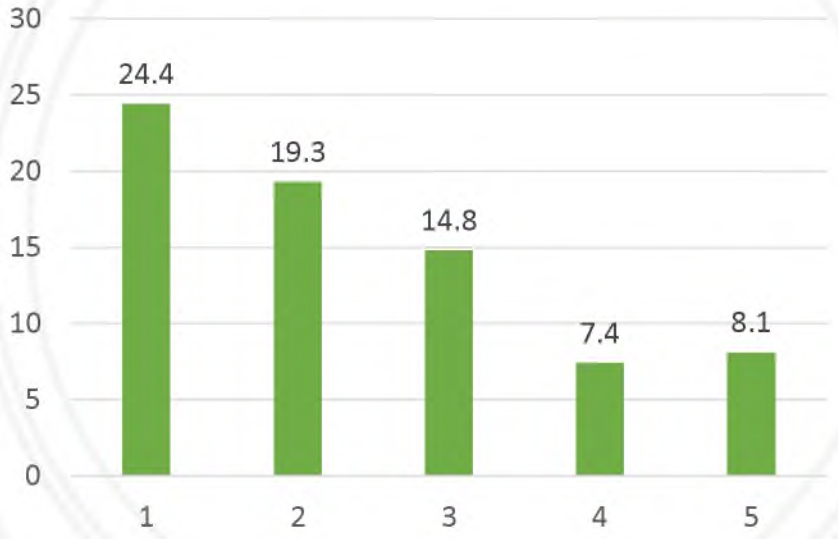
Reasons	Responses N=155	Percent
Decayed	64	41.3%
Salinity	60	38.7%
Cyclone	47	30.3%
Tidal-surge	1	0.6%
Lower quality materials use	36	23.2%
Others	8	5.2%



Field Survey Result

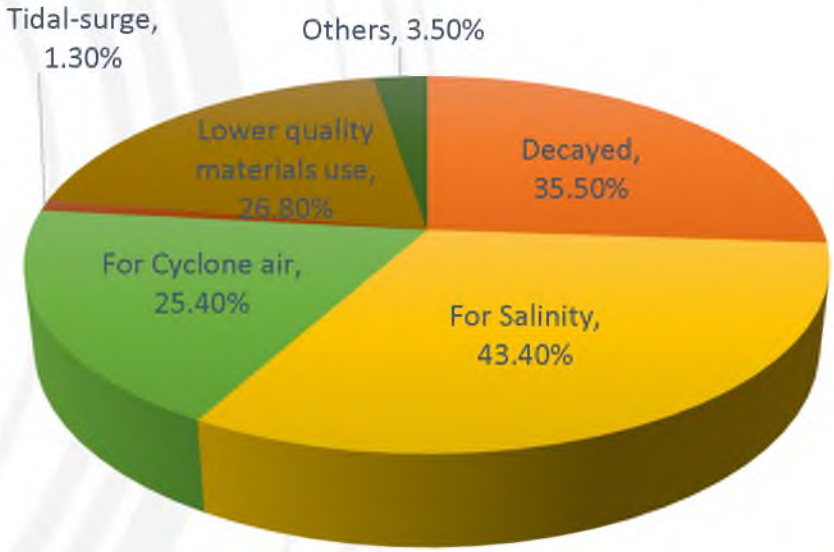
Number of cracks in a wall

No	N= 135	Percent
1	33	24.4
2	26	19.3
3	20	14.8
4	10	7.4
5	11	8.1



Reason for crack in wall (multiple responses considered)

Reason of crack	Responses N	Percent
Decayed	81	35.5%
For Salinity	**99**	**43.4%**
For Cyclone air	58	25.4%
Tidal-surge	3	1.3%
Lower quality materials use	61	26.8%
Others	8	3.5%



Utilization of field survey result

Utilization of field survey result

- Considering the result of data analysis necessary steps will be taken

- A project proposal in addressing the needs of the community people can be org anized

Thank You

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and BUILDING TECHNOLOGY

Review of building materials and component alternatives for southern coastal housing

2018. 11. 12.

Tae Hyeob, Song

KICT KOREA INSTITUTE of CIVIL ENGINEERING and BUILDING TECHNOLOGY

Content

1. Purpose and method of review
2. Geography and Climate Status
3. Review existing material performance and guideline
4. Review affordable materials
5. Characteristics of materials and framework for housing construction
6. Proposal of proper materials and framework

Purpose and method of review

Purpose of Review

Background and Method

Background

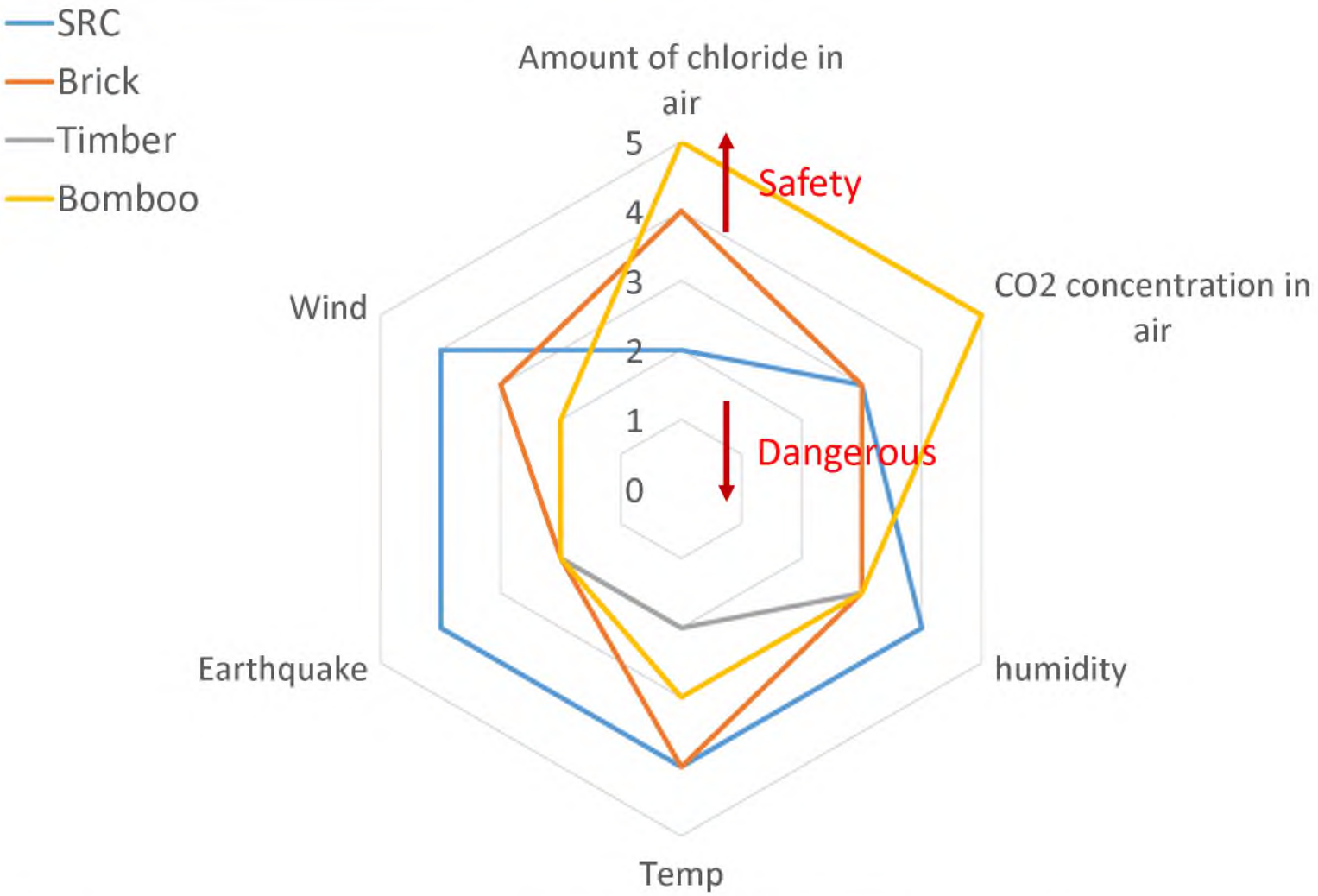
- ✓ Proposal of proper construction material after climate environment analysis
- ✓ Deriving supply of durable building materials
- ✓ Proposal for supply of building materials using local materials

Method

- ✓ Analysis of factors that may affect the durability of buildings
- ✓ Analysis of economical housing construction plan
- ✓ Construction plan of housing using materials of the site
- ✓ Manufacture of simple construction materials
- ✓ Durability, economy, use of local materials

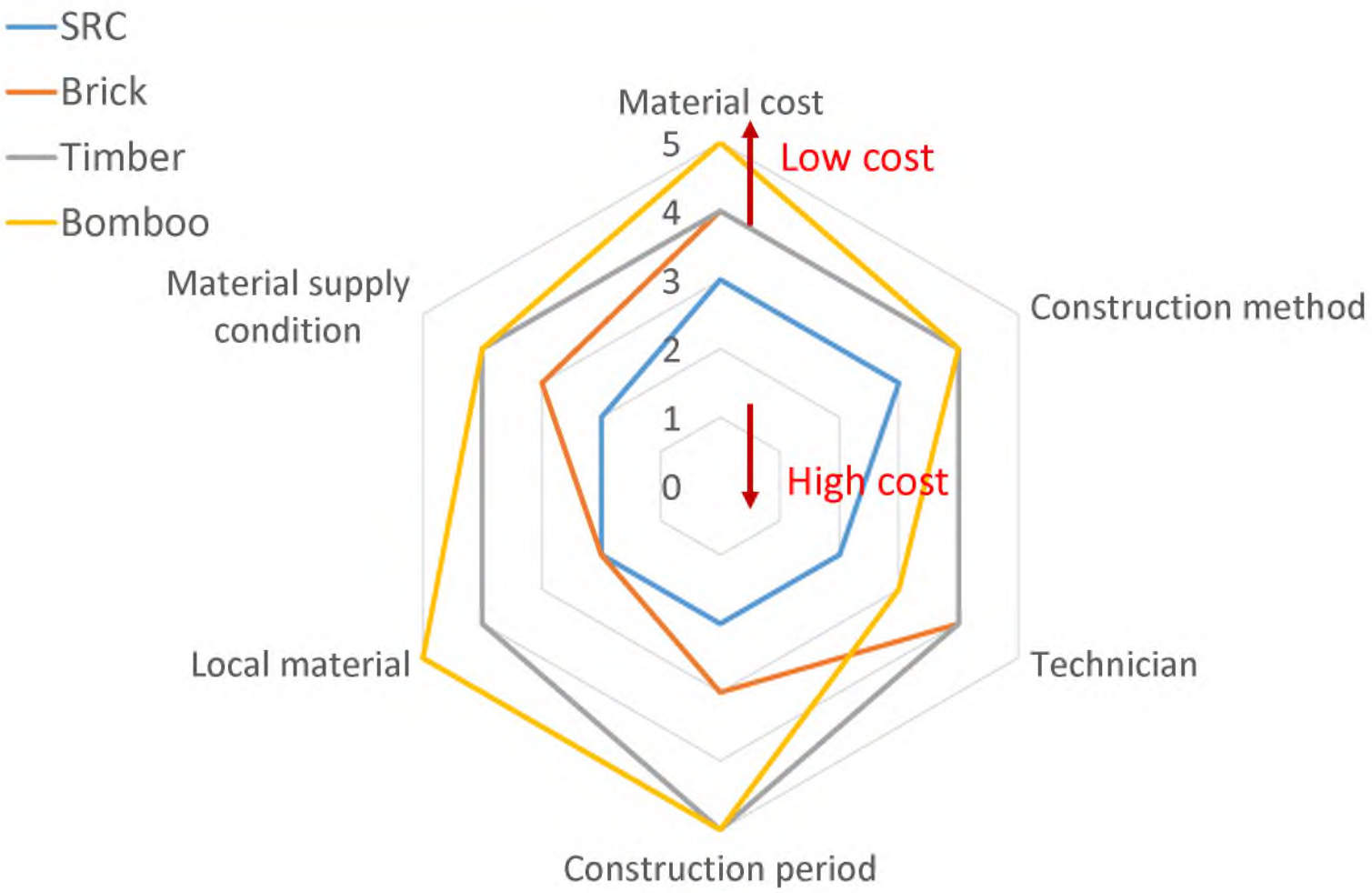
Purpose of Review

Durability factor



Purpose of Review

Economical factor



Geography and Climate Status

Geography and Climate

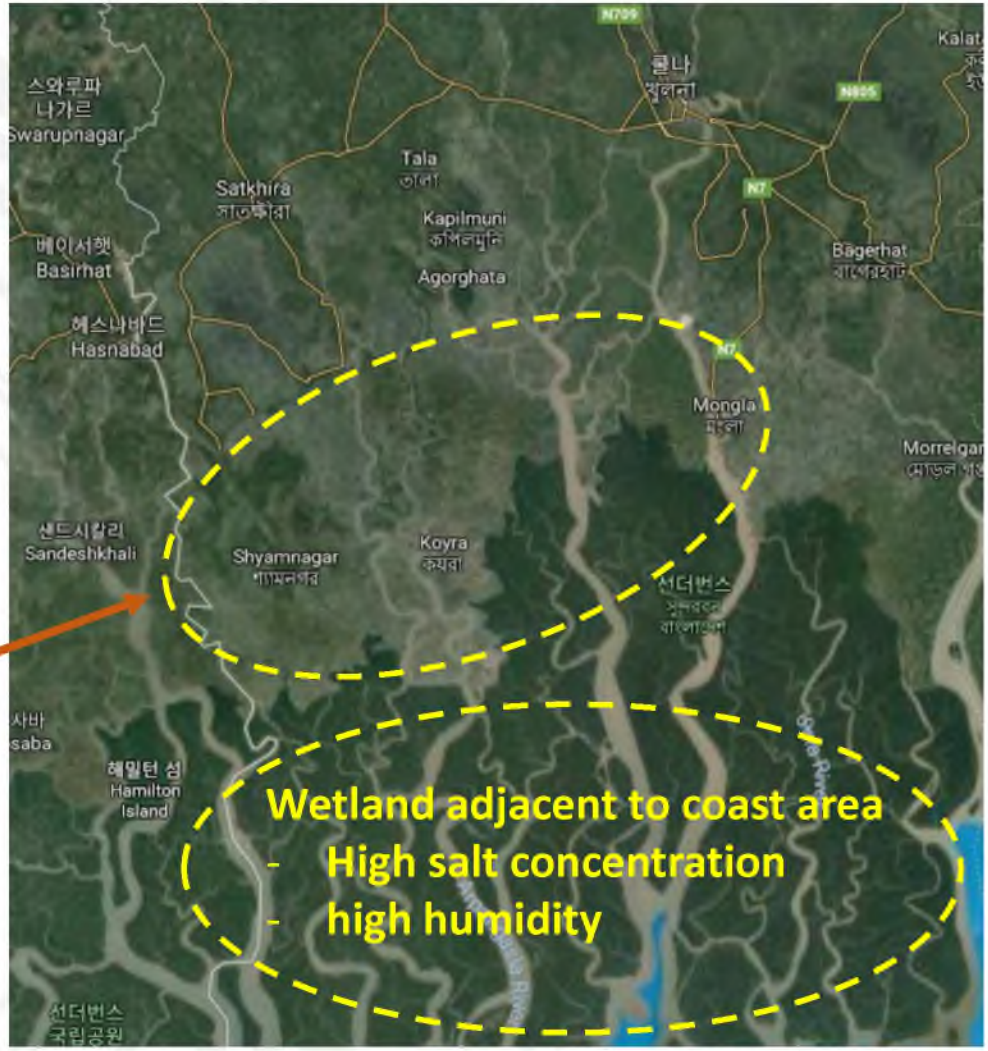
Southern coast environment

Item	Current Status	Problems
Salt attack	• Large amount of chloride in air, soil, water quality	• Promoting corrosion of steel and metals • Decrease in durability of buildings • Increased chloride content of concrete (Improvement on concrete strength but rebar affected badly)
CO_2 attack	• Low CO_2 concentration in Southern coast • Little impact on CO_2	• Carbonation of concrete $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$ • Durability degradation due to surface cracks in concrete
High Temperature & High Humidity	• High temperatures over 30 degrees from late March to early October • High humidity (approx. 80%)	• Need to adjust indoor environmental condition according to temperature rise • High humidity causes low durability in building materials • Need to use building materials that can control humidity
Earthquake	• Northern mountainous area - prone areas for earthquake • Southern coast is relatively safe for earthquakes than Northern area	• Earthquake resistant design required • Brick masonry buildings are very weak for earthquakes
Strong Wind & Flooding	• Frequent flood areas during rainy season • Average rainfall (250mm) from June to September • Flood with cyclone	• Flooding decrease durability of buildings • Damage to weak structured buildings • Ground subsidence

Geography and Climate

Geography

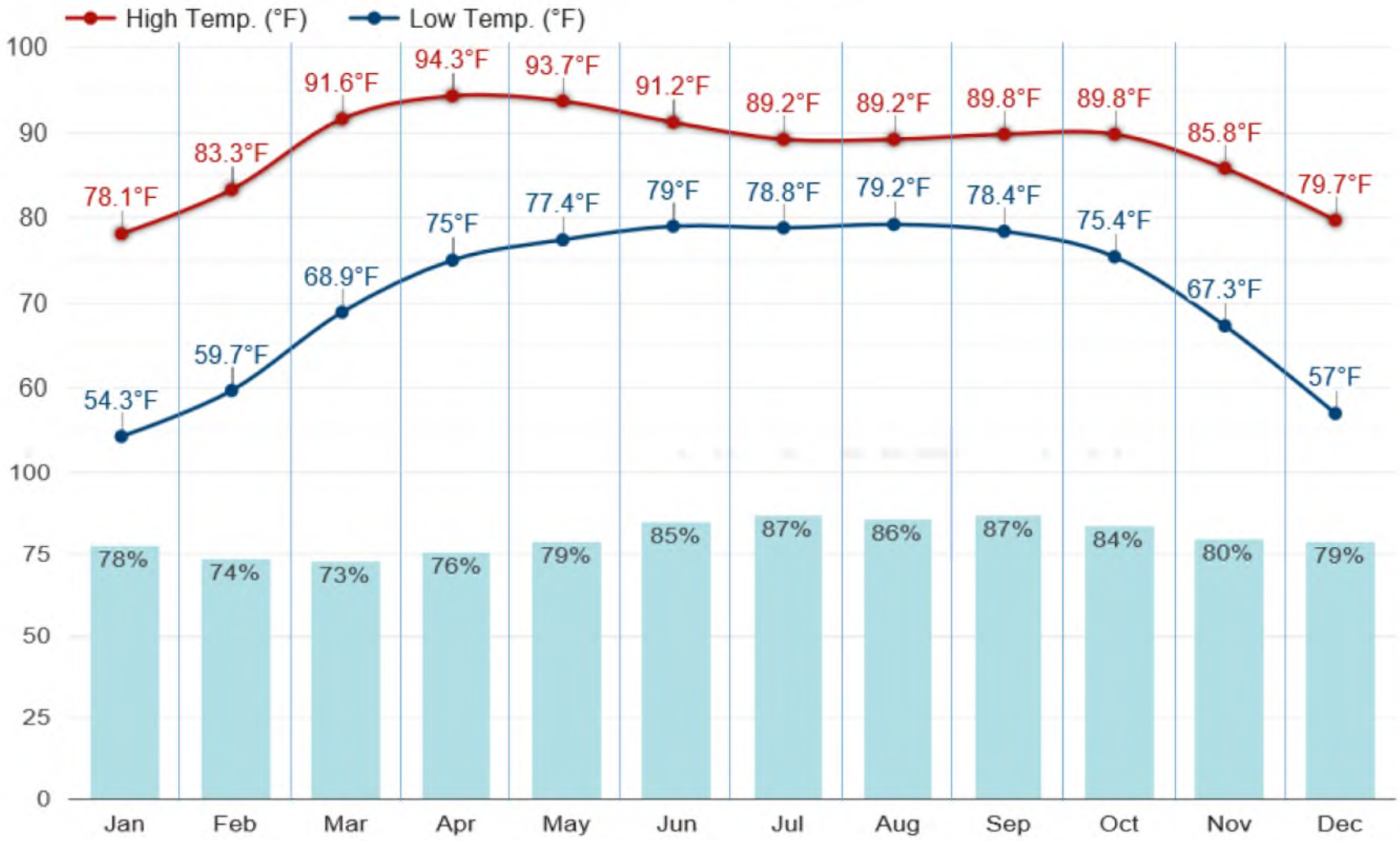
- Latitude : 22.27~22.49
- Long : 89.19~89.59



Source: google earth

Geography and Climate

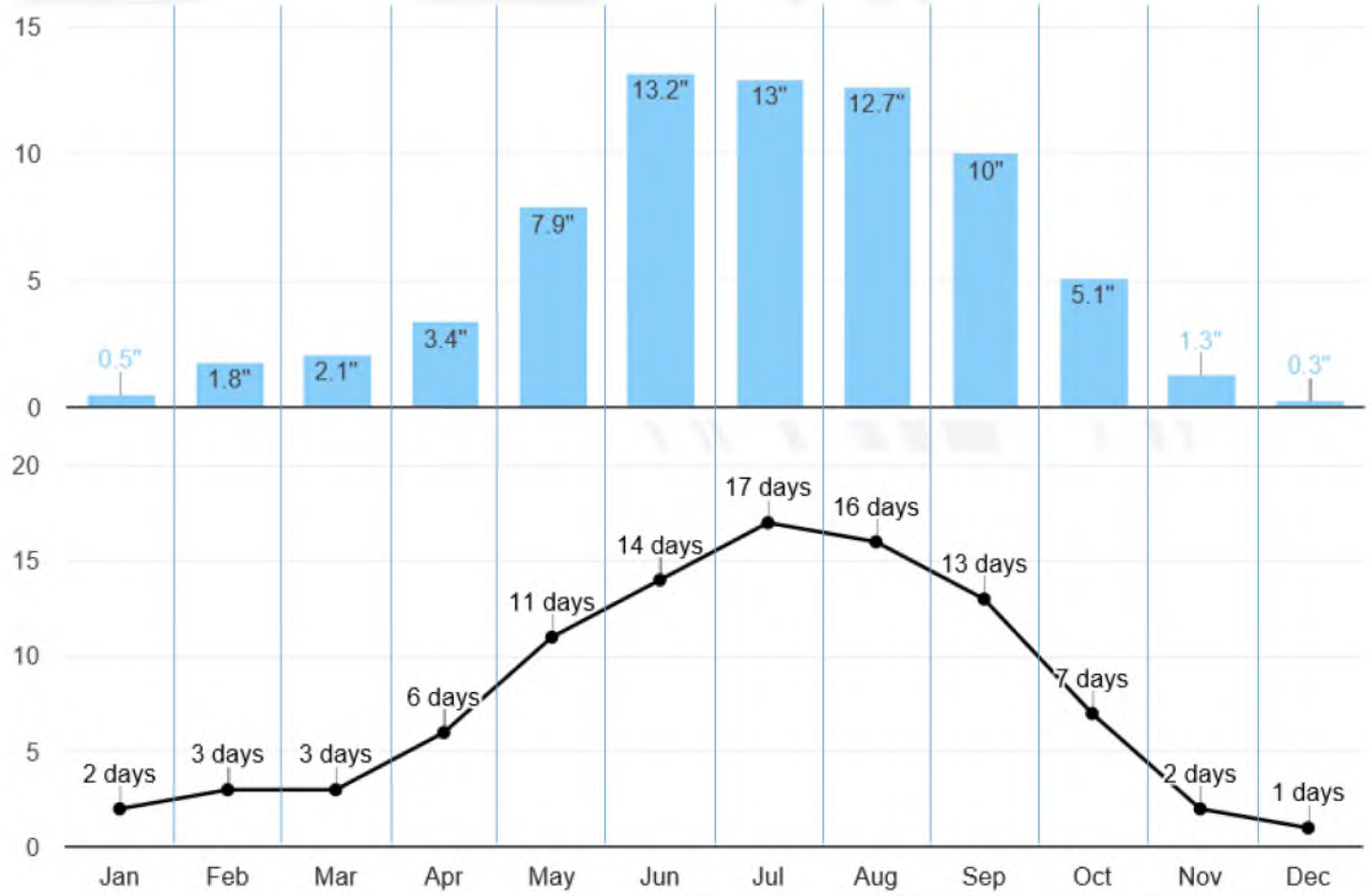
Temperature and humidity



Source: weatheronline

Geography and Climate

Rainfall amount & Rainfall days



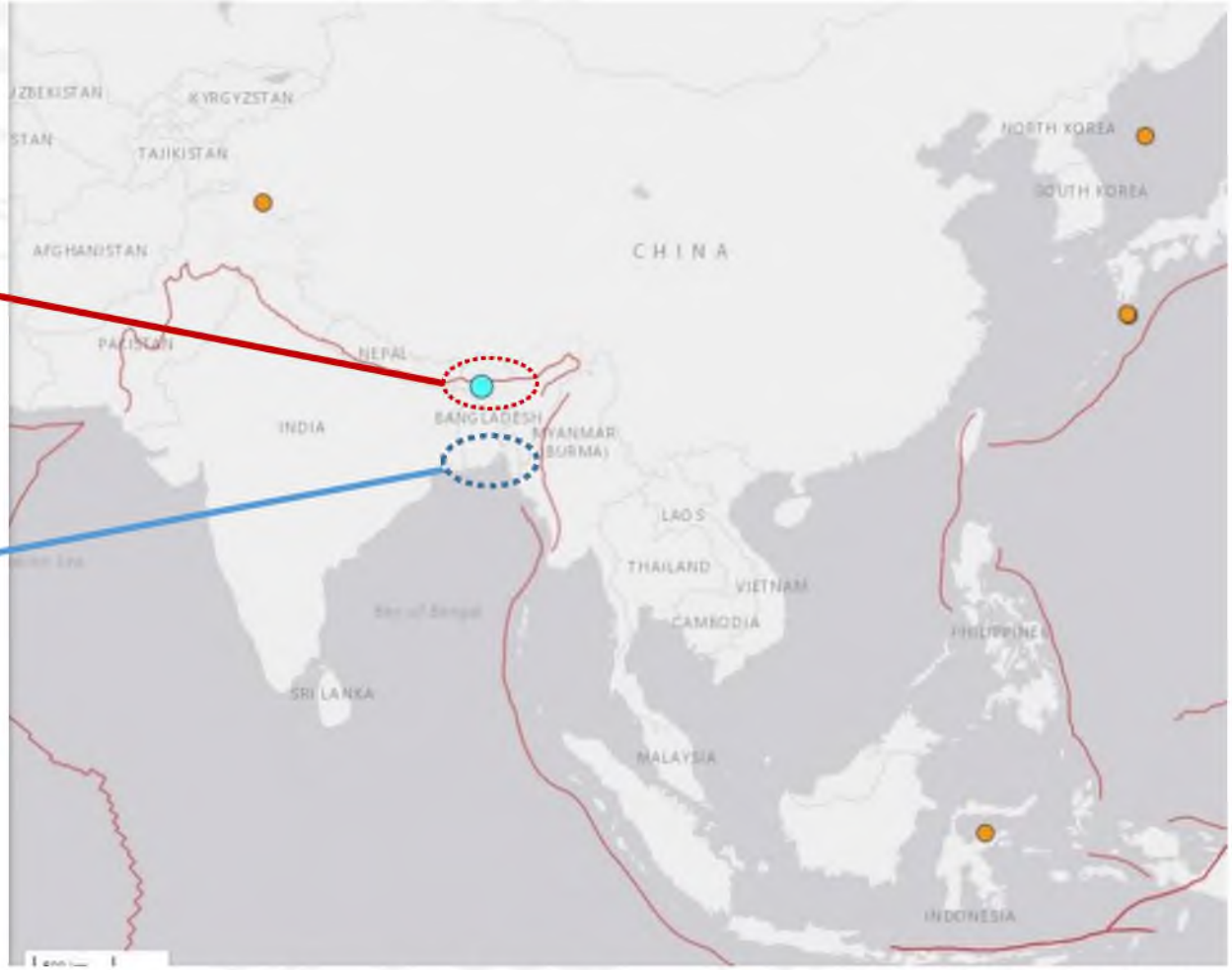
Source: weatheronline

Geography and Climate

Earthquake

Northern Mountain Area :
- High frequency of earthquakes

Northern Coast Area :
- low frequency of earthquakes

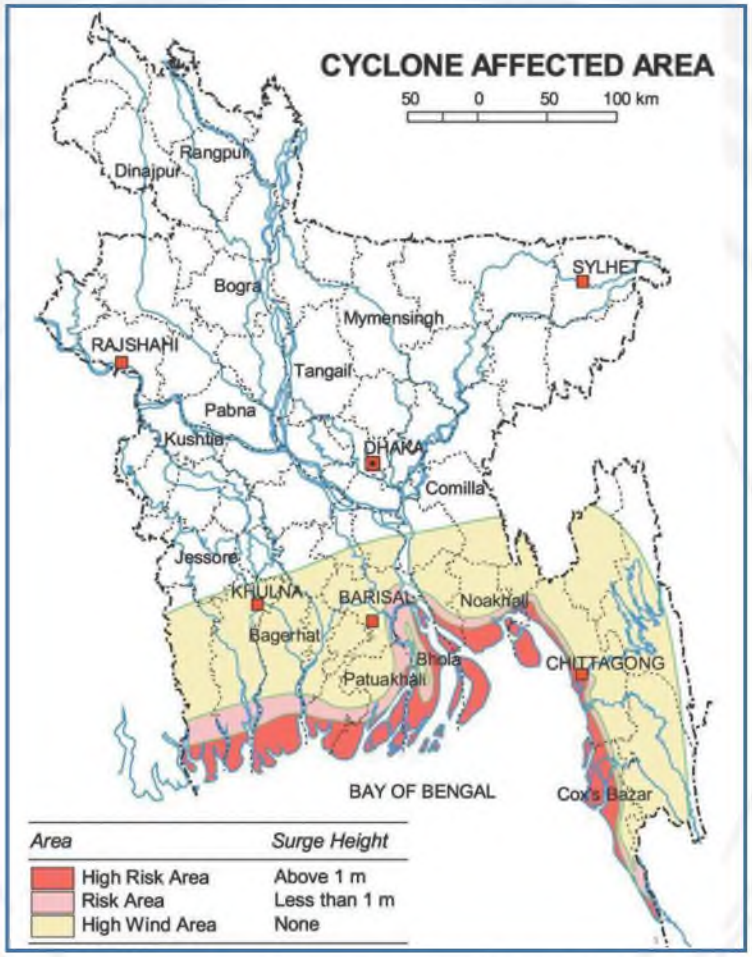


Source: The Dailystar

Geography and Climate

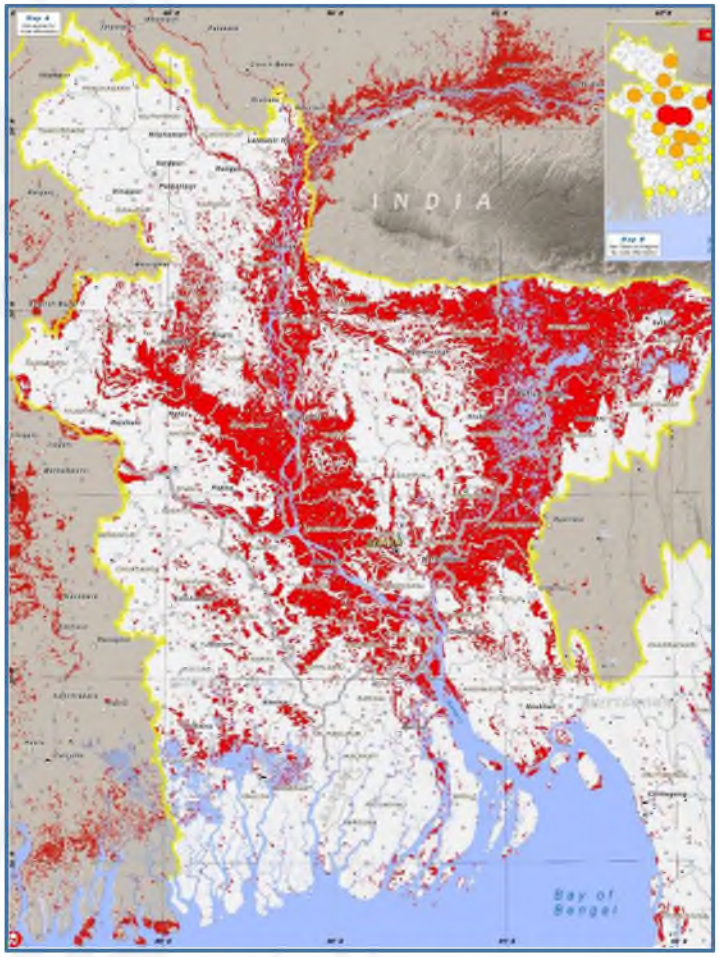
Cyclone & Flooding

- Cyclone map in Bangladesh



Source: www. Sparrso.gov.bd

- Flooding map in Bangladesh



Source: www. Unitar.org

Review existing material performance and guideline

Guideline of construction materials

Minimum Standards for Adequate Housing

No	STANDARDS	SPECIFIC DETAILS
1	Security of tenure is guaranteed for a set period of time of at least 30 years	• Assessed the current situation • Deriving necessary items to guarantee 30 years • Proof and documentations is to be provided to the inhabitatnts
2	Access to safe water and sanitation solutions are to be provided	• At least 1 standard toilet per household • Access to ample safe water – 300m from house • Construction of toilet & water supply solution from hazard
3	All housing is built with materials and techniques that allow easy maintenance, repair and duplication	• Preference to local, well-known and available materials • Focus on local techniques and tricks • Introduction of new materials and techniques • Look into options to produce new materials locally • Repair and maintenance cost within the household's budet
4	All housing and sites are adapted to the local hazard profile to resist recurrent disaster over 30 years	• Public: Elimination of obvious exposed risks • Individual/site: Alternative plans for risky areas such as river edge • Built in the minimum technical standard set

Guideline of construction materials

Minimum Standards for Adequate Housing

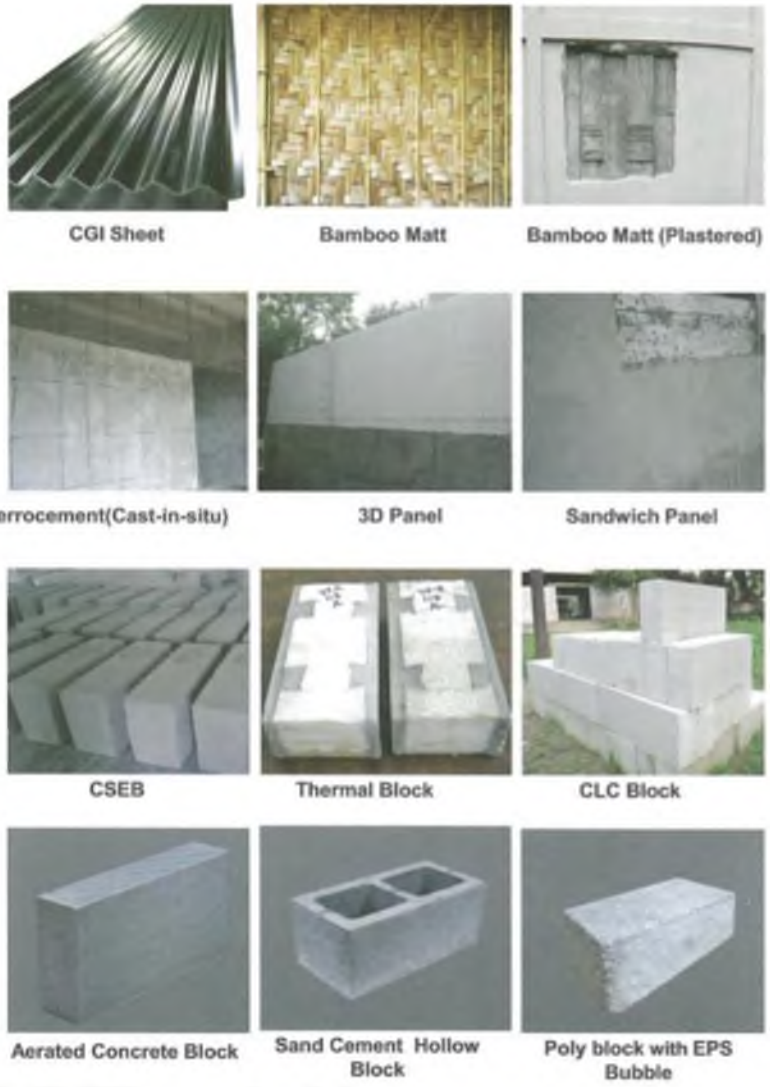
No	STANDARDS	SPECIFIC DETAILS
5	All housing offers a comfortable and healthy internal climate	• Minimum area for 2-3 house members (min. 3.6m^2 /person) • At least 2 windows for main room/ at least 1 window in each additional spaces • All windows must all fitted with a system • Additional ventilation openings (Kitchen, under the roof)
6	All housing is adapted to special and specific needs of its inhabitants	• 5~10% of the budget for the house is allocated to adapt standard house designs to the specific needs of individual households Spaces that can secure for household's spare time
7	All housing is functional, culturally appropriate and adaptable	• Each house should be provided with 2 doors if it is possible (main entry and secondary exit) • Standard designs are adapted to cultural practices • Additional space for training is to be conducted for repair and maintenance • Each house is built so that it can be easily adapted or expanded upon • Safe and appropriate place for education and training
8	All housing should be situated as close as possible to employment and education opportunities, medical and other social services	• Accessibility to housing sites is to be guaranteed • Accessibility to livelihood opportunity and services

Local construction material producer

Available construction materials

- ✓ According to HBRI guidelines, available materials on Southern coast area are shown on pictures (RHS)
- ✓ Field-based materials based on cement
- ✓ Masonry - Cement blocks
- ✓ 3D panels and double styrofoam blocks by foamed styrofoam
- ✓ Foam block and Cellulose mixture block

- ✓ Materials other than CGI Sheet and Bamboo Matt are not utilized locally
- ✓ Development of product with low cost supply is necessary



Local construction material producer

Cement based construction materials

- ✓ Production of various vibration molding products (eg. flooring material, and brick etc. which mainly based on cement)
- ✓ Production of 10mm tile panel (using silicon mold)
- ✓ Quality controls at Khulna University
- ✓ Good product quality

- ✓ Due to the high price of cement and aggregate, it is difficult to apply for low-income class
- ✓ Can be mixed with low cost materials
- ✓ Able to apply on Southern coast area middle-class

Cement Brick Factory

Vibration process

Molded cement bricks

Brick mold

Cement tile

Silicon mold

Construction Material Manufacturers in Southern coast area

Clay & soil based construction materials

- ✓ Locally, many fired brick factories are scattered - Coal is used as fuel (Imports from India etc.)
- ✓ Able to supply various plastic products (roofing material, bricks etc.)
- ✓ Press molding due to the manual method
- ✓ Smooth supply of raw materials (existence of large amount foreign substances)

- ✓ Problems of heat source due to restriction of coal use
- ✓ Limitation of wood usage as fuel
- ✓ Need alternative fuel (in Rwanda, use banana leaf stem)
- ✓ Excellent durability with good maintained proper price which brings good result on utilization

Brick Factory by use of coal fuel

Plastic brick

Plastic roof tile

Fired fuel

Clay raw material

Various product

Proposal of localization construction material

Localization situation analysis

SWOT analysis

S Strength 강점

- ✓ Establish guidelines for various agencies such as HBRI
- ✓ Abundant workforce and low labor costs
- ✓ Possibility of securing materials for localization of construction materials

W Weakness 약점

- ✓ Weak infrastructure for housing construction(eg. roads)
- ✓ Diversity of site condition (riverside areas, inner areas, etc.)
- ✓ Quality problems of mixed water for construction materials (eg. high salt concentration on material)
- ✓ High price of basic construction materials (eg. cement etc.)

O Opportunity 기회

- ✓ Strong will to improve on village
- ✓ Abundant workforce
- ✓ High economic growth rate
- ✓ Industrial activation based on region (Agriculture and fishery)
- ✓ Many support organization (NGOs, etc.)

T Threat 위협

- ✓ Regional imbalance
- ✓ Insufficient establishment of social infrastructure (Politics, Economy)
- ✓ Weak at technical education infrastructure
- ✓ Weak at construction material product infrastructure

Proposal

Construction materials for wall

- **Aerated Inoganic Blocks: The main raw material is Cement, Fly ash, Soil, Sodium silicate, Hydrogen peroxide**
- **Cellulose Light-weight Block & Boards: The main raw material is Straw, Cement, Clay**
- **Cement Extrusion Panels : The main raw material is Cement, Silica powder, sand, Fiber mortar construction**

Aerated Bricks	Cellulose Brick & Boards	Vacuum extrusion panel (Exterior)
		
✓ Use small amount of cement, fly ash and clay ✓ Manufacture hardening form with in room temperature ✓ Lightweight, excellent processable product ✓ Able to use local materials	✓ Use rice straw for main material ✓ Glue is applied differently depending on purpose of use ✓ Exterior material -cement-bonded ✓ Interior material – glued resin material. ✓ Able to utilize with local abundant rice straw	✓ Need to examine exterior materials utilization to ensure durability ✓ High price and weak field processability ✓ Optimized product with high density and 30 years of durablity

Proposal

Aerated Inoganic Blocks

	Law material	Additive	Description	Specifications	Cost
Wall	Cement Fly ash Soil	Sidium Silicate Hydrogen peroxide	• Fly ash with high CaO content and other minerals are used for raw material • Use of alkali stimulant such as cement to improve the reactivity • Providing more than 50% of voids to result on lightweight and excellent heat insulation • Superior workability in the field by using saw • Finishing mortar applied to improve surface water absorption	- Density : > 0.5g/cm3 - Compressive strength : < 3Mpa - Water absorption : >15%	Same as ordinary cement brick

- It is divided into general curing and autoclave curing.
- Autoclave curing products can have high strength. However, equipment is very expensive
- Excellent on moisture control due to the plenty of pores in the material, and which is suitable for humid areas such as Southern coast of Bangladesh
- However, since it is not highly resistant to water, it can be used only as an interior material.

Proposal

Cellulose Light-weight Block & Boards

	Law material	Additive	Description	Specifications	Cost
Interior & Exterior Wall	Straw	Cement, Resin	• After drying the straw, cut it into 25mm and mixed with cement. • Depending on the type of binder, it is divided into interior and exterior materials. • Various products can be produced according to molding pressure • Variety of products can be produced by adjusting the thickness of the straw • For use of exterior materials, need to take water resistance measures.	- Density : 0.3~1.0g/cm3 - Flexural strength : < 2Mpa - Water absorption : Cement base : >20% Resin base : >5%	

- ✓ Various types of products can be produced depending on the kind of straw, pressure molding method
- ✓ Manual method will have limitation to product difference sizes (Possibility to make product smaller than the board size 500 * 500 * 15mm)
- ✓ Able to perform both humidity control function and insulation function by micro-pores of fiber and heat insulation.
- ✓ Necessary to increase moisture resistance for exterior materials
- ✓ Increase economic efficiency by use of the largest amount of raw materials which is available in Bangladesh

Proposal

Cement Extrusion Panels

	Law material	Additive	Description	Specifications	Cost
Interior & Exterior Wall	Cement, Silica Powder, sand	HPMC, Fiber,	• High density of vacuum extrusion molding products • No surface degradation due to excellent moisture resistance and length stability • Highlighted exposed concrete image • Able to use as interior material, exterior material, flooring material, roof material by various assembly methods • Reinforced fibers can be substitute as straw pulverized powder • Used polypropylene and pulp for now	- Density : <1.5g/cm3 - Flexural strength : < 14Mpa - Water absorption : Cement base : >15%	

- ✓ Depending on the type of mold, product thickness can be varied from 25mm to 60mm
- ✓ Excellent durability with high density (30 years warranty - KICT exterior materials, many other Korean buildings built more than 30 years ago)
- ✓ High-density products which require separate processing tools and manufacture in the field
- ✓ Excellent sound quality which secure spaces
- ✓ Need to establish a plan for localization

Thank You

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Capacity Training Workshop
12-13 November 2018

DESIGN GUIDELINE FOR HOUSING CONSTRUCTION IN SOUTHERN COASTAL AREAS OF BANGLADESH

Mohammad Abu Sadeque PEng
Former Director
Housing and Building Research Institute
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Country Profile

Bangladesh at a Glance

- *Population - Over 160 million*
- *Total area - 147570 sq. km*
- *Population Density = 1100/sqm*
- *Agricultural land: 14 decimal per capita*
- *Clay Burnt Bricks Production = 25 billions*
- *Carbon emission from bricks = 25 million tons (25% of total National emission)*
- *25 million dwelling units in rural area*
- *Most houses are not disaster resilient*
- Fully damaged houses approx. 300,000 and Partially damaged houses more or less 500,000.

Agricultural Land

- Every year land loss about 1%
  - 80% due to Unplanned Rural Housing
  - 17% due to Brick Manufacturing
- In 2040 – Projected Population 240 million
  - Projected Food Shortage – 50 million (if it continues)

Agricultural Land ..??

Land Fertility ..??

Food Security..??

Some Definitions:

Housing Typology: Types of house based on materials and technology use. Example: Pre-cast Ferro-cement Type

Housing Class: Types of house based on structure life or longevity. Example: Durable Class

Safer House: Houses which are resilience to both vertical and lateral loads. Example: Cyclone resilient Transitional House

Emergency Class: Shelters having life more or less one year and are of very temporary nature

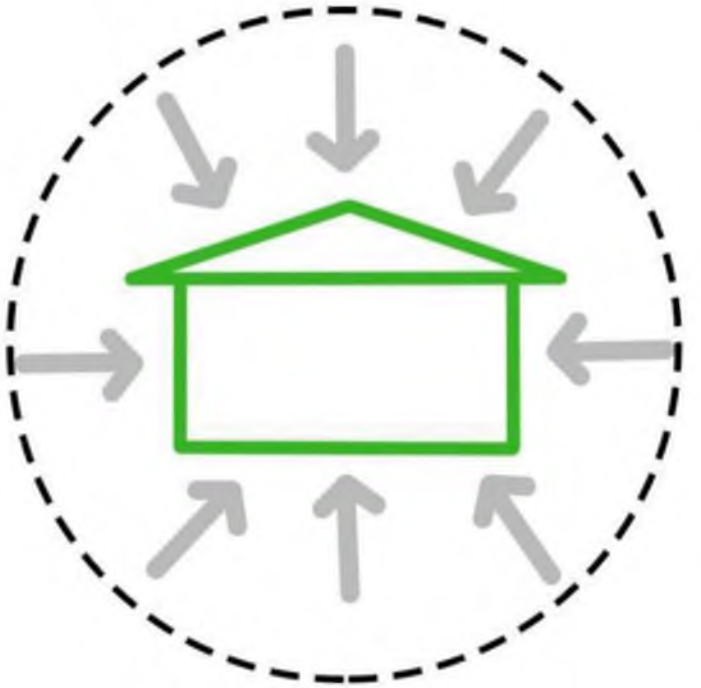
Transitional Class: Shelters having life from 10 to 15 years and are of Safer House.

Durable Class: Shelters having life more than 30 years and are of Safe House

DESIGN CONSIDERATIONS

DESIGN CONSIDERATIONS

1. Resilience Against the Impacts

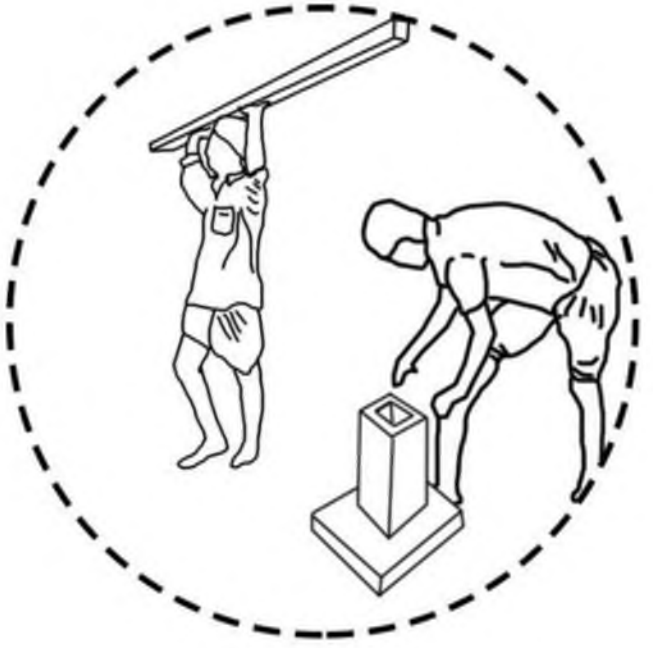


2. Climate responsive design approach

DESIGN CONSIDERATIONS

3. Introduction of low impact building material and construction technology

4. Development of standardized and labour-friendly Pre -fabricated mode of construction using minimum/ economic building elements



DESIGN CONSIDERATIONS

5. Addressing contextual issues

PRESENT HOUSING PRACTICES
and
CONSEQUENCE OF CYCLONE, TIDAL SURGE & SALINITY

Existing Local Practices in Coastal Regions

Chungapasha Government Housing

Houses by INGO

INGO Housing

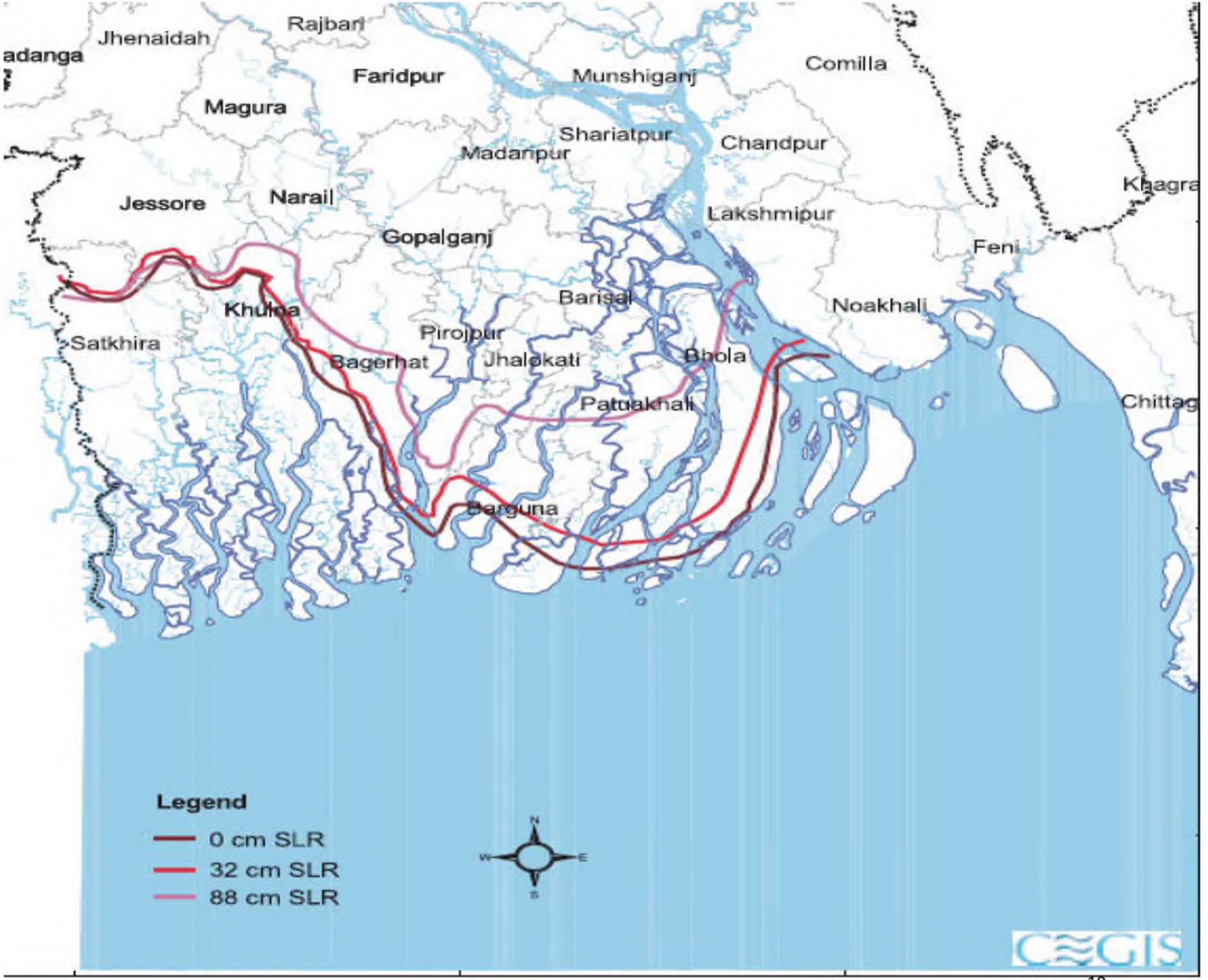
Rakhain Community Houses

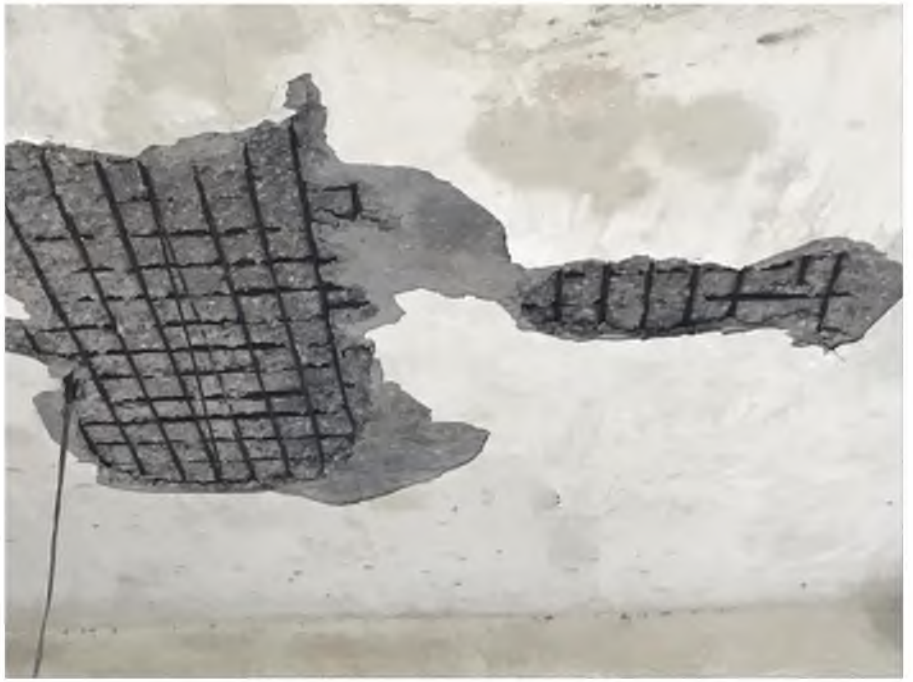
HOUSES BUILT ON
AGRICULTURAL LAND

USE OF CGI SHEET IN COASTAL AREA

After Cyclone and Surge

SALINITY MAP





Cyclone Shelter:

- Structure service life 15 years (as per local people)
- Coarse Aggregate – stone chips (physical inspection)

Photo: Sadeque, Aug 18

Cyclone Shelter Masterplan 1991
Coarse Aggregate is brick chips

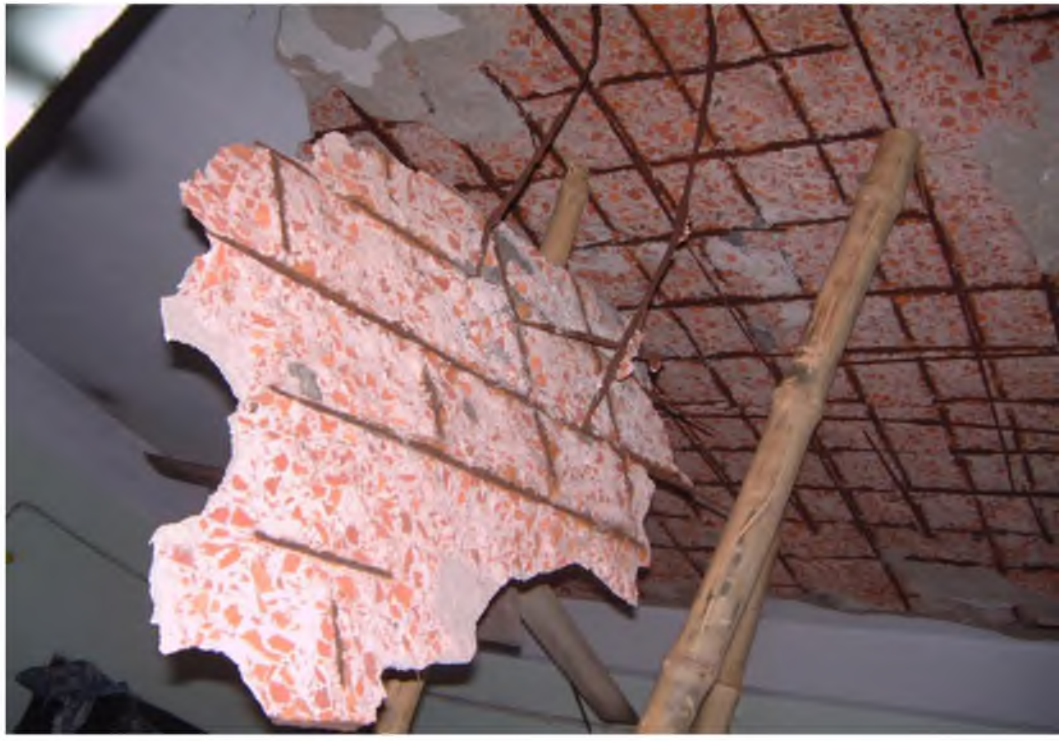


Photo: Sadeque, Around 2010

7th Five Years Plan

Housing and Building Research Institute will focus on bringing innovation including alternatives to traditional bricks with a target of achieving zero use of agricultural top soil for brick production, and standardization of new construction materials through research.

Prime Minister's Directives to HBRI

- An intense initiative has to be undertaken to publicize the HBRI's act of innovations regarding new Building Materials.
- Appropriate planning has to be drafted to properly utilize and apply the research outcomes.
- Ferro cement must be introduced in various housing and rural settlement.
- Research initiatives must be undertaken regarding construction of hollow blocks from river dredged sand &
- Measures must be taken to produce environment-friendly bricks (Non-fire) from river dragged soil.

Bangladesh and COP-21

In this INDC (Intended Nationally Determined Contributions) Bangladesh pledged an unconditional 5% greenhouse gas emission cut by 2030, adding that with financing and technology support it will cut emissions by 15%.

Bangladesh and COP-22

Bangladesh address the climate challenges and calling for global efforts to address the issue of climate-induced migrants to make the objectives of SDGs successful.

Bangladesh and COP-23

Strongly raised the climate change issues emphasized the importance of the Paris agreement and gave the opinion that the integration of NDCs and SDGs into national development process is important.

Goal 11

Sustainable cities and Communities: Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 13

Climate action: Take urgent action to combat climate change and its impacts

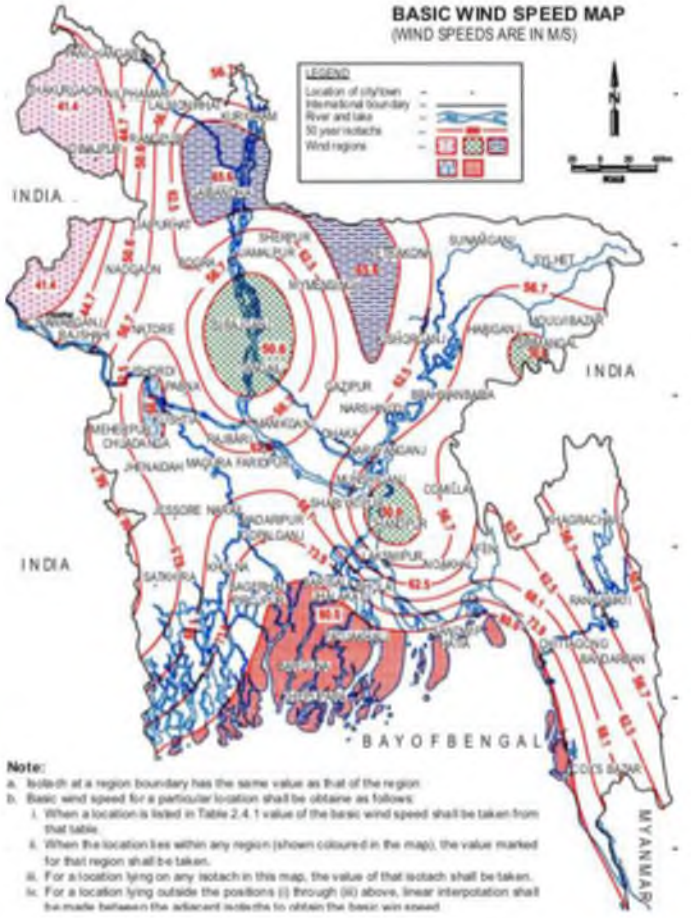
Goal 15

Life on land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Disaster Map for Coastal Areas

Map of area affected by cyclone, with indication of storm surge risk

Seismic Zoning Map - Bangladesh



Basic Wind Speed Map- Bangladesh

Design Standards for Rural Housing

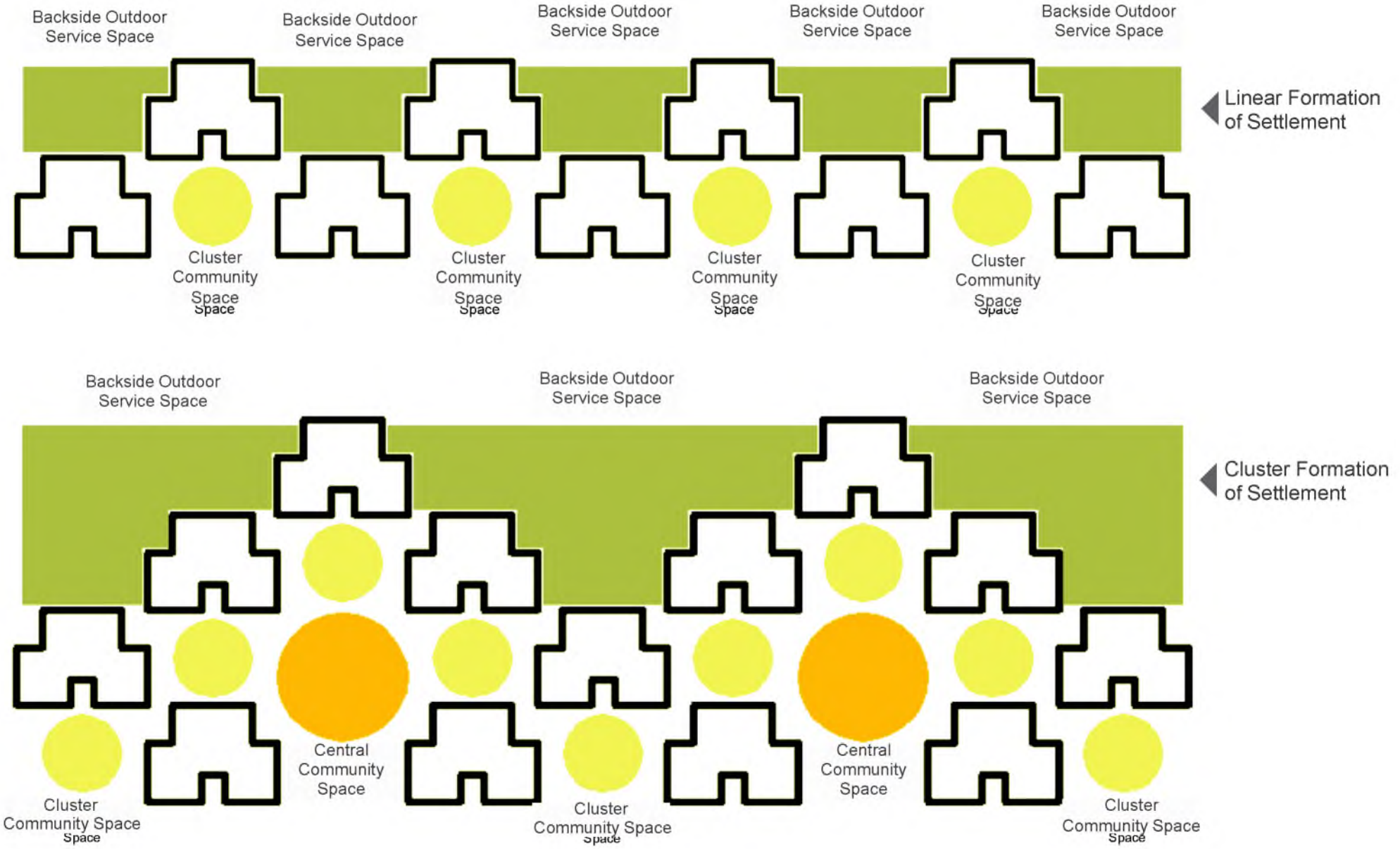
Standard 1	Security of tenure is guaranteed for a set period of time of at least 30 years
Standard 2	Access to safe water and sanitation solutions are to be provided
Standard 3	All housing is built with materials and techniques that allow easy maintenance, repair and duplication
Standard 4	All housing and sites are adapted to the local hazard profile to resist recurrent disasters over 30 years
Standard 5	All housing offers a comfortable and healthy internal climate
Standard 6	All housing is adapted to special and specific needs of its inhabitants
Standard 7	All housing is functional, culturally appropriate and adaptable
Standard 8	All housing should be situated as close as possible to employment and education opportunities, medical and other social services

DESIGN GUIDELINES

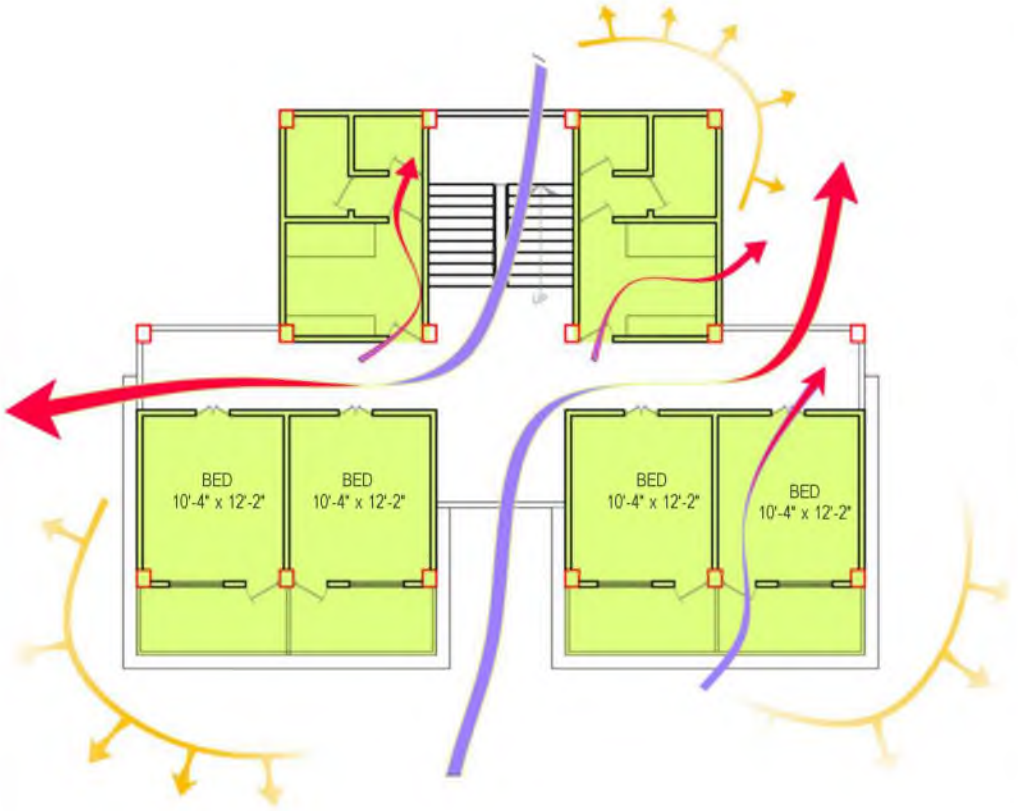
Climatic Factors for Design Consideration

Cyclone
Tidal Surge
High Wind
Salinity
Nor Westerly
Driving Rain
River Bank Erosion
Solar Radiation

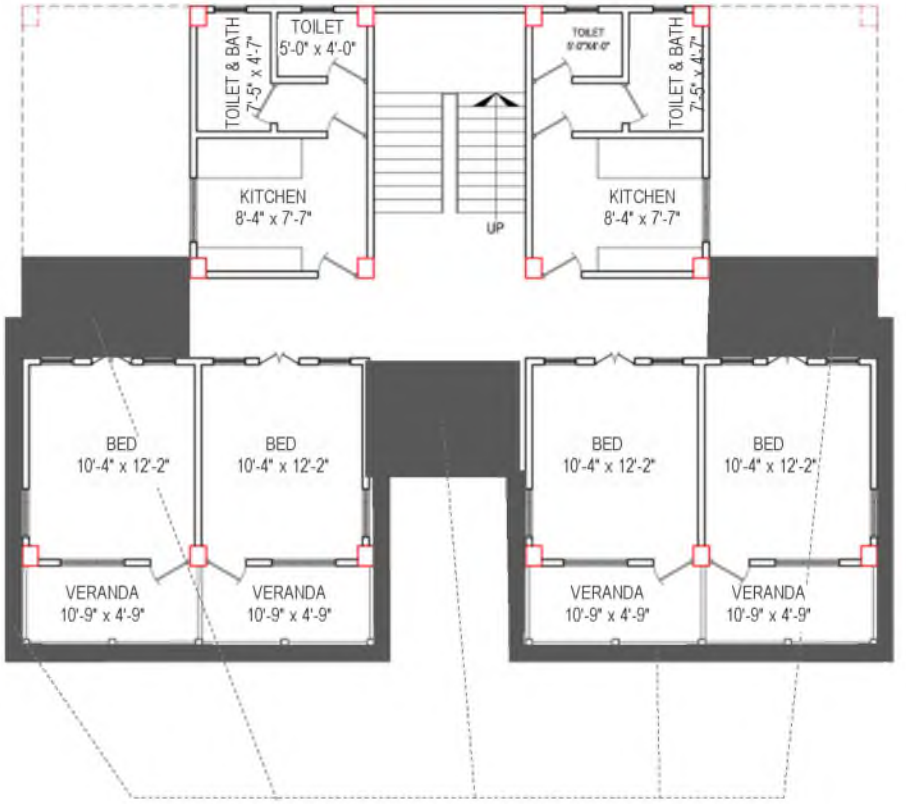
SETTLEMENT FORMATION



CLIMATIC CONSIDERATIONS

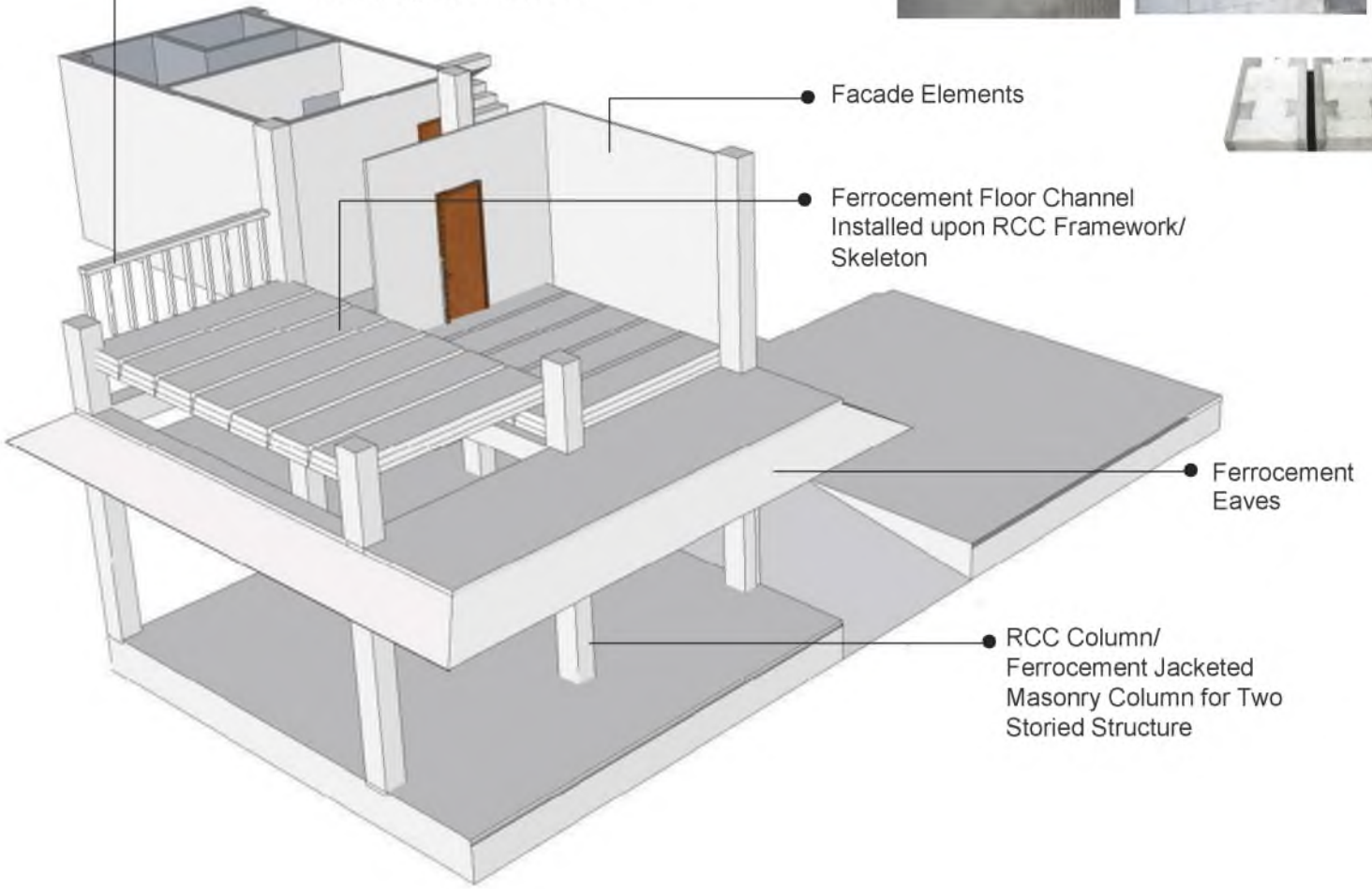


Collection of fragmented forms help in quick cooling off the whole mass via radiated heat dissipation and enhanced mode of cross ventilation



Shading Devices all around the living units in forms of either balcony, eaves or corridor turns the structure into somewhat a heat sink rather being a thermal mass and hence reduce the degree of heating up.

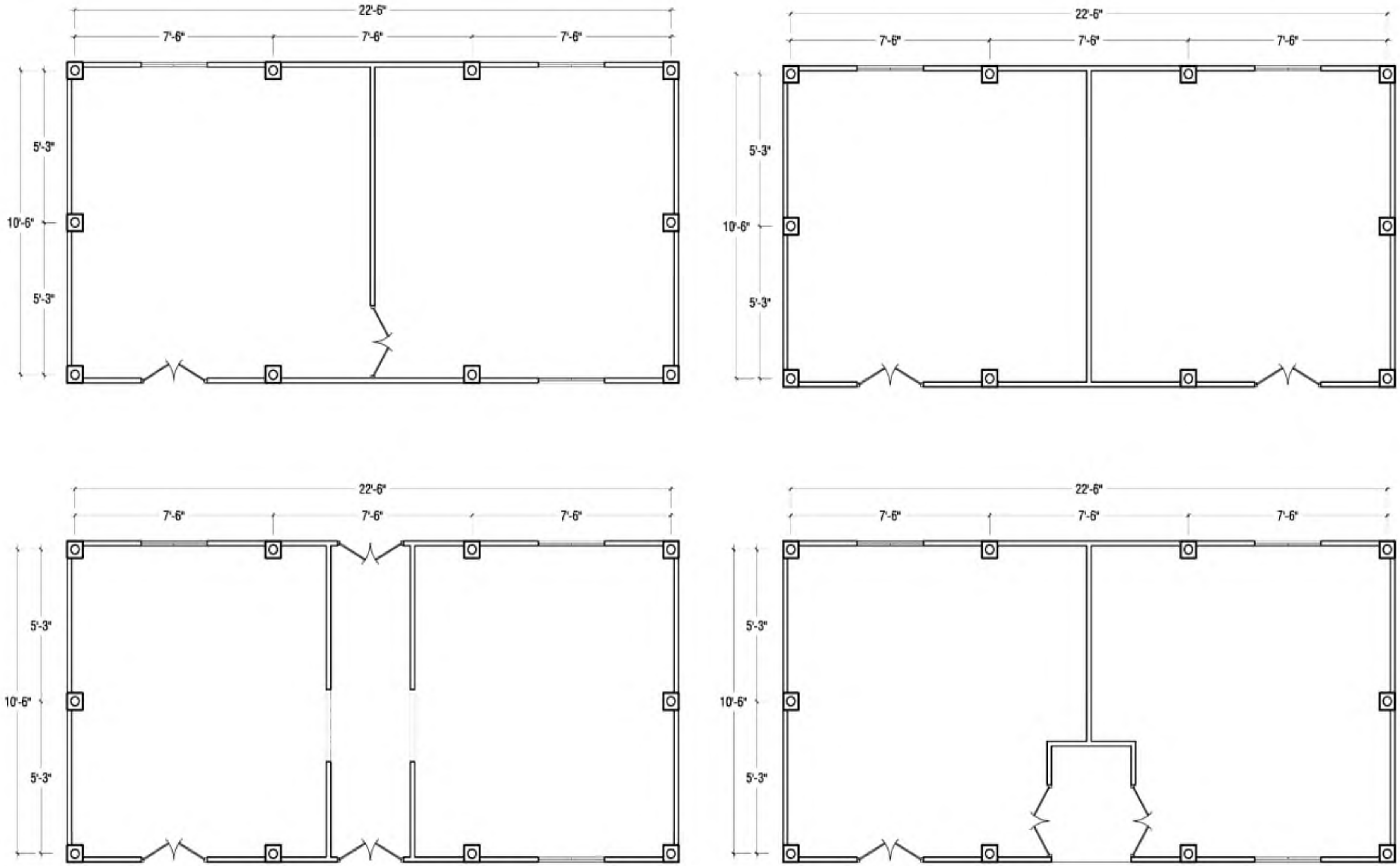
STRUCTURE & MATERIAL



Facade Elements

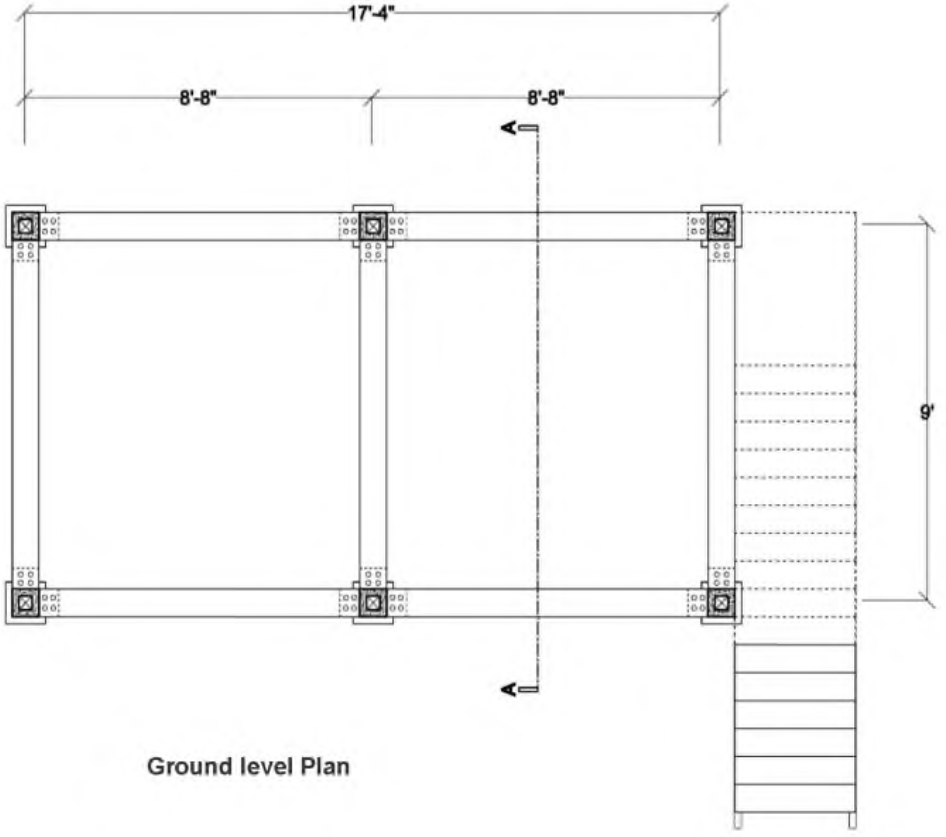
Roofing and slab Element

Example – 1: Single Story House

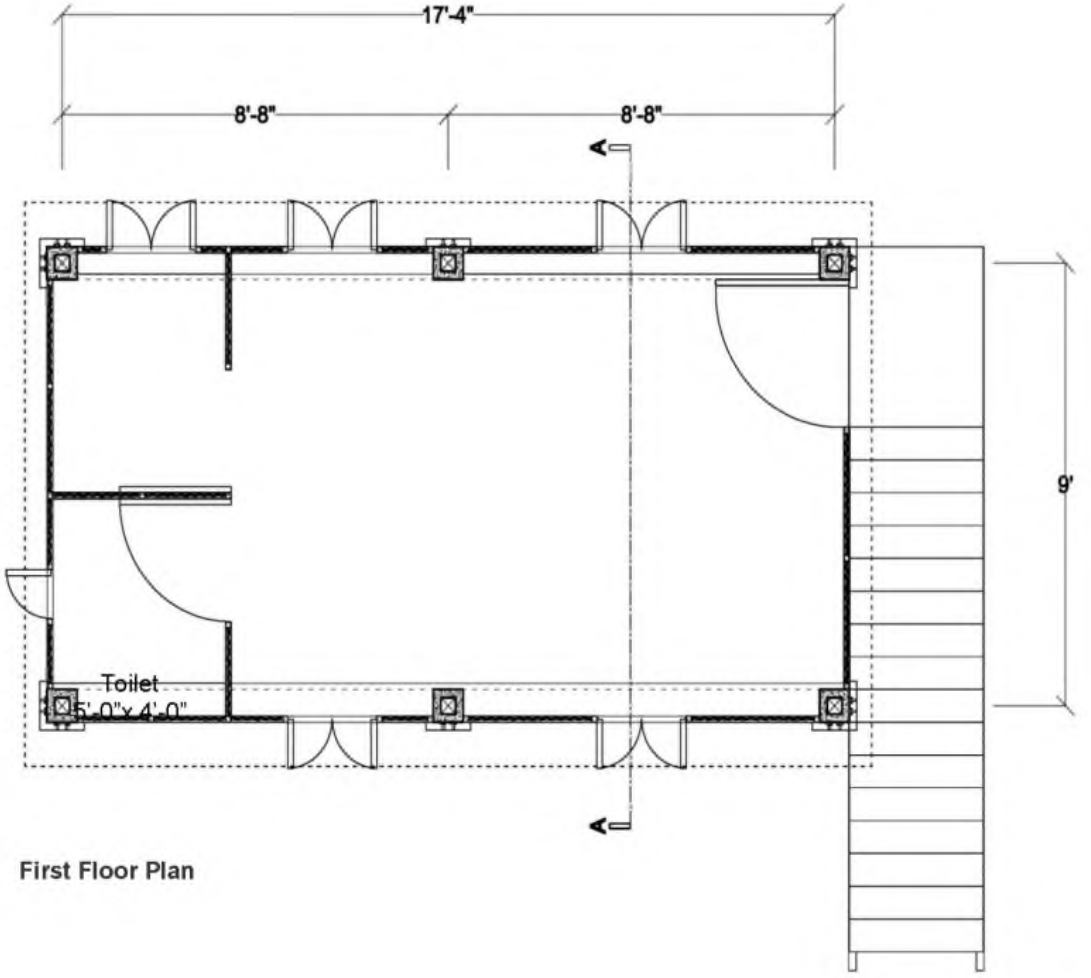


PLAN

Example – 2: Stilt House

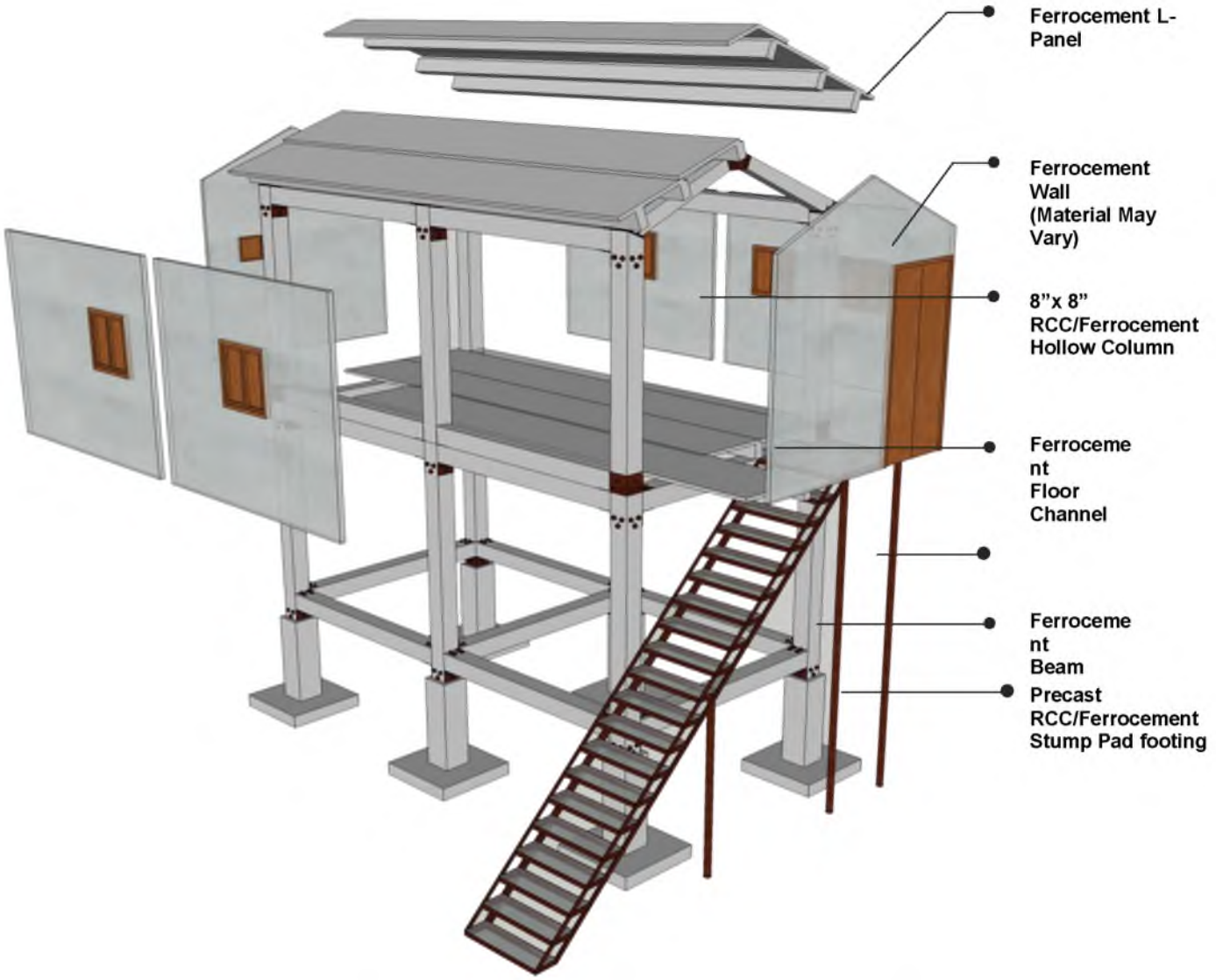


Ground level Plan



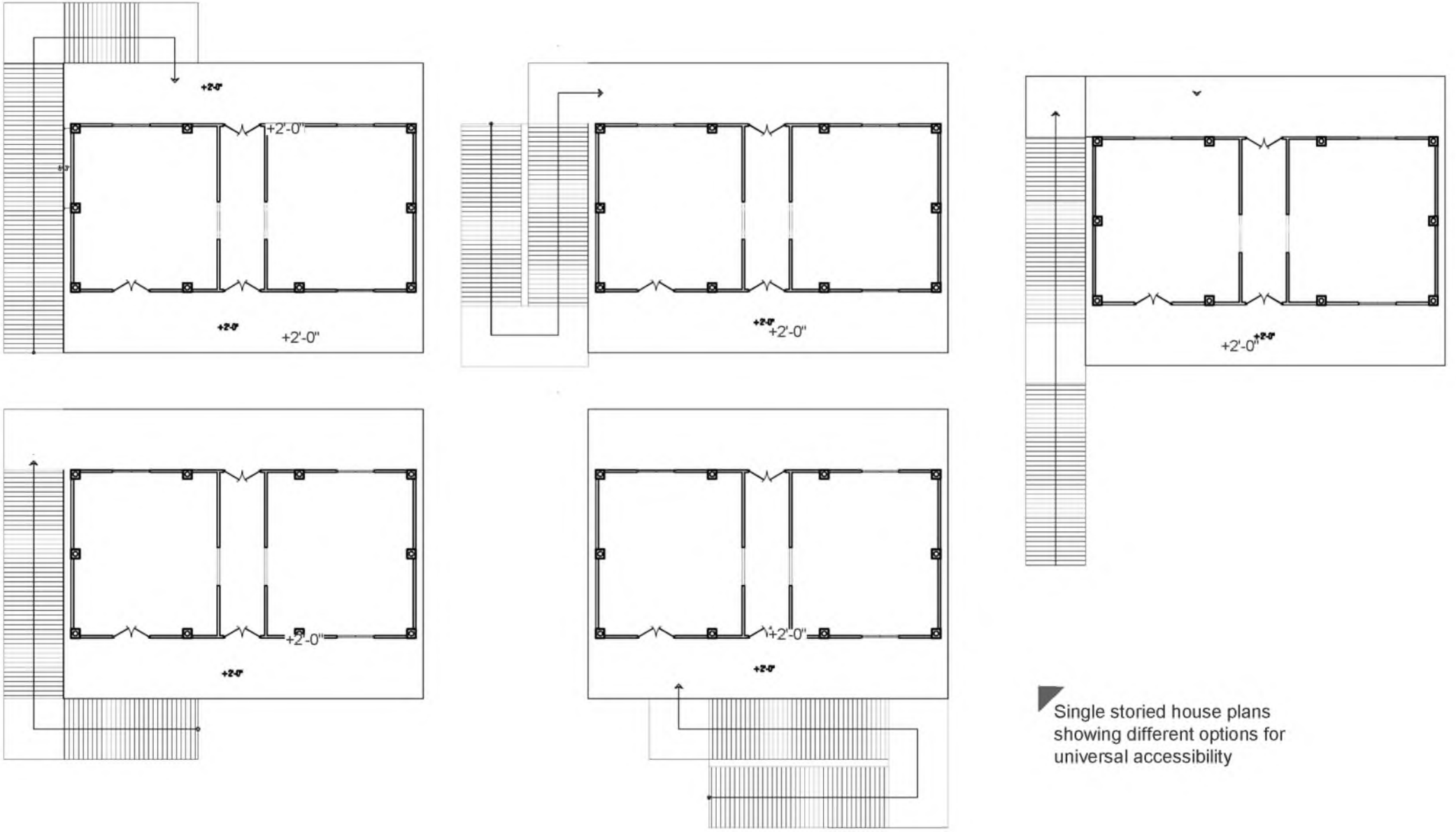
First Floor Plan

PLAN OF STILT HOUSE



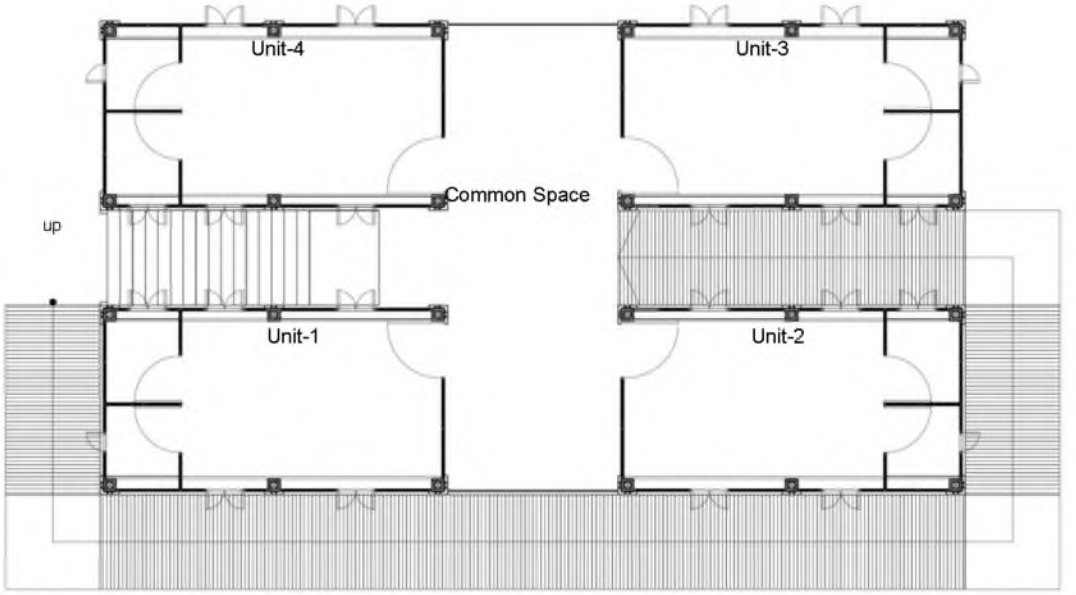
EXPLODED AXONOMETRIC VIEW OF THE SINGLE UNIT STILT HOUSE

Example – 3: Universally Accessible House



Single storied house plans showing different options for universal accessibility

Example-4: Universally Accessible Stilt House with Multiple Unit Options



Stilt house plan with four units for universal accessibility

House plans showing different options for universal accessibility

Example – 5: Stilt House with Future Expansion Provisions

Single House Unit with Grounded Footings

An improvised form of stump pad footing is employed to form the foundation for the overall assemblage of this stilt house unit.

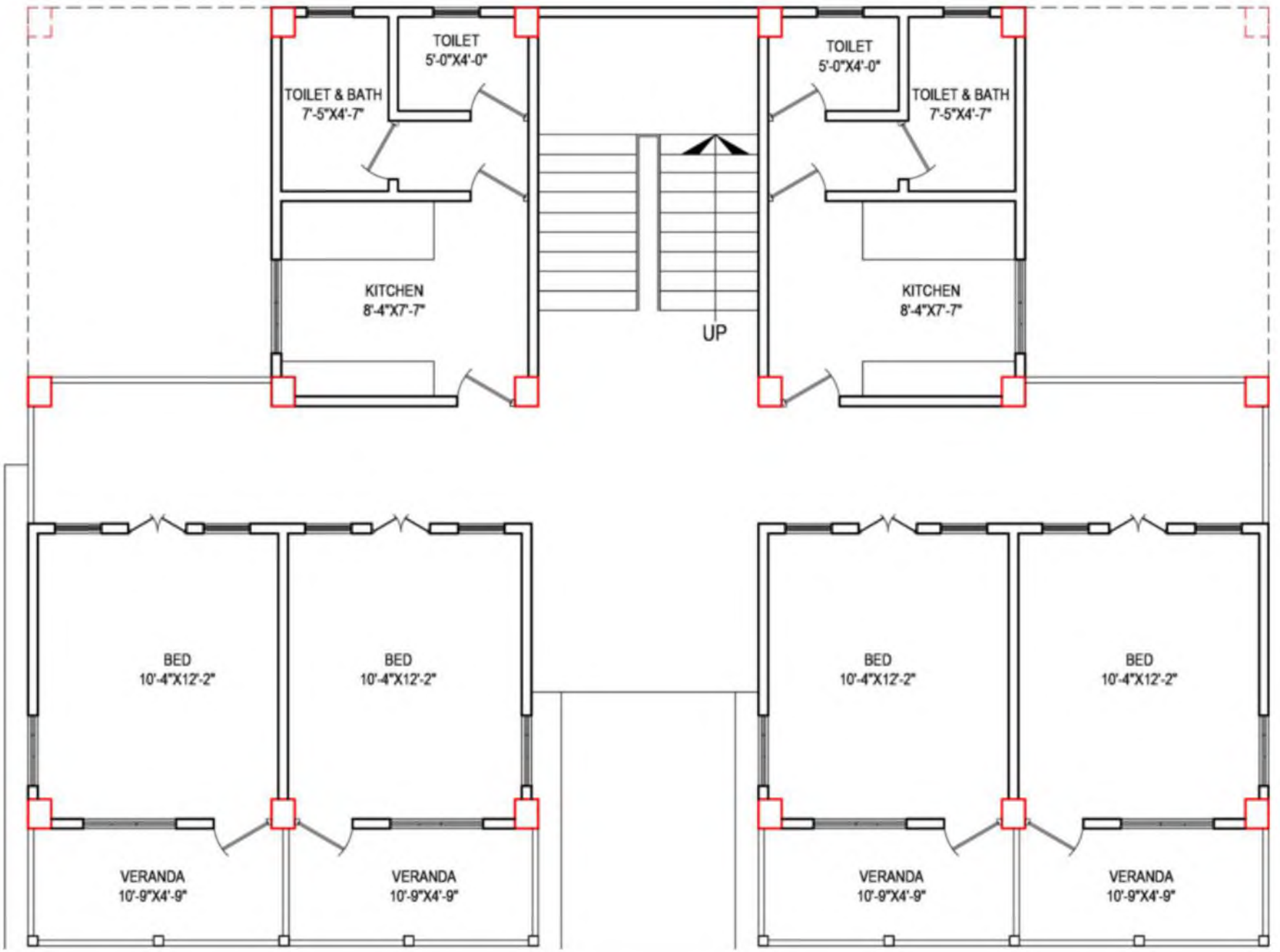
Single House Unit

The Single House unit comprises of a stair made of metal frame and Ferrocement trades that, if necessary can be shifted in accordance with the future expansion of the households. This flexible staircase, in its fixed position, can also indicate the directions for the future cluster formation.

Single House Unit with Possible Future Expansion

Considering the Inhabitant's requirement the house module can be multiplied around the given position of the staircase and formed into a cluster of multiple units.

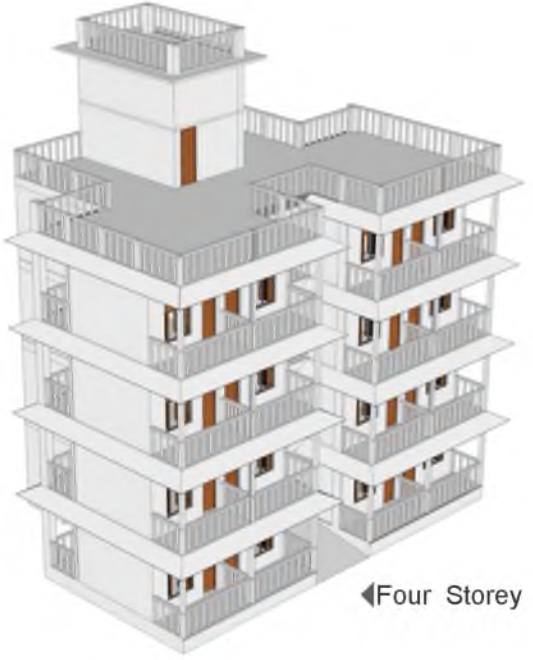
Example-6: Multi-story House with Future Expansion Provision



DIFFERENT FORMS OF STORY FORMATION

Single Storey

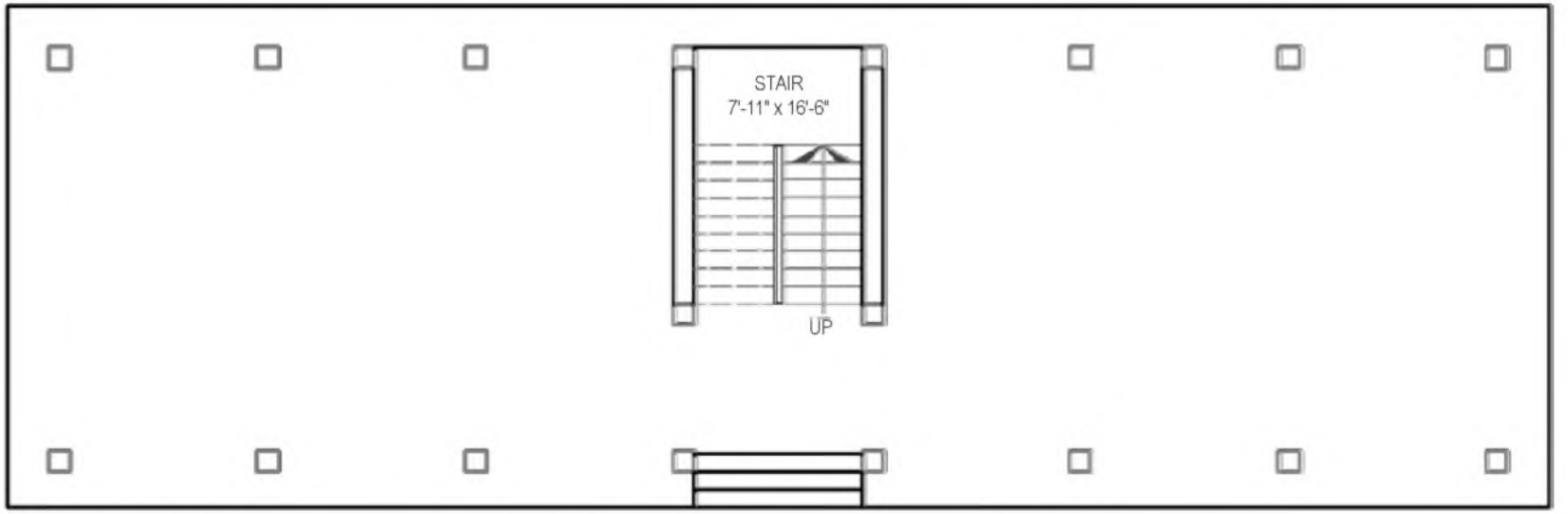
Two Storey



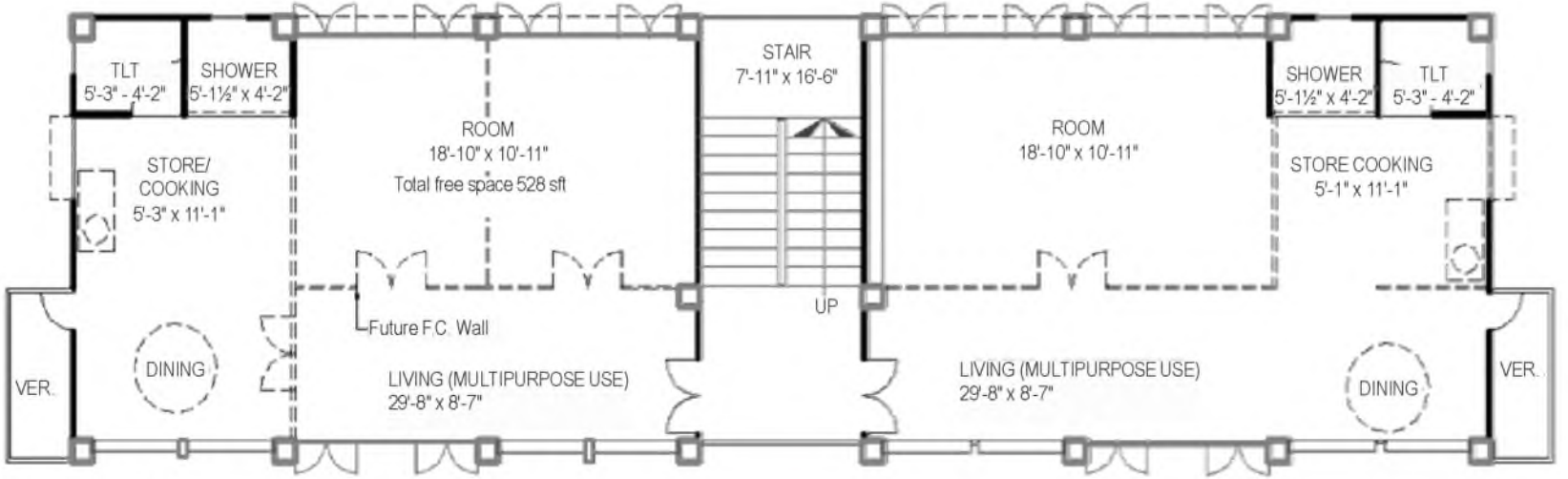
Four Storey

Three Storey

Example-7: Multi-story House



Ground Floor Plan



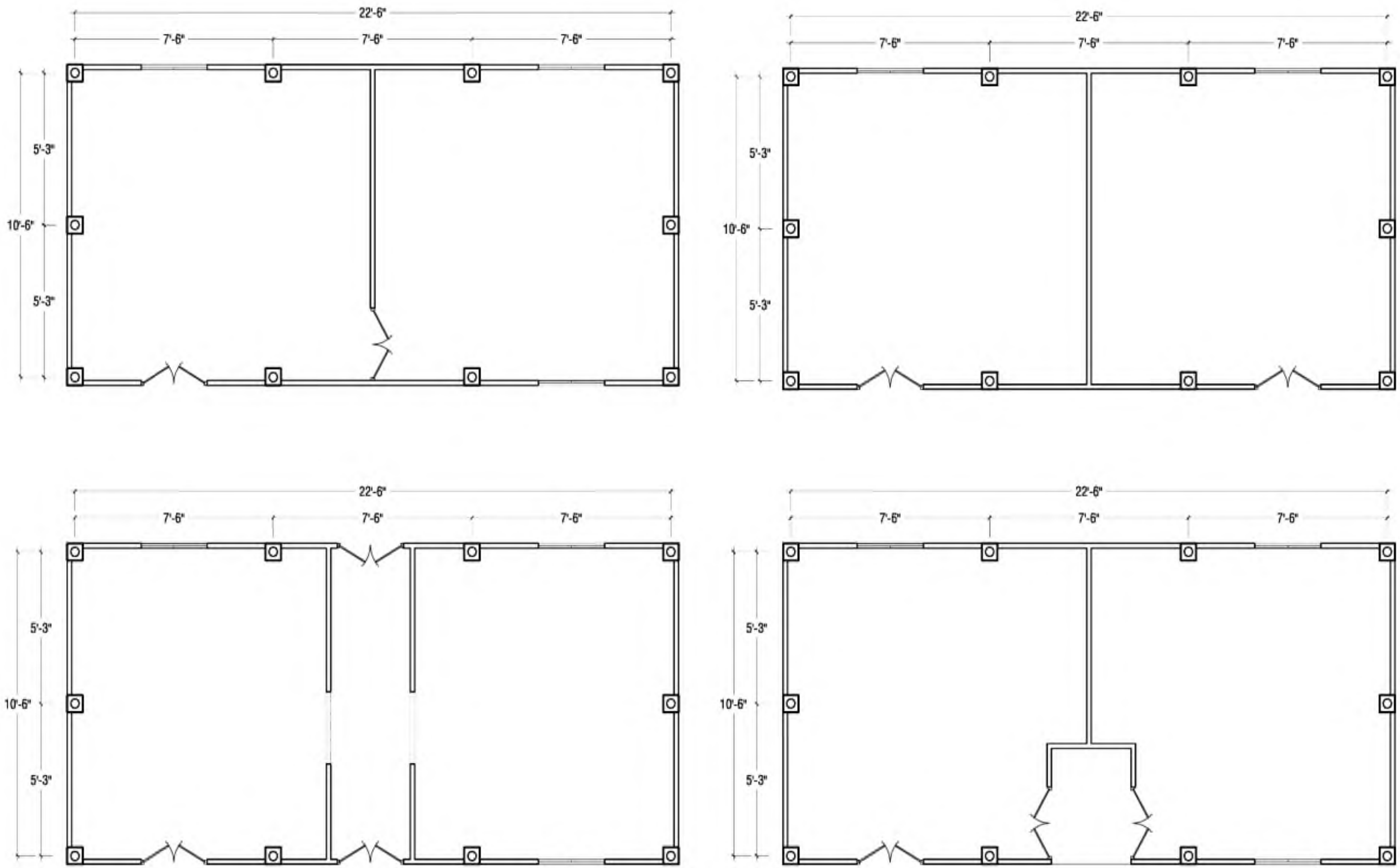
Typical Floor Plan

FIVE STORY MODEL HOUSE BUILT IN HBRI PREMISES

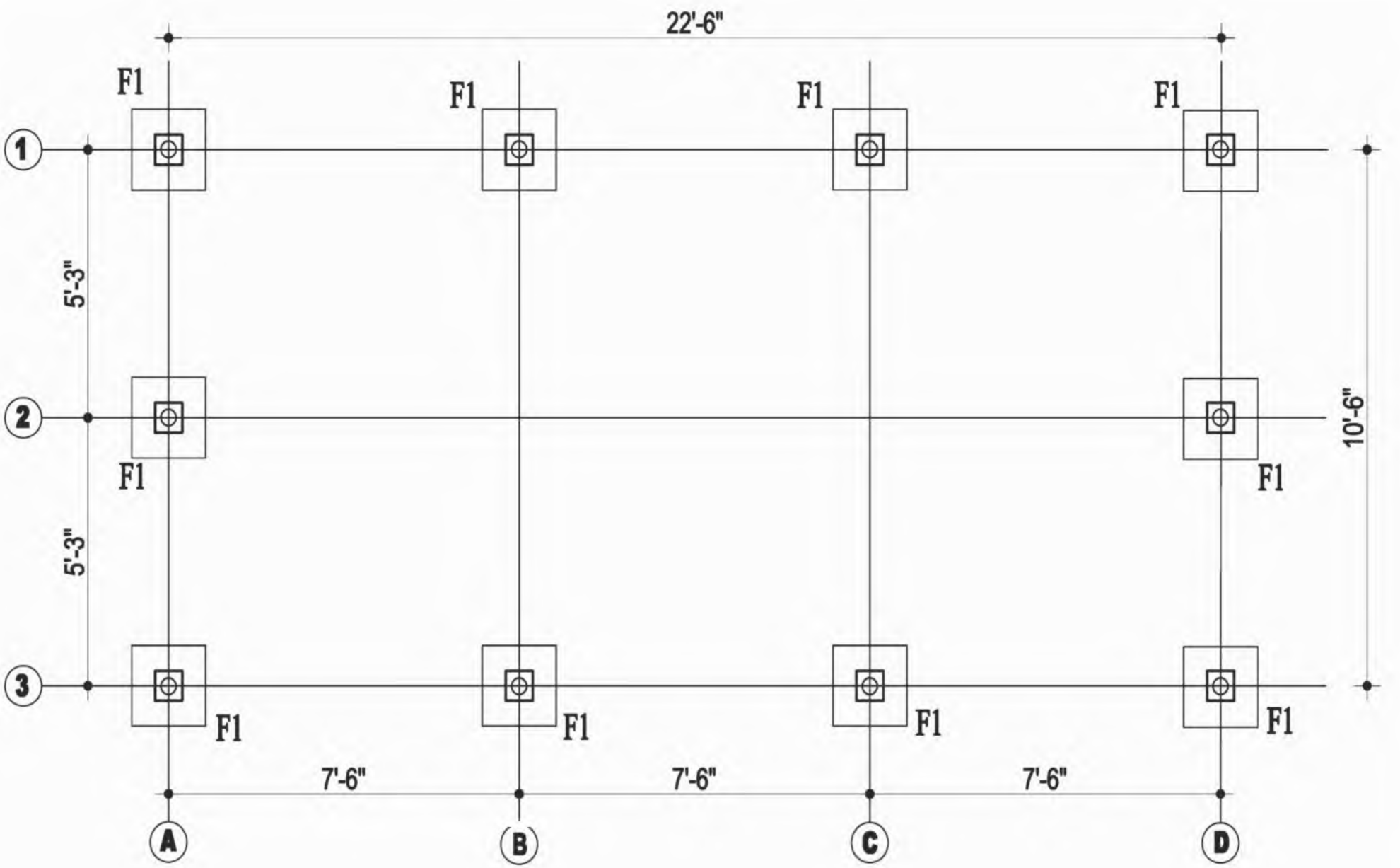
PERSPECTIVE VIEW

STRUCTURAL DETAILS

Example – 1 (Single Story)

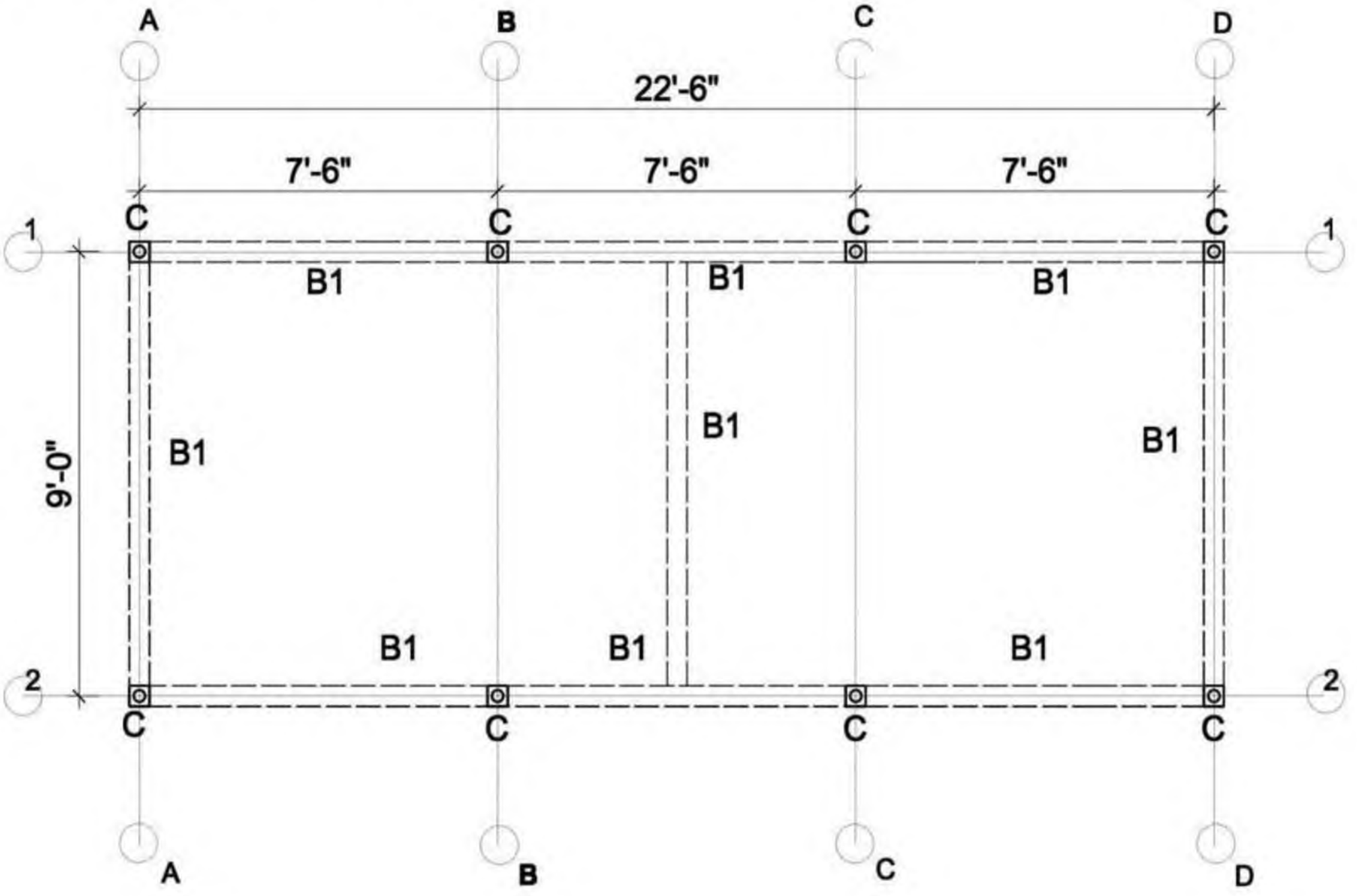


PLAN

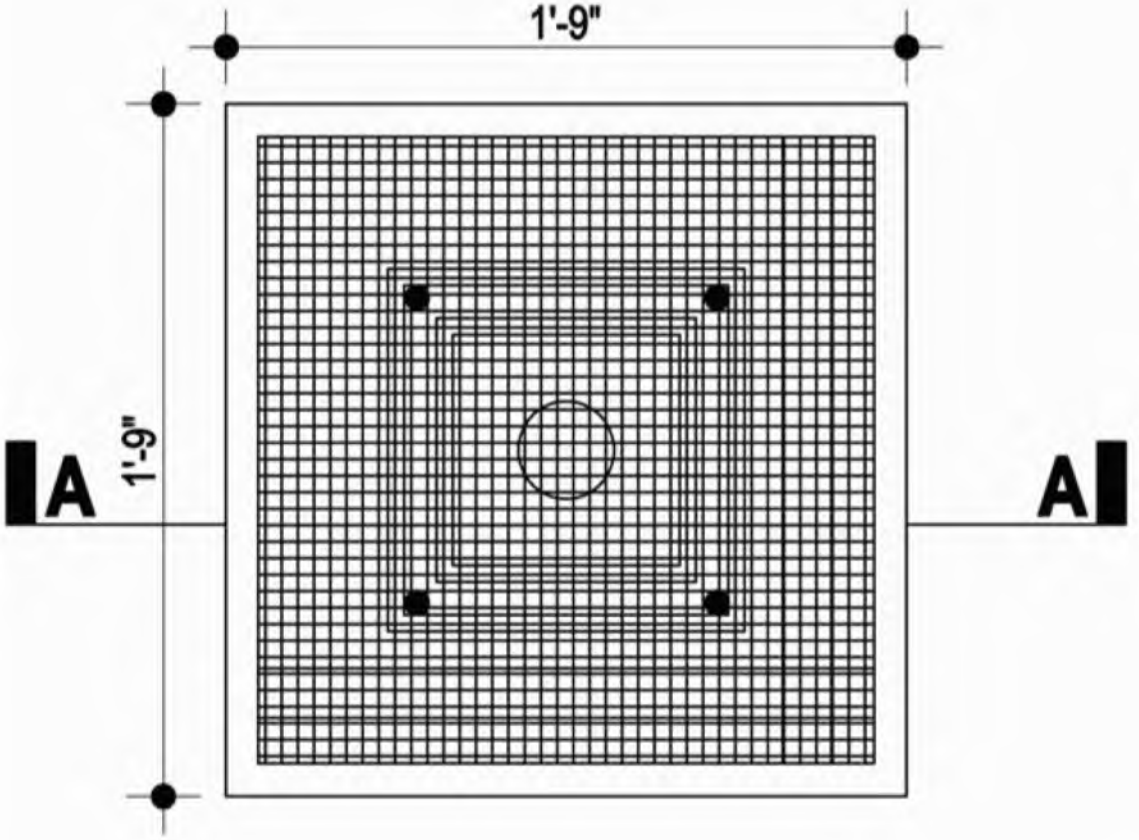


Foundation Layout Plan

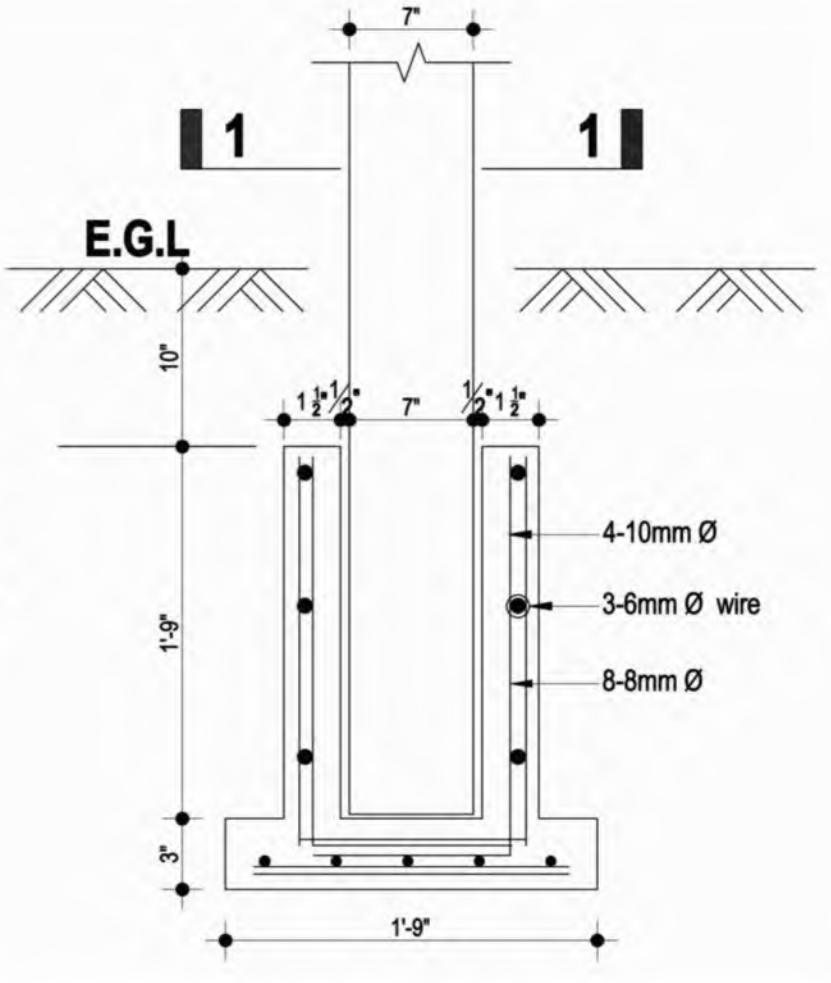
BEAM-COLUMN LAYOUT



Ferro-cement Footing & Column

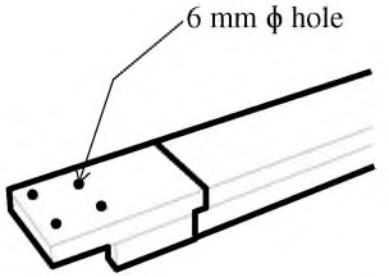


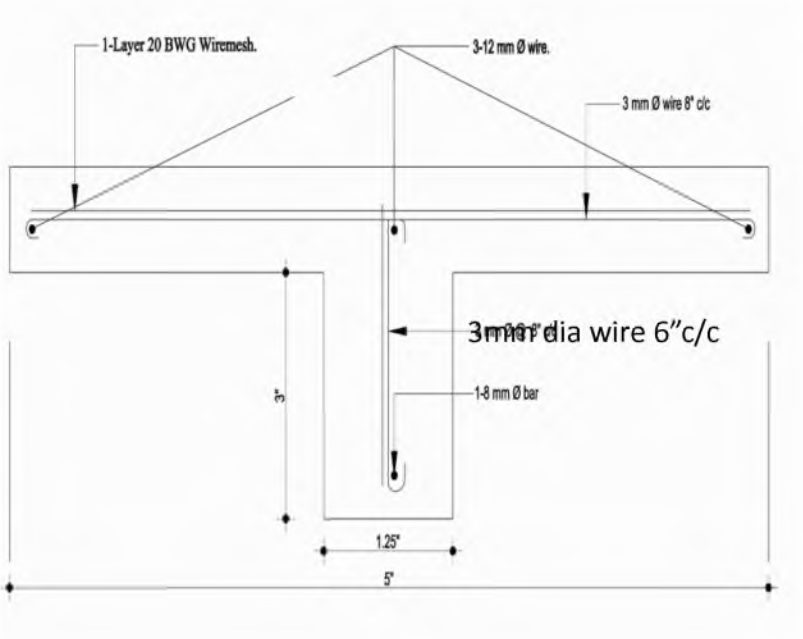
Footing Plan

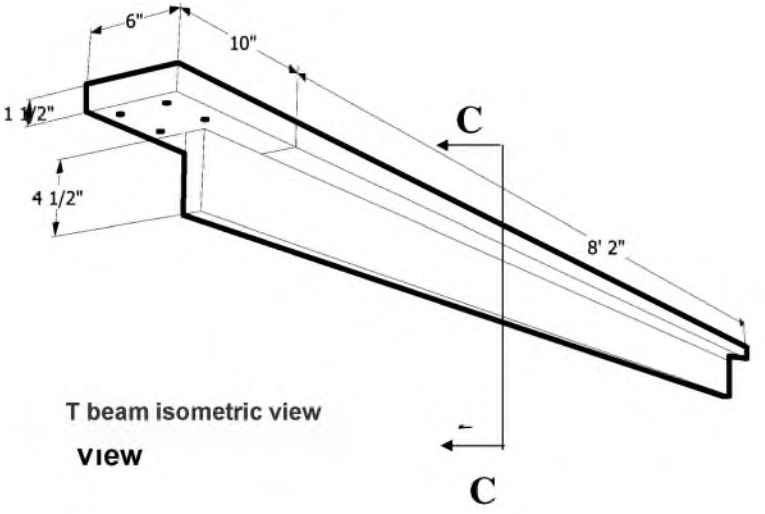


Section A-A

Ferro-cement Beams



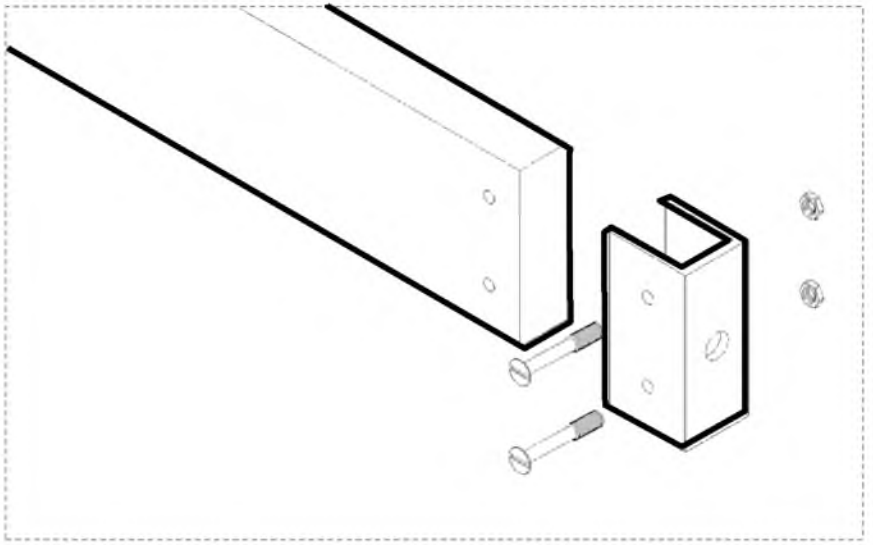


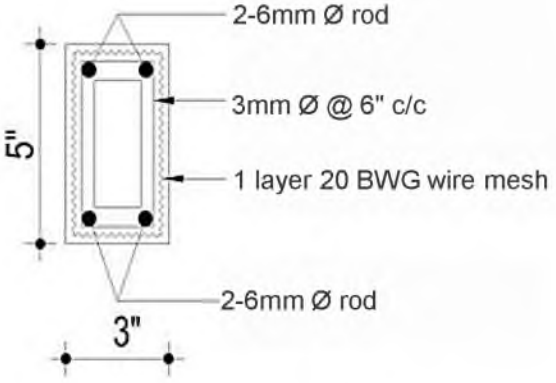


T beam isometric view

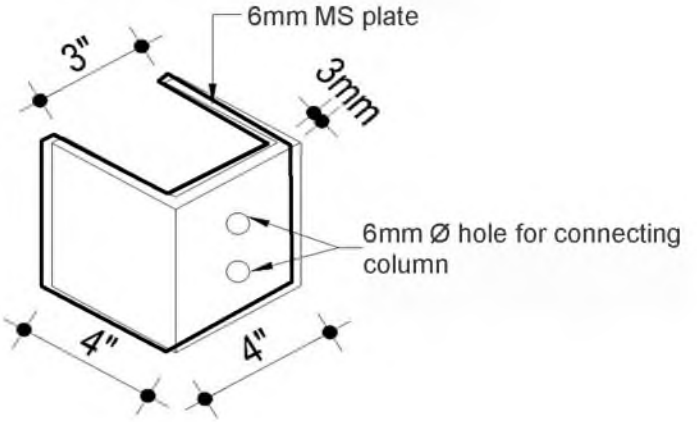
view

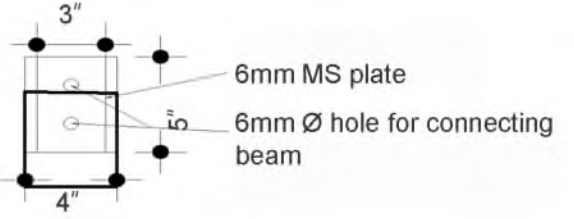
Beam & Joint Element Details

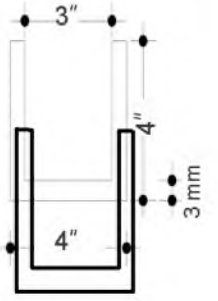




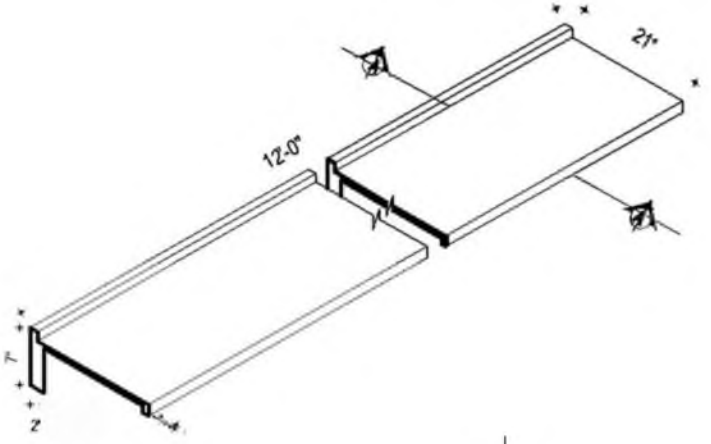
Screw joint details



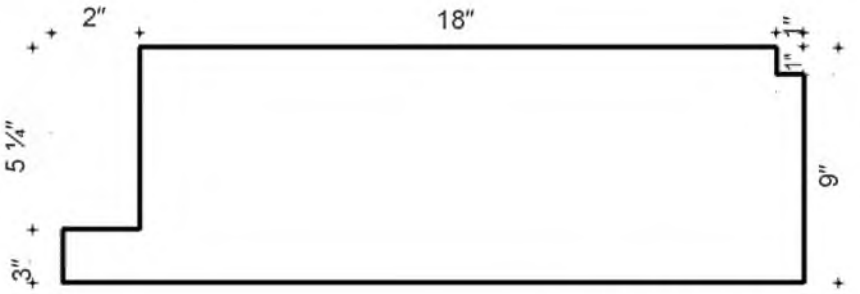




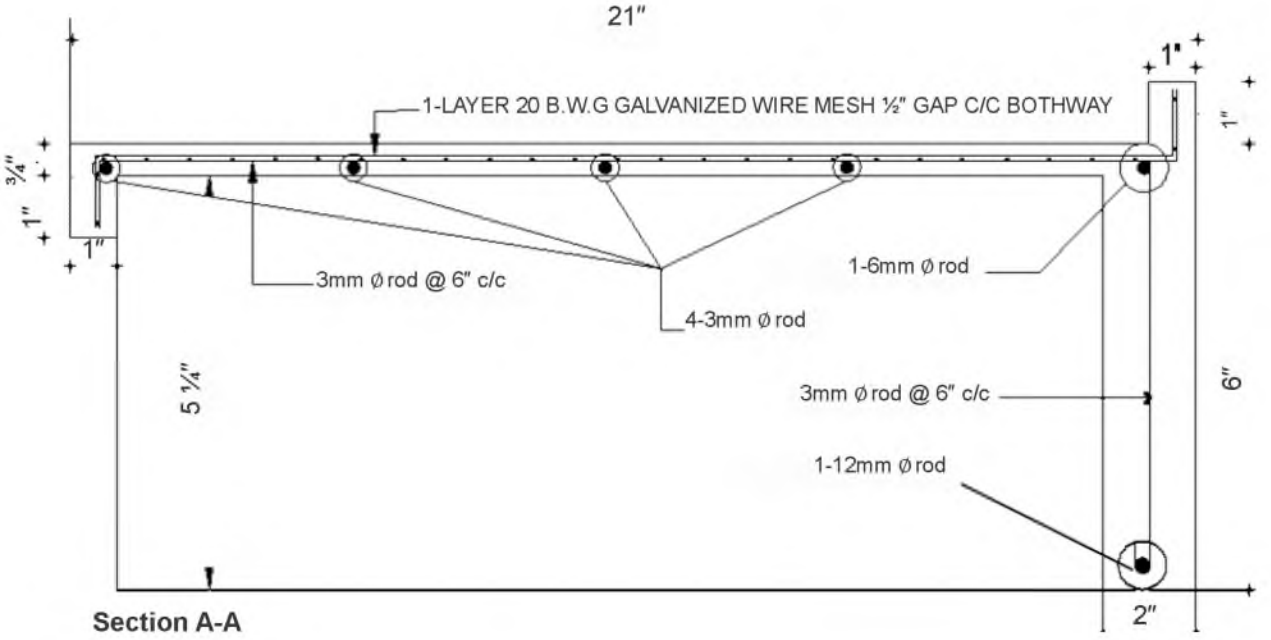
Ferro-cement L-Panel



Isometric View

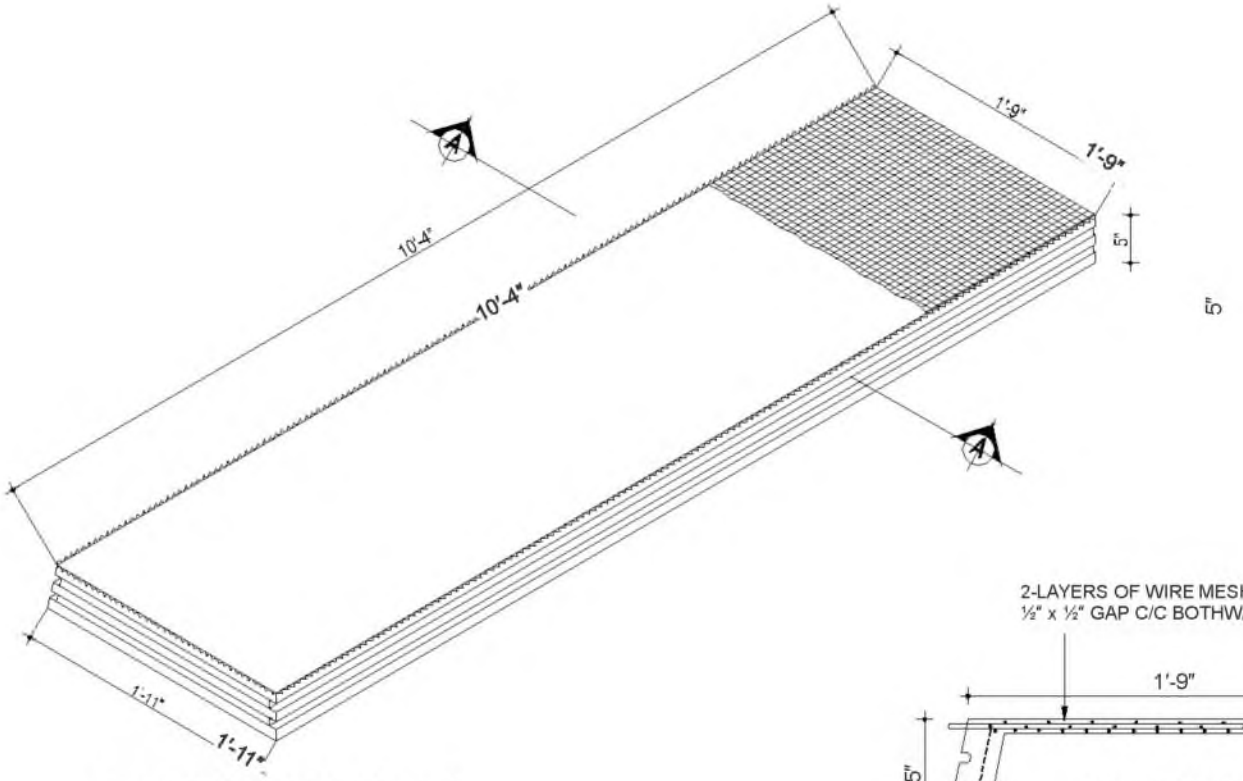


Section of L-panel mould

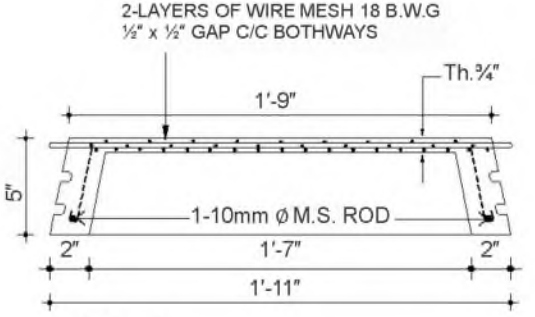


Section A-A

Ferro-cement Roof Panel

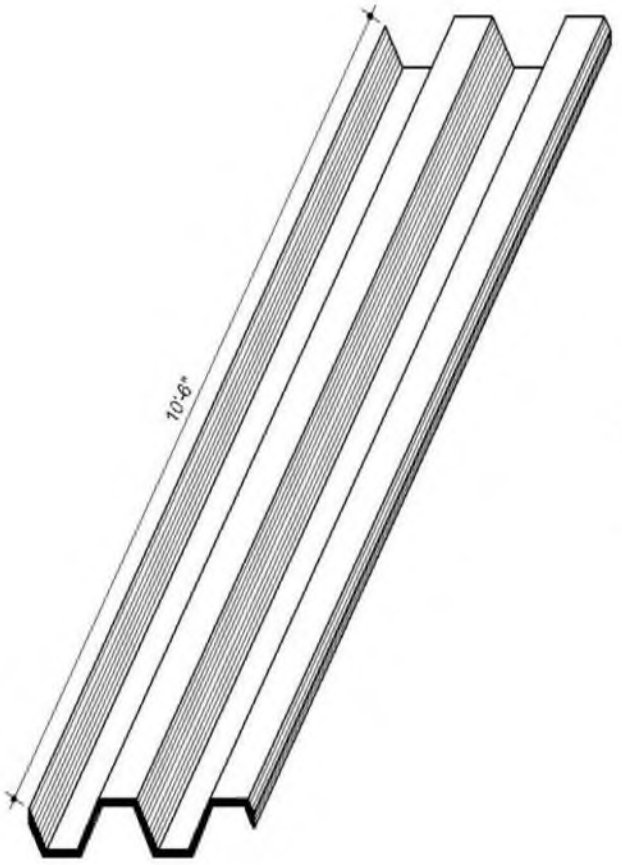


Isometric View of F. C. Channel

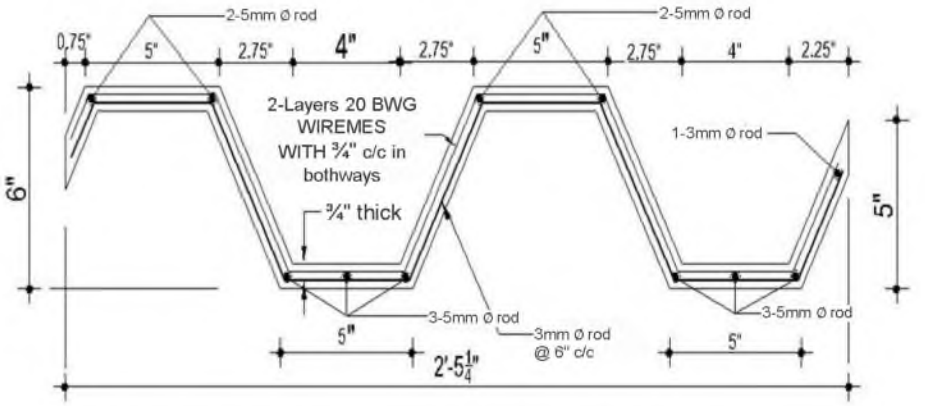


Section A-A

Ferro-cement Corrugated/Folding Roof Sheet

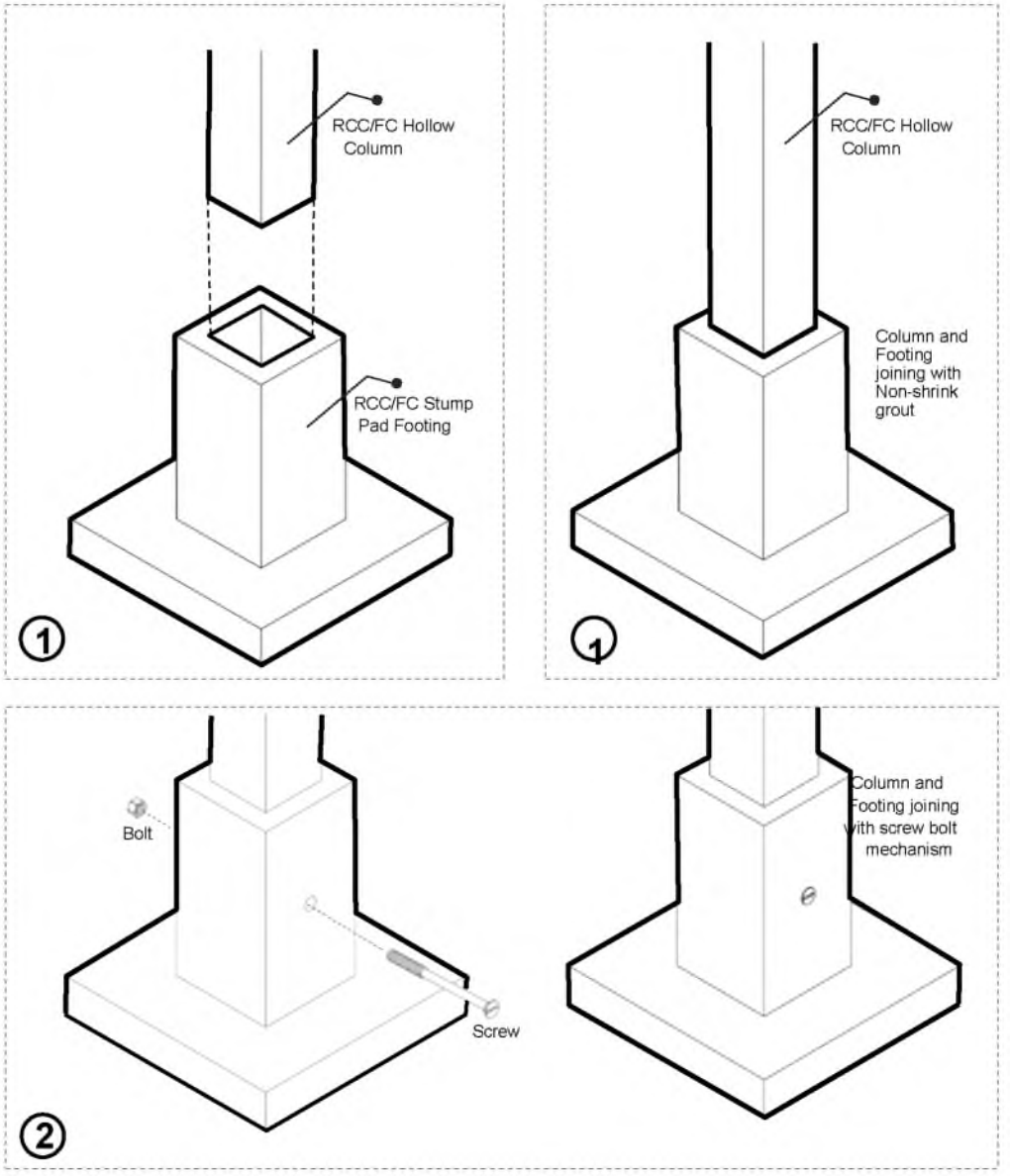


ISOMETRIC VIEW OF F.C. CURRUGATED SHEET



CROSS SEC. OF F.C. CURRUGATED SHEET DETAILS

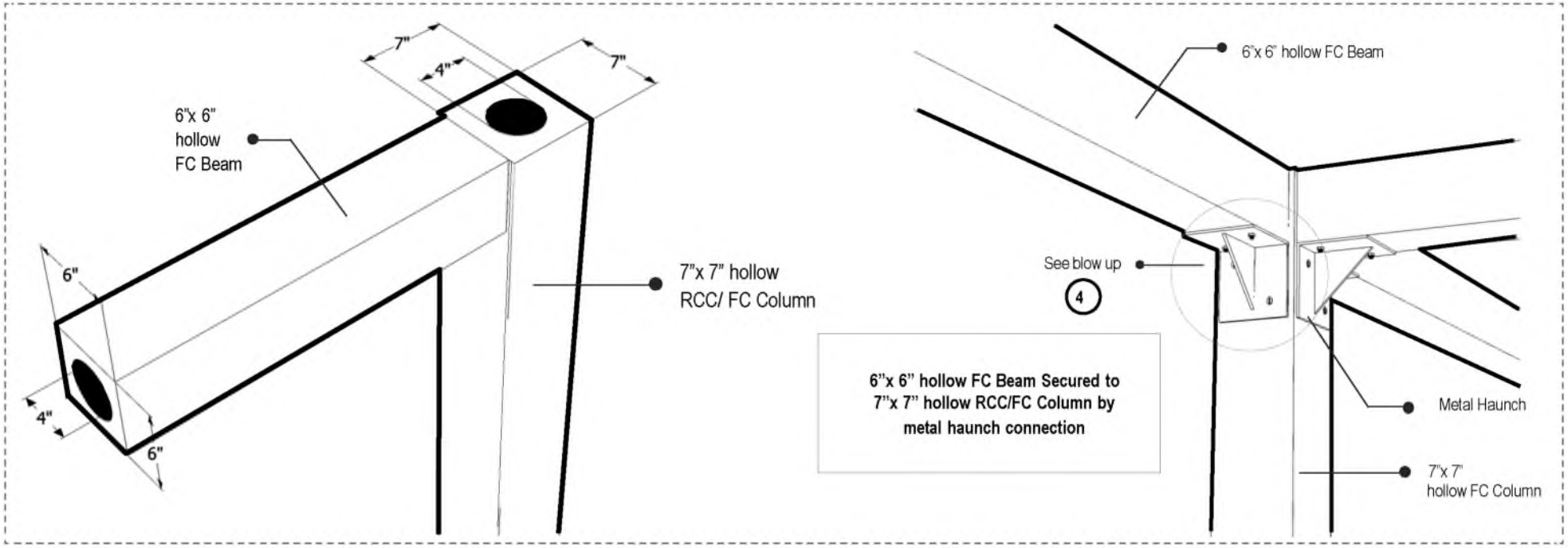
Joint Details

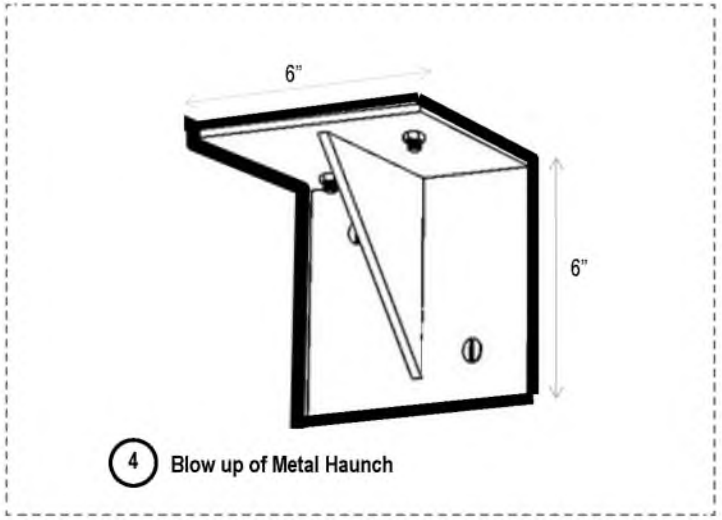


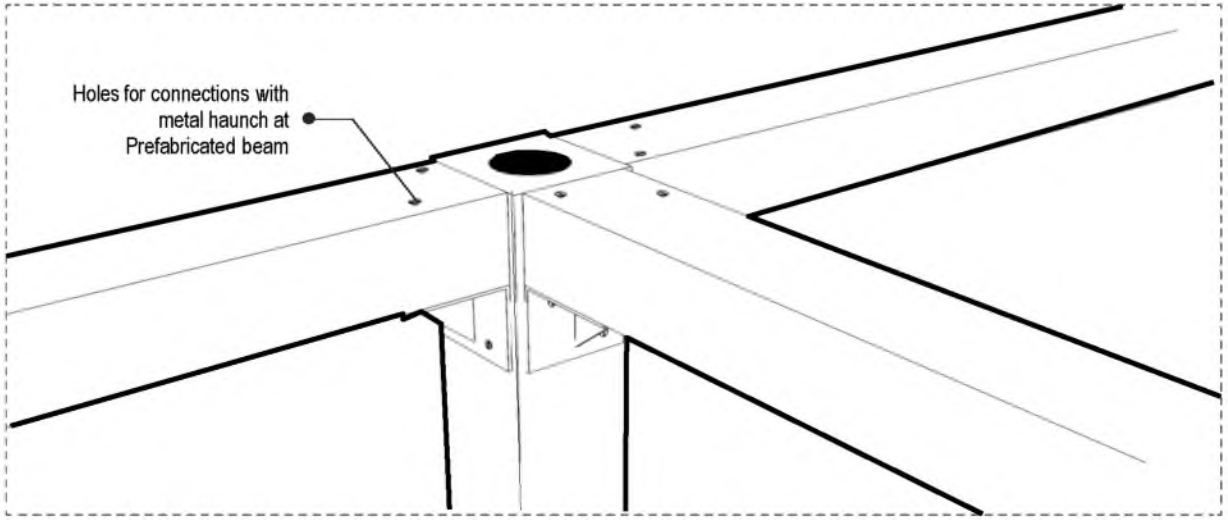
① RCC/FC Column joint with stump pad footing using non-shrink grout

② RCC/FC Column joint with stump pad footing using screw joint

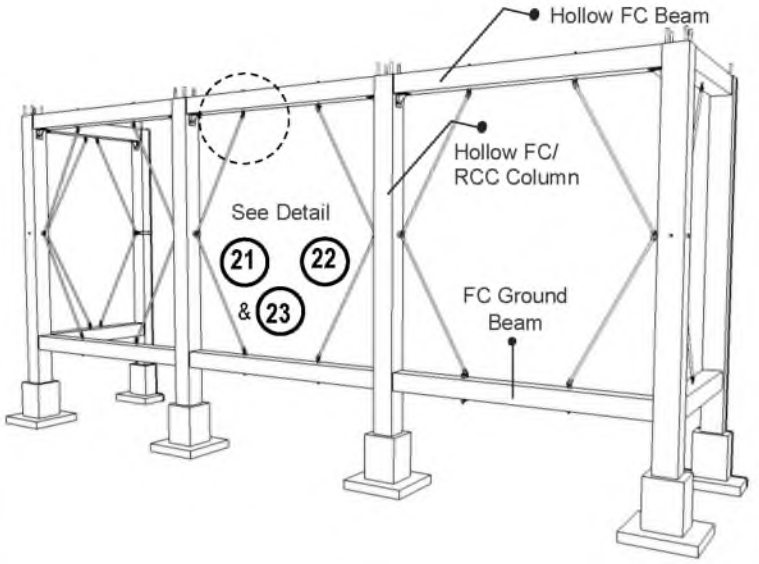
FC Roof Beam Joint Details

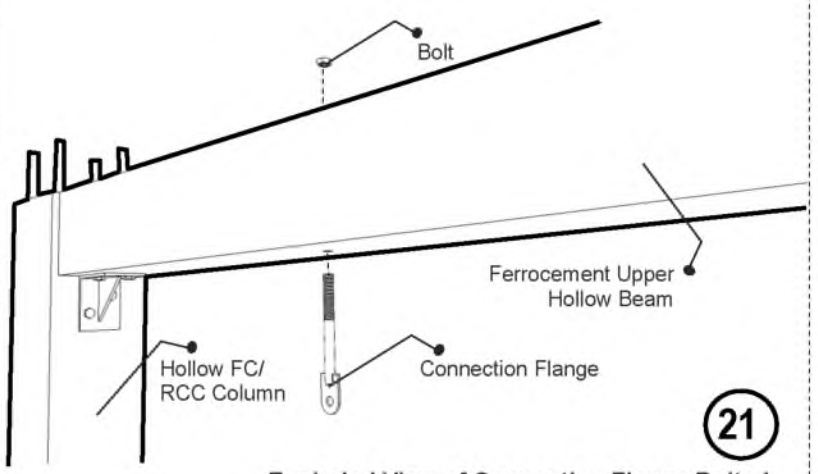






Joint & Bracing Details

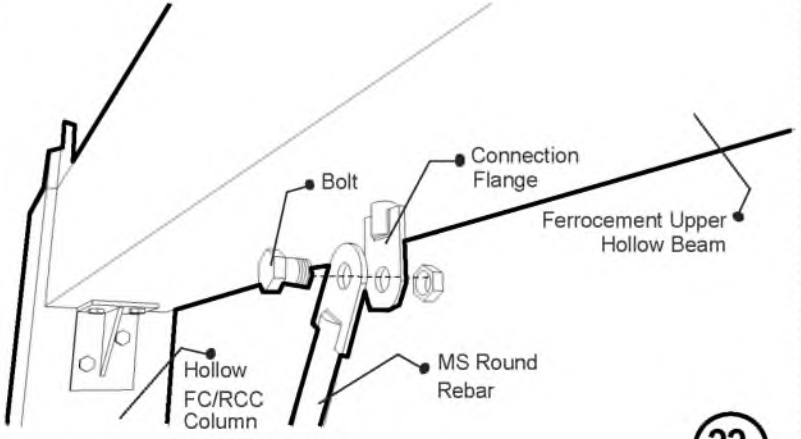




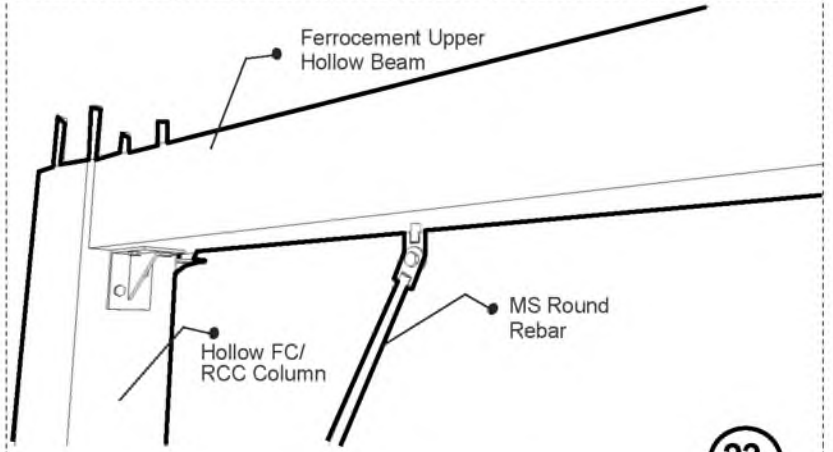
Exploded View of Connection Flange Bolted Joint Elements with FC upper Beam

21 + 22 + 23

MS Round Rebar Bracing and Connection Flange Joint Detail at FC Upper Beam



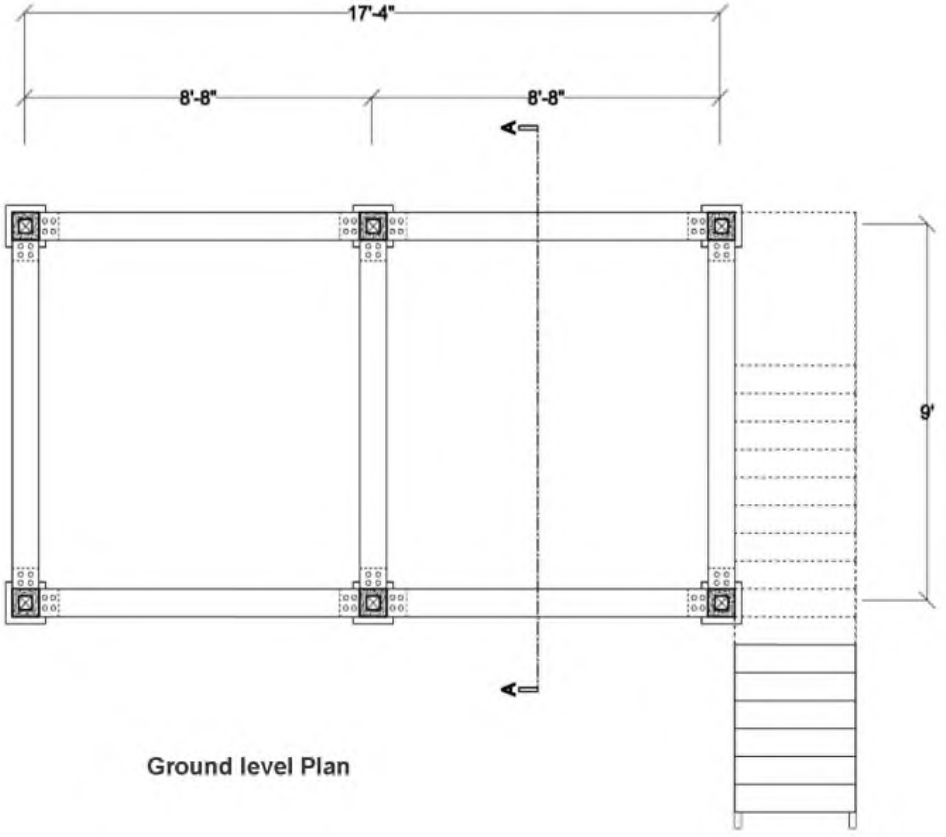
Exploded View of MS Rebar and Connection Flange Bolted Joint Elements with FC upper Beam



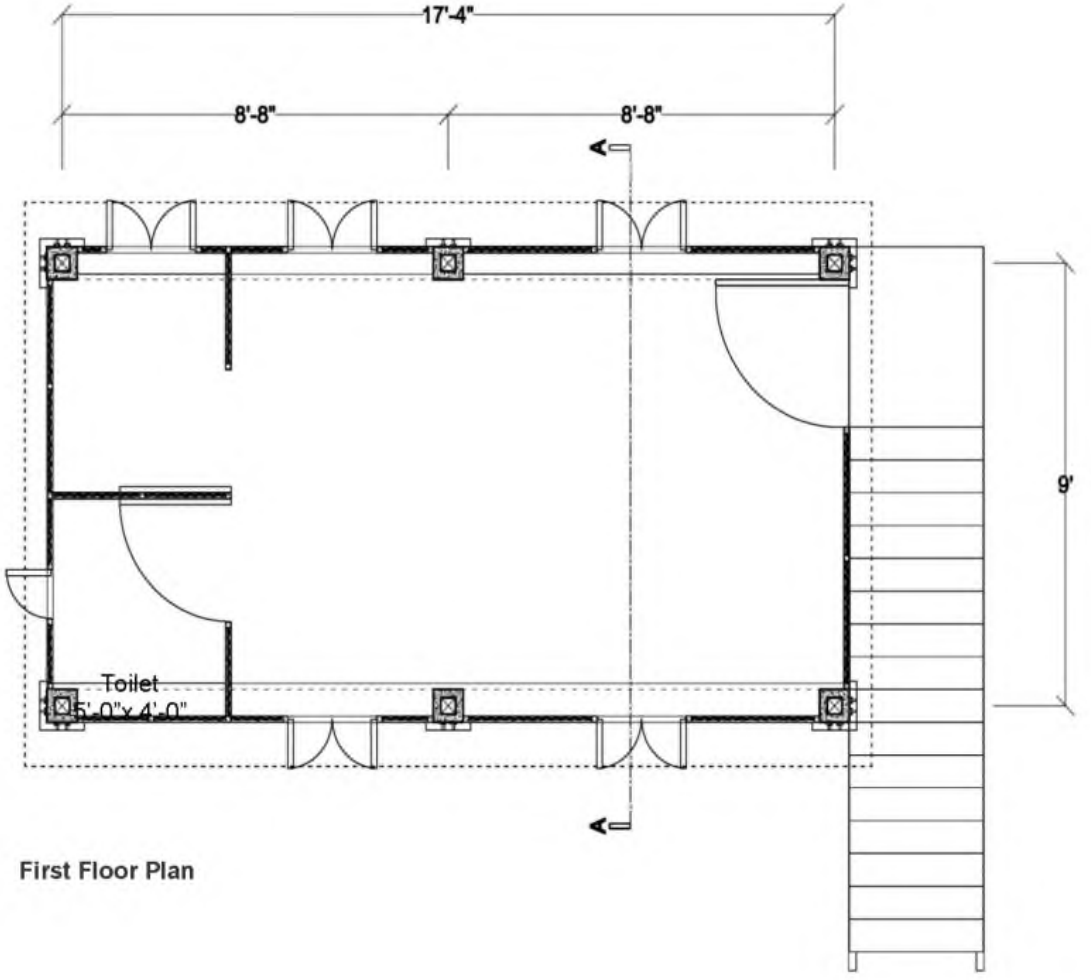
Secured Assemblage of MS Rebar and Connection Flange Bolted Joint Elements with FC upper Beam

STRUCTURAL DETAILS

Example – 2: Stilt House



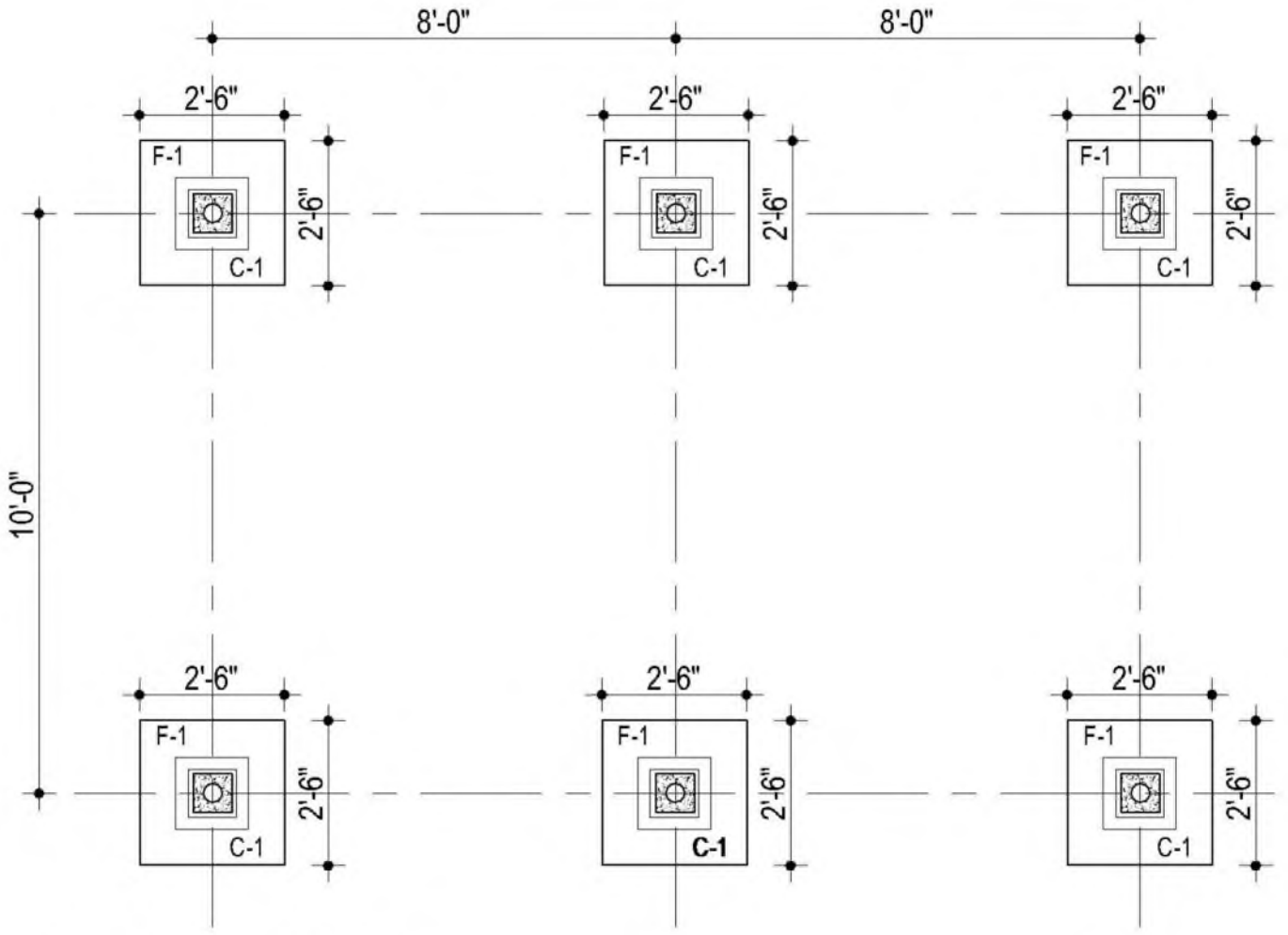
Ground level Plan



First Floor Plan

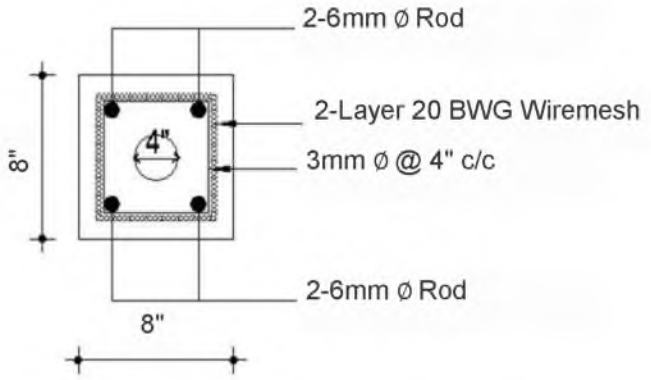
PLAN OF STILT HOUSE

COLUMN & FOOTING LAYOUT PLAN

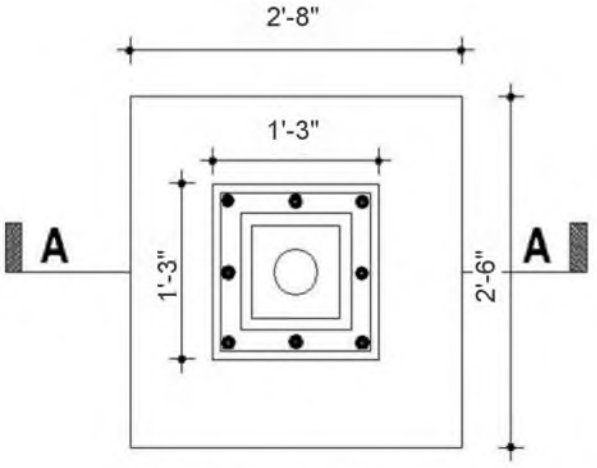


Footing and Column Layout Plan

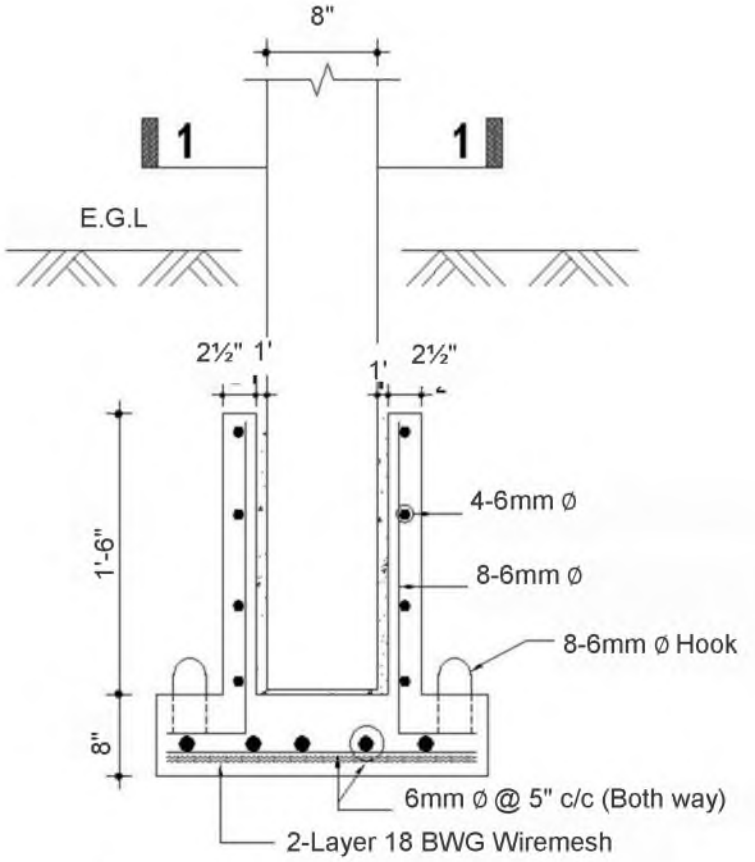
DETAILS OF COLUMN & FOOTING



Section 1-1 (F.C. Hollow Column C-1)

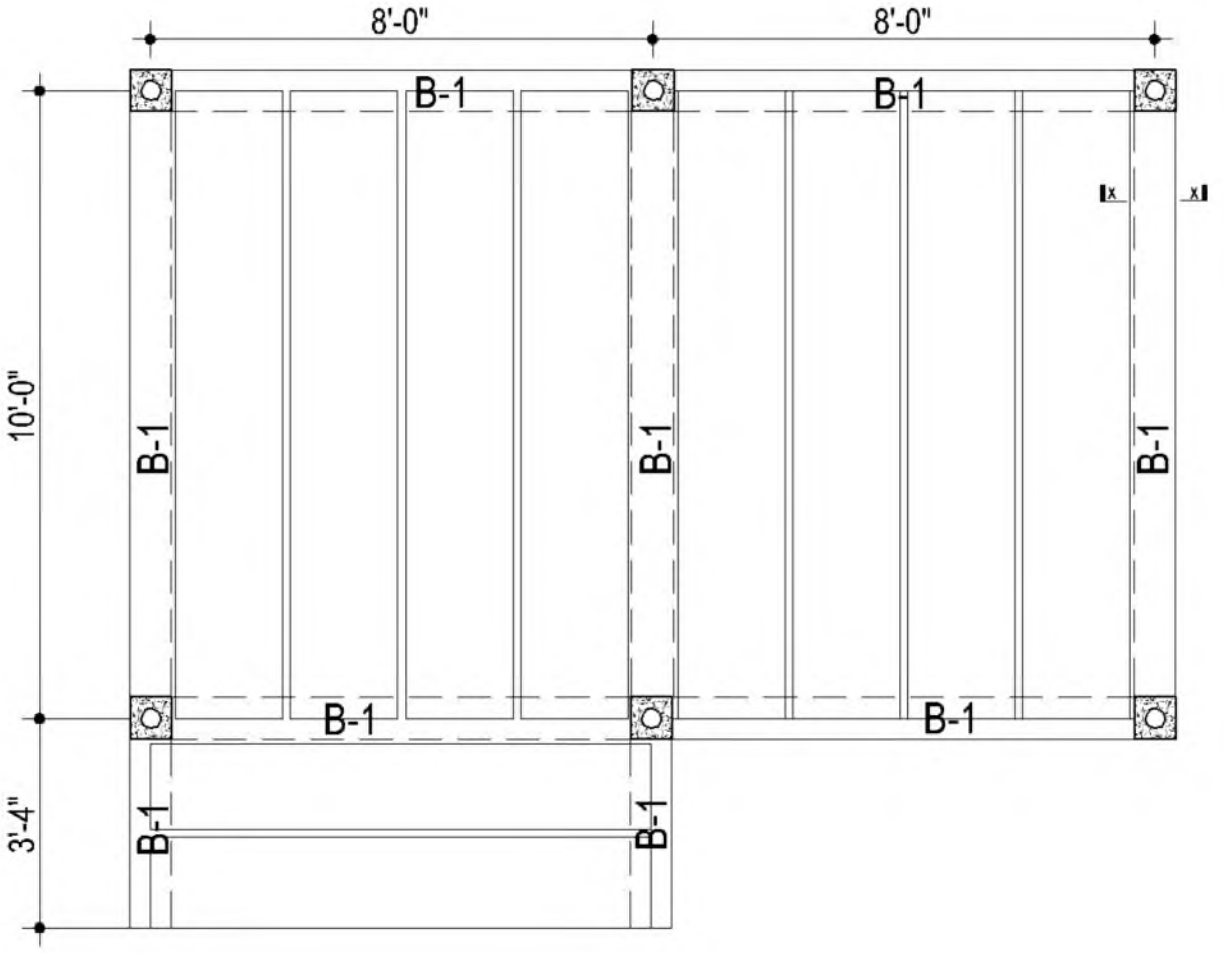


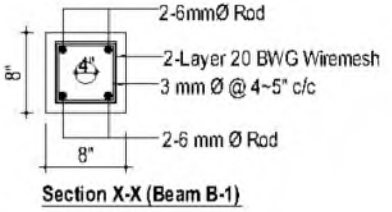
Plan of Precast (F.C.) Pocket Footing F-1



Section A-A

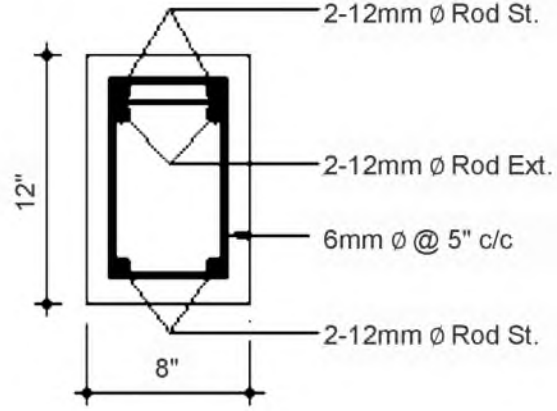
FLOOR BEAM & PANEL LAYOUT PLAN



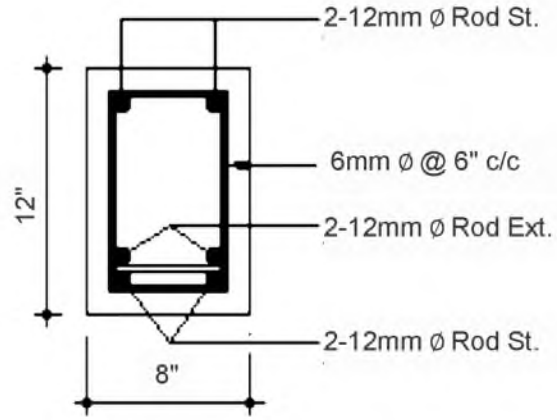


Section X-X (Beam B-1)

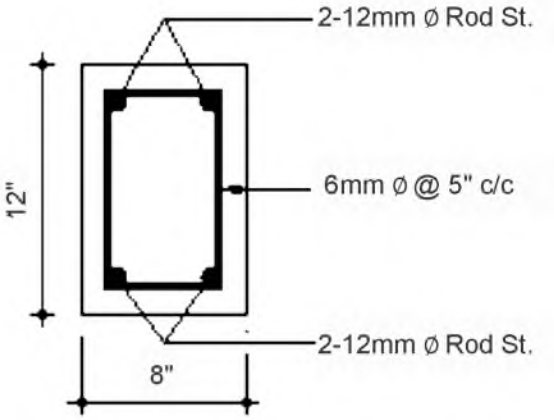
BEAM DETAILS



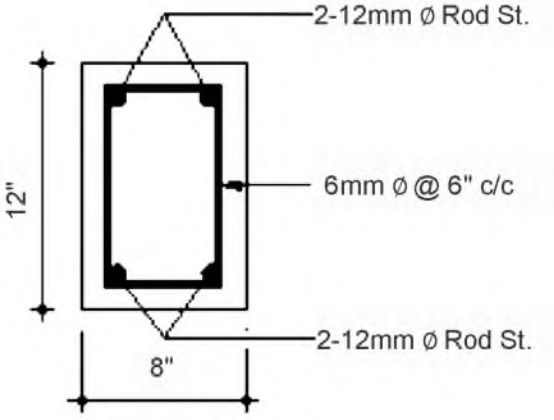
End Section of Beam B-1



Mid Section of Beam B-1

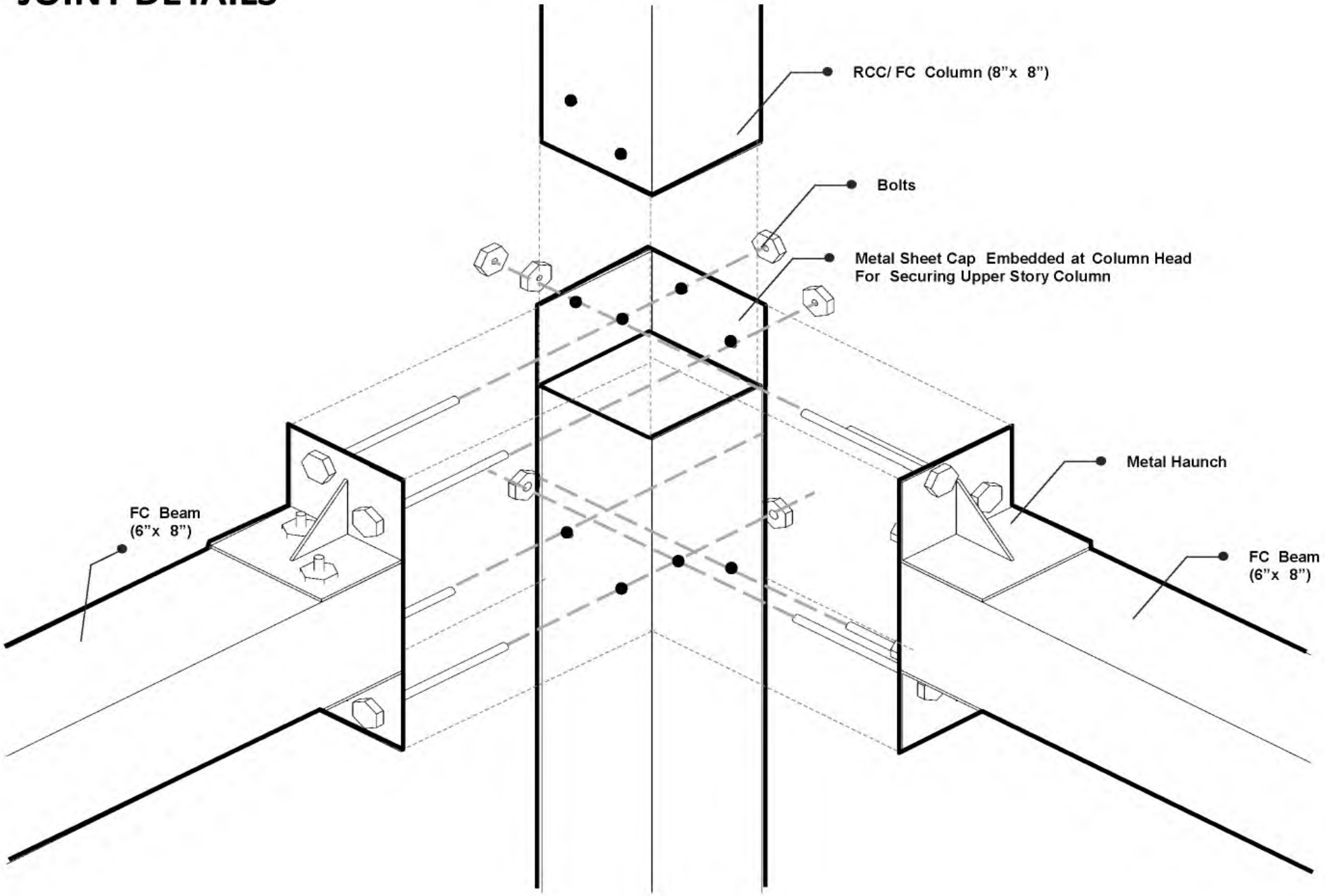


End Section of Beam B-2



Mid Section of Beam B-2

JOINT DETAILS



FACADE & ROOFING ELEMENTS

Pre-cast Ferrocement

Cast-in-situ Ferro-cement

3D Panel

Thermal Block

CLC Block

Sandwich Panel

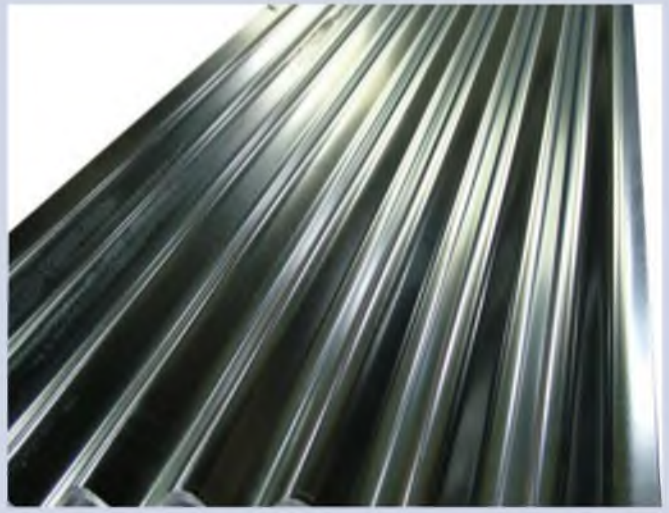
Compressed Stabilized Earth Block

Sand-Cement Hollow Block

Poly Block

Aerated Concrete Block

Interlocking Blocks



CGI Sheet

ROOFING & FLOORING MATERIALS

Ferro-cement Pre-cast Panel

Ferro-cement Folded Plate

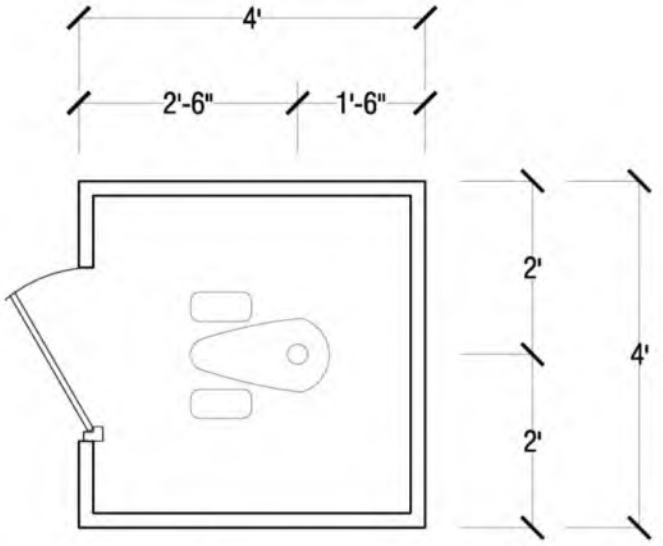
Cast-in-situ Ferro-cement Roof

Ferro-cement L Panel

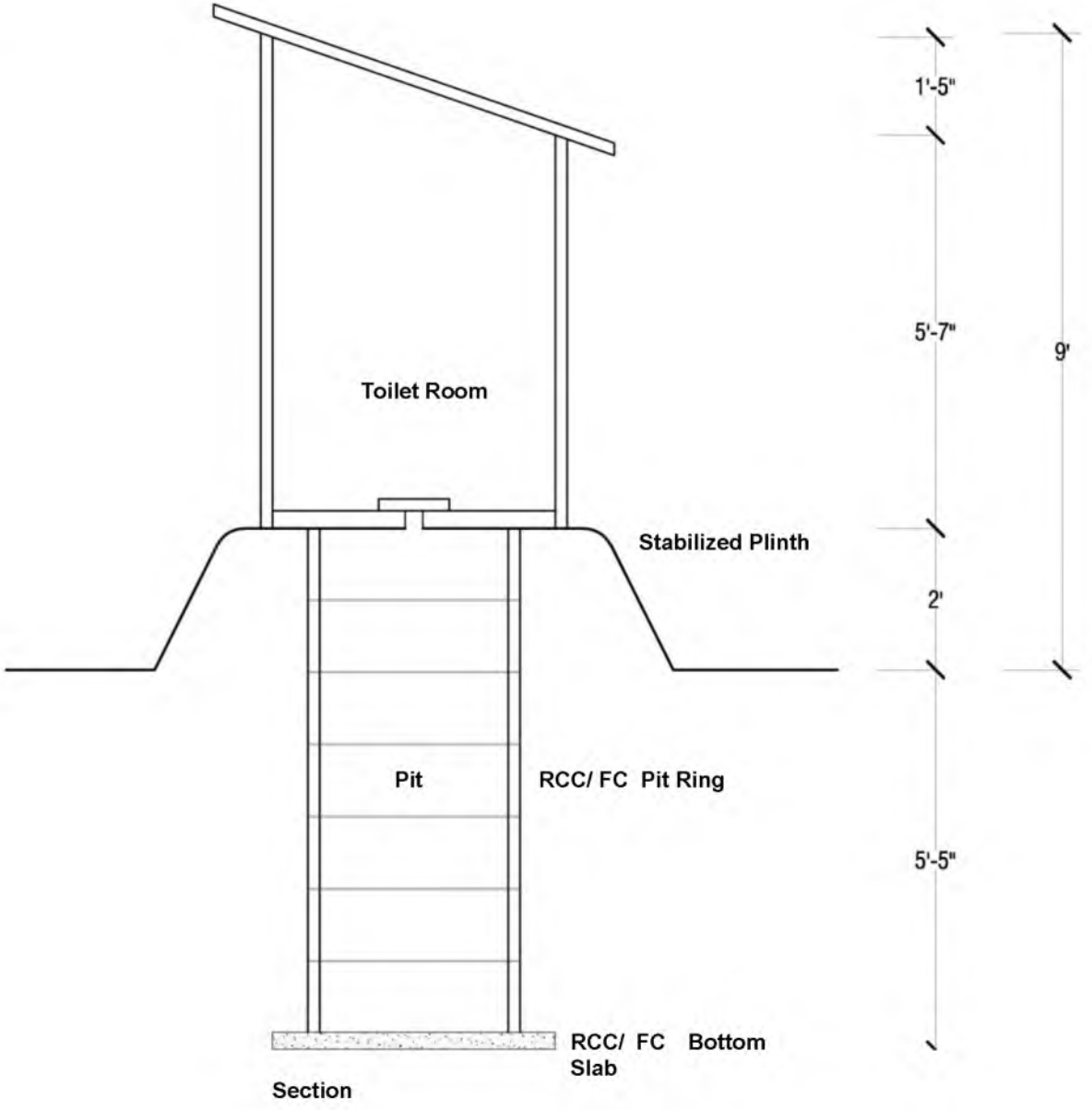
Ferro-cement Corrugated Sheet

SANITATION MODELS

Example-1: SIMPLE PIT LATRINE

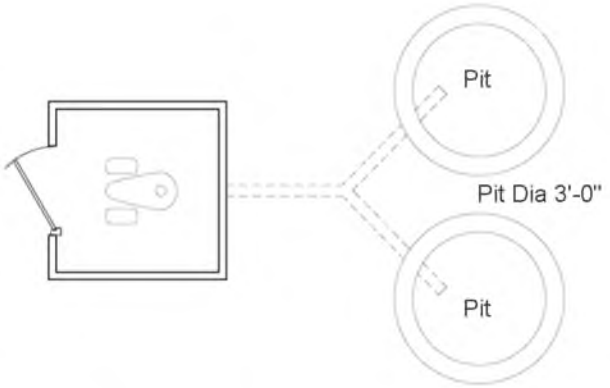


Toilet plan

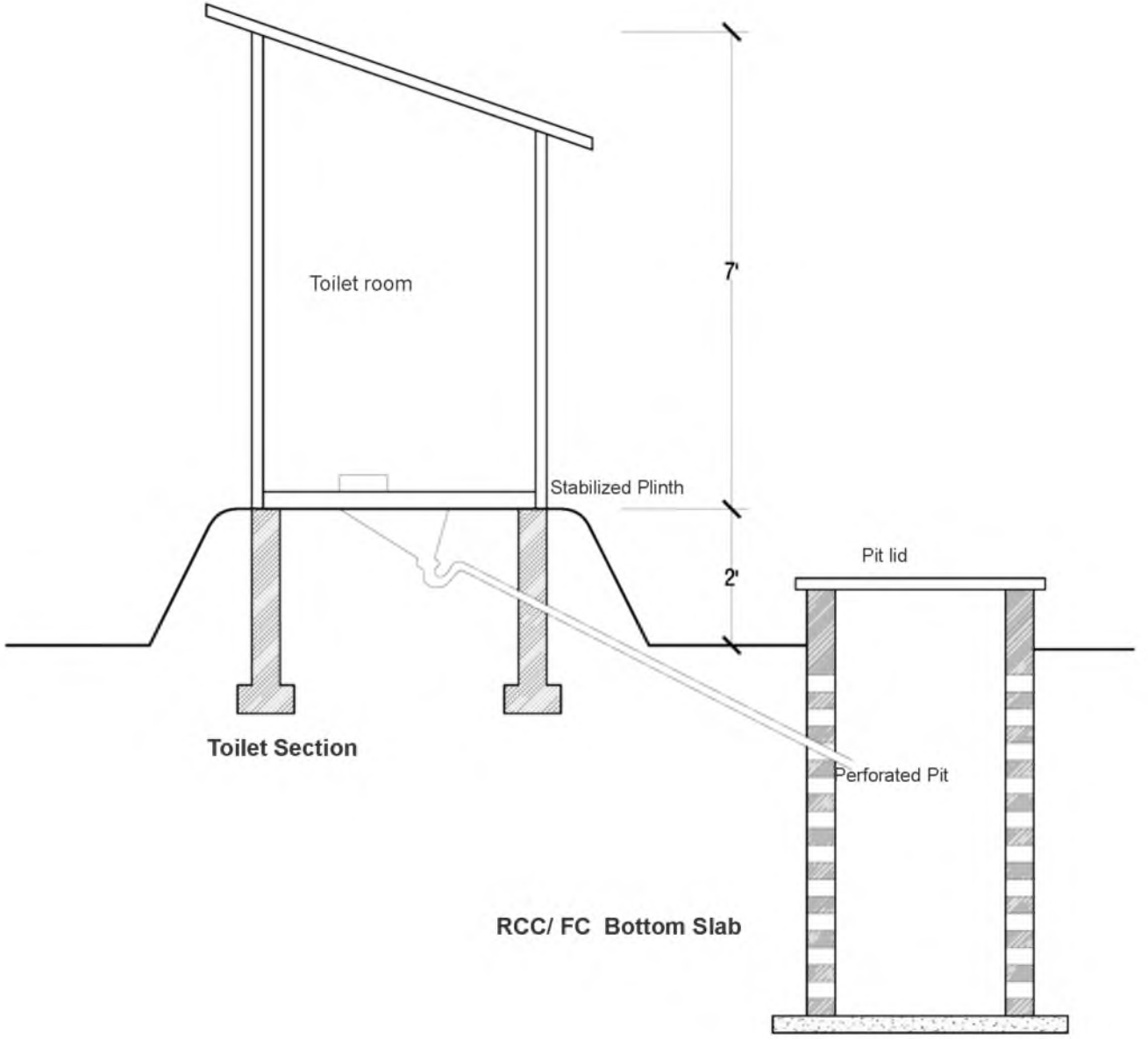


Section

Example-2: DUAL PIT LATRINE



Toilet plan (4'-0"X4'-0")



Toilet Section

Recommendations:

- Ferro-cement is the most suitable Technology for coastal areas
- Pre-cast pre-fabricated technology is the most preferred one
- Concrete must be durable and minimum compressive strength shall be 4000 psi
- Brick chips should not be used as coarse aggregate for concrete
- Present transitional houses need to upgrade as Safer shelters
- New shelter should be of Durable Type
- Promote multi-story foundation for conservation and expansion of agricultural land
- Updated Wind velocity data and Inundation data from BNBC and IWM respectively need to consider for shelter design
- Epoxy coated bar may be used for RCC

Proposal of housing model for southern coastal areas of Bangladesh

2018. 11. 12.

Chang-U Chae / Young Wan Kim

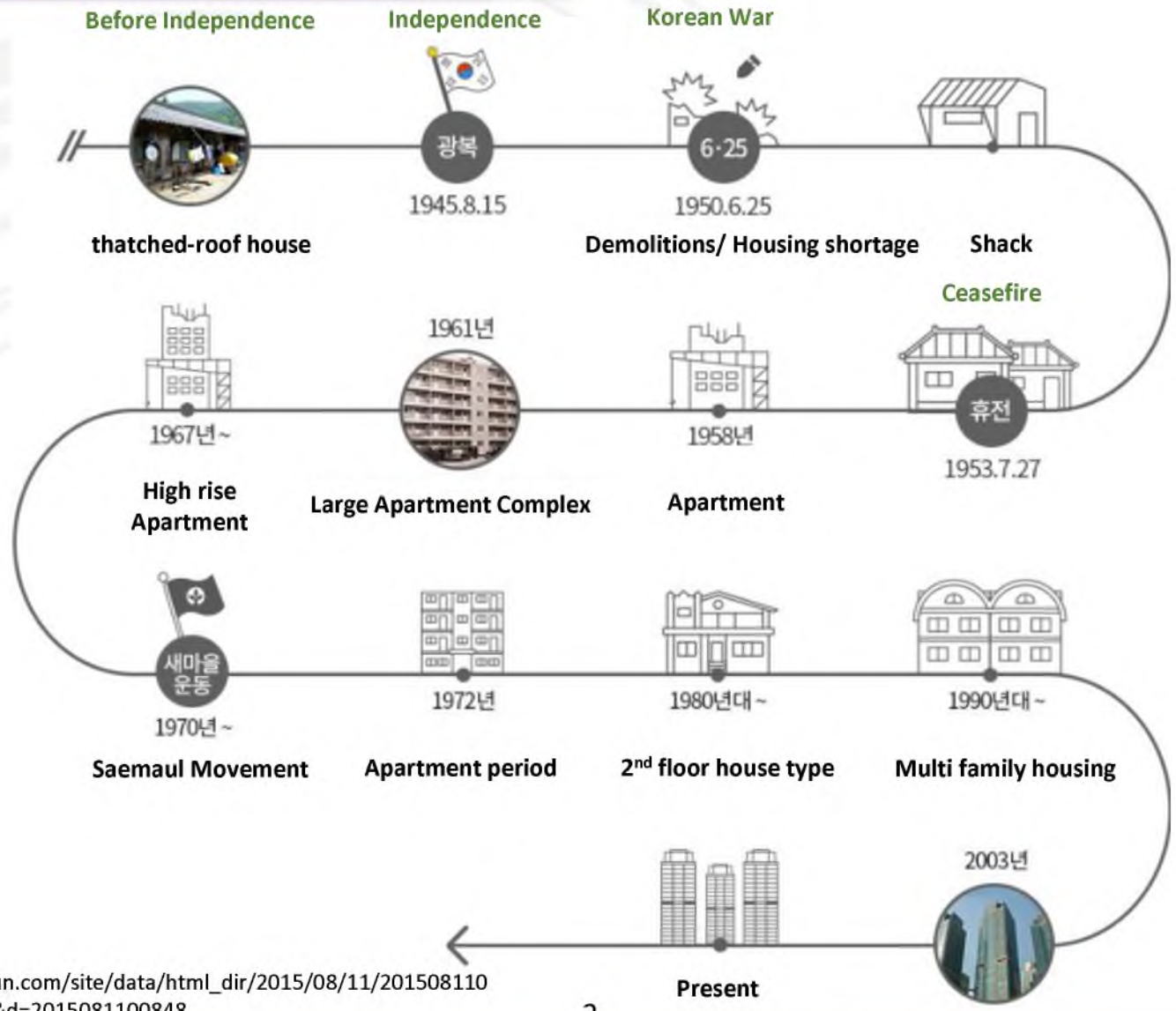
KICT KOREA INSTITUTE of CIVIL ENGINEERING and BUILDING TECHNOLOGY

BOF KOREA Solution Architecture & Design

History of housing type in Korea

History of housing type in Korea

History of housing style



Source:http://news.chosun.com/site/data/html_dir/2015/08/11/2015081100848.html?Dep0=twitter&d=2015081100848

History of housing type in Korea

History of housing style

1940’ ~ 1950’

Major Social Issues
- Liberation, the Korean War

< Thatched-roof house >

Roof :Straw

Door : Local timber

Wall : Local clay + Straw

Door & Windows : Paper

	1960’s
Total Population (Ten thousand people)	2,498
Per capita birth rate	5 persons
Population Density (person/km2)	-
GDP(One hundred million dollars)	-
GNI per capita (US $)	79
Economic growth(%)	-
Major industries	Agriculture

History of housing type in Korea

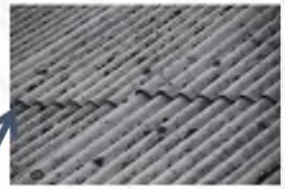
History of housing style

1960'
~
1970'

Major Social Issues
- the beginning of Saemaeul Movement and Industrialization

< Slate-roof house >

Asbestos Slate



Cement Block

	1970's
Total Population (Ten thousand people)	3,088
Per capita birth rate	4.5 persons
Population Density (person/km2)	320
GDP(One hundred million dollars)	82
GNI per capita (US $)	255
Economic growth(%)	9.05
Major industries	Light industry

History of housing type in Korea

History of housing style

1980'

Major Social Issues
- Seoul Olympic, Democratization, Apartment

Glass windows

Concrete slab

Firing bricks wall

	1980's
Total Population (Ten thousand people)	3,743
Per capita birth rate	2.8 persons
Population Density (person/km2)	378
GDP(One hundred million dollars)	633
GNI per capita (US $)	1660
Economic growth(%)	9.76
Major industries	Light industry, Heavy industry

The real beginning of Apartment culture in the 1980's

History of housing type in Korea

History of housing style

1990’

Major Social Issues
- The New Town Construction, and Heavy chemical industry

Reinforced concrete structures

	1990’s
Total Population (Ten thousand people)	4,341
Per capita birth rate	1.5 persons
Population Density (person/km2)	438
GDP(One hundred million dollars)	2,702
GNI per capita (US $)	6,303
Economic growth(%)	6.6
Major industries	Heavy and chemical industries, Automotive Industry

- A Low-rise apartment(below the fifth floor) – the beginning of a high-rise apartment(over the fifteen floor)
- Construction of 4 major new towns(Il-san, Bun-dang, Pyeongchon, Jung-dong) – Satellite towns in Seoul
- A short supply of construction materials consequence of rapid housing supply – imported from China

History of housing type in Korea

History of housing style

2000'

Major Social Issues
- Informatization, Prevention of Global Warming

The beginning of application for environmental-friendly materials

	2000's
Total Population (Ten thousand people)	4,613
Per capita birth rate	1.3 persons
Population Density (person/km2)	464
GDP(One hundred million dollars)	5,308
GNI per capita (US $)	11,292
Economic growth(%)	4.2
Major industries	Information & communications, semiconductor, service Industry

- Spread of high-rise apartment throughout the country
- An explosion of interest in improving residential conditions – Insulation, Noise and indoor air etc.

History of housing type in Korea

History of housing style

2000’

Major Social Issues
- Energy-saving, Improvement of welfare

Using of low Carbon and high insulation Materials

- ► Application of High insulation Materials for Energy-saving
- ► Minimization of using Cement

	2010’s
Total Population (Ten thousand people)	4,858
Per capita birth rate	1.2 persons
Population Density (person/km2)	485
GDP(One hundred million dollars)	10,160
GNI per capita (US $)	20,562
Economic growth(%)	2.5
Major industries	Information & communications, services (by internet)

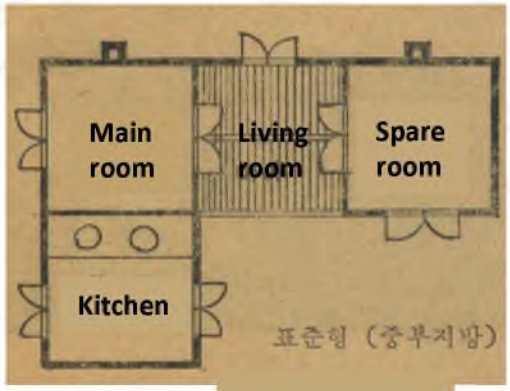
History of standard design patterns on rural housing in Korea

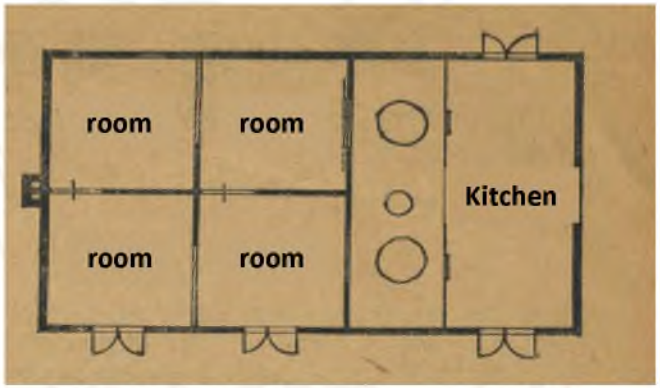
Changes in standard design patterns

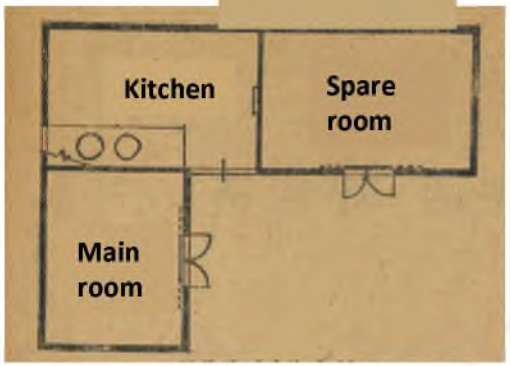
Changes in Rural Housing

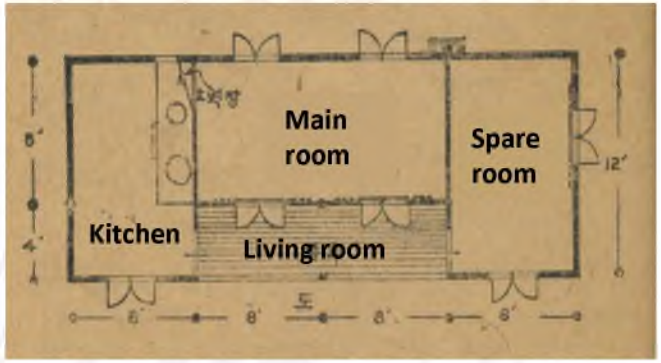
Conventional rural housing (~ 1975)

- Conventional Korean style (Han-ok)
- '—' type, 'ㄱ' type, 'ㄷ' type, '田' type are the basic standard design for rural area









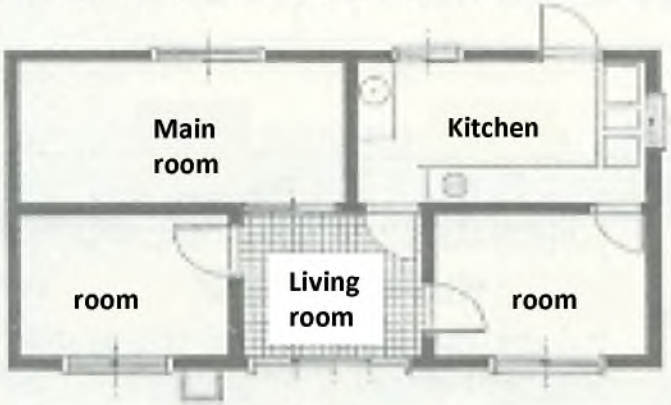
Source: 1. Status and Improvement of Housing in Korean Rural Area pg32-33, Rural Development Administration/ National Institute of Agricultural Sciences
2. http://wiki.uosarch.ac.kr/reading_jutaek/%EC%A3%BC%ED%83%9D4%ED%98%B8

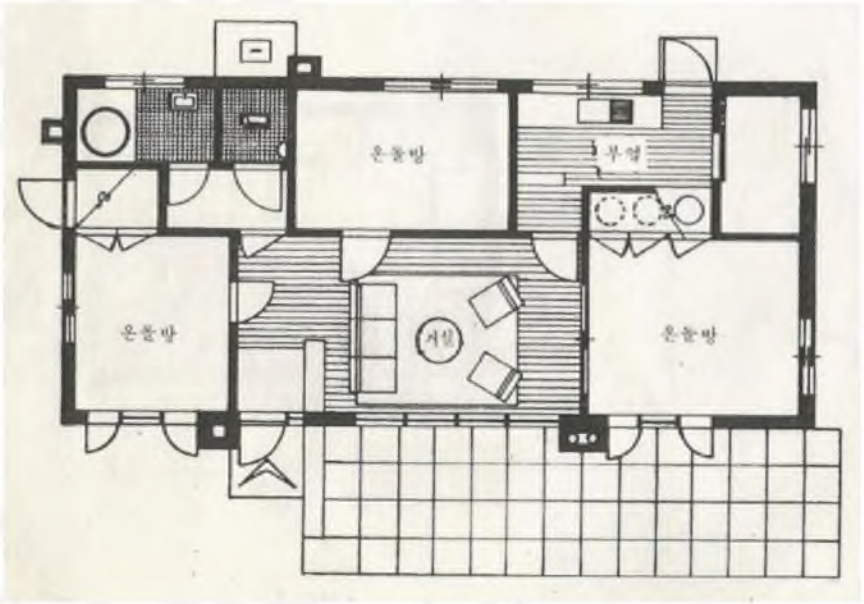
Changes in standard design patterns

Changes in Rural Housing

Modern rural housing (1976-1993)

- Design to have living room below the ridged roof
- Start to have 2 main horizontally planned room location
- Start to have 2nd storey house
- Start to close the spaces
- Design to connect spaces

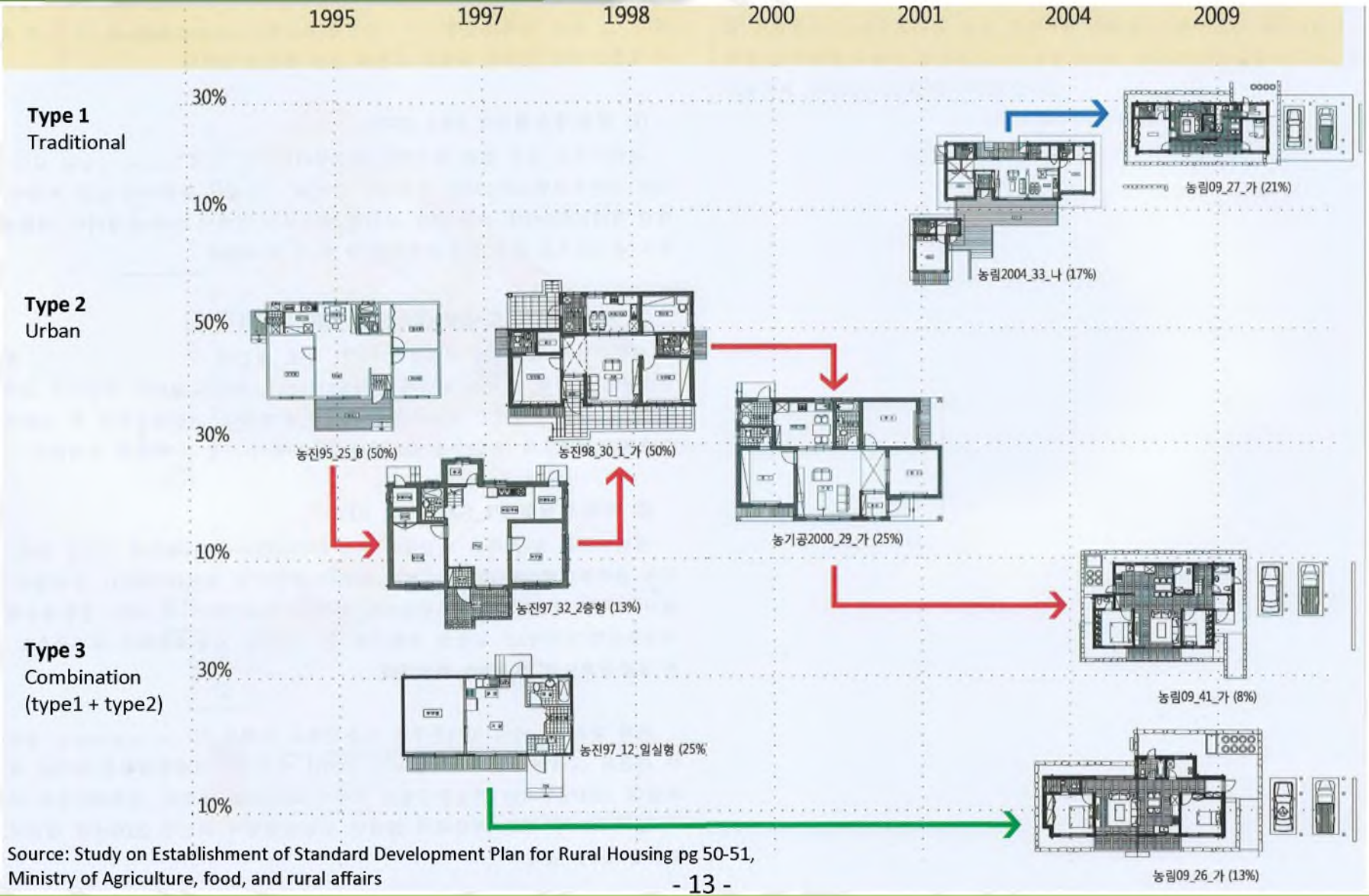




Source: 1. Status and Improvement of Housing in Korean Rural Area pg32-33, Rural Development Administration/ National Institute of Agricultural Sciences
2. http://news.khan.co.kr/kh_news/khan_art_view.html?art_id=201602162047575

Changes in standard design patterns

Standard design patterns



Source: Study on Establishment of Standard Development Plan for Rural Housing pg 50-51, Ministry of Agriculture, food, and rural affairs

Changes in standard design patterns

Changes in Rural Housing

Modern rural housing (1994~)

- Start on “Rural Cultural Village Project” from 1994
- Rural Community Standard Housing Plan was built
- Start to have “living room centered housing”
- Material – red brick, concrete, prefabricated sandwich panels etc.
- Structure – masonry, reinforced concrete, steel house, prefabricated structure etc.

Source: 1. Status and Improvement of Housing in Korean Rural Area pg32-33, Rural Development Administration/ National Institute of Agricultural Sciences
2. http://news.khan.co.kr/kh_news/khan_art_view.html?art_id=201602162047575

Changes in standard design patterns

Development policy for rural area by period

Source : Status and Improvement of Housing in Korean Rural Area pg34, Rural Development Administration/ National Institute of Agricultural Sciences

Division	Project	Ministry	Year	Related Law	Main Content
1970's	Village restoration improvement	Ministry of home affairs	1976	Promotion Act of development of rural housing	• Development of village structure, infrastructure maintenance • New construction of housing
1980's	Development of rural residential environment	Ministry of home affairs	1981	Promotion Act of development of rural residential environment	• Development of rural residential housing (budget support) • Kitchen, bathroom, toilet etc. partial develop on facilities
	Housing development of rural area	Ministry of agricultural development	1988	Housing development of rural area	• Development of rural residential housing (budget support) • Clean up the vacant house • Budget support to change into western style of Kitchen
	Island development	Ministry of home affairs	1988	Promotion Act of island development	• Development on electricity, water supply, traffic, hygiene, medical, welfare facilities

Changes in standard design patterns

Development policy for rural area by period

Division	Project	Ministry	Year	Related Law	Main Content
1990's	Expansion of base settlement	Ministry of Agriculture and Forestry	1990	Rearrangement of rural area Act	• Support development of whole rural housing • Development of road, cultural and welfare facilities
	Development of remote rural area	Ministry of home affairs	1990	Promotion Act of development of remote rural area	• Improvement of residential environment • River maintenance
	Development of rural village	Ministry of Agriculture and Forestry	1991	Rearrangement of rural area Act	• Infrastructure maintenance of village • New construction and reconstruction of housing • Development of new village, maintenance of existing village

Source : Status and Improvement of Housing in Korean Rural Area pg34, Rural Development Administration/ National Institute of Agricultural Sciences

Changes in standard design patterns

Development policy for rural area by period

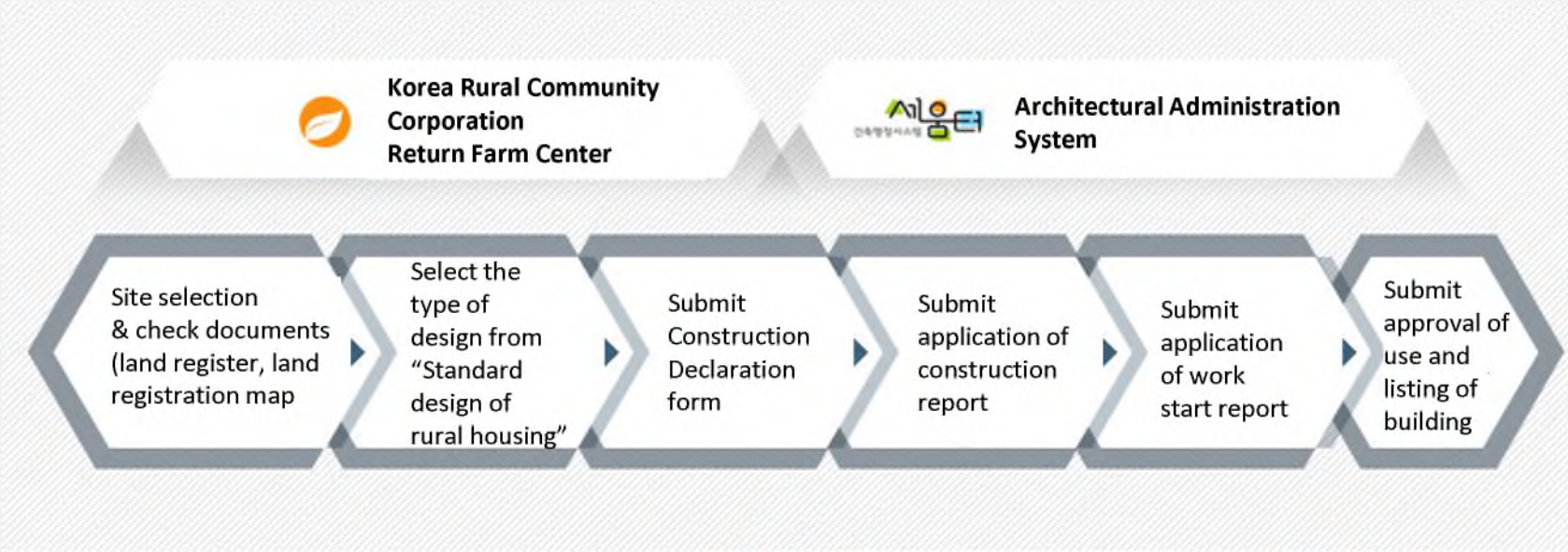
Division	Project	Ministry	Year	Related Law	Main Content
2000's	Detail development of rural village	Ministry of Government Administration and Home Affairs	2000	-	• Development of eco-friendly theme village
	Information demonstration village	Ministry of Government Administration and Home Affairs	2001	-	• Computer supply and internet activation per village
	Excellent ecological village	Ministry of Environment	2001	Rearrangement of rural area Act	• Priority assignment for budget applications on Natural environment preservation facility, environmental foundation facility etc.
	Green farm experience village	Ministry of Agriculture and Forestry	2002	Agriculture Rural Basic Law	• Pursuing Local Activation • Creating leisure facilities and village scenery for rural tourism

Source : Status and Improvement of Housing in Korean Rural Area pg34, Rural Development Administration/ National Institute of Agricultural Sciences

Standard design of rural housing

Standard design of rural housing

- Ministry of Agriculture, food, and rural affairs & Korea rural community corporation has develop and provide “Standard design of rural housing” to support the construction of high-quality house design of rural area.



Ministry of Agriculture, Food and Rural Affairs

Korea Rural Community Corporation

Source: Ministry of Agriculture, food, and rural affairs & Korea rural community corporation

Standard design of rural housing

Development of standard design of rural housing

Year	1994	1999	2004	2009	2010	2012	2014
Type	7	4	6	24	10	8	8
Development direction	Rural single housing		Rural landscape housing		Low energy eco-friendly housing	Rural life style housing	Rural type adequate housing
Note	Abolition	Abolition	Abolition	Abolition (18) Supplementation (6)	Supplementation	Supplementation	New development

Source: Ministry of Agriculture, food, and rural affairs & Korea rural community corporation / Usage status of standard design of rural housing 2016

Standard design of rural housing

Standard design of rural housing -2014

2014 농촌주택 표준설계도 • 설계 _ (주)오우재건축사사무소 김주경, 최교식 • 연구 _ 이화여자대학교 류창수

최소주택 보급형 _ 농림-14-13-가

설계조건

- 최소주택 _ 보급형
- CPCMS 위 수성페인트
- 경골목구조

건축개요

- 연면적 : 41.92㎡
- 건축면적 : 41.92㎡

6

최소주택 고급형 _ 농림-14-13-나

설계조건

- 최소주택 _ 고급형
- 적삼목 + 탄성스타코
- 경골목구조

건축개요

- 연면적 : 41.92㎡
- 건축면적 : 41.92㎡

7

Standard design of rural housing

Standard design of rural housing -2014

2014 농촌주택 표준설계도

비농업 보급형 _ 농림-14-17-가

설계조건

- 비농업 _ 보급형
- [illegible]
- 경량목구조

건축개요

- 연 면 적 : 55.21㎡
- 건축면적 : 55.21㎡

비농업 고급형 _ 농림-14-17-나

설계조건

- 비농업 _ 고급형
- [illegible]
- 경량목구조

건축개요

- 연 면 적 : 57.65㎡
- 건축면적 : 57.65㎡

Standard design of rural housing

Standard design of rural housing -2014

2014 농촌주택 표준설계도

농업 보급형 2 _ 농림-14-27-가

설계조건

- 농업 _ 보급형
- CRC보드 위 수성페인트 + 탄성스타코
- 경골목구조

건축개요

- 연 면 적 : 88.77㎡
- 건축면적 : 88.77㎡

농업 고급형 2 _ 농림-14-27-나

설계조건

- 농업 _ 고급형
- 적삼목 + 전벽돌 + 탄성스타코
- 경골목구조

건축개요

- 연면적 : 106.40㎡
  - 주택 / 87.84㎡
  - 창고 / 18.56㎡
- 건축면적 : 64.15㎡

Standard design of rural housing

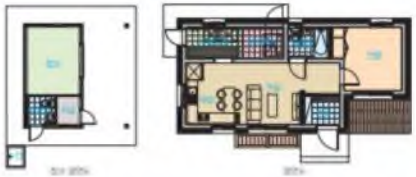
Standard design of rural housing -2014

2012 농촌주택 표준설계도(변경)

고령자 농업가구형 _ 농림-12-26-가-1

고령자 비농업가구형 _ 농림-12-25-가-1

고령자 농업가구형 _ 농림-12-20-가-1



젊은세대 비농업가구형 _ 농림-12-25-나-1

Standard design of rural housing

Standard design of rural housing -2014

2010 농촌주택 표준설계도(변경)

저에너지 전원생활형

저에너지 사랑방형

저에너지 사랑방형

저에너지 사랑방형

Minimum Standards for Adequate Housing in Bangladesh

Minimum Standards for Adequate Housing

Minimum standards

Standard for Adequate Housing in Bangladesh	
Standard 1	Security of tenure is guaranteed for a set period of time of at least 30 years
Standard 2	Access to safe water and sanitation solutions are to be provided
Standard 3	All housing is built with materials and techniques that allow easy maintenance, repair and duplication
Standard 4	All housing and sites are adapted to the local hazard profile to resist recurrent disaster over 30 years
Standard 5	All housing offers a comfortable and healthy internal climate
Standard 6	All housing is adapted to special and specific needs of its inhabitants
Standard 7	All housing is functional, culturally appropriate and adaptable
Standard 8	All housing should be situated as close as possible to employment and education opportunities, medical and other social services

Minimum Standards for Adequate Housing

Minimum Standards

No	STANDARDS	SPECIFIC DETAILS
1	Security of tenure is guaranteed for a set period of time of at least 30 years	• Assessed the current situation • Deriving necessary items to guarantee 30 years • Proof and documentations is to be provided to the inhabitatnts
2	Access to safe water and sanitation solutions are to be provided	• At least 1 standard toilet per household • Access to ample safe water – 300m from house • Construction of toilet & water supply solution from hazard
3	All housing is built with materials and techniques that allow easy maintenance, repair and duplication	• Preference to local, well-known and available materials • Focus on local techniques and tricks • Introduction of new materials and techniques • Look into options to produce new materials locally • Repair and maintenance cost within the household's budet
4	All housing and sites are adapted to the local hazard profile to resist recurrent disaster over 30 years	• Public: Elimination of obvious exposed risks • Individual/site: Alternative plans for risky areas such as river edge • Built in the minimum technical standard set

Minimum Standards for Adequate Housing

Minimum Standards

No	STANDARDS	SPECIFIC DETAILS
5	All housing offers a comfortable and healthy internal climate	• Minimum area for 2-3 house members (min. 3.6m^2 /person) • At least 2 windows for main room/ at least 1 window in each additional spaces • All windows must all fitted with a system • Additional ventilation openings (Kitchen, under the roof)
6	All housing is adapted to special and specific needs of its inhabitants	• 5~10% of the budget for the house is allocated to adapt standard house designs to the specific needs of individual households Spaces that can secure for household's spare time
7	All housing is functional, culturally appropriate and adaptable	• Each house should be provided with 2 doors if it is possible (main entry and secondary exit) • Standard designs are adapted to cultural practices • Additional space for training is to be conducted for repair and maintenance • Each house is built so that it can be easily adapted or expanded upon • Safe and appropriate place for education and training
8	All housing should be situated as close as possible to employment and education opportunities, medical and other social services	• Accessibility to housing sites is to be guaranteed • Accessibility to livelihood opportunity and services

Housing Proposals

Low income class housing model - 53m^2

Proposal

Model-1

Low income-class housing model – 572sft/53m^2

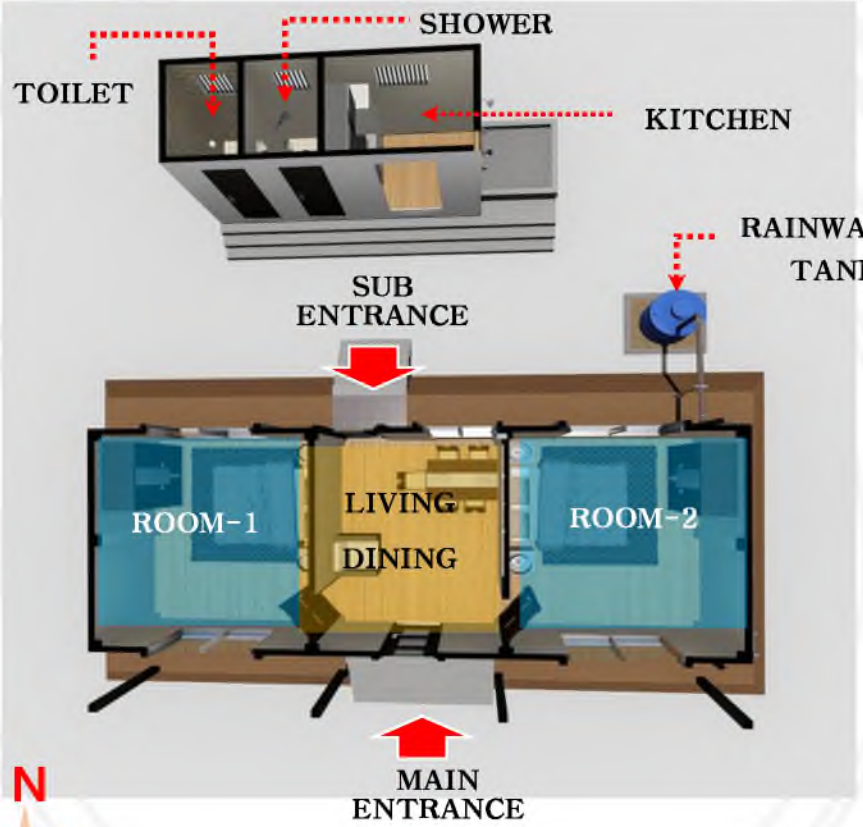
TYPE	MAIN STRUCTURE	MAIN MATERIAL	SURFACE AREA	PRICE/HOUSEHOLD,USD
SINGLE	WALL : CEMENT HOLLOW BLOCK	LIGHTWEIGHT	572sft/53m2	10,000$~15,000$
HOUSE	ROOF : G.I STEEL GABLE ROOF	FOAM BLOCK	HOUSEHOLD	(BDT:1,500tk/sft)

Proposal

Model-1

Low income-class housing model– 572sft/53m²

FLOOR PLAN



FLOOR AREA ANAYSIS

ROOM	UNITS	AREA
BED ROOM-1	12'-0"X14'-0"	168sft/15.6m2
BED ROOM-2	12'-0"X14'-0"	168sft/15.6m2
LIVING/DINING	10'-0"X14'-0"	140sft/13m2
KITCHEN	8'-0"X6'-0"	48sft/4.4m2
SHOWER	4'-0"X6'-0"	24sft/2.2m2
TOILET	4'-0"X6'-0"	24sft/2.2m2
TOTAL AREA		572sft/53m2

Proposal

Model-1

Low income-class housing model– 572sft/53m^2

SOUTH ELEVATION

NORTH ELEVATION

EAST ELEVATION

WEST ELEVATION

Proposal

Model-1

Low income-class housing model – 572sft/53m²

Proposal

Model-1

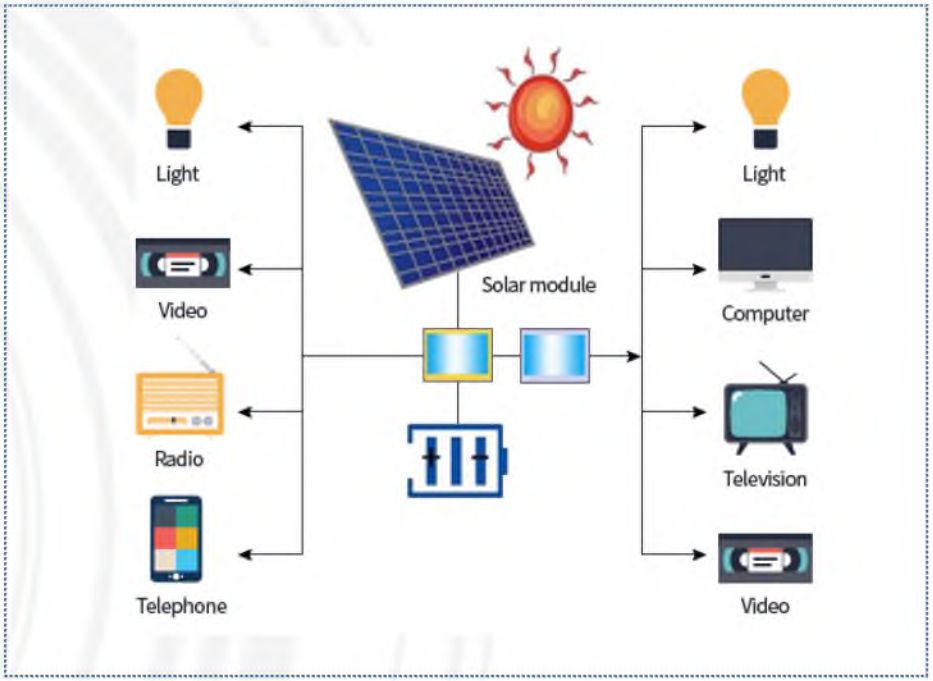
Low income-class housing model – 572sft/53m²

Proposal

Model-1

Low income-class housing model – 572sft/53m²

SOLAR SYSTEM



How We Turn Solar Energy Into Electricity

Low income class housing model - 53m^2

Proposal

Model-2

Low income-class housing model– 758sft/70m2

TYPE	MAIN STRUCTURE	MAIN MATERIAL	SURFACE AREA	PRICE/HOUSEHOLD,USD
SINGLE	WALL : BRICK or CONCRETE PANEL	BRICK	758sft/70.1m2	15,000$~20,000$
HOUSE	ROOF : G.I STEEL GABLE ROOF	CONCRETE PANEL	HOUSEHOLD	(BDT:1,500tk/sft)

Model-2

Low income-class housing model– 758sft/70m2

FLOOR PLAN

N

FLOOR AREA ANAYSIS

ROOM	UNITS	AREA
BED ROOM-1	12'-0"X14'-0"	168sft/15.6m2
BED ROOM-2	12'-0"X12'-0"	144sft/13.3m2
LIVING/DINING	13'-5"X14'-0"	256sft/23.7m2
KITCHEN	10'-0"X12'-0"	120sft/11.1m2
TOILET	5'-0"X7'-0"	35sft/3.2m2
VER-1	3'-0"X4'-0"	12sft/1.1m2
VER-2	5'-0"x3"-7"	23sft/2.1
TOTAL AREA		758sft/70.1m2

Proposal

Model-2

Low income-class housing model– 758sft/70m2

SOUTH ELEVATION

NORTH ELEVATION

EAST ELEVATION

WEST ELEVATION

Proposal

Model-2

Low income-class housing model– 758sft/70m2

Low income-class housing model– 758sft/70m2

Proposal

Model-2

Low income-class housing model– 758sft/70m2

LOW INCOME CLASS HOUSEING MODEL ANIMATION

BACE PANEL

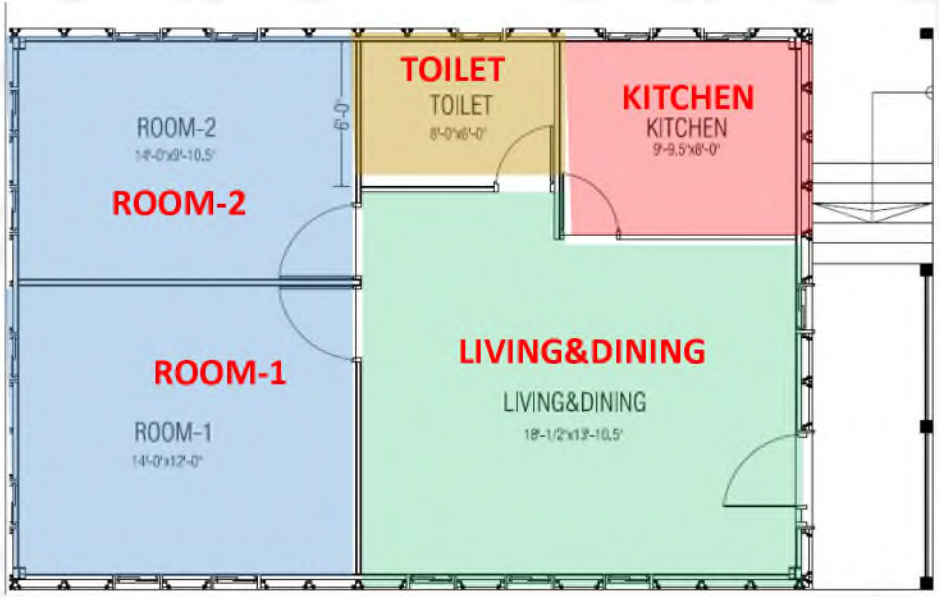
PREFINISHED LIGHT WEIGHT EXTRUDED PANEL

ANIMATION

Model-3

Low income-class housing model– 785sft/72.8m2

TYPE	MAIN STRUCTURE	MAIN MATERIAL	SURFACE AREA	PRICE/HOUSEHOLD,USD
SINGLE HOUSE	WALL : BRICK or CONCRETE PANEL ROOF : G.I STEEL GABLE ROOF	BRICK CONCRETE PANEL	758sft/70.1m2 HOUSEHOLD	15,000$~20,000$ (BDT:1,500tk/sft)



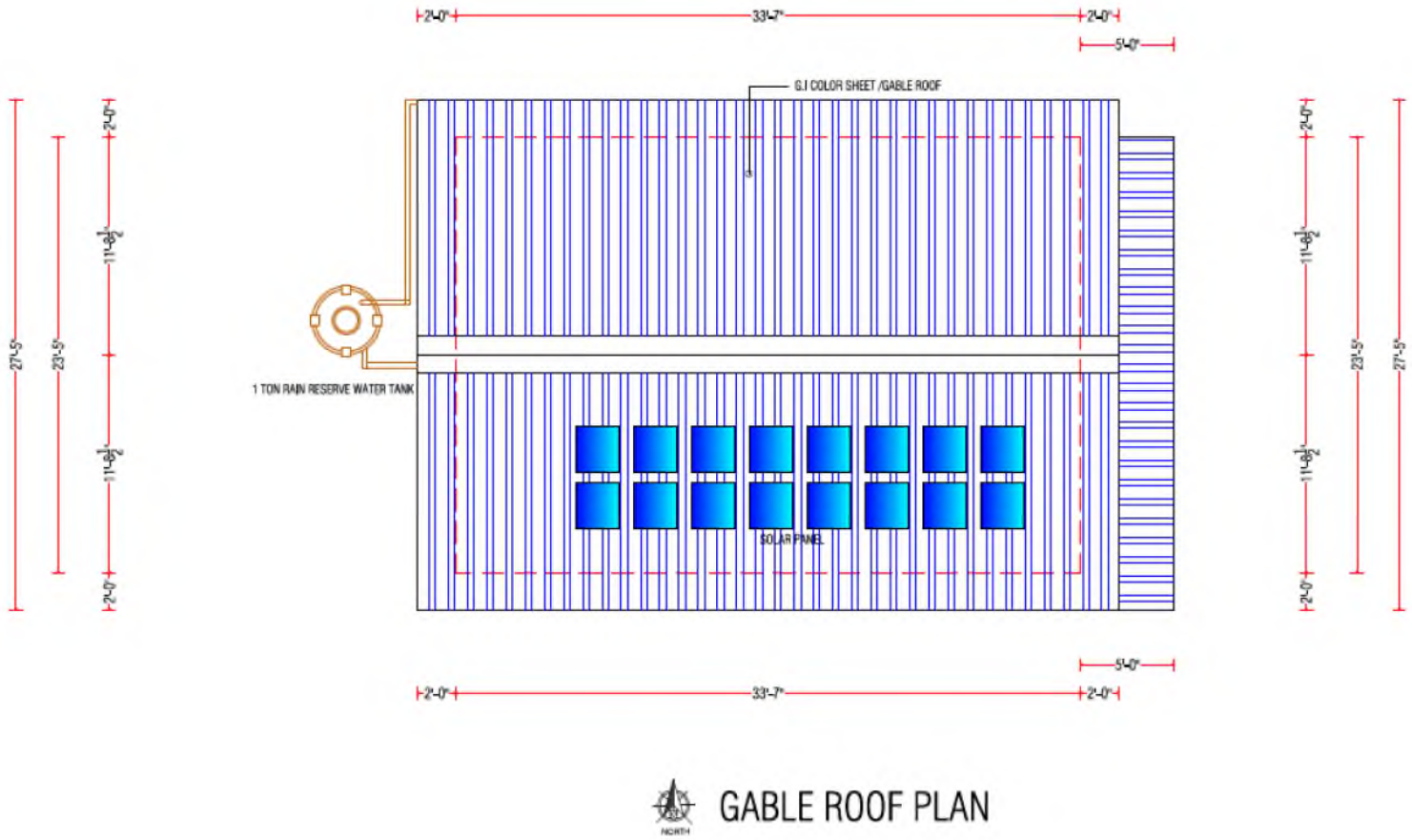
FLOOR AREA ANAYSIS

ROOM	UNITS	AREA
BED ROOM-1	12’-0”X14’-0”	168sft/15.6m2
BED ROOM-2	14’-0”X9’-10”	138sft/12.8m2
LIVING/DINING	18’-1”X13’-10”	353sft/32.8
KITCHEN	9’-9”X8’-0”	78.4sft/7.2
TOILET	8’-0’X6’-0”	48sft/4.4
TOTAL AREA		785sft/72.8m2

Proposal

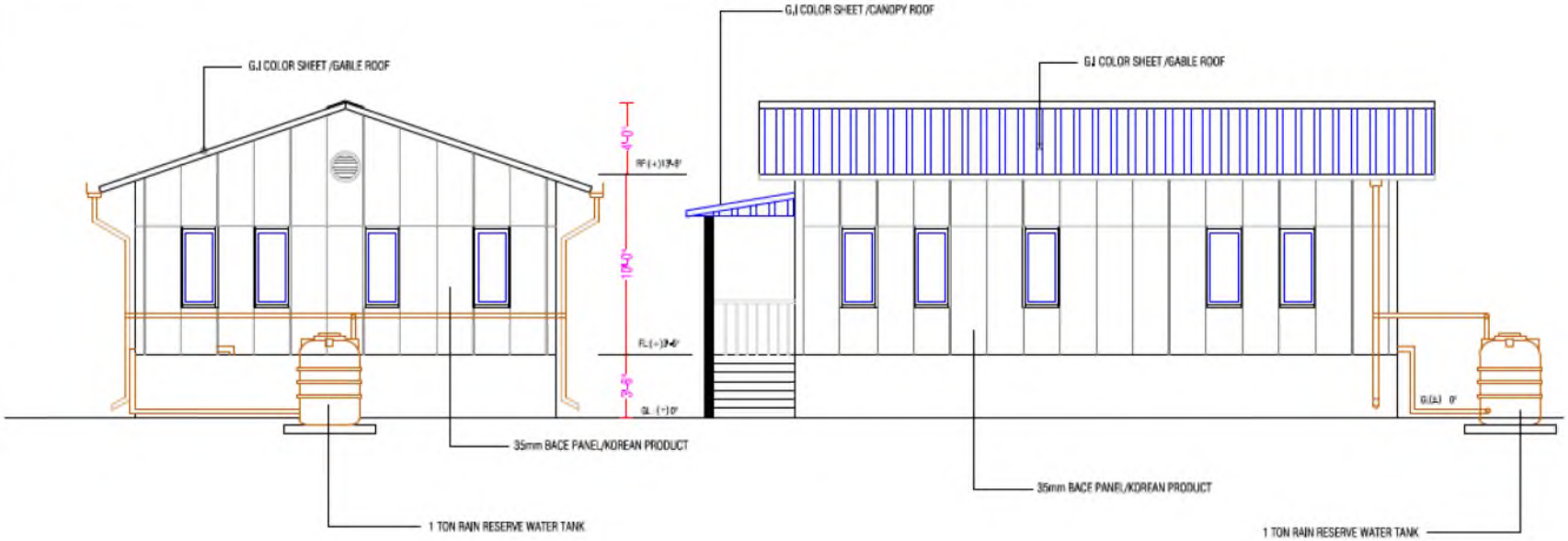
Model-3

Low income-class housing model– 785sft/72.8m2



GABLE ROOF PLAN

Low income-class housing model– 785sft/72.8m2



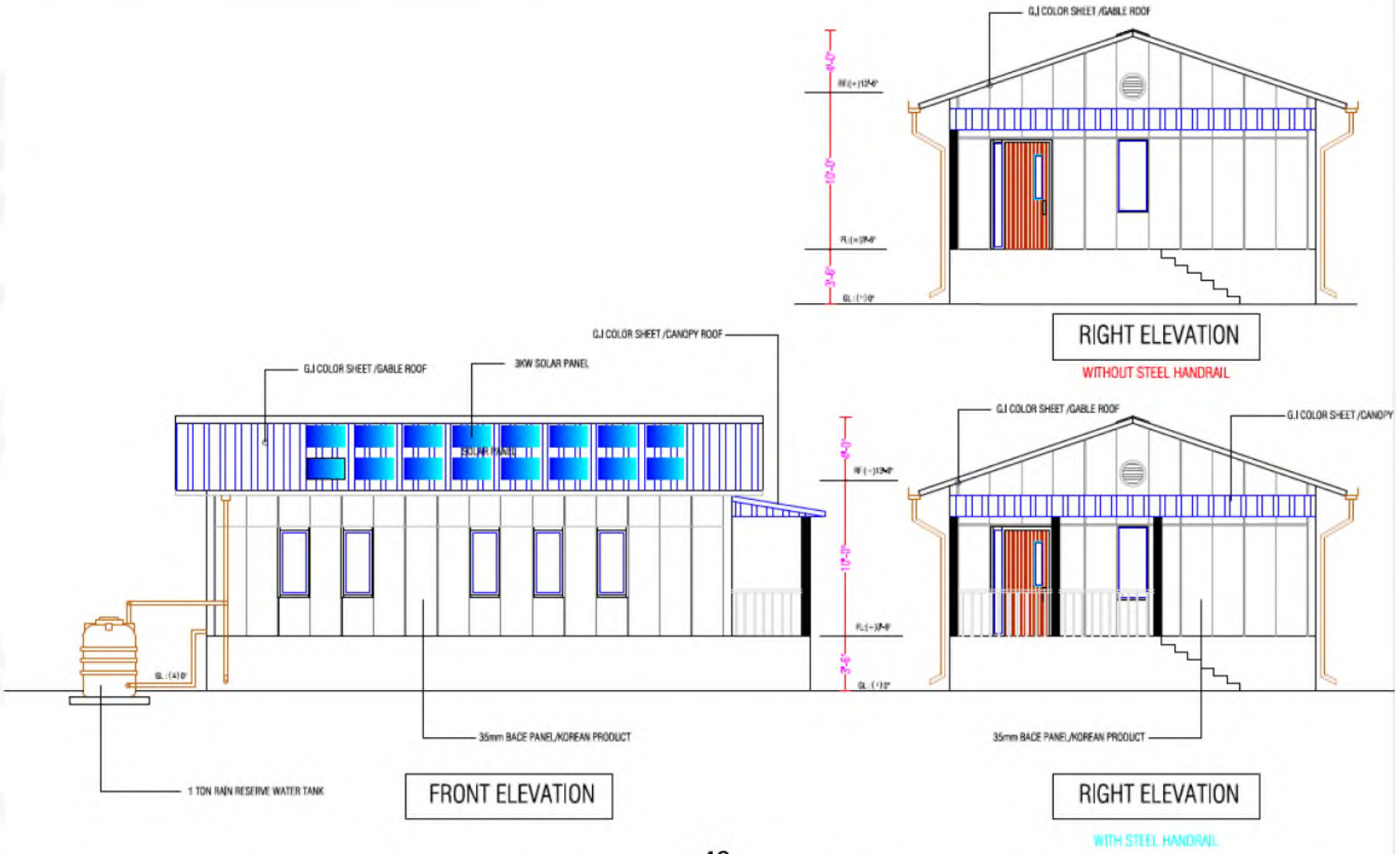
LEFT ELEVATION

BACK ELEVATION

Proposal

Model-3

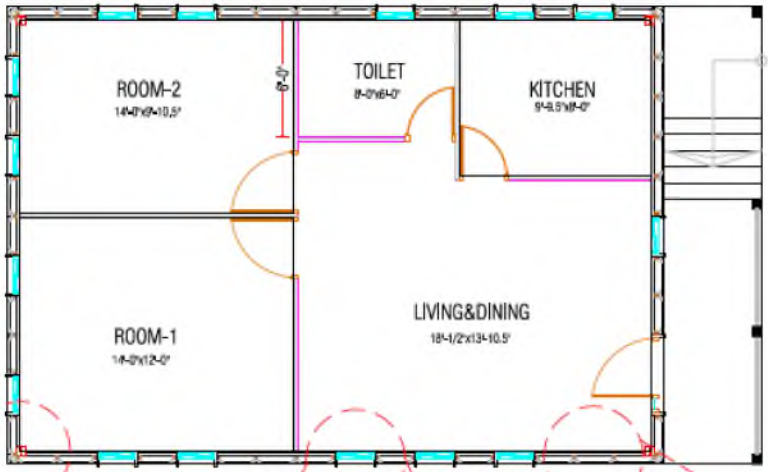
Low income-class housing model– 785sft/72.8m2



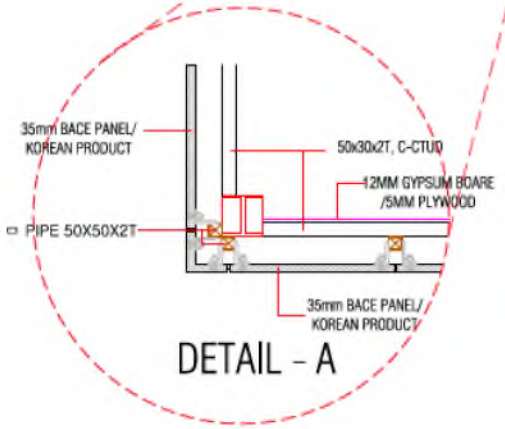
Proposal

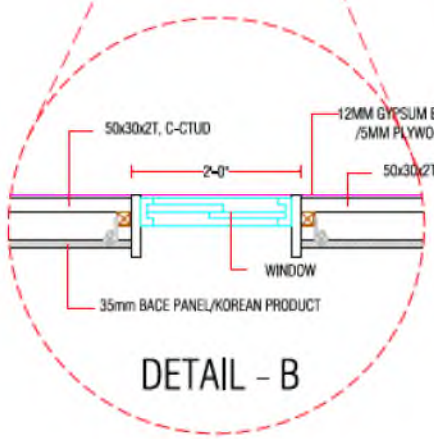
Model-3

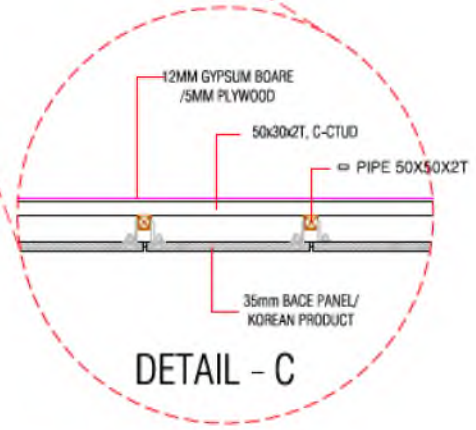
Low income-class housing model– 785sft/72.8m2



EXTERIOR BACE PANEL DETAIL





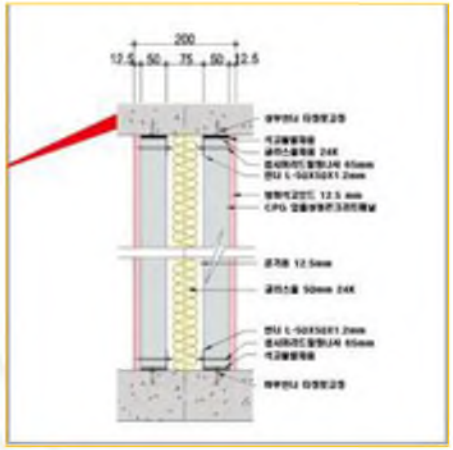


Proposal

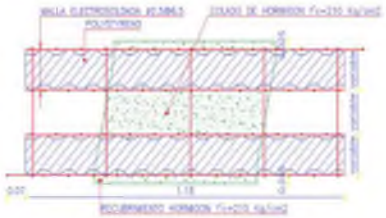
Construction of lightweight wall

- **Exterior:** Vacuum extrusion panel + Dry mortar construction
- **Interior:** Cement composite panel (can be produced locally)
- Easy to assemble by clip and anchor

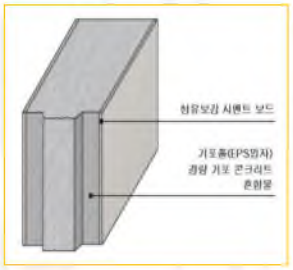
Vacuum extrusion panel (Exterior)

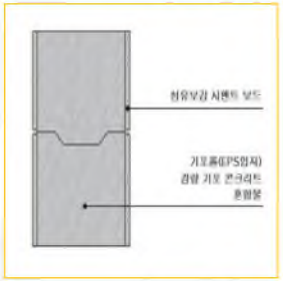


Styrofoam Panel (Exterior)



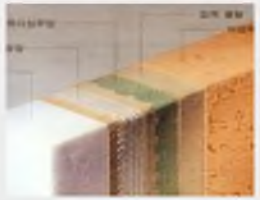
Cement composite panel (interior)





Proposal

Major building materials

Component	Material	Advantage	Disadvantage	Relevant photo
Wall	Extrusion panel	Superior durability	Expensive Process industry	
	Composite panel	Low cost	Low durability	
Roof	Sandwich panel	Light weight Excellent durability	Process industry	
Finish	Mortar finish	Low cost	Low durability	

Proposal

ASP technology

ASP Technology	
Technical Features	- ASP(Advanced Stabilization Polymer) is enzymes vinyl polymer compound which can combine between the soil particles by making polymer film on the surface of the soil particles. It is economic and easy to construct quickly because of using the local soil for ground reinforcement, shatter-proof and erosion control.
Applicability	- Soil packaging, roads in a apartment complex, parking, etc. - Does not receive a large load such as bike trails, promenades, comin way road - Soil packaging, roads in a apartment complex
Application to the housing sector in Bangladesh	- Local clay + ASP Mixed compaction / ASP coating or other surface treatment

Proposal

ASP technology

[Application to the housing sector in Rwanda]

- Local clay + ASP Mixed compaction / ASP coating or other surface treatment

Processing to stabilize the bottoms of the housing inside and around

Soil packing in Housing complex

Proposal

ASP technology

How to apply ASP technology to housing		
Processing housing Floor	 ▪ Local clay + ASP Mixing	 ▪ Manpower compaction
Soil packaging	 ▪ Local clay + ASP Mixing	 ▪ Equipment compaction
		 ▪ Manpower compaction

Thank You

KICT
KOREA INSTITUTE of CIVIL ENGINEERING
and BUILDING TECHNOLOGY

CAPACITY TRAINING WORKSHOP

General Water Purification Techniques using Membrane Technologies

2018. 11. 12

Presenter : Prof. Sangho Lee
(Kookmin University in Korea)

Contents

02 Membrane Technology

50 percent

The number of people who don't have access to the quality of water available to the citizens of Rome 2,000 years ago

40 billion

The number of hours spent each year in Africa due to the need to collect and haul water

Source: Blue Planet Run, Smolan, Erwitt

5.3 billion

The number of people - two-thirds of the world's population - who will suffer from water shortages by 2025.

1.1 billion

The number of people worldwide - 1 in every 6 - without access to clean water

Source: Blue Planet Run, Smolan, Erwitt

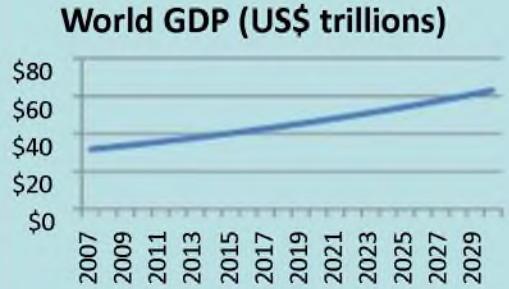
Global Water Demand

1)) GDP

US$1M GDP/yr

=

22,000 m_3 of water



Sources: IMF, World Bank.

CAGR to 2030:

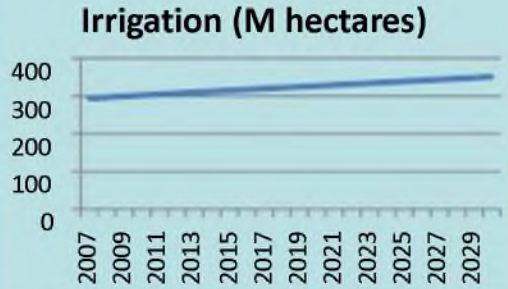
3.0%

2) Irrigation

1 hectare of land/yr

=

10,000 m_3 of water



Source: U.N. Food and Agriculture Org.anization.

CAGR to 2030:

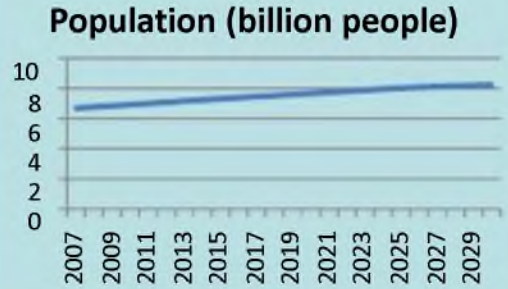
1.5%

3) Population

1 person/yr

=

60 m_3 of water



Source: U.N Population Division.

CAGR to 2030:

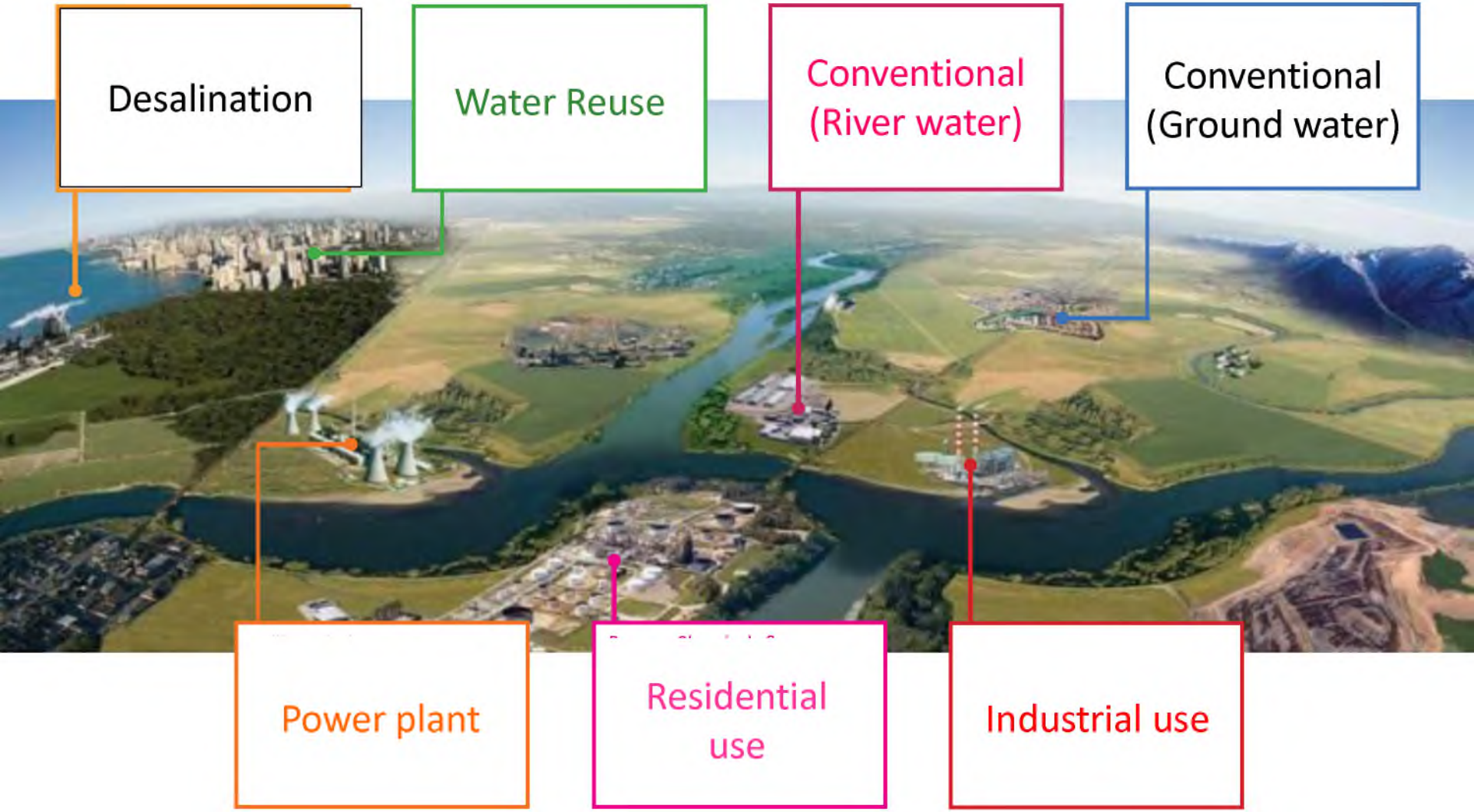
0.9%

Together, these factors account for more than 98% of the variance between different countries' annual water usage

[Hoekstra & Chapagain, 2008]

[Hoekstra & Chapagain, 2008]

Enabling the future with portfolio solutions



Membrane is an emerging technology to mitigate water shortage problem!

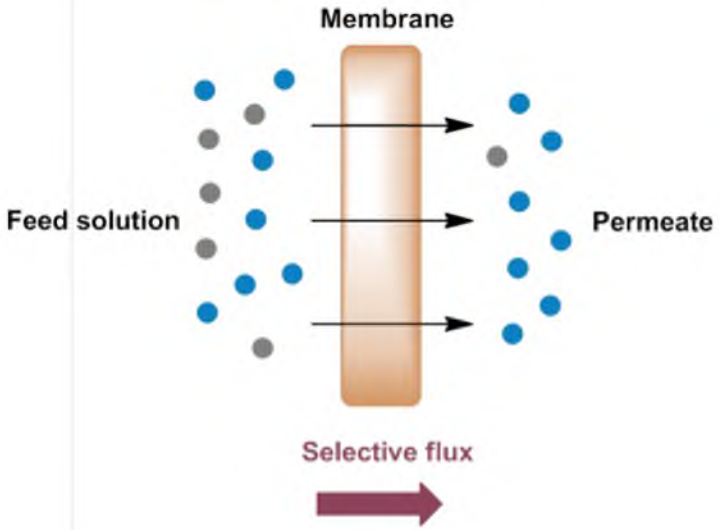
02 Membrane Technology

02-1 Definition of Membrane

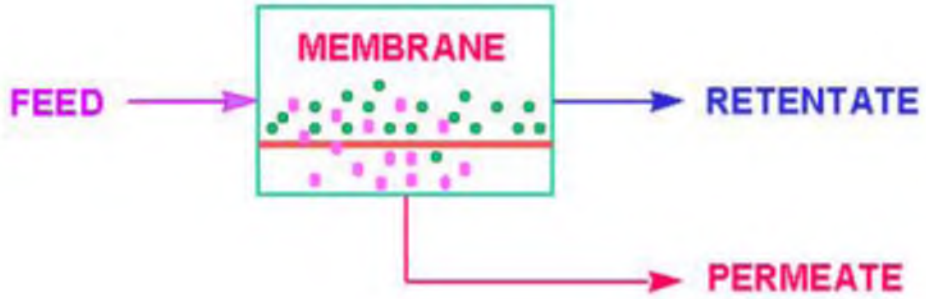
Membrane

A membrane is a selective barrier, allowing some things to pass through but stops others.

Driving Force : 압력차, 농도차, 전위차 등



Definition of Permselective Membrane



Principle of Membrane Operation

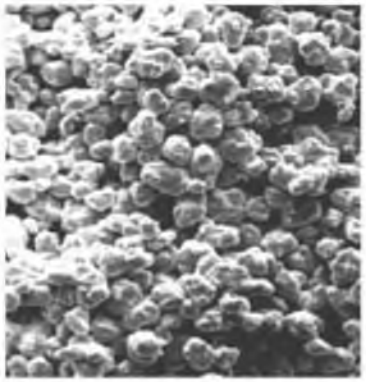
Brief History of Membrane Technology for Water Applications...

1956 - early 1980s :	RO desalination, no commercial MF/UF for drinking water
mid-1980 - early 1990s :	Development of Memcor (MF), Aquasource (UF), clean waters & small capacities (1993 - Milwaukee- cryptosporidium crisis)
mid-1990 - 2002:	Start of market growth, new competitors (Zenon, Xflow,Hydranautics, Pall, Ionics) with second generation membranes/modules) Use on not so clean waters Start of immersed MBR products
Now	Large plants > 200000m^3/d Strong growth of RO desalination market

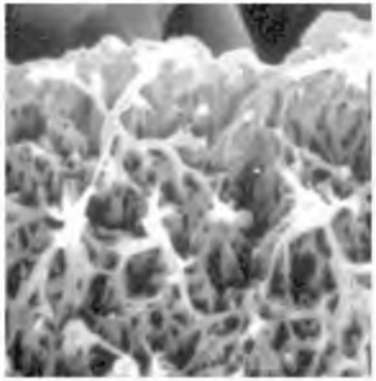
Structure of Membranes

Structure: assymetric
Material: Polysulphone
Method: casting

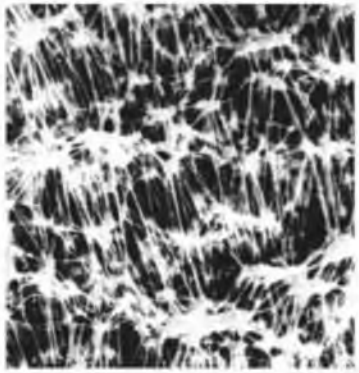
Structure: symetric
Material: glass
Method: sintering



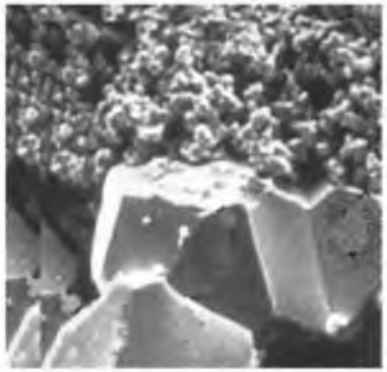
Structure: symetric
Material: Polysulphone
Method: casting



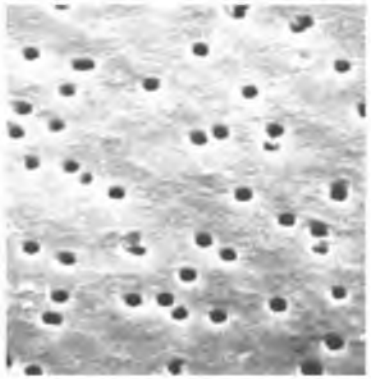
Structure: symetric
Material: Polypropylene
Method: stretching



Structure: assymetric
Material: α-Al2O3/ZrO
Method: sintering



Structure: assymetric
Material: polycarbonate
Method: track-etching



02-2 Types of Membranes

Desalting/Removal of Dissolved Organics

- Reverse Osmosis (RO)
- Nanofiltration (NF)

} *Dense membranes*

Membrane Filtration

- Ultrafiltration (UF)
- Microfiltration (MF)

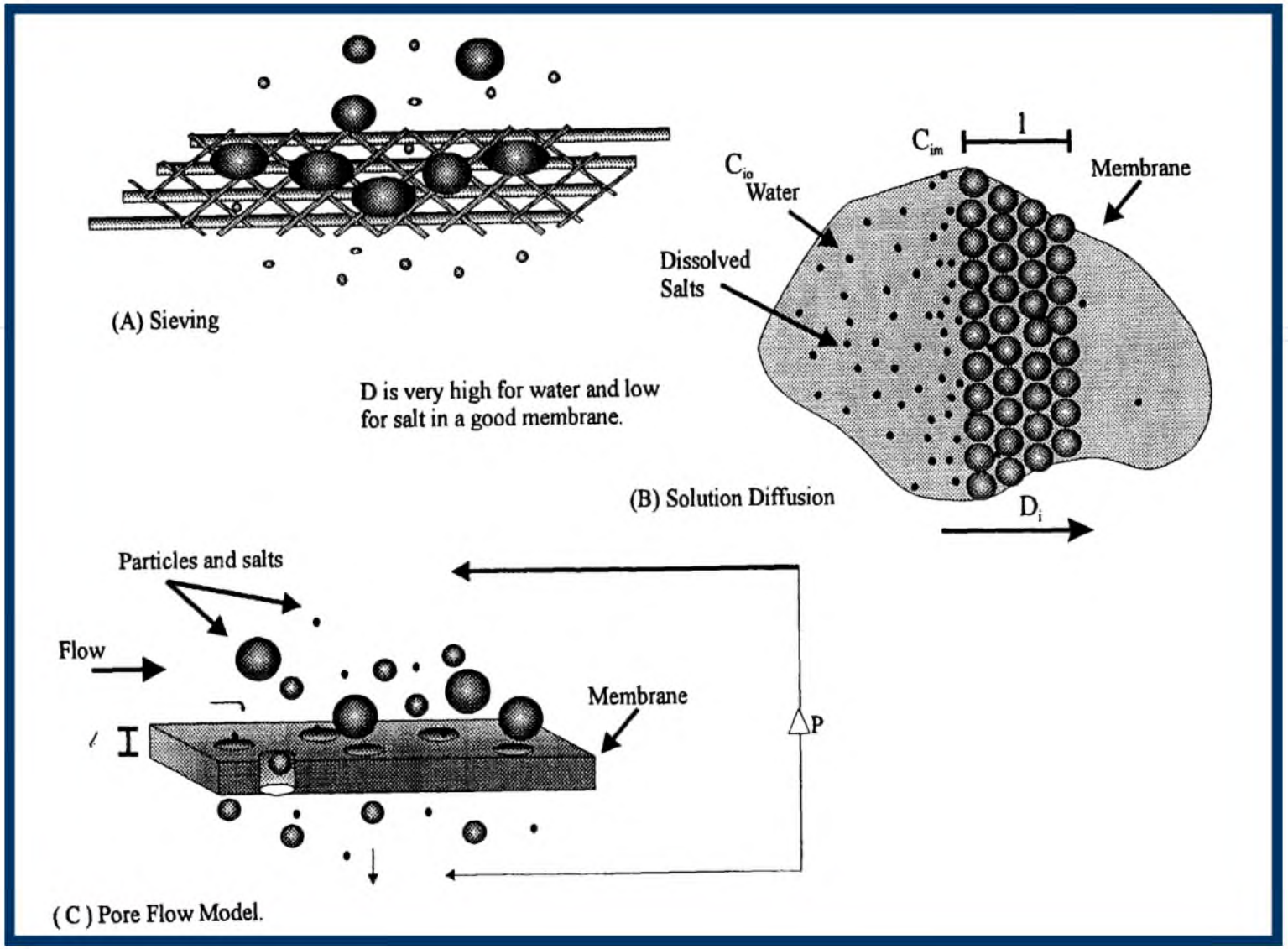
} *Porous membranes*

Membrane Bio-Reactors (MBR)

- UF and/or MF membranes coupled with aerobic bio-reactor

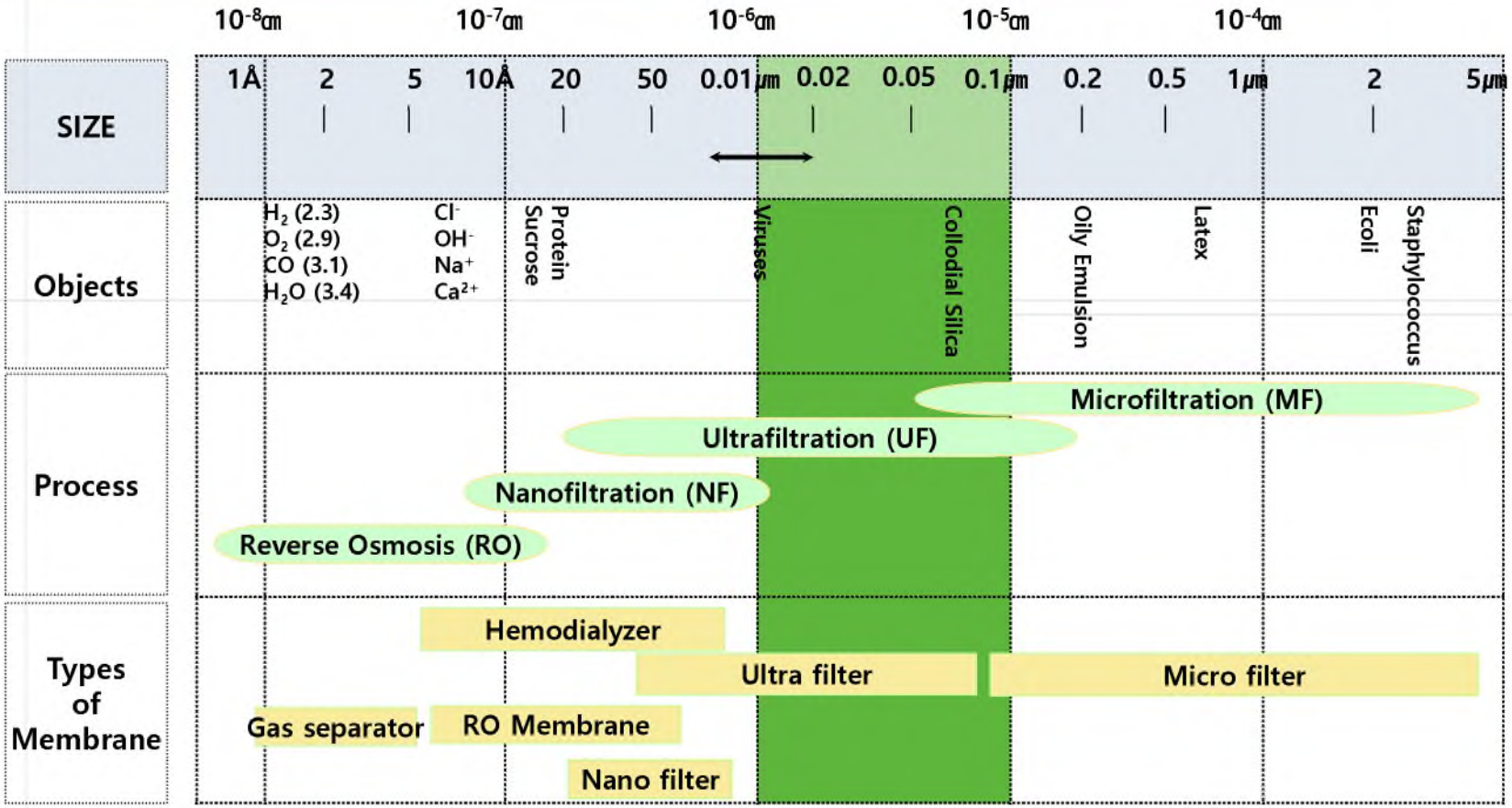
Source: Pearce (2010)

Separation Mechanisms by Membranes



Types of Membranes

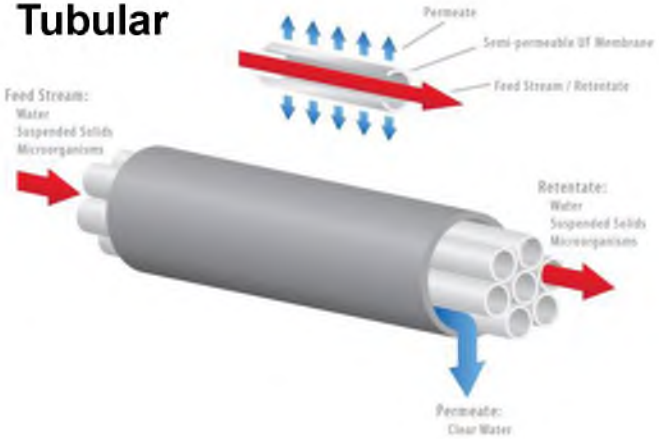
Filtration Spectrum



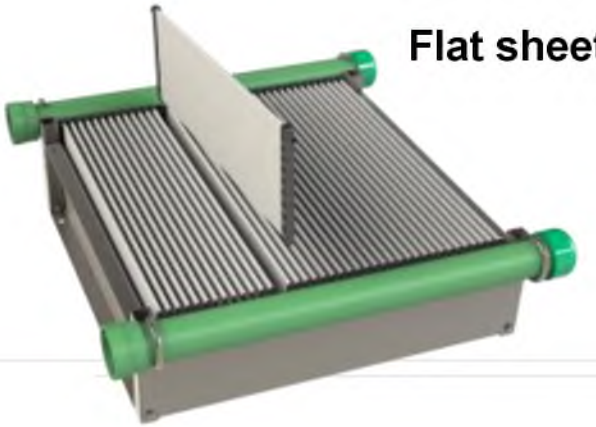
Source: Shin (2011)

Types of Membrane Modules

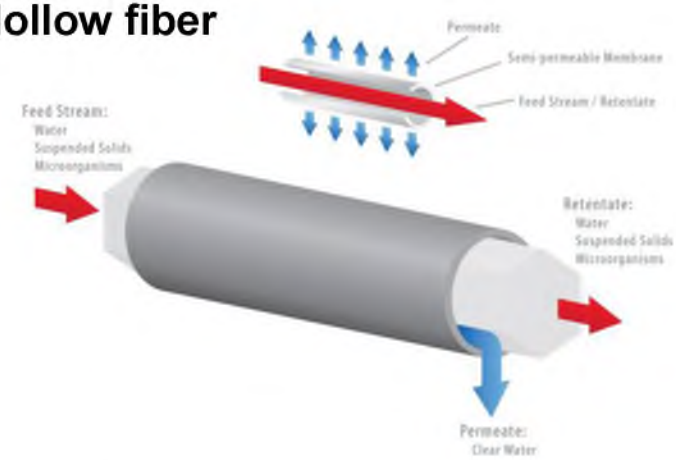
Tubular



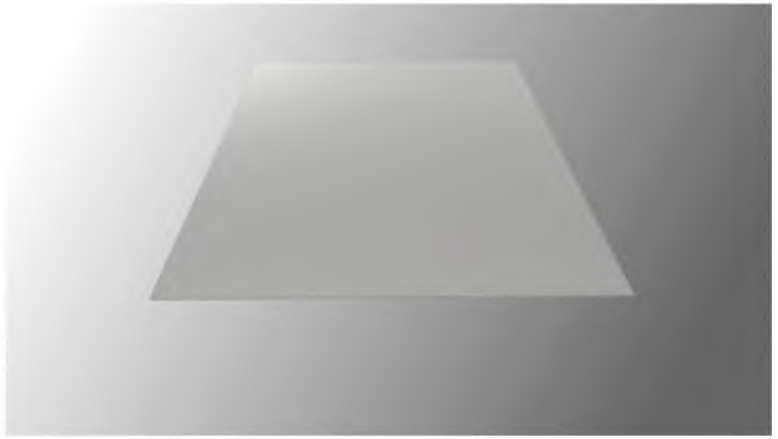
Flat sheet



Hollow fiber



Spiral wound



Source: http://synderfiltration.com/learning-center/articles/module-configurations-process/hollow-fiber-membranes/

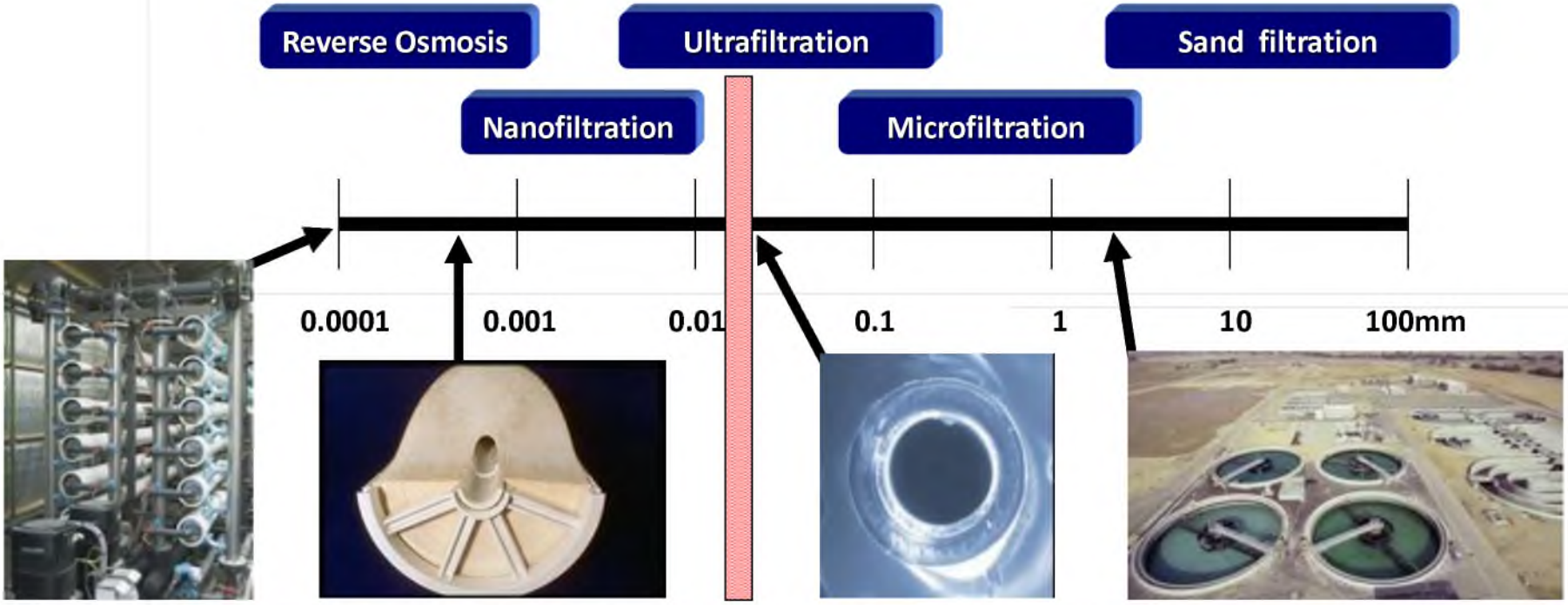
Source: http://cembrane.com/membranes-and-modules/

Characteristics of Different Membrane Processes

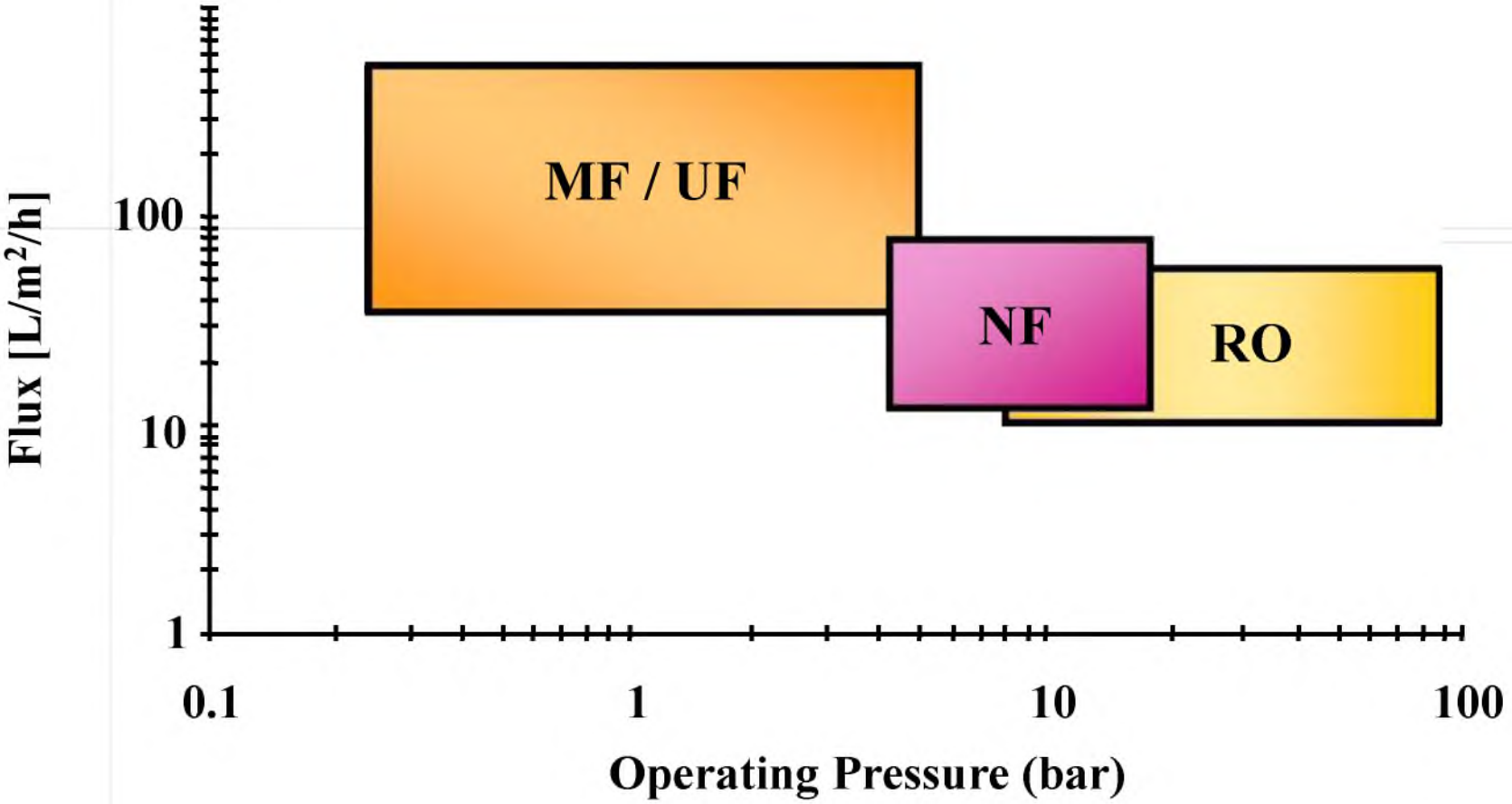
	Membrane Types			
Properties	**RO (Reverse Osmosis)**	**NF (Nanofiltration)**	**UF (Ultrafiltration)**	**MF (Microfiltration)**
Pressure Capability	High 10~100 bar	High 5~9 bar	Low 0.5~5 bar	Low 0.3~3 bar
Flux (l/m2/hr)	5~40	20~80	3~200	50~500
Pore Size(㎛)	Less than 0.001	0.001~0.1	0.01~0.1	0.1 이상
Recovery	50~80%	75~90%	More than 90%	More than 95%
Pollutants to be removed	All Particles, Ionic Species	All Particles, Not Monovalent Species	Particl, Colloids, Proteins	Particle, Colloids, Not Proteins

	Module Types			
Module	**Spiral-Wound**	**Hollow Fiber**	**Tubular**	**Plate and Frame**
Cost	Low	Low	High	High
Fouling Resistance	Fair	UF/MF-Good RO/NF-Poor	Very good	Fair

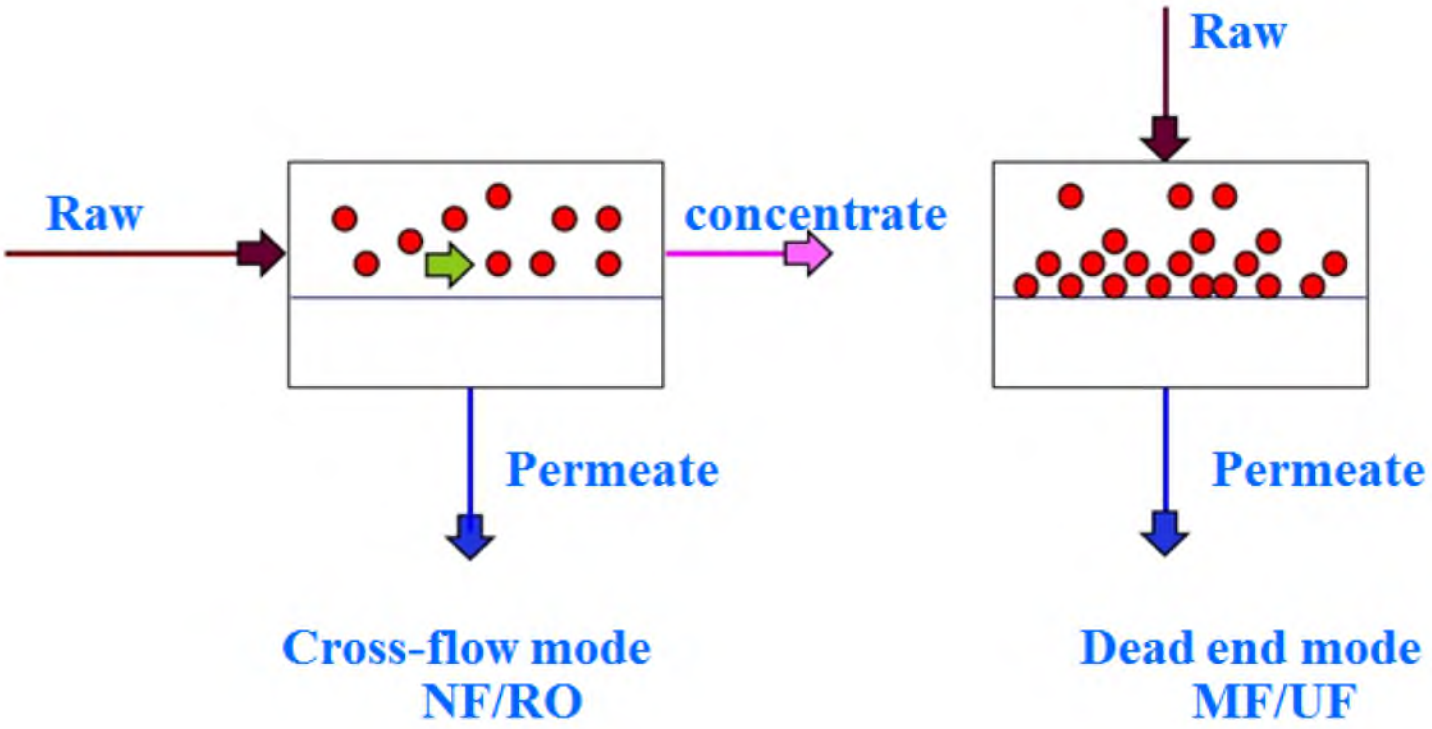
Characteristics of Different Membrane Processes



Membrane Operating Conditions



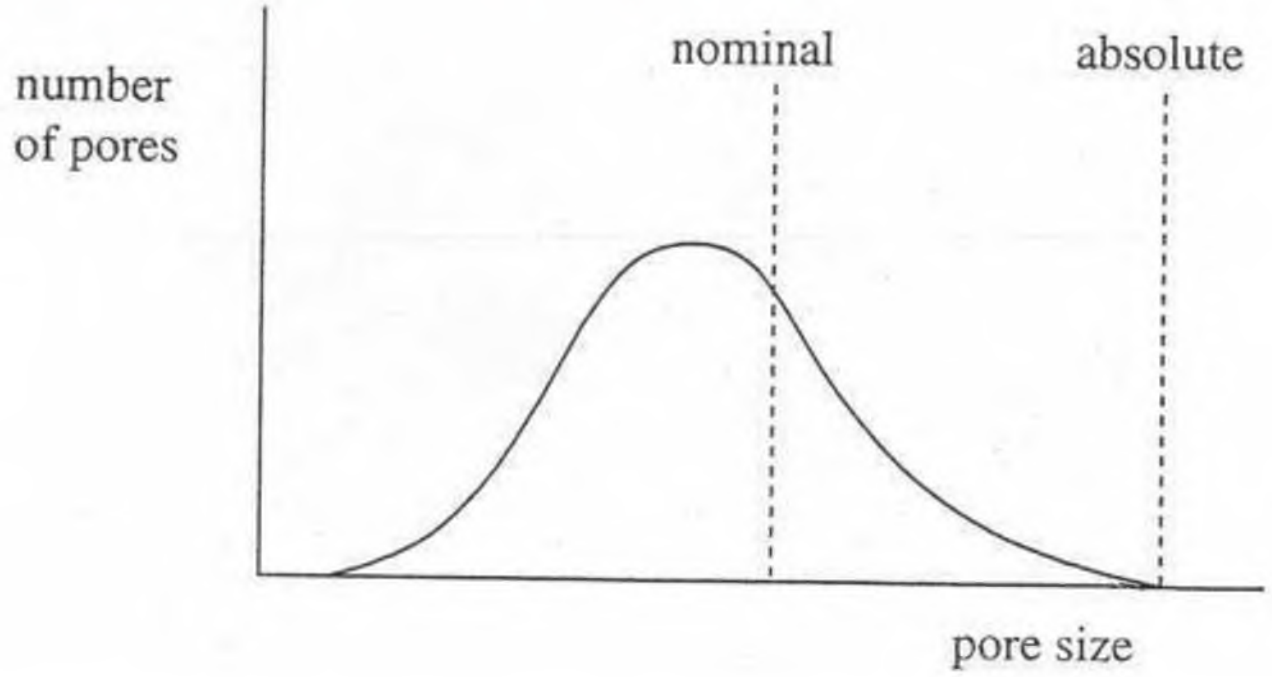
Membrane Operating Modes



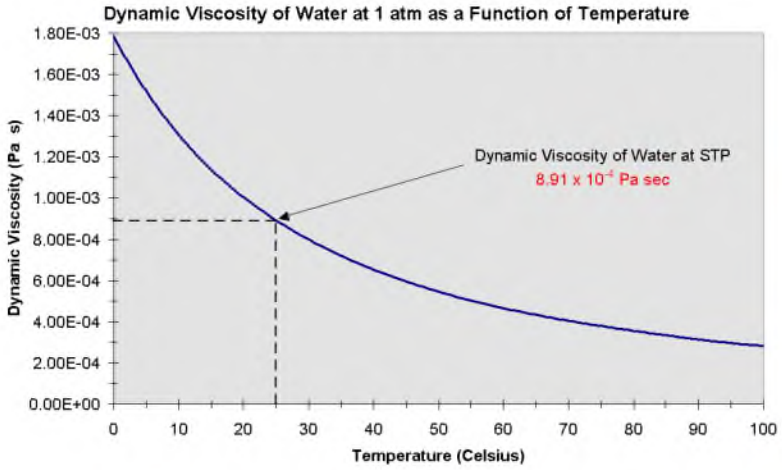
02-3 Understanding of Membrane Process

Pore size distribution

The pore size provided by the manufacture may not be the real pore size of the membrane

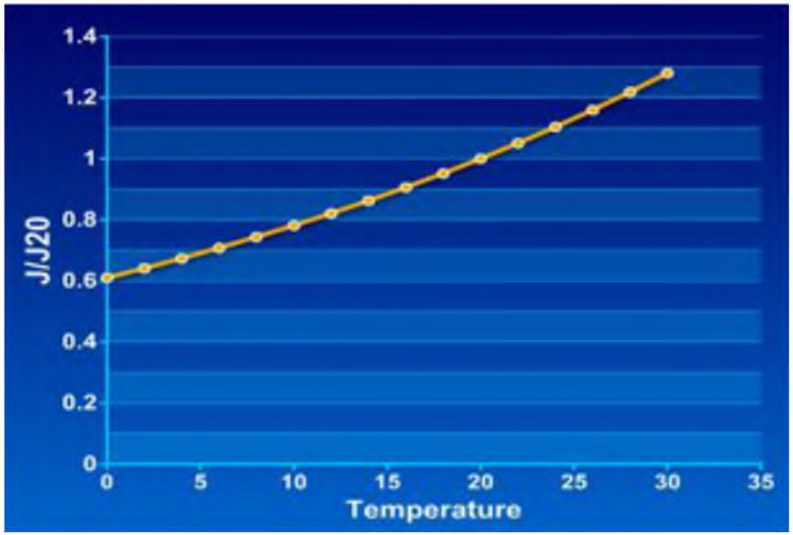


Effect of water temperature

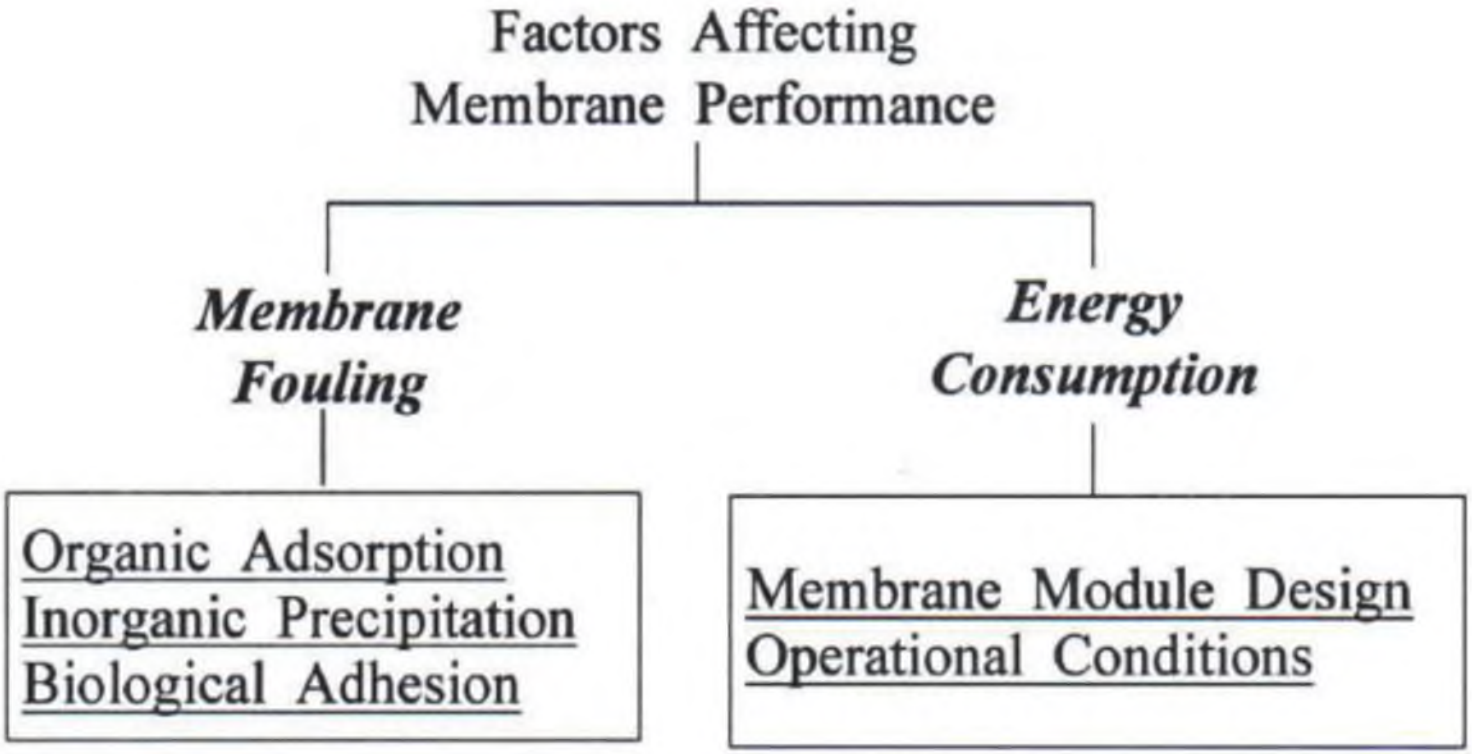


$$J = \frac{\Delta P}{\eta\left(R_m + R_f\right)} \propto \eta^{-1}$$

- Membrane permeability decreases with a decrease in feed water temperature
- For example, the membrane permeability decrease by 40 % when the water temperature decreases from 20 °C to 0 °C.

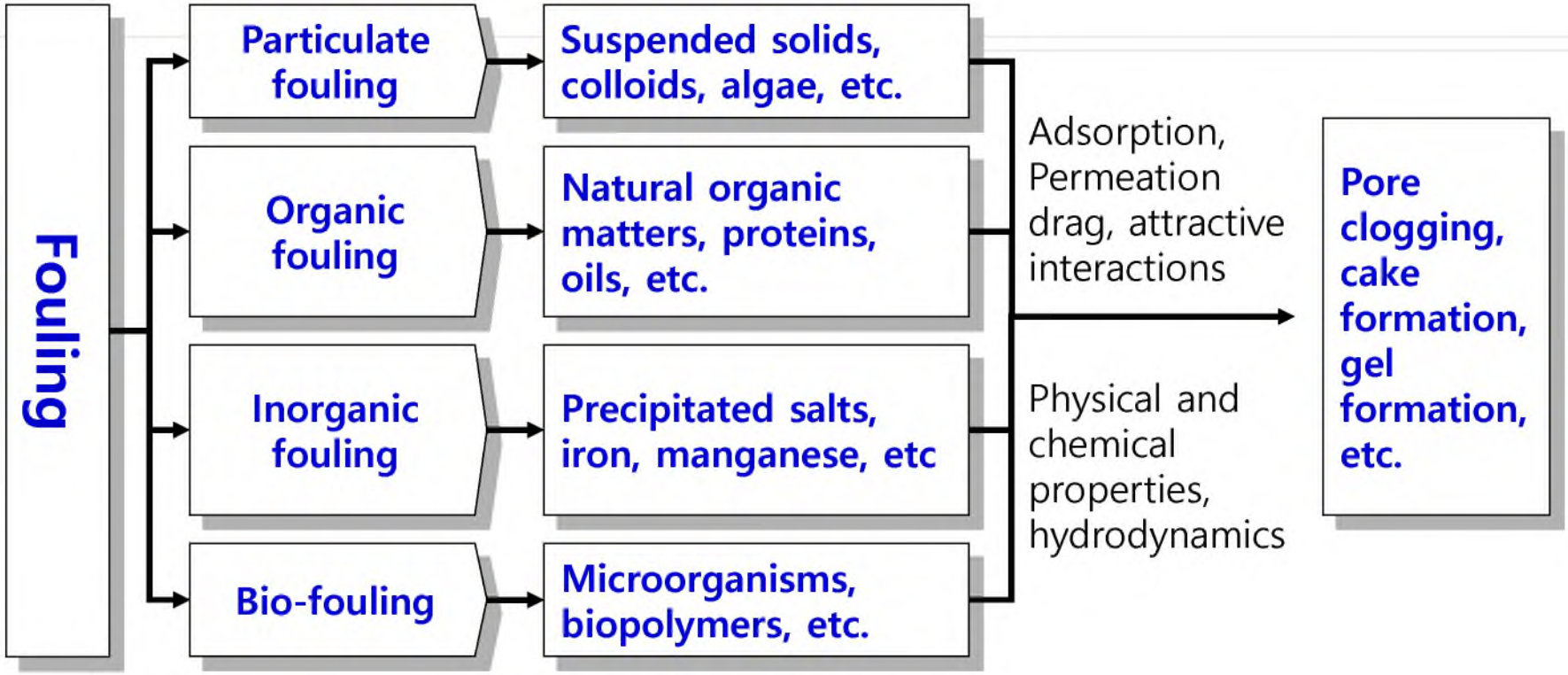


Factors affecting the membrane performance



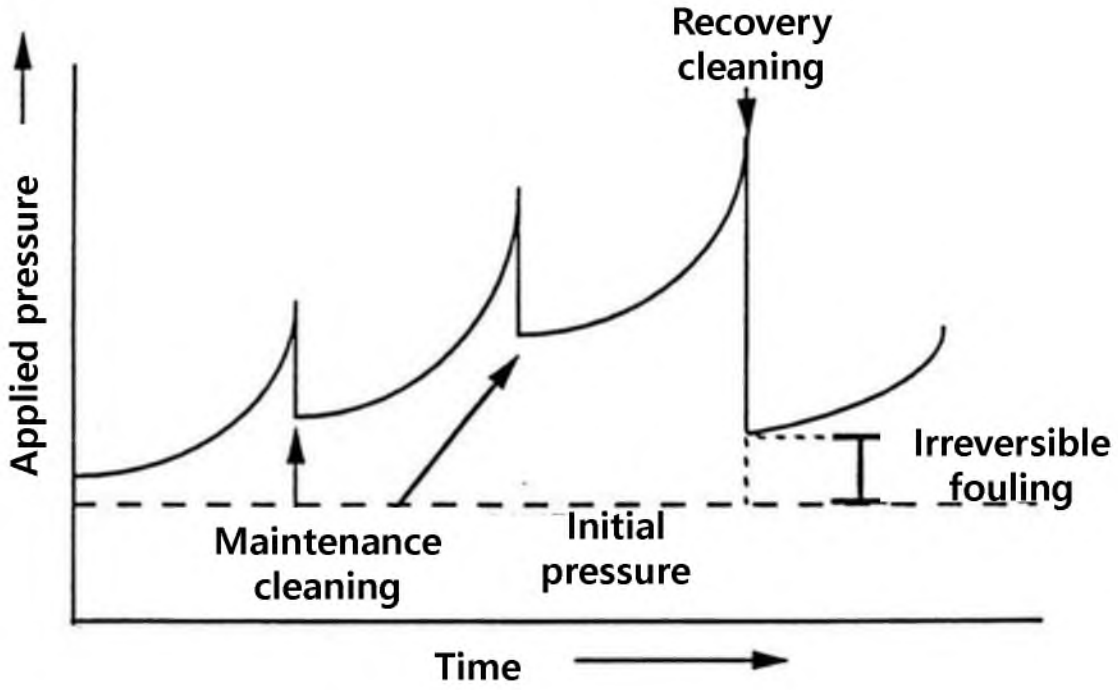
Membrane fouling

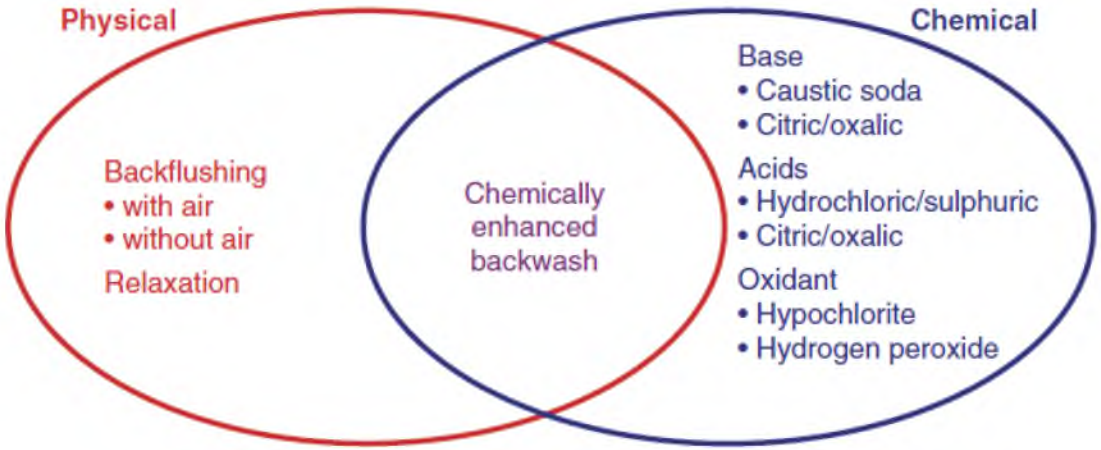
- Membrane fouling is a process whereby a solute or a particle is deposited on a membrane surface or in membrane pores in a processes.
- Membrane fouling is inevitable.



Membrane Cleaning

Membrane operation and cleaning





Types of cleaning methods

02-4 Membrane Technology for Water Treatment

Desalination

SWRO
BWRO
EDR

Salt removal

Wastewater Treatment

MBR
MF/UF

Biomass separation

Drinking Water Treatment

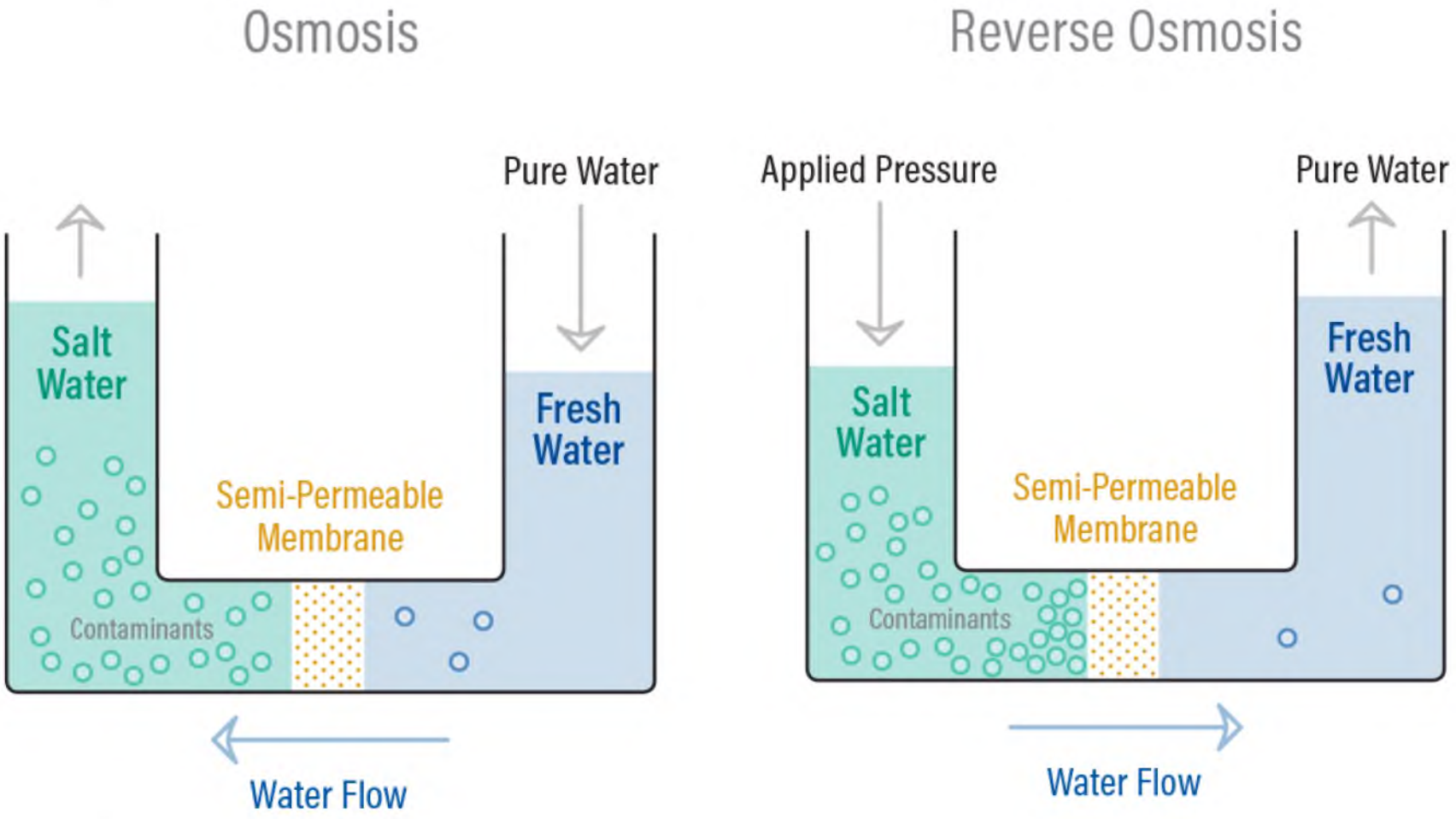
MF/UF
NF

Particle/pathogen/
hardness removal

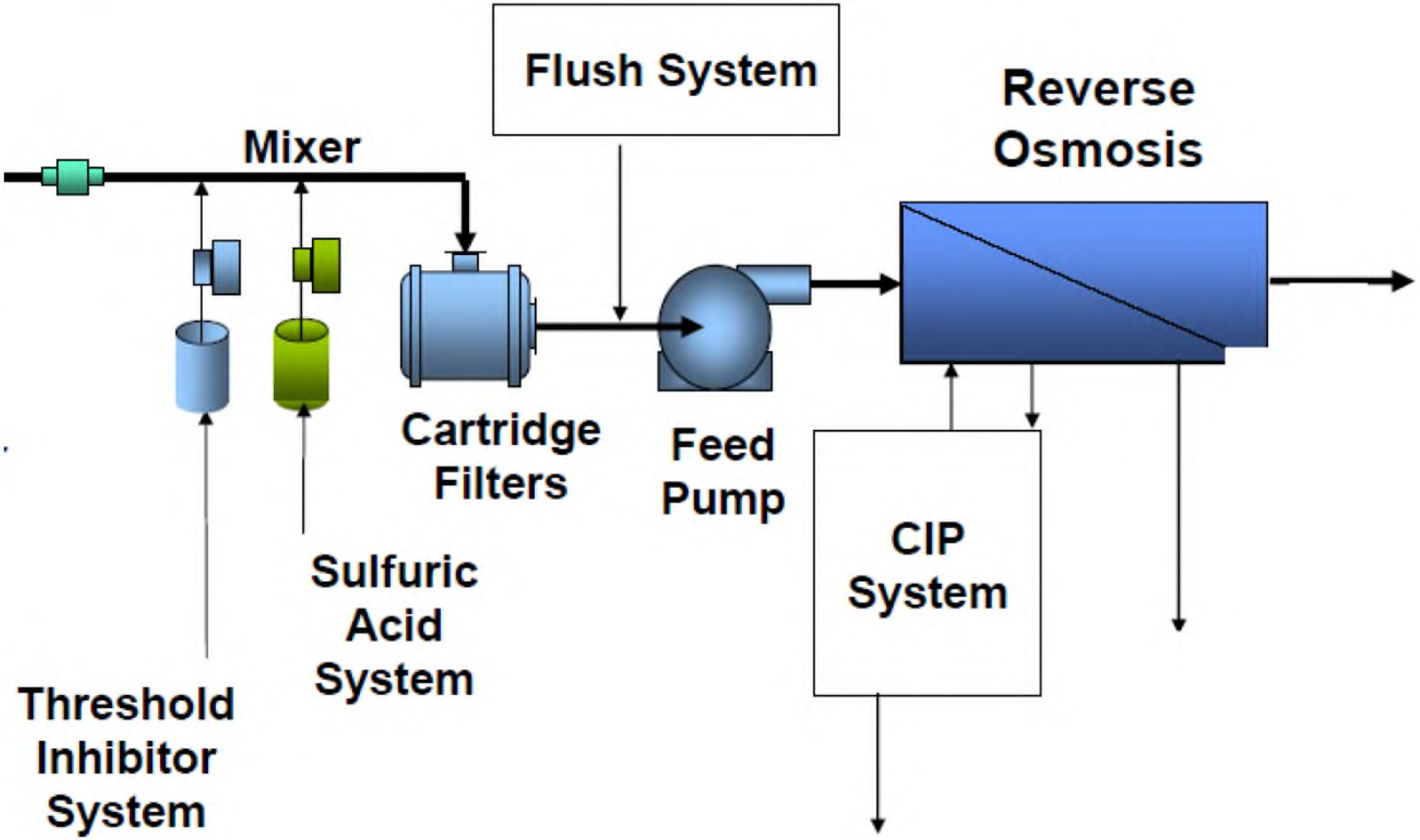
03 Reverse Osmosis

03-01 Fundamentals of RO

Principle of RO

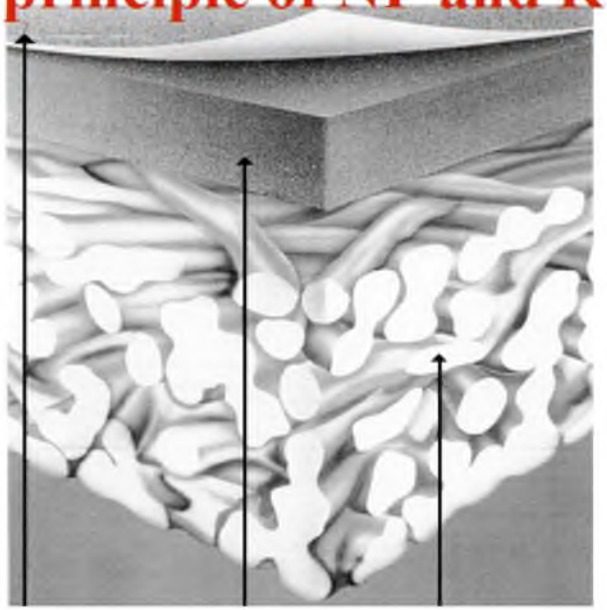


Basic Configuration

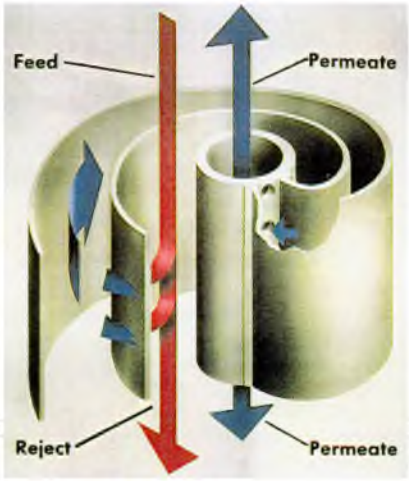


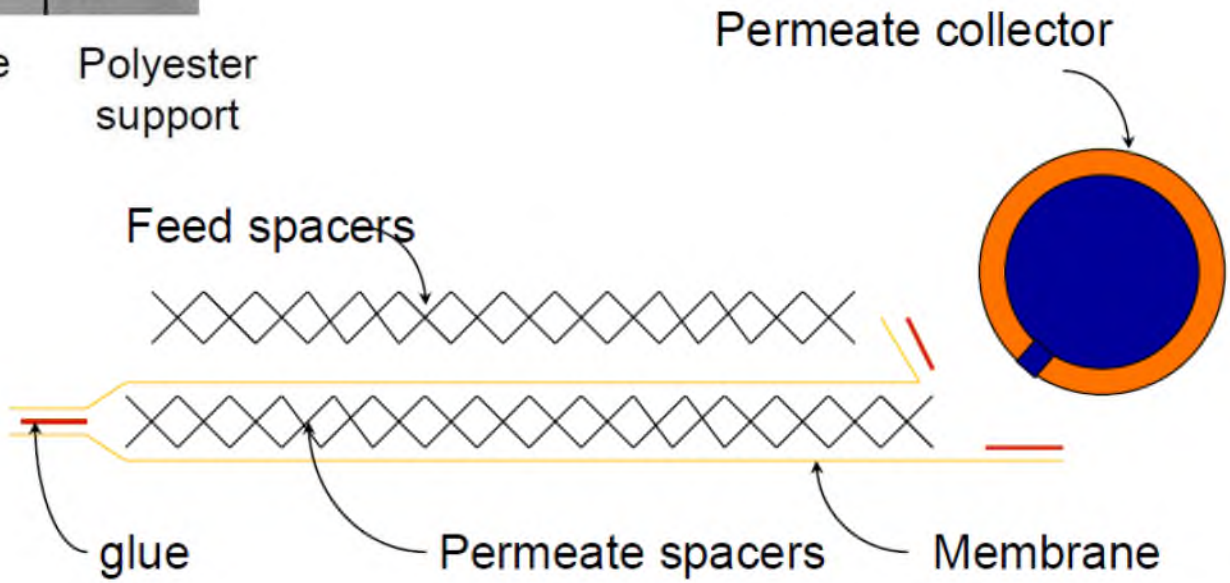
03-02 RO Membrane and Module

Basic principle of NF and RO systems

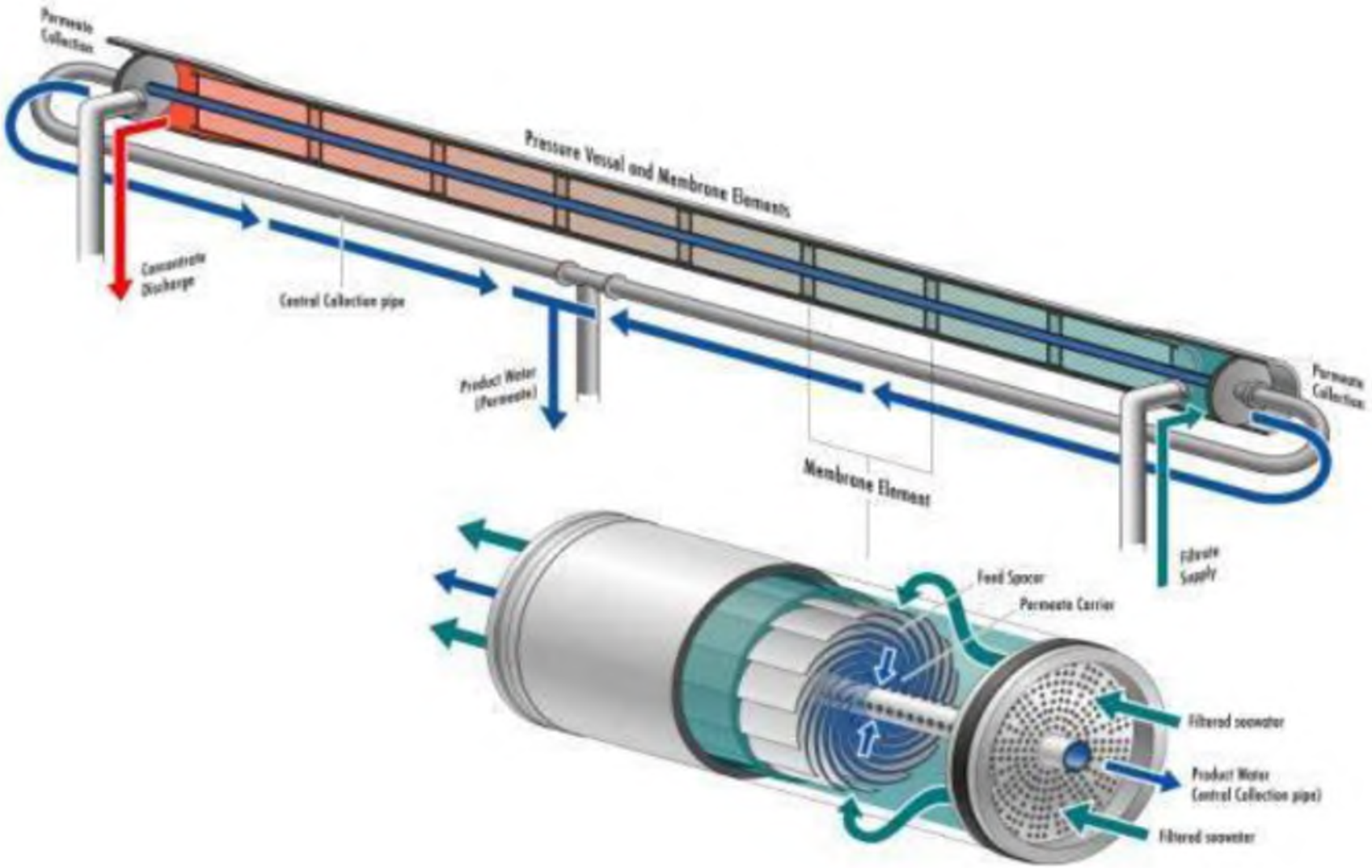


Polyamide Membrane | Polysulfone layer | Polyester support





RO Membrane Element and Vessel



RO Process Unit

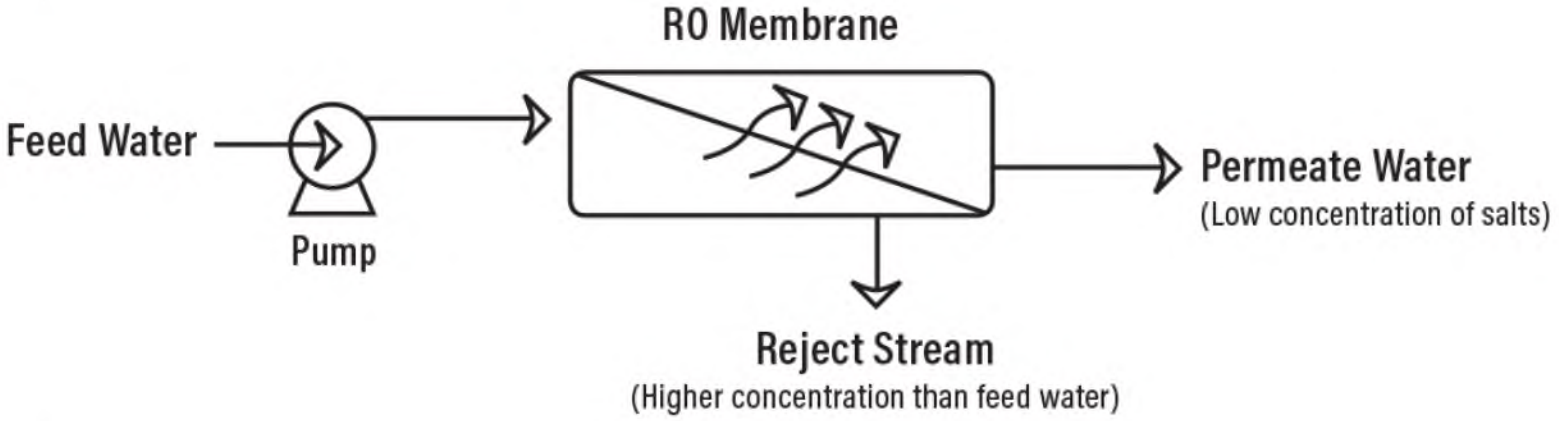
Household scale

Large scale

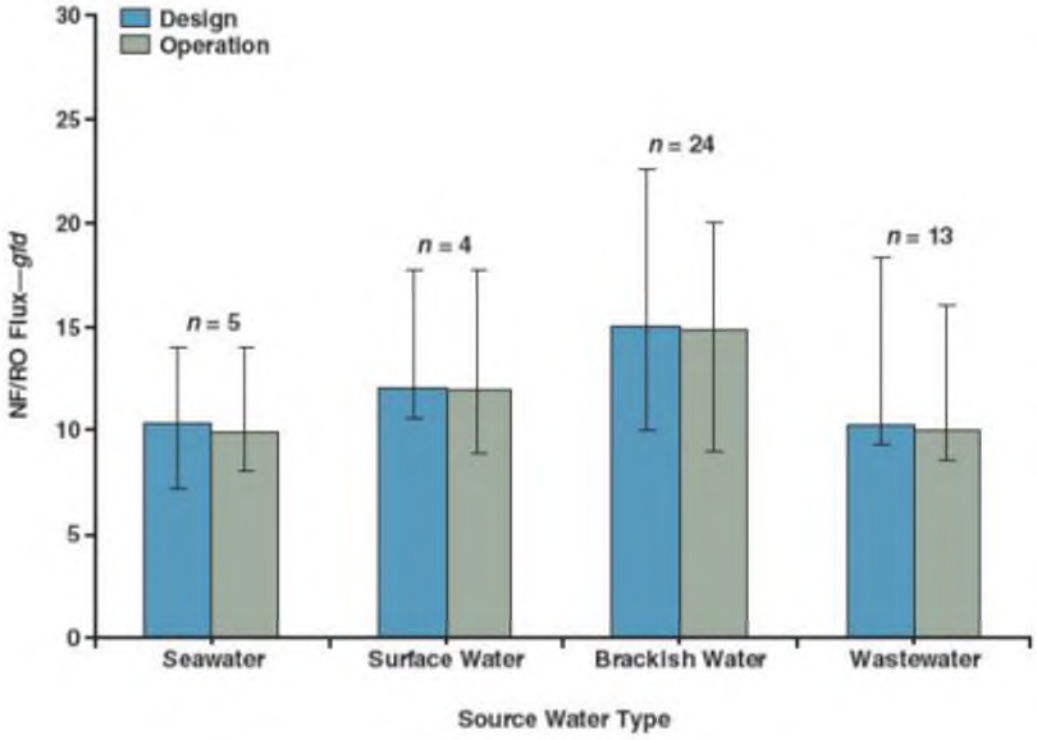
03-03 Operation of RO Process

Operating Conditions

	TDS (mg/L)	Typical Driving Pressure (bar)	Typical Recovery %	Typical Energy Use (kWh/m^3)
Conventional Treatment	< 500	NA	95%	0.16 – 0.24
Brackish Water RO	1,000 – 5,000	8 - 30	65 - 85	0.7 – 1.25
Seawater RO	> 35,000	30 - 90	30 - 50	2.5 – 5.0



Energy Consumption is related to feed water TDS



n—*number, NF—nanofiltration, RO—reverse osmosis*

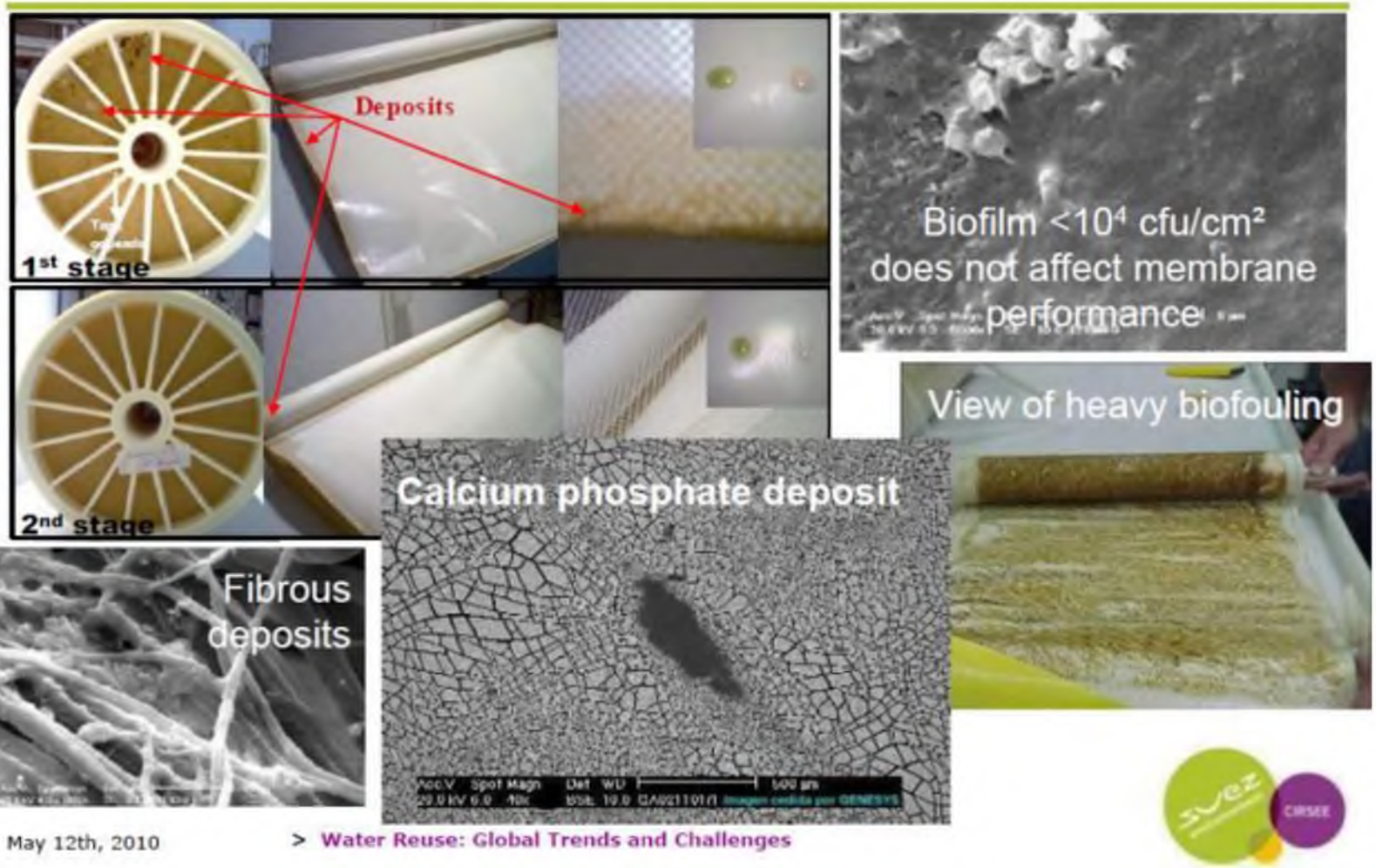
Only 46 of the 62 plants surveyed provided information for this parameter. Color bars indicate median of the reported values. Narrow bars indicate range

1 GFD = 1.698 LMH

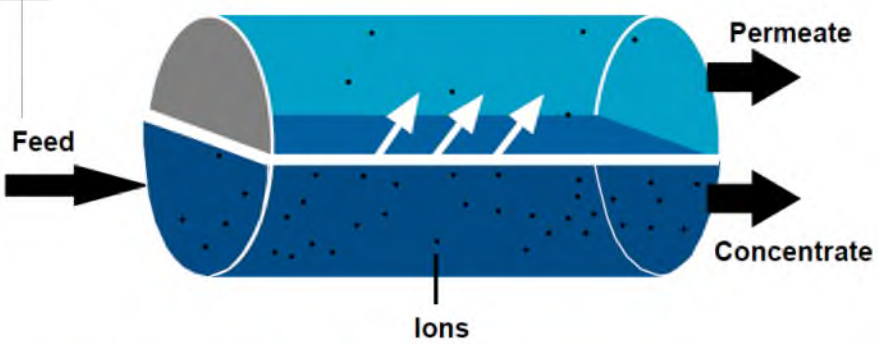
Source: Burbano, AWWA, 2007

- Flux
  - Desalination: 13~24 LMH
  - Brackish RO: 14~34 LMH
  - Wastewater: 15~25 LMH
- Pressure
  - Desalination: 50~70 bar
  - Brackish RO: 7~40 bar
  - Wastewater: 7~20 bar
- MF/UF
  - Flux: 40~80 LMH
  - Pressure: 0.2~1.5 bar

RO Membrane Fouling



RO Brine Management



- recovery factor

$$\text{recovery factor} = \frac{\text{permeate flow rate}}{\text{Feed Flow rate}}$$

04 Frequently Asked Questions

FAQ #2

❖ **If RO remove all minerals in the product water, it is okay to drink it?**

⇒ First of all, RO does not remove all ions. Moreover, depending on the requirements, the ions in the product water can be adjusted.

⇒ Since there are other sources of minerals, there is virtually no impact on human health by drinking the RO treated water. In fact, there are countless water purification units operating in many countries including Korea.

FAQ #2

❖ **Is it possible to operate RO or other membrane processes without electricity?**

⇒ If this is a small scale system (i.e. household scale), it may be. There are technologies using natural pressure or mechanical pressure to operate RO.

⇒ If this is a communityscale system, it will be necessary to build a power source such as photovoltaic system or wind power generator.

Thank you very much

CTCN-TA Project

Investigation of local water use in the villages of Satkhira, Bagerhat region

12, Nov. 2018

D.J. YANG

Research Director, GATC

CONTENTS

I. Project Background

I. Project Background

Title	Technical Assistance for **Saline water purification technology at household level** and **low-cost durable housing technology** for coastal areas of Bangladesh
Goal	A. Selection and introduction of **desalination techniques available at the household level** B. Selection and introduction of **low-cost housing technologies that can respond to salinity**
Expectation	A. Expansion of **pilot project** B. Link **GCF** Resources

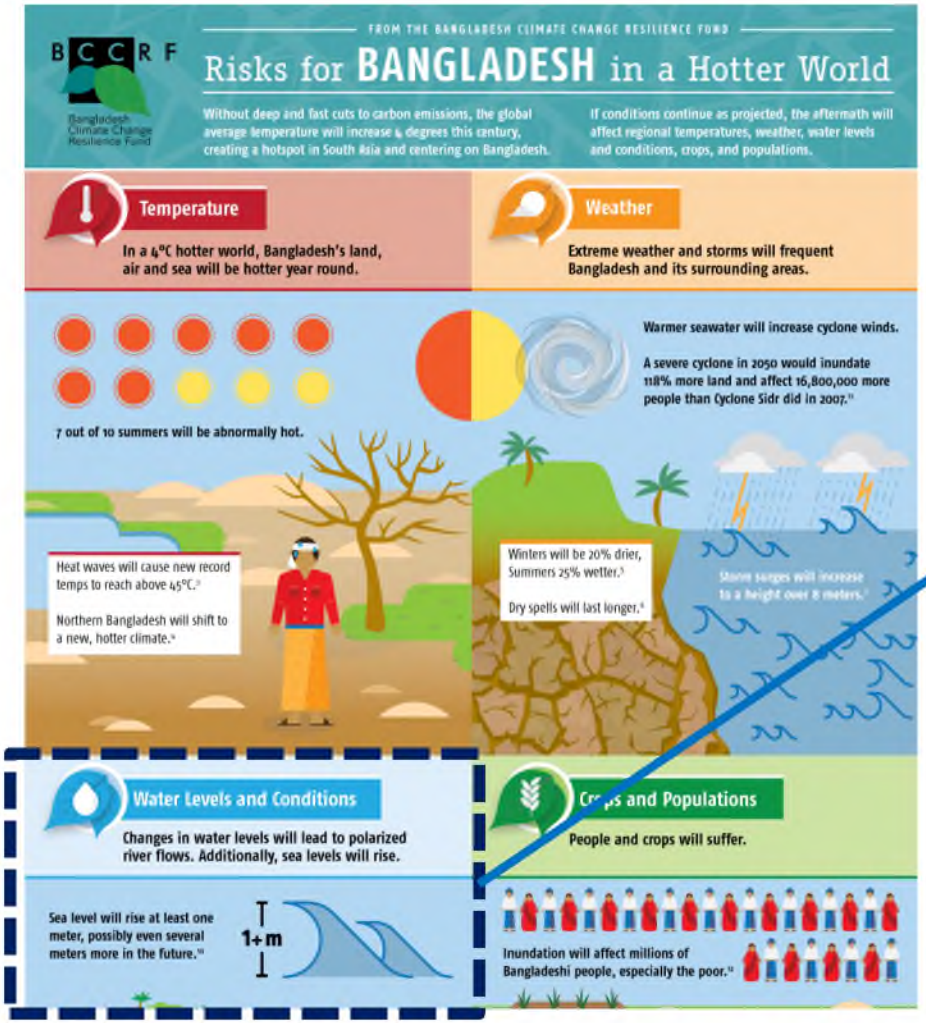
Consortium Structure

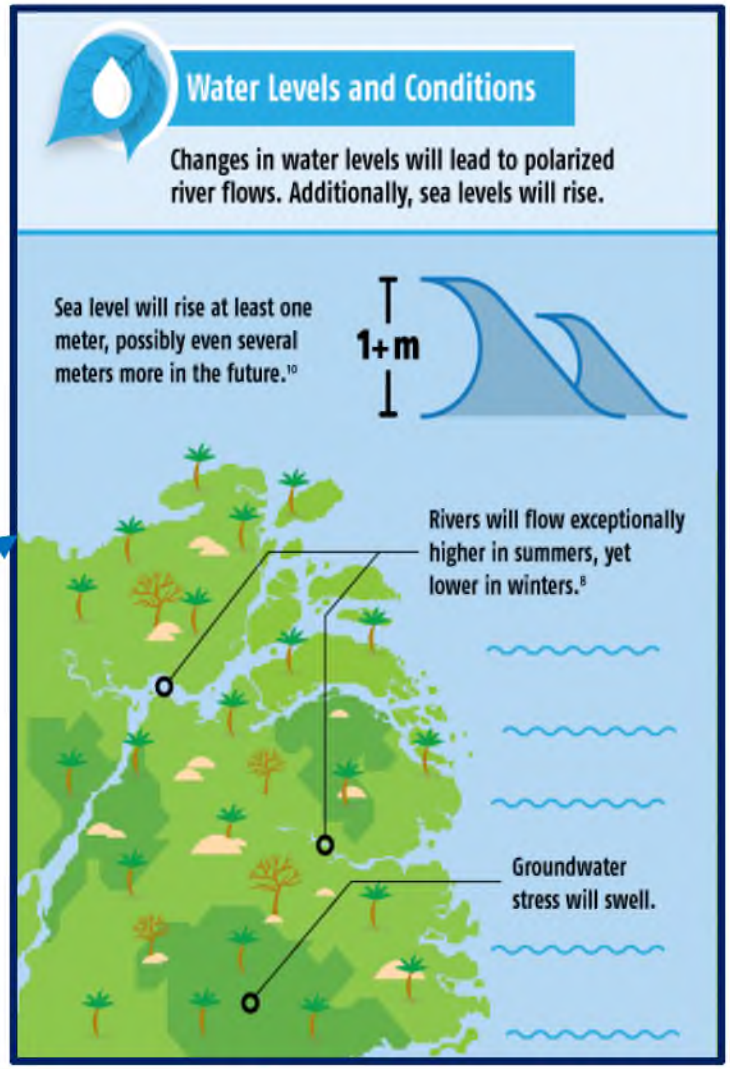
- Project Management
- Preparation of response plan and financing plan

- Review and select the optimum **housing technology** for climate and saline purification technology
- Review and select **high-concentration saline desalination technology**

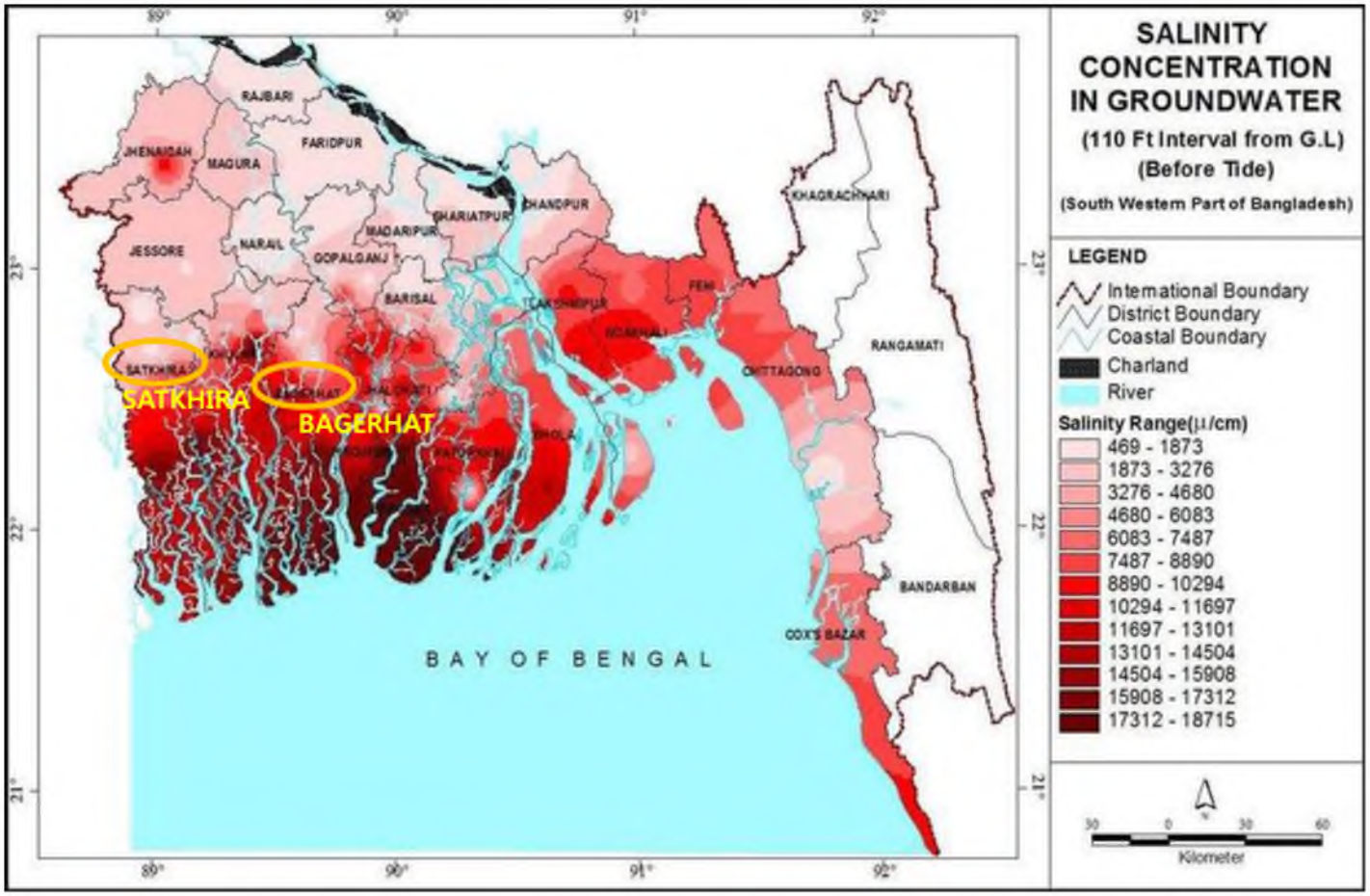
- Review and select **low-concentration saline desalination technology**
- Development and Implementation of Capacity Enhancement Program

RISKS for Bangladesh in a HOTTER World





An invasion of seawater into groundwater in Bangladesh

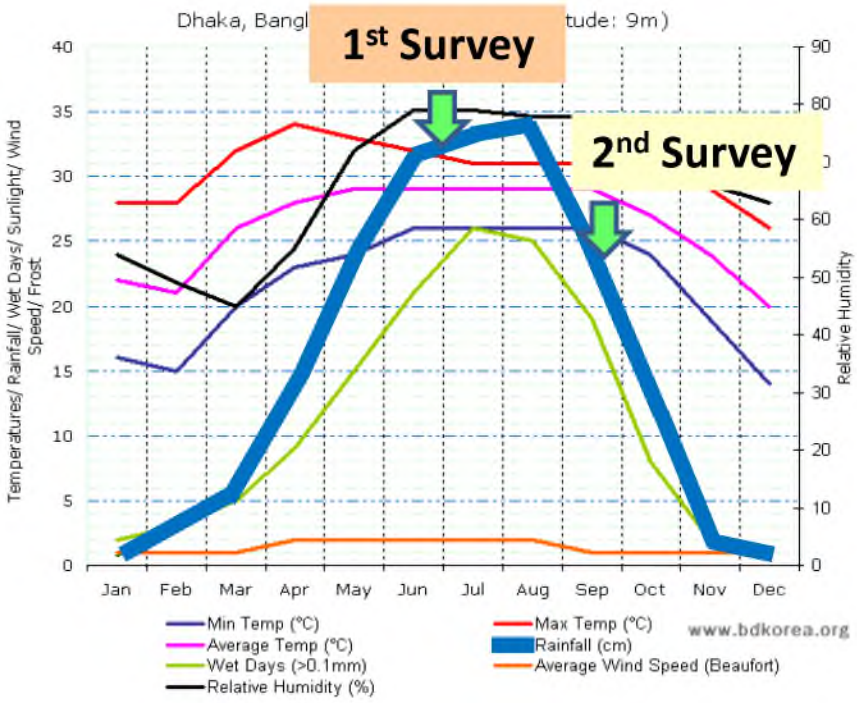


Source: Quarterly Journal of Indian Pulp and Paper Technical Association 21(3):111-117 · July 2009

II. 1st Field Survey in Satkhira, Bagerhat districts

Period and area of field survey

1st Survey	
Period	24-26, Jun, 2018
Survey area	1. Tala upazila, Satkhira district 2. Sadar upazila Bagerhat district



1st Field Survey (Satkhira & Bagerhat district)

5 Villages (30 households)
in Satkhira district

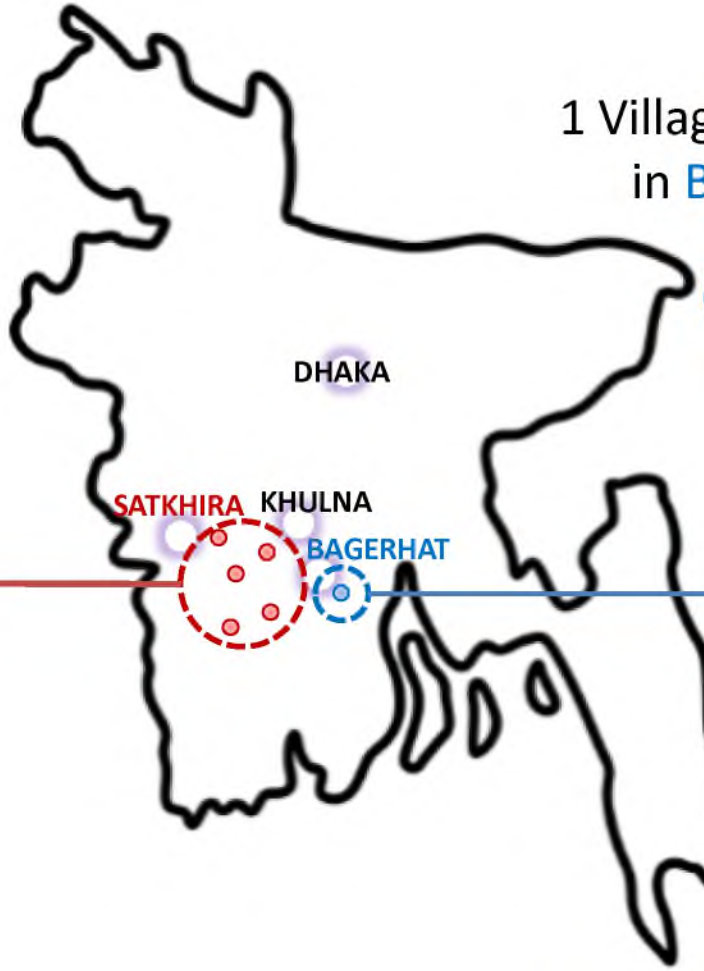
Salua (8 households)

Balia (3 households)

Kanaidiya (6 households)

Keshora (12 households)

Tala (1 household)



1 Village (30 households)
in Bagerhat district

Korori
(30 households)

Populations in every households

Districts	Population in households				Daily drinking water required per household*	
	Age	Max.	Min.	Average	Average	Max.
Satkhira	Adult (≥13 years old)	8	2	4.3	**12L**	**22L**
	Children (<13 years old)	3	0	1.3		
Bagerhat	Adult (≥13 years old)	12	2	6.5.	**15L**	**32L**
	Children (<13 years old)	4	0	1.1		

* This is assumed that 2 liters of drinking water per day per person.

Drinking water sources and water facilities in household

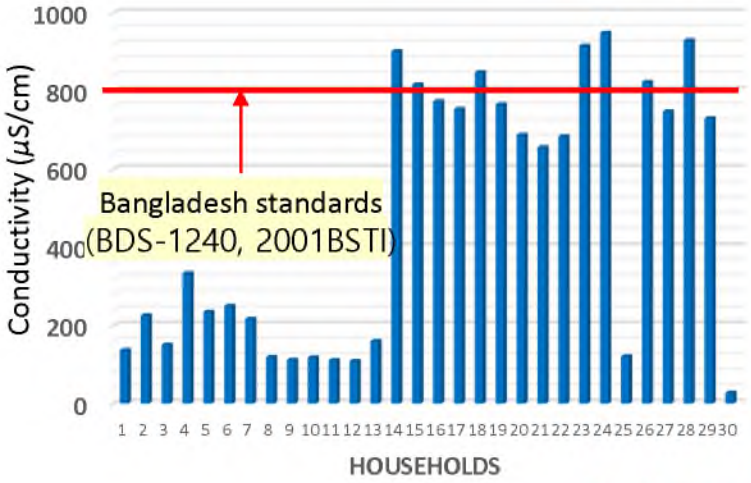
Districts	Water Source		Households with Well	Households with Drinking tank
	Ground water	Ground water + Rain water		
Satkhira	29	1	3	1
Bagerhat	30	0	27	5

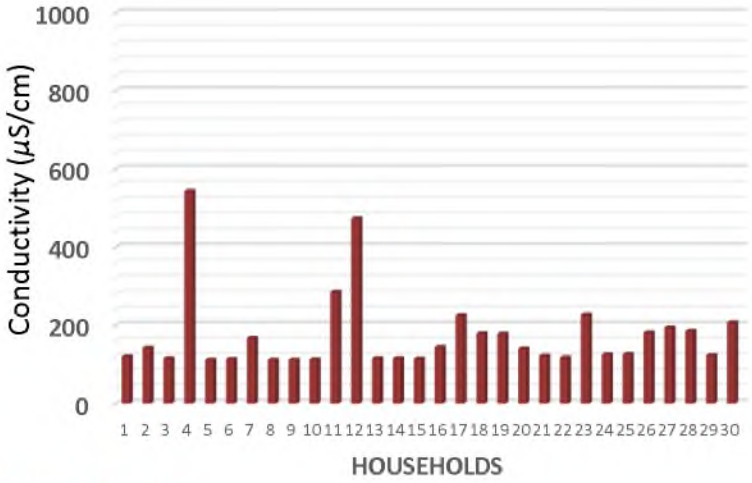
Rainwater Tank

Shallow Tube Well

Drinking Water Tank

Satkhira vs Bagerhat regarding water qualities - Conductivity





Satkhira > Bagerhat

Districts	Conductivity (µS/cm) in 1st fields survey		
	Max.	Min.	Average
Satkhira	949	28	480.4
Bagerhat	574	112	175.0

Satkhira vs Bagerhat regarding water qualities

Water Quality Parameter (unit)	Groundwater in Bagerhat	Groundwater in Satkhira	Bangladesh standards	WHO Guide Lines
Hardness as CaCO3 (mg/L)	400	1,400	200-500	-
Potassium permanganate consumption (mg/L)	3.8	10.1	-	10
Manganese (mg/L)	0.342	0.136	0.1	-
Boron (mg/L)	0.04	n.d.	1.0	-
Fluoride (mg/L)	0.27	n.d.	1	1.5
Arsenic (mg/L)	0.032	n.d.	0.05	0.01
pH	7.2	7.3		6.5-8.5
Ammonia (mg/L)	0.08	2.57	0.5	-
Chloride (mg/L)	55.5	1,727.9	150-600	-
Total Dissolved Solids (mg/L)	642	4,309	1000	-
Nitrate (mg/L)	0.1	0.1	10	50 as N
Iron (mg/L)	0.19	n.d.	0.3-1.0	-
Turbidity (NTU)	4.41	0.73	10	-
Conductivity (μS/cm)	574	949	800 (BDS-1240, 2001 BSTI)	

In terms of water qualities, Satkhira is worse than Bagerhat

The opinions of the villagers

※ Satisfaction with drinking water

Districts	Satisfactory	Unsatisfactory	Total
Satkhira	1	29	30
Bagerhat	27	3	30

The majority of the residents of Satkhira community expressed dissatisfaction with the use of water and demand for the replacement and installation of drinking water and water-related facilities.

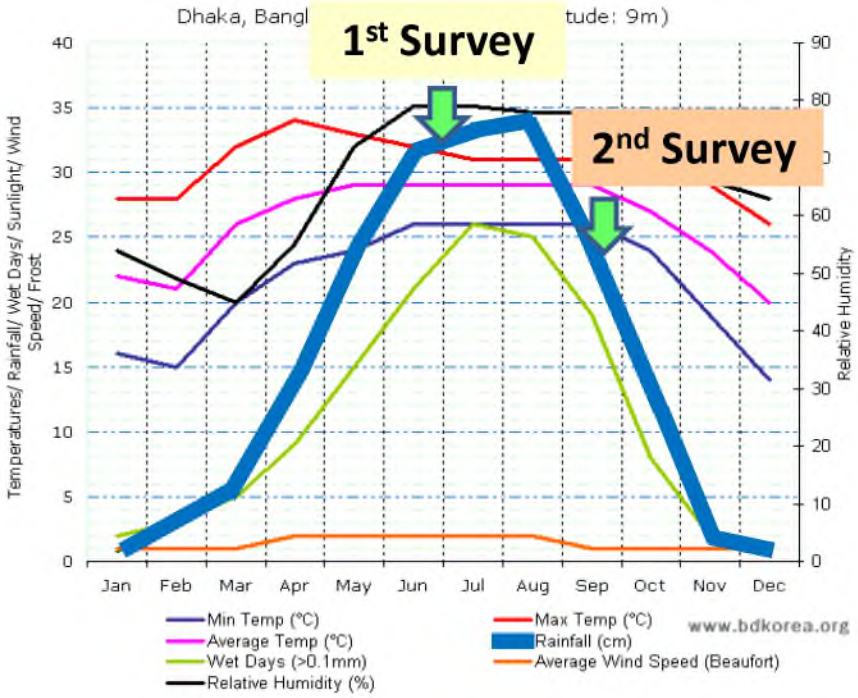
The opinions of the village representatives

	Opinions on the Existing Water Supply System	Opinions on improvement
Representative of Bagerhat (Korori)	Most of the family used the DTW(deep tube well). It is safe for the life.	To increase the DTW for the poor family
Representative of Sakhira (Khesora, Salua, Kanaidiya)	Most of the people are not follow the actual rules of pure water. Suitable system(e.g. piped water supply, RO plant) are not available into our village.	Proper develop the actual way of STW(shallow tube well) for drinking water. To collect the actual way of rainwater.

III. 2nd Field Survey in Satkhira district

Period and area of field survey

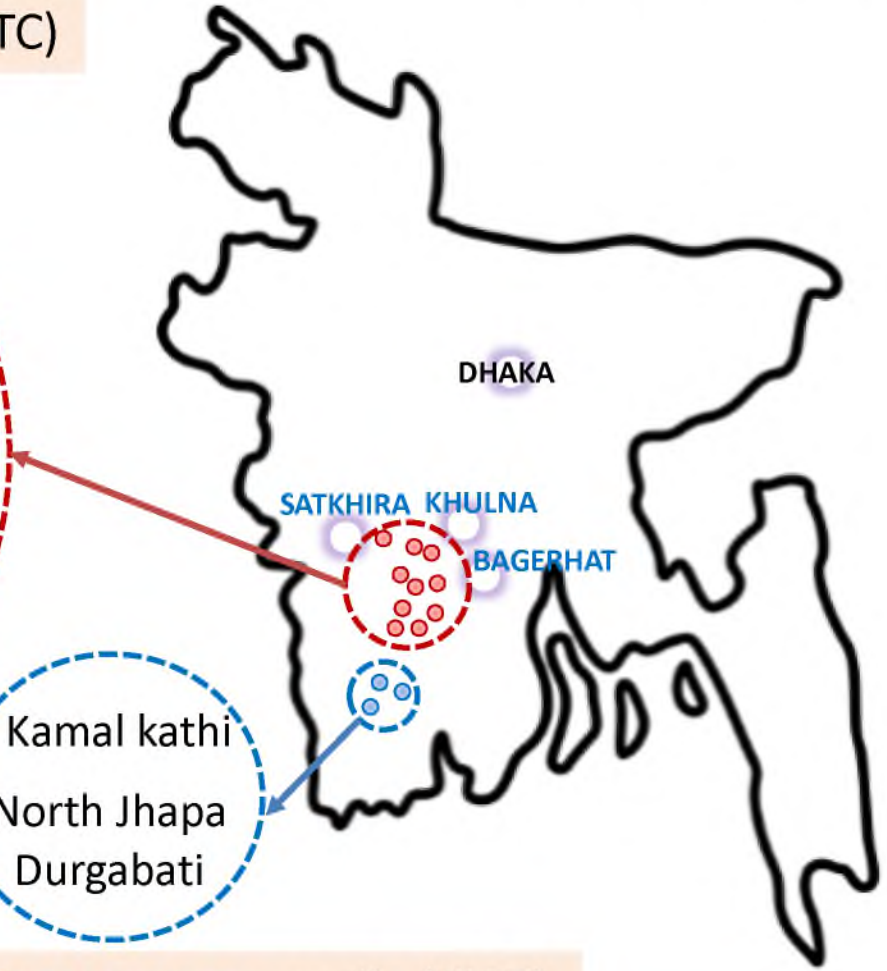
2nd Survey	
Period	11-12 Sep, 2018
Survey area	1. Tala upazila, Satkhira district 2. Shyamnagar upazila Satkhira district



2nd Field Survey (Tala & Shyamnagar upazila, Satkhira district)

10 villages in **Tala** upazila (GATC)

Balia
Sreemonto Kati
South Solua
Moraqucha
Kanaidiya
Tailkupi
Keshora
Horidhali
Khanpur
Fotepur



Kamal kathi
North Jhapa
Durgabati

3 villages in **Shyamnagar** upazila (KICT)

Typical drinking water facilities (Tala upazila)

All 10 villages use underground water as drinking water through shallow tube well(STW).

Typical drinking water facilities (Tala upazila)

Power supply facilities (Tala upazila)

A Utility Pole

Household electric distribution system

Electrical supply is not stable and requires the use of solar or generator.

Analysis of underground water quality (Tala upazila)

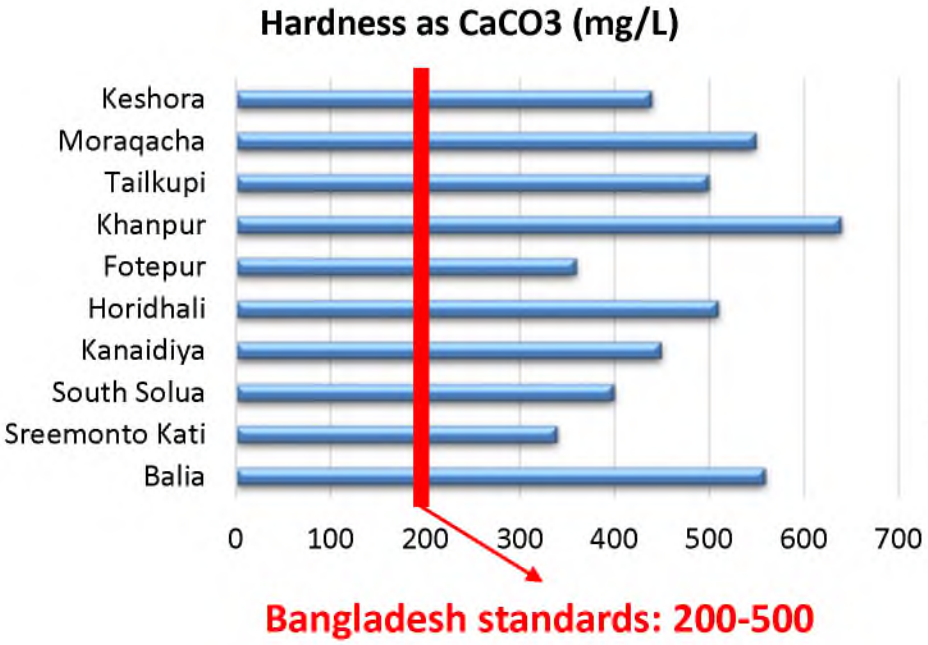
pH	7.1-7.5	(WHO Guide lines: 6.5-8.5)
Boron(mg/L)	0.03-0.13	(Bangladesh standards: 1)
Fluoride(mg/L)	0.00-0.17	(Bangladesh standards: 1)
Nitrate(mg/L)	0.0-0.1	(Bangladesh standards: 10)

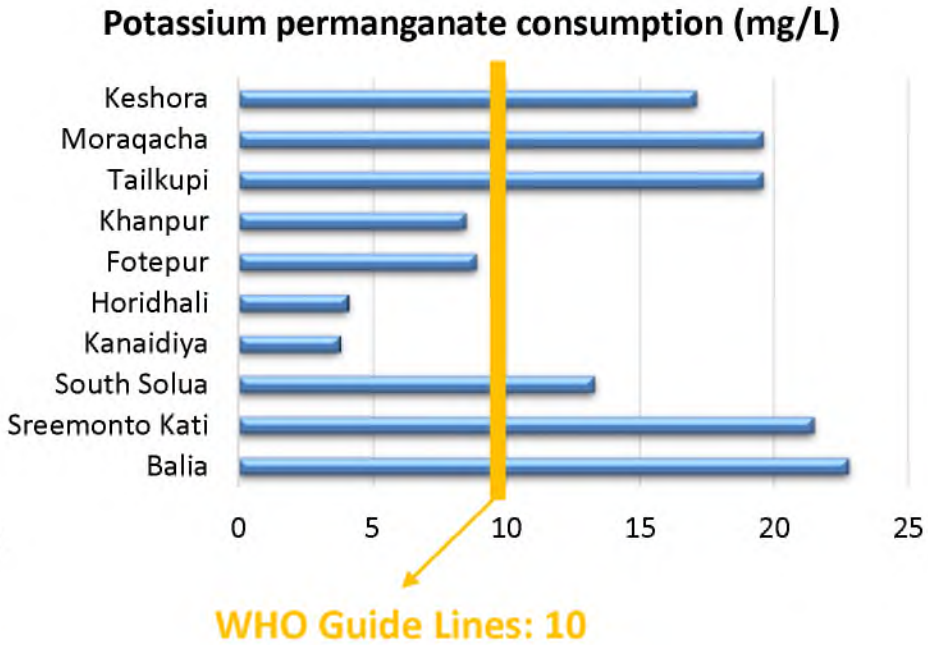
Satisfy drinking water quality standards

DHAKA Tap Water | Khanpur Groundwater | Balia Groundwater

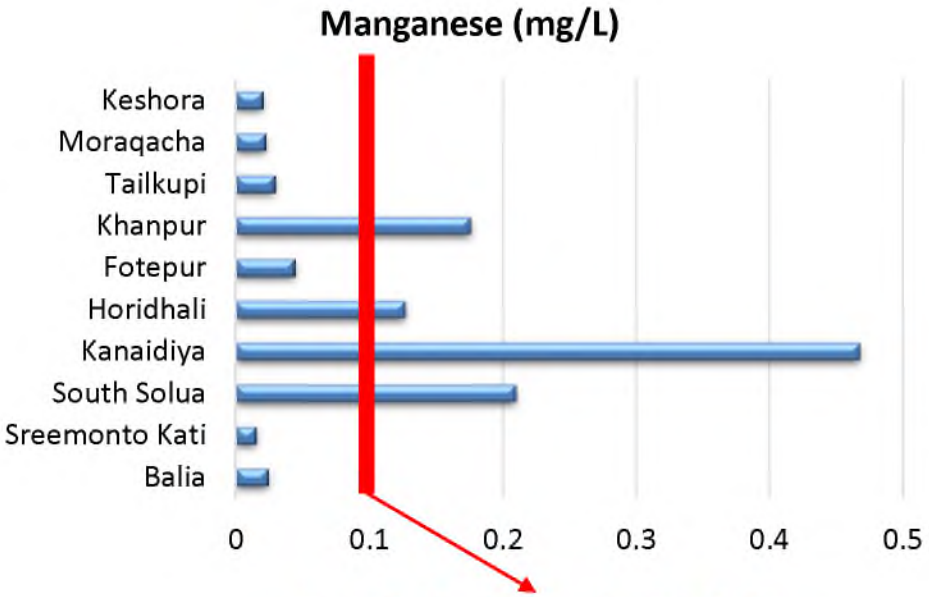
But…

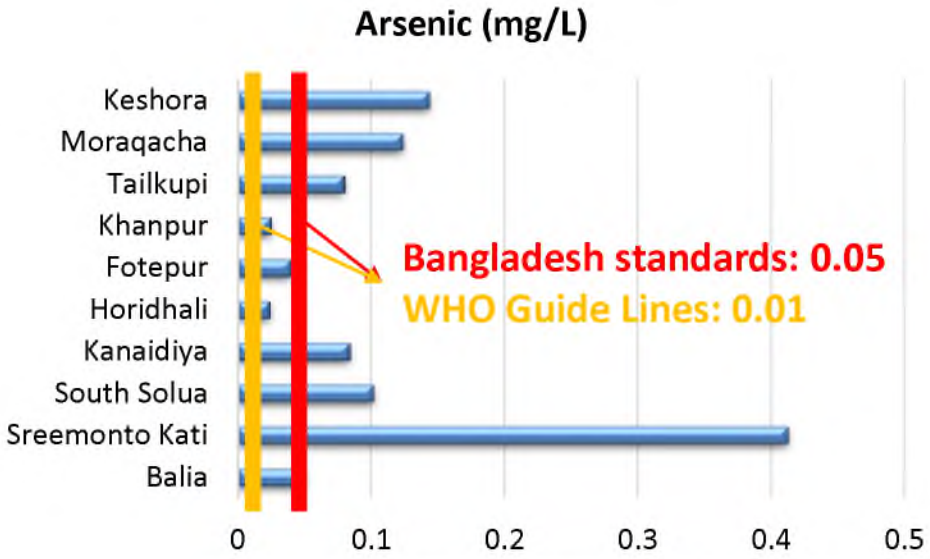
Analysis of underground water quality (Tala upazila)

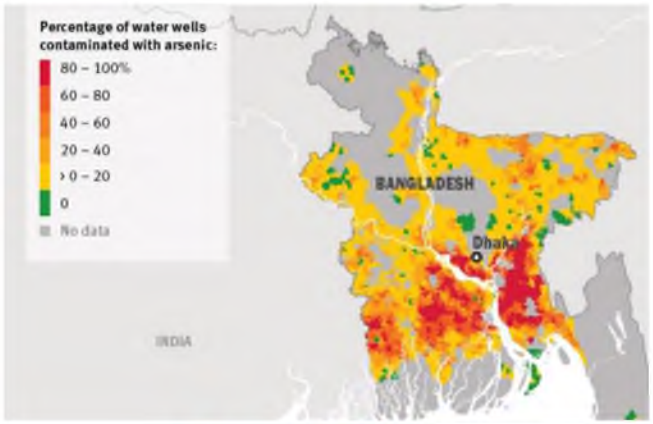




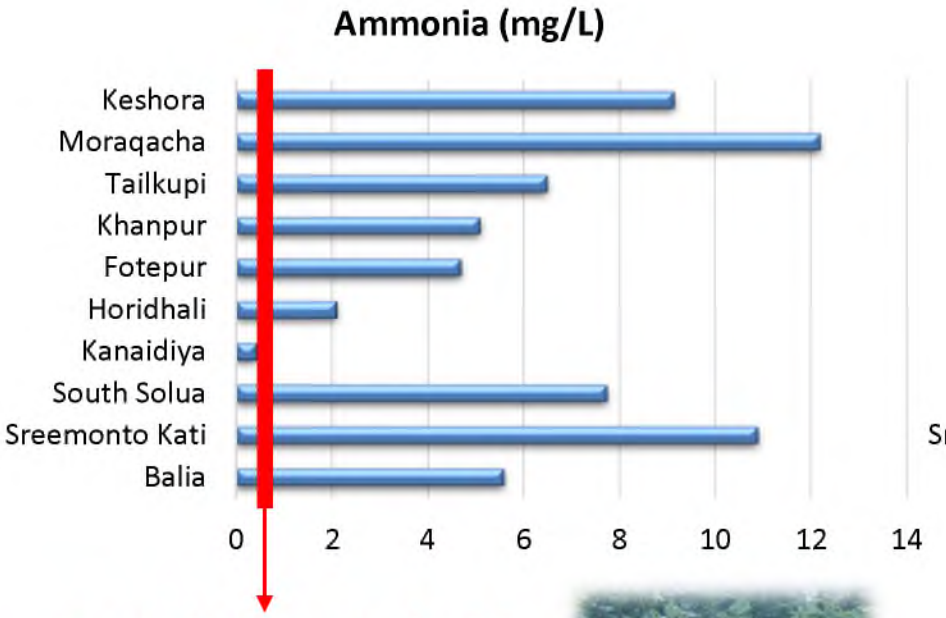
Analysis of underground water quality (Tala upazila)





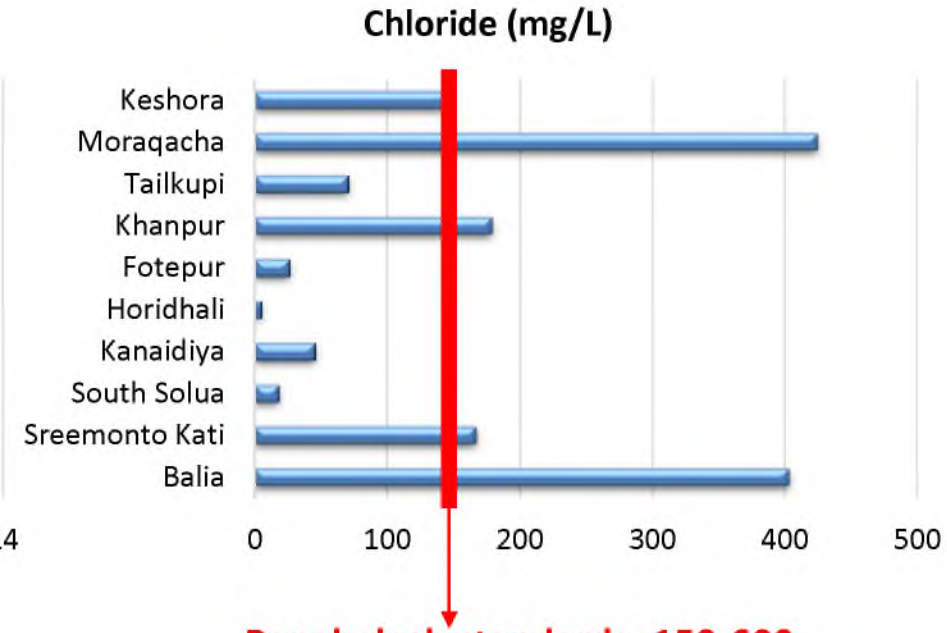


Analysis of underground water quality (Tala upazila)



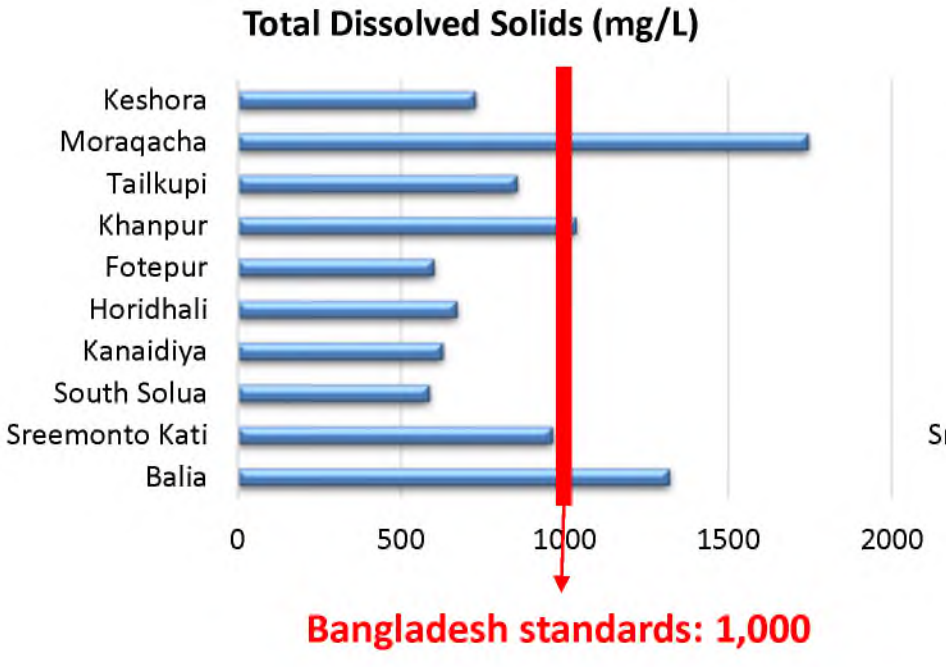
Bangladesh standards: 0.5

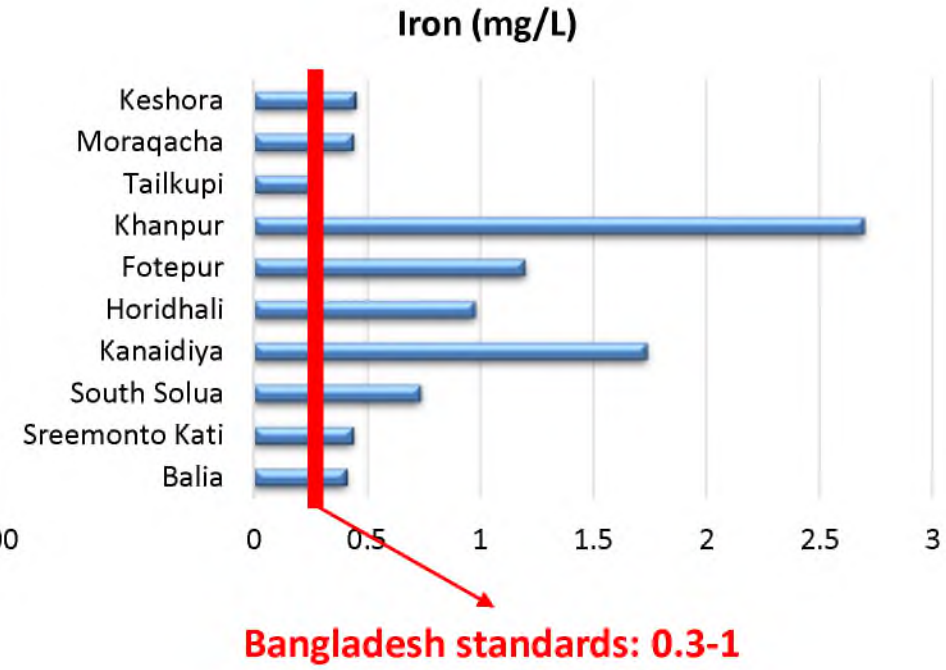
Additional biological tests are required



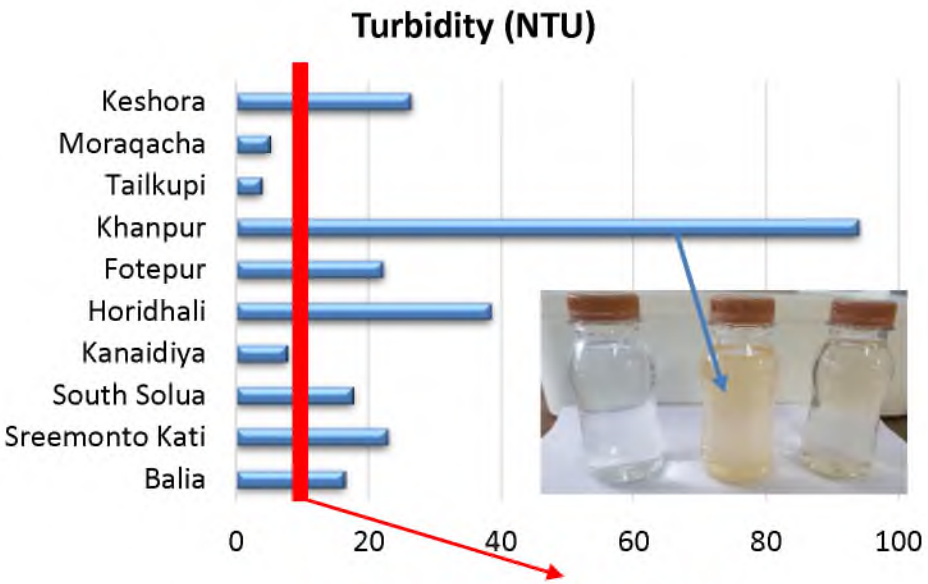
Bangladesh standards: 150-600

Analysis of underground water quality (Tala upazila)

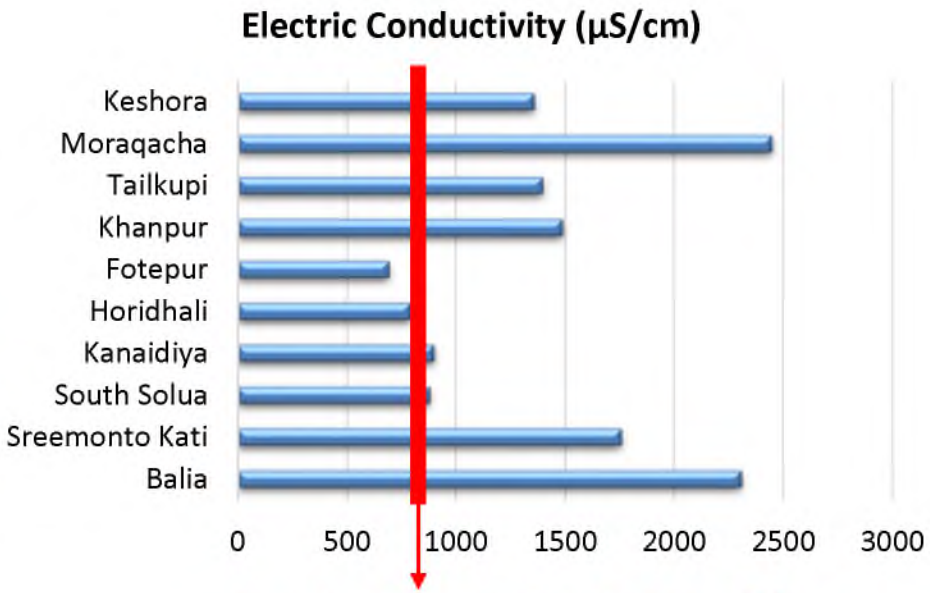




Analysis of underground water quality (Tala upazila)



Bangladesh standards: 10



Bangladesh standards: 800 μS/cm
(BDS-1240,2001 BSTI)

Status of water use in three villages in Shyamnagar upazila

Village	Kamal kathi	North Jhapa	Durgabati
Population	300	1,000	1,500
Chloride content for soil and underground water(g/L)	0.17 - 0.42	0.05 - 0.15	<0.01
pH of drinking water	7.95 - 8.04	6.74 - 6.95	6.56 - 6.72
Drinking water management status	Use of groundwater pumping at the base of 70m (manual work)	Drinking Water Supply by the community water RO system	Use drinking water after storing rainwater

Community drinking facility (North Jhapa, Shyamnagar upazila)

RO water purification system for village (about 200 households)

→ Requires stable electrical and plumbing connections

Rainwater Harvester (Durgabati, Shyamnagar upazila)

IV. Further discussion

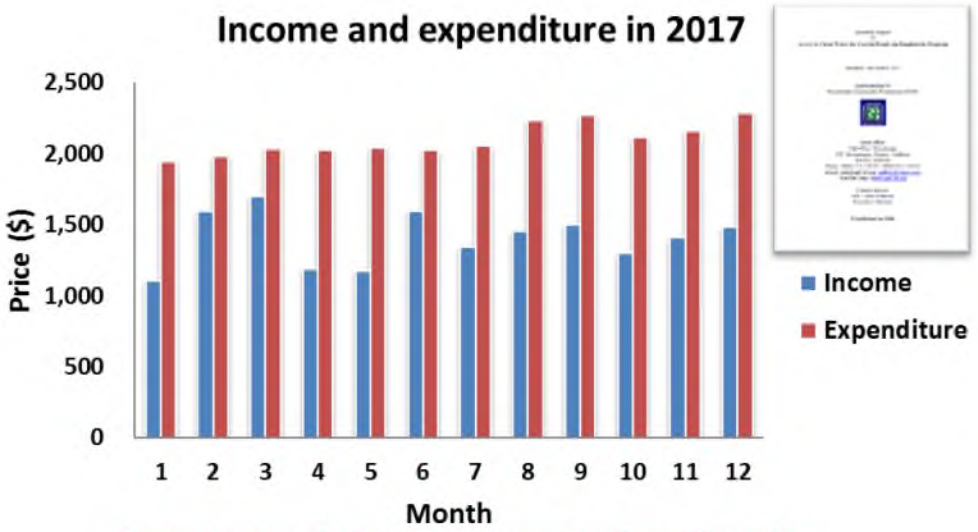
VI. Further discussion

Sustainability

1. Electricity supply
2. Distribution system
3. Revenue structure

Build-up of a Sustainable

Drinking Water Supply System

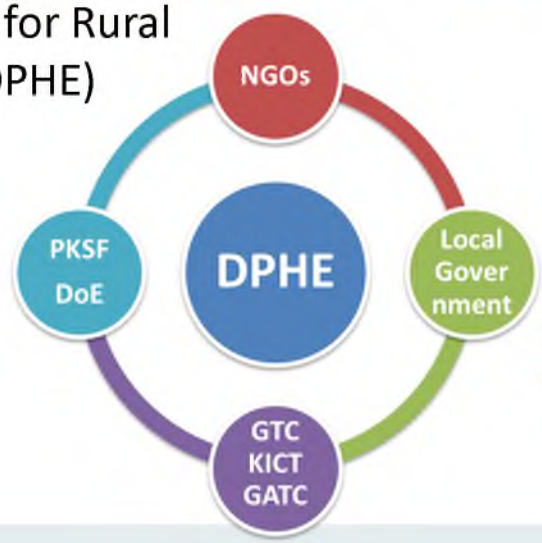


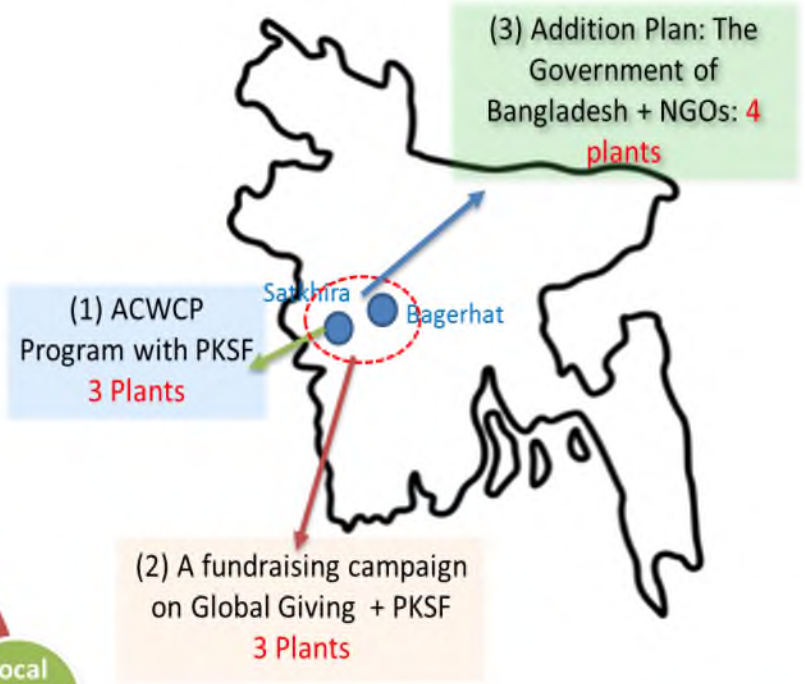
Source: Quarterly Report on Access to Clean Water for Coastal People (in Bangladesh) Program(2017) by NGF

VI. Further discussion

Cooperation

Policy and Strategy for Rural Water Supply(DPHE)





Source: Quarterly Report on Access to Clean Water for Coastal People (in Bangladesh) Program(2017) by NGF

Technical aspects

1. Diversification of water sources: Groundwater + Rainwater etc.
2. Reliable power supply system: Solar system, Wind power etc.
3. Combination of domestic water purifier and community water supply facilities.

GTC 녹색기술센터
GREEN TECHNOLOGY CENTER

KICT

GTAT

Thank You For Listening

NGF EXPERIENCE

on

Safe Drinking Water Supply Technologies and it's Application

Working Area:
Climate vulnerable southwest coastal region
(remote areas community people who are living with Mangrove Eco-system)

Climate Vulnerability Risk #4
High Salinity

GONOMUKHI NOWABENKI FOUNDATION
Shyamnagar, Satkhira

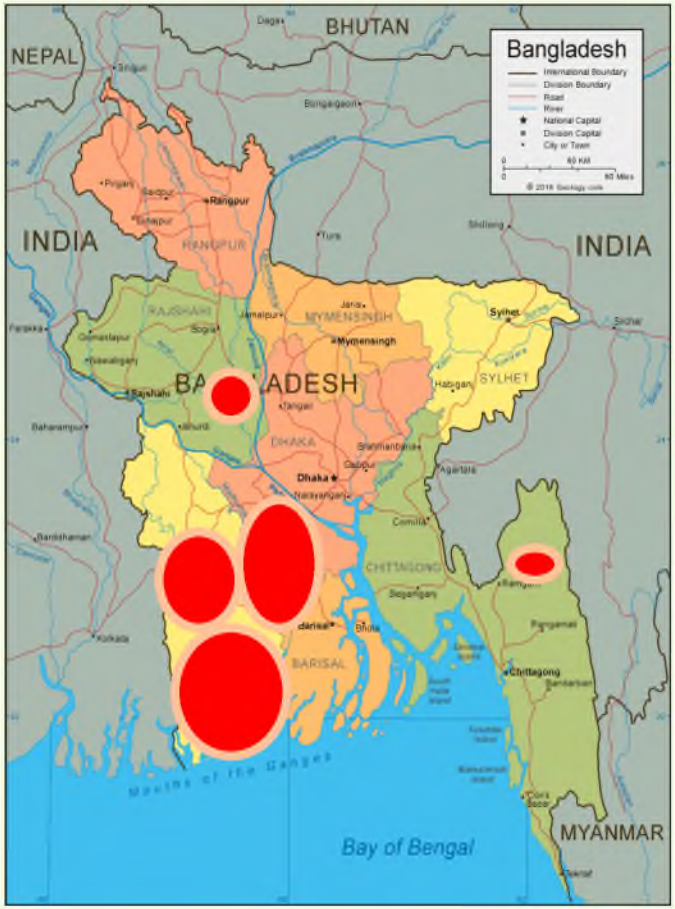
Motto: Vision 21
Inclusive Empowerment for sustainable Development.

Nowabenki Gonomukhi Foundation-NGF

Nowabenki, Shyamnagar, Satkhira, Bangladesh
Email: ngfbd1@yahoo.com, lutfor.rahman@ngf-bd.org
www.ngf-bd.org

GONOMUKHI
NOWABENKI FOUNDATION
Shyamnagar, Satkhira

NGF Working Area



We Are

A non-profit based non government, non political and social development organization works focusing on poor & vulnerable people in the different part of the country emphasizing on southwest coastal region of Bangladesh.

Since 1987, *NGF has been working with coastal people and provide need based support /services for increasing their better livelihood together.*

Development Partners

IFAD
Investing in rural people

DFID

christian aid

UKaid

CREDIT & DEVELOPMENT FORUM (CDF)
The National Networking Organization working for the Microfinance Industry in Bangladesh

OSMONIC
Water filtration process
Health Care

NGO FORUM
FOR PUBLIC HEALTH

german cooperation

BCCRF
Bangladesh Climate Change Resilience Fund

Muslim Aid
Serving Humanity

edge CONSULTING

Prithula Corporation
Green Life - Green Environment

Partnership

NGF has been developing productive partnership with diverse people/ organization/ donors who are supportive, people centered and similar understanding on issues, same goals and objectives and together we can contribute to achieve the results.

NGF
Nowabenki Gonomukhi Foundation

On going Project

Project Management & Implementation:

NGF has implementing *diverse development projects/program* throughout the working areas under *Satkhira, Khulna and Jessore district*. The Micro - Finance as an fruitful instrument of poverty reduction model provided by PKSF through it POs. Accordingly, Since 1992, NGF has been working with PKSF. as dedicated and trustworthy partner in the south-west coastal areas. The Micro-Finance program provides borrowers with training and credit for self-employment

Core Micro-Finance Program

SL	Running Micro-credit Products
1	***Jagoron** (Rural Micro-Credit)*
2	***Buniad** (Ultra Poor Program) Micro-credit*
3	***Agrosor** (Micro-Enterprise) ME Program*
4	***Sufalon** (Agriculture Sector Micro-Finance (ASM) & Seasonal*
5	***ENRICH Loan** (IGAs, Livelihood Support & Assets Creation L.)*
6	***SAHOS** (Special Assistance for Housing of SIDR Affected R.)*
7	***RESCUE** (R. Coastal Fishery, SMEs and Livestock Enterprises)*

Development Programme

- ***Sustainable Agricultural Practices***
  - *Agriculture Development*
  - *Livestock & Fisheries Development*
  - *Transfer of Feasible Technology*
- ***Environment & Climate Change Issues***
  - *Adaptation & Resilient Building/*
  - *Social Security (Food & Nutrition)*
  - *Livelihood Support & Health Care Services*
- ***Value Chain Development***
  - *Sub-sector wise value chain development*
  - *Market system and business development*
  - *Cluster based SME/MEs Development*





Development Programme

For

- ***WASH Programme***
  - *Transfer of different water production technologies in the coastal areas to resolve the crisis of sate drinking water.*
  - *Hygiene & Sanitation Promotion/al Support/ and Services*

For

- ***Business Initiatives on***
  - *Pipeline water supply to the HHs and agricultur field*
  - *Green Business -Solar Home System*
  - *Crab Hatchery Development*

For

- ***Micro-finance Program***
  - *PKSF funded diversified financial product and services*
  - *SMEs development*
  - *Cross cutting issues and CSR*

Picture-01: People are waiting for collect potable water from "Desalination Water Treatment Plant" operate by Solar Panel and management by community mechanism.

Picture-02:
NGF has been managing one "Desalination Water Treatment Plant" operated by by both way (electricity/generator) at Atulia Union since 2013 and continue production without any major disturbance till today.

Picture-02::
Crab fattening and Eel fairing practice refer to resilient to climate change and both subsector are very promising for investment.

NGF Enterprises

NGF has a good reputation in managing and developing MEs at rural level. Also, NGF has more technical expert who are dedicated to develop MEs and their business capacity until the enterprise is ready?

Therefore, each MEs has confident to grow up his/her business with full potentials that creates high quality products as well as increase their income

.

So that each enterprise generated additional income and employment. Accordingly, **we have a good number of enterprises who have ability to manage their farm and produce quality products** that sale to the market. This regular business transaction has been creating a good business practices in the rural market which contribute to change the rural economy as well as national GDP.

However, the organization has been been covered *5 districts, 17 Upazila 36 Branch Office, 5 Project Office, 5 Area Offices* and achieved a significant number which direct outreach *1,22,583 beneficiaries* among them *96,035 are female*.

ACCESS TO WATER

NGF Initiatives (Access to Potable Water):

Describe your organizational experiences on implementing in the following technologies at it's results....

1. Dip Tube well
2. Re excavate & Protect Pond:
2. Pond Sand Filter (PSF)
3. Rain Water Harvesting Plant (RWHP)
4. Iron Removal Plant
5. Pipeline water supply in both HHs & irrigation
6. Water Tank Distribution
7. Water Collection Point Development
8. Promote HHs level Reverse Osmosis Plant
7. Desalination Water Treatment Plant
   - 7.1. Desalination Water Treatment Plant (Electricity)
   - 7.2. Desalination Water Treatment Plant (Generator)
   - 7.3. Desalination Water Treatment Plant (Solar)
8. DWTP Operation (Org. Management)
9. DWTP Operation (Community Mechanism)

Feasible Water Technology

●●●●●●●●●●?

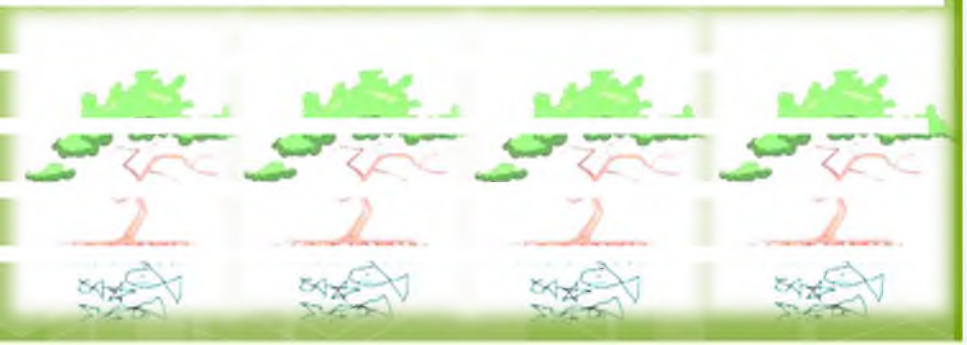
Combat with access to Potable Water behind the high saline content areas of coastal region.

CTCN - Climate Technology Centre & Network

CTCN Team, South Korea has been conducting a feasibility study on water purification model at household level in the coastal areas of Bangladesh.

Field visit memory share with CTCN

Sharing knowledge & Learning



GONOMUKHI NOWABENKI FOUNDATION
Shyamnagar, Satkhira

Motto: Vision 21
Inclusive Empowerment for sustainable Development.

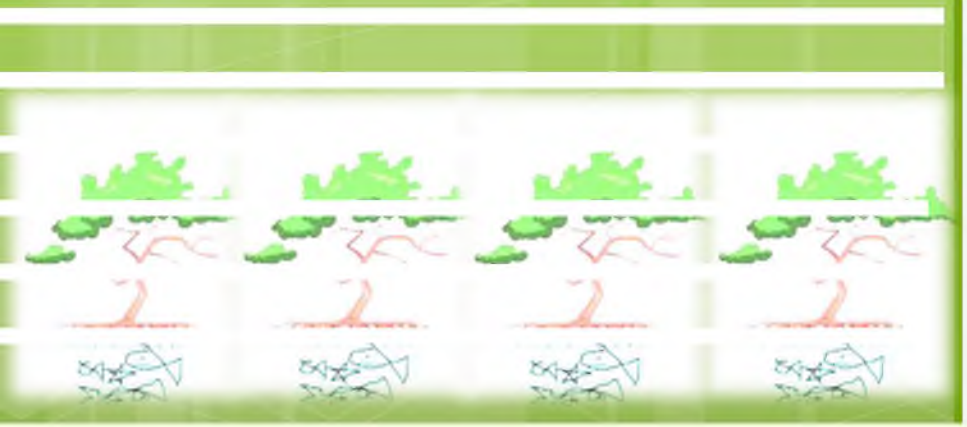
Nowabenki Gonomukhi Foundation (NGF)

Nowabenki, Shyamnagar, Satkhira, Bangladesh
Email: ngfbd1@yahoo.com, lutfor.rahman@ngf-bd.org
www.ngf-bd.org

We Acknowledged To

Climate Technology Centre & Network

To Ensure Our Participation in this Study Program



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Nowabenki, Shyamnagar, Satkhira, Bangladesh
Email: ngfbd1@yahoo.com, lutfor.rahman@ngf-bd.org
www.ngf-bd.org

GONOMUKHI NOWABENKI FOUNDATION
Shyamnagar, Satkhira

Access to Safe Water

(At Household Level Intervention)

NGF has been Implementing various water technology in high saline content areas and lastly we introduced

Desalination Water Treatment Plant

We are here to

Share our findings

Desalination Water Treatment Plant

?

How it works ?

GONOMUKHI NOWABENKI FOUNDATION
Shyamnagar, Satkhira

We can see a Video Clip

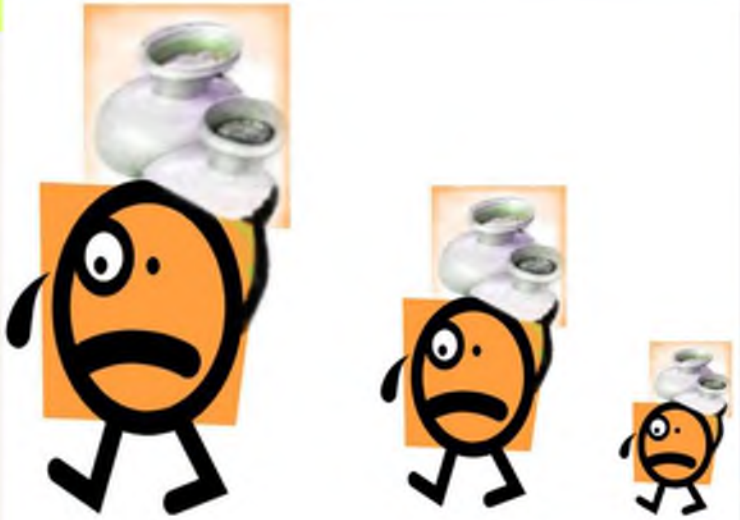
The Context

The local context of the project areas are ***Shyamnagar & Koira*** upazila (adjacent of Mangrove) under Satkhira & Khulna district are experiencing in ***recorded changes in atmosphere includes transformation of landscape and livelihood pattern.***

In the recent decade, repeated ***natural disaster, cyclone includes increased salinity, changed seasonality that occurred extreme weather conditions***. Another issue is manmade saline intrusion that ***reduced fresh water sources*** from ground water .

Working Area:

Remote Coastal Upazila of
Shyamnagar & Koira
Climate Vulnerability
Risk: Salinity



Accordingly, ***scarcity of water is a fundamental problems that mostly faced & suffer by women*** to serve their household water requirement.

NGF Initiatives (Access to Potable Water):

1. Dip Tube Well
2. Re excavate & Protect Pond:
3. Pond Sand Filter (PSF)
3. Rain Water Harvesting Plant
4. Iron Removal Plant
5. Pipeline water supply
6. Water Tank Distribution
7. Collection Point Development

Among all those water technologies, some die out and some are still alive; but with limitations!

Yes, only Rain Water Harvesting Plant is successful

for 6 months only!

WATER IS EVERY WHERE B
UT NOT DROP TO DRINK

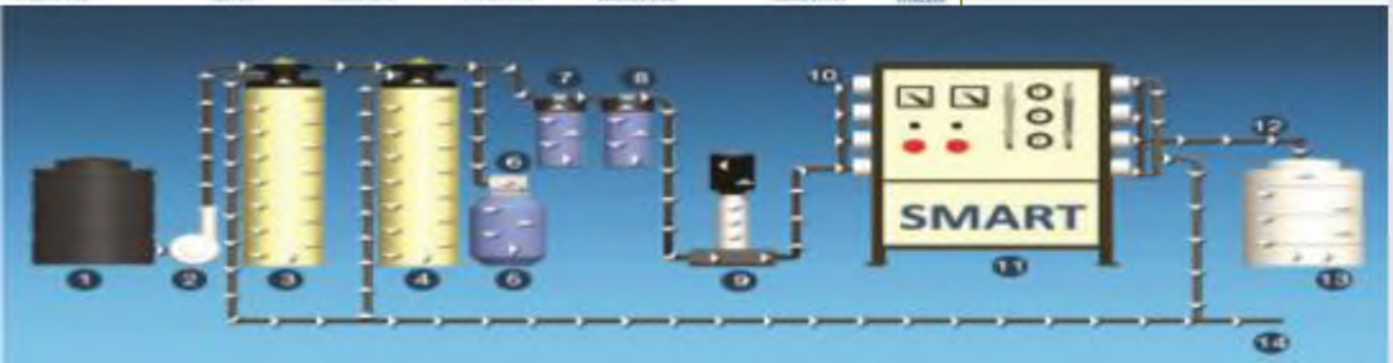
What are the Solution

?

Desalination Water Treatment Plant (DWTP):

NGF has introduced the technology on 2013 under LIFT Project and then scale up the initiative by CCCP project of PKSF. So far, NGF has experimented 3 types of RO plant;

1. **DWTP operated by Electricity**
2. **DWTP operated by Generator**
3. **DWTP operated by Solar**
4. **RO water plant at HHs level**



Total 11 RO Plant has been serving 44000 HHs in the high saline content coastal areas .

RO Plant at HHs level

Desalination Water Plant
Operation & Management

Community Mechanism

Union Parishad Chairman	Water Plant establishment, operation & management Step-1: Form Management Committee (Member, Teacher, Social worker & host organization) • Plant site selection • Land requisition • Plant set up
FGD Participants	

Role of Plant Management Committee

The management committee s task are involved in the following

- Management & operation
- Oversee the daily production & Sale
- Water pricing
- if any management problems , host organization will take initiative to solve it
- Open a bank account one signatory by host organization
- Regular maintain bookkeeping including income & expenditure at daily basis
- One plant manager recruited for plant operation and get salary from water sale

Desalinization Water Treatment Plant

An effort towards sustainable solution for coastal areas people

Desalination Water Plant

Plant Operation & Management

NGF has been promoting
Community Mechanism Approach
for smooth operation & maintenance of Desalination Water Treatment Plant

CMA-Functions/how it works....click the link
https://drive.google.com/file/d/1e6adx4N5PzwdynF168Ar_dloetngQ9rX/view?usp=sharing

CMA- Way forward.....click the link
https://drive.google.com/file/d/1Ya9c7XOFZhE6WFvwaEMmrfWc4z7kgXP_/view?usp=sharing

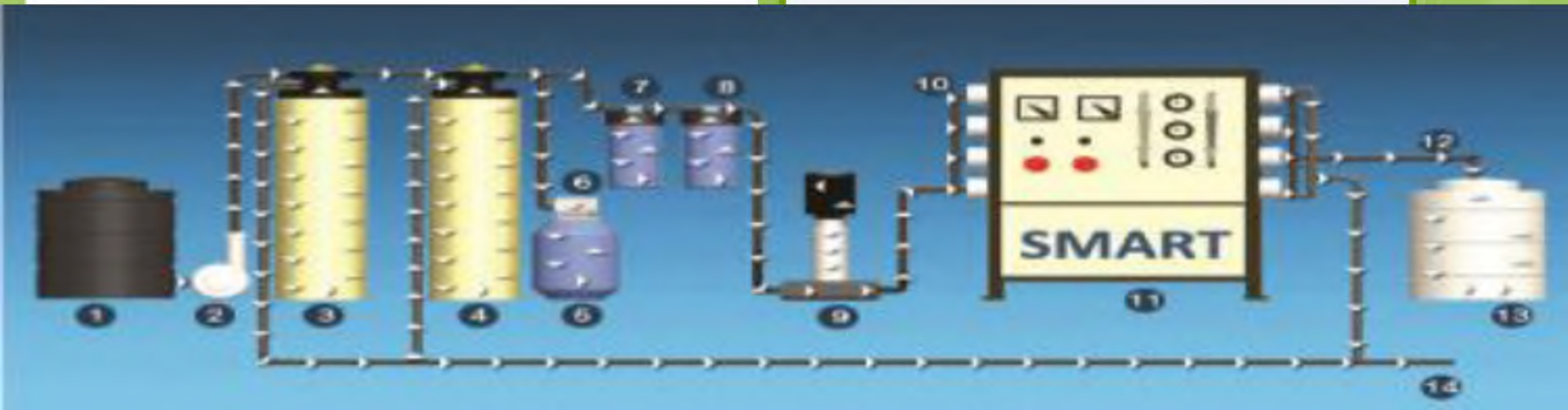
Desalinization Water Treatment Plant
An effort towards sustainable solution for coastal areas people

Technological feasibility and viability

- *Feasible and user friendly technology*
- *Managed by local staff after trained*
- *Availability of quality accessories and services*

Findings

Available accessories & services can run the plant efficiently,

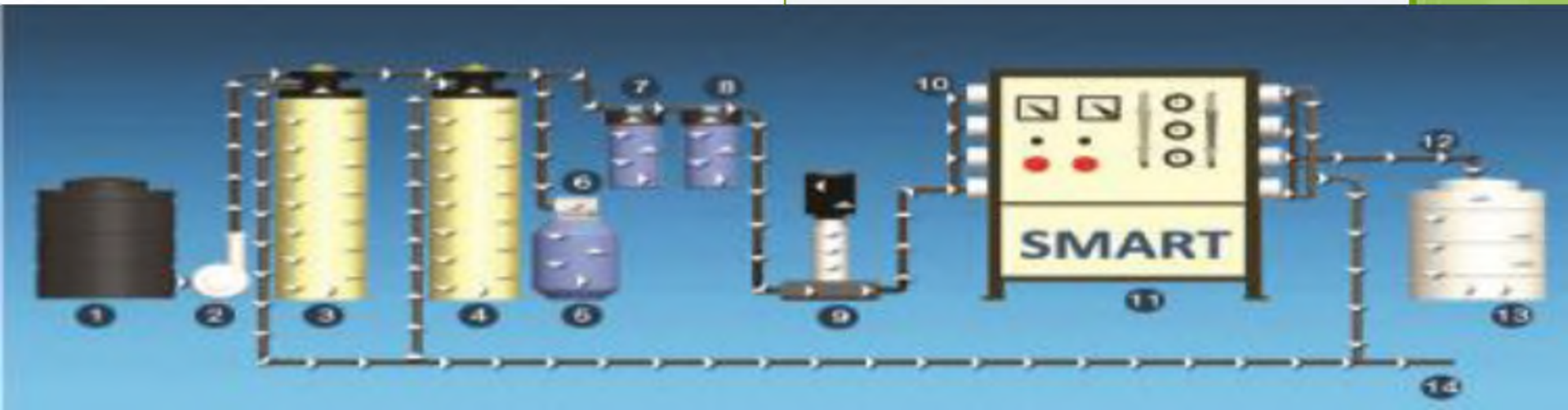


Present Status of
Desalination Water Plant

Currently, there are about 8-10 companies are involved in marketing DWTP technology in southwest coastal region and 80% market share o Chinese product.

Findings

About 50+ DWTP has establish (both public & private) in that areas among them 11 of NGF



Desalination Water Treatment Plant

Line Items	Description
Plant Capacity	Total 8000 households will be covered per day among them 1200 students have access to free water during the school time.
Access to Free Water	Primary school students have free access to water in the school time.
Water Price	Per liter water cost will be 0.30 BDT at plant and 25 taka per jar (20 liter) in HHs and community level.

Plant –B.1
Cost Analysis

Desalination Water Treatment Plant

Accounts of

NGF Own Management Plant

Income & Expenditure

Monthly Accounts Report

https://drive.google.com/file/d/1IRdkyAn509RbJUtkc-h5pe9sT12yLU6D/view?usp=sharing

Desalination Water Treatment Plan Solar Power

Managed by Community Mechenism

we`y¨Z PvwjZ wWm¨vwj‡bkb IqvUvi cø¨v ‡mŠi PvwjZ wWm¨vwj‡bkb IqvUvi cø¨v›U

ms¯’vi wmwmwmwc I wjdU cÖK‡íi AvIZvq G ch©šÍ 11wU wWm¨vwj‡bkb IqvUvi cø¨v›U ¯’vcb K‡i‡Q, hvi gva¨‡g 3wU Dc‡Rjvq (k¨vgbMi, Kqiv I cvBKMvQv) cÖwZw`b 55 nvRvi wjUvi my‡cq cvwb mieivn Kiv n‡”Q| jeb cvwb wgwó Kivi gva¨‡g my‡cq cvwb mieiv‡ni Rb¨ GKwU †UKmB I cwi‡ekevÜe cÖhyw³ wn‡m‡e DcK,jxq AÂ‡j cwiwPwZ †c‡q‡Q|

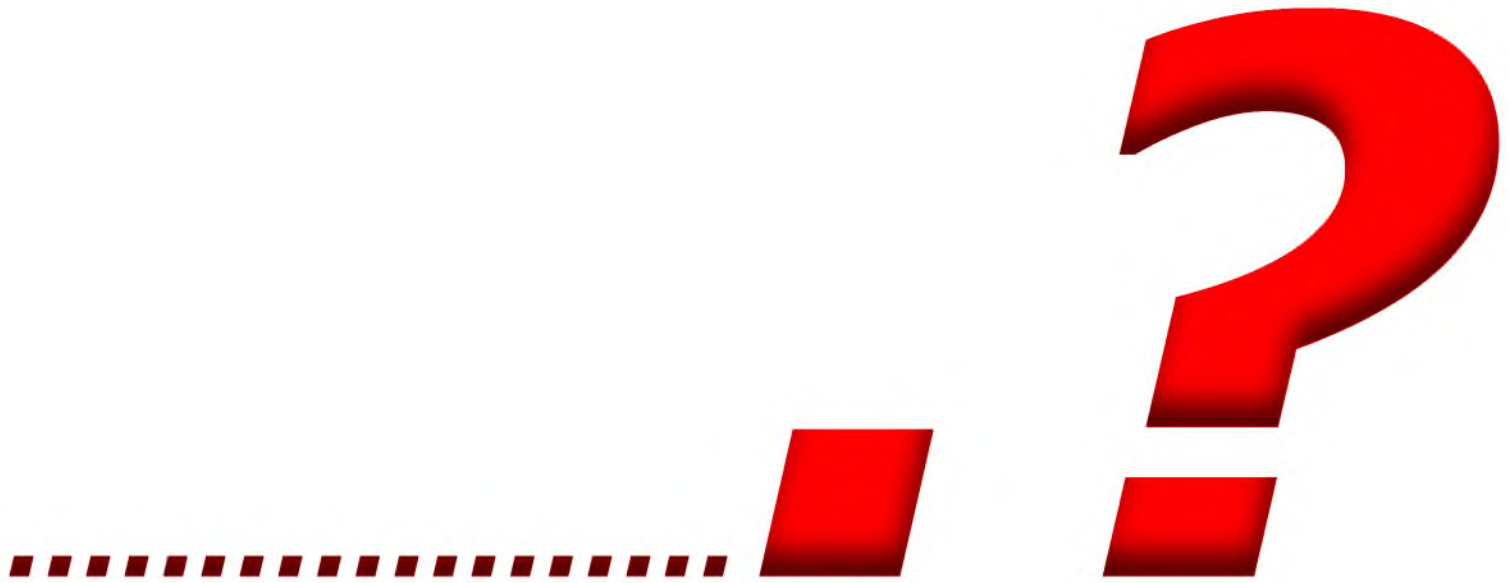
Generator

Desalination Water Treatment Plant

Managed by Community Mechanism

Line Items	Description
Plant Capacity	Total 8000 households will be covered per day among them 1000 students have access to free water during the school time.
Access to Free Water	Primary school students have free access to water in the school time.
Water Price	Per liter water cost will be 0.30 BDT at plant and 25 taka per jar (20 liter) in HHs and community level.

Question Please, if any



12. Nov. 2018

Low-cost desalination applications to solve water problems in coastal areas of Bangladesh

Yun Chul Woo[a], Dong–Jin Yang[b], Soon–Ho Park[b], June–Seok Choi[a],

[a] Korea Institute of Civil Engineering and Building Technology (KICT)

[b] Glory and Technology (GAT)

Agenda

I Project Team

II Project experience

III Survey in coastal areas

IV Potential applications at household levels

1. Project team

Team member (KICT)

Dr. June-Seok Choi

- Role: **Team Leader**
- Position: Senior Researcher
- Ph.D. at Korea University (South Korea)
- More than 20 yrs experience
- Expert area: Desalination (RO, FO, MD, PRO)

Dr. Tae Mun Hwang

- Role: **Desalination expert**
- Position: Research Fellow
- Ph.D. at Yonsei University (South Korea)
- More than 15 yrs experience
- Expert area: Desalination (RO, MD, PRO)

Dr. Yun Chul Woo

- Role: **Desalination scientist**
- Position: Senior Researcher
- Ph.D. at University of Technology Sydney (Australia)
- More than 8 yrs experience
- Expert area: Desalination (MD, FO, RED, CDI)

Team member (Glory and Technology, GAT)

Dr. Soon-Ho Park

- Role: Desalination expert
- Position: CEO
- Ph.D. at Seoul National University (South Korea)
- More than 20 yrs experience
- Expert area: Desalination (SWRO, BWRO)

Dr. Dong-Jin Yang

- Role: Desalination expert
- Position: Research Director
- Ph.D. at Seoul National University (South Korea)
- More than 10 yrs experience
- Expert area: Desalination (EDI, CDI)

MS. Ha Young Park

- Role: Coordinator
- Position: Researcher
- B.S. at Seoul National University (South Korea)
- Expert area: Environmental Planning, English

Team member (Kookmin University)

Prof. Sangho Lee

- Role: **Desalination expert**
- Position: Professor
- Ph.D. at Seoul National University (South Korea)
- More than 20 yrs experience
- Expert area: Desalination (RO, FO, MD, PRO)

Dr. Yong-Jun Choi

- Role: **Desalination expert**
- Position: Research Professor
- Ph.D. at University of Science & Technology (South Korea)
- More than 10 yrs experience
- Expert area: Desalination (RO, MD, PRO)

2. Project experience

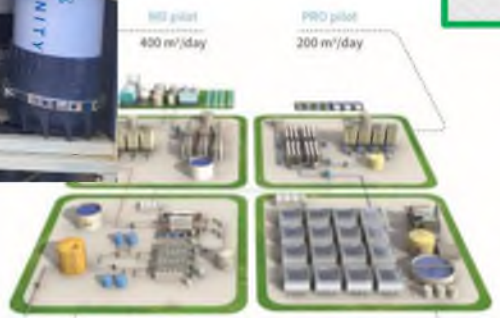
KICT

Oversea experience – Case

President's House in Africa Tanzania: Small water treatment facility

- May 16, 2017 Transportation of small-scale water purification units
- May 18, 2017 Equipment power connection and watering
- May 19, 2017 Administrator training and quality assurance delivered
- May 20, 2017 Visit to the senior officials of the Water Authority of Tanzania

Desalination experience – MD/PRO

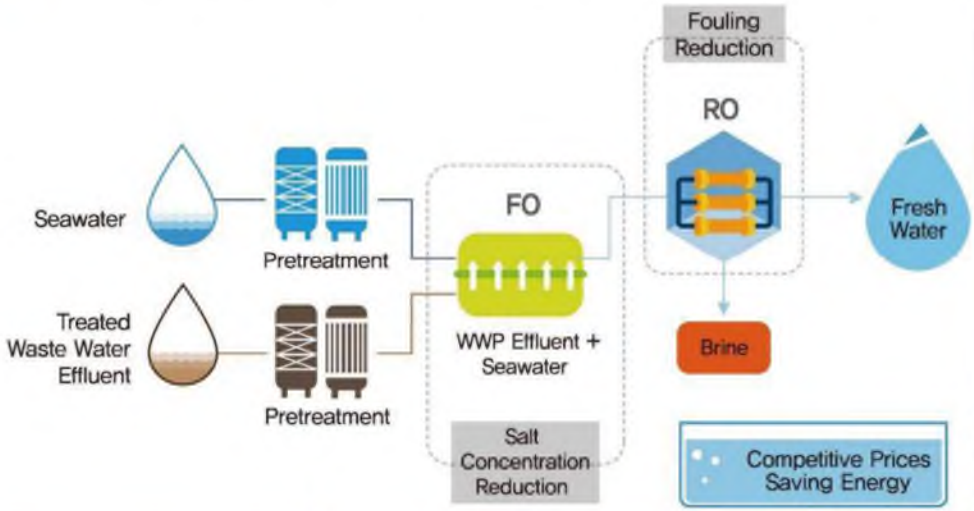


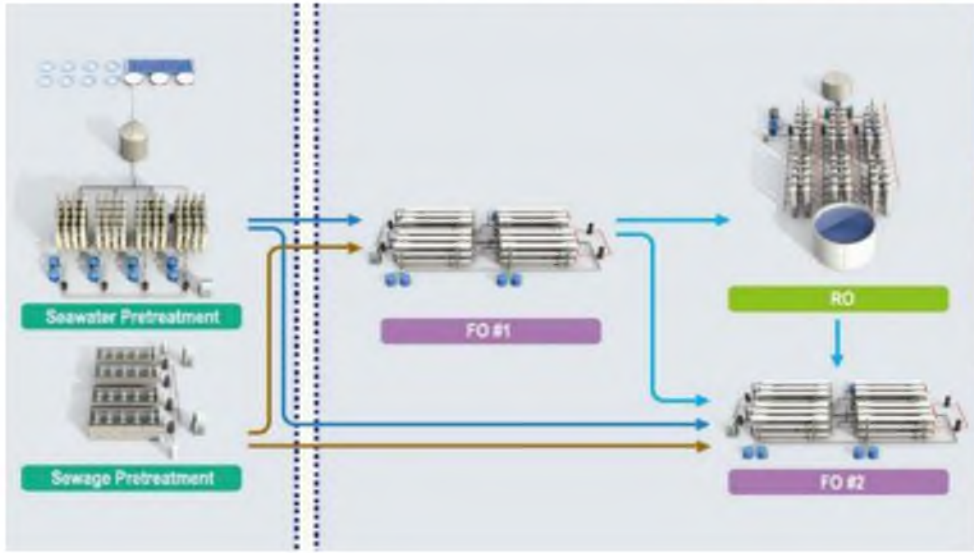
Valuable resource recovery (Li recovery: 1 m^3/d)

SWRO (1,000 m^3/d) – MD (400 m^3/d) Desalination

Desalination experience – FO/RO hybrid

Development of Large Scale FO-RO Hybrid Plant (1,000 m^3/d)





Glory and Technology (GAT)

Desalination experience

Mokmbul Primary School(Cambodia)
Drinking Water 20m^3/d (Jan. 2017)

Tirumkaet Primary School(Cambodia)
Drinking Water 20m^3/d (Dec. 2016)

School/Village Water Supply Facility

New Hope School(Cambodia)
Drinking Water 20m^3/d (Jul. 2017)

Joy & Disciple Kindergarten(Cambodia)
Drinking Water 20m^3/d (Aug. 2017)

3. Survey in coastal areas

Status of desalination in target areas

- Due to the effectiveness of desalination processes in providing safe drinking water, both government and non-government organizations are now promoting this technology specially in southwest coastal Bangladesh.

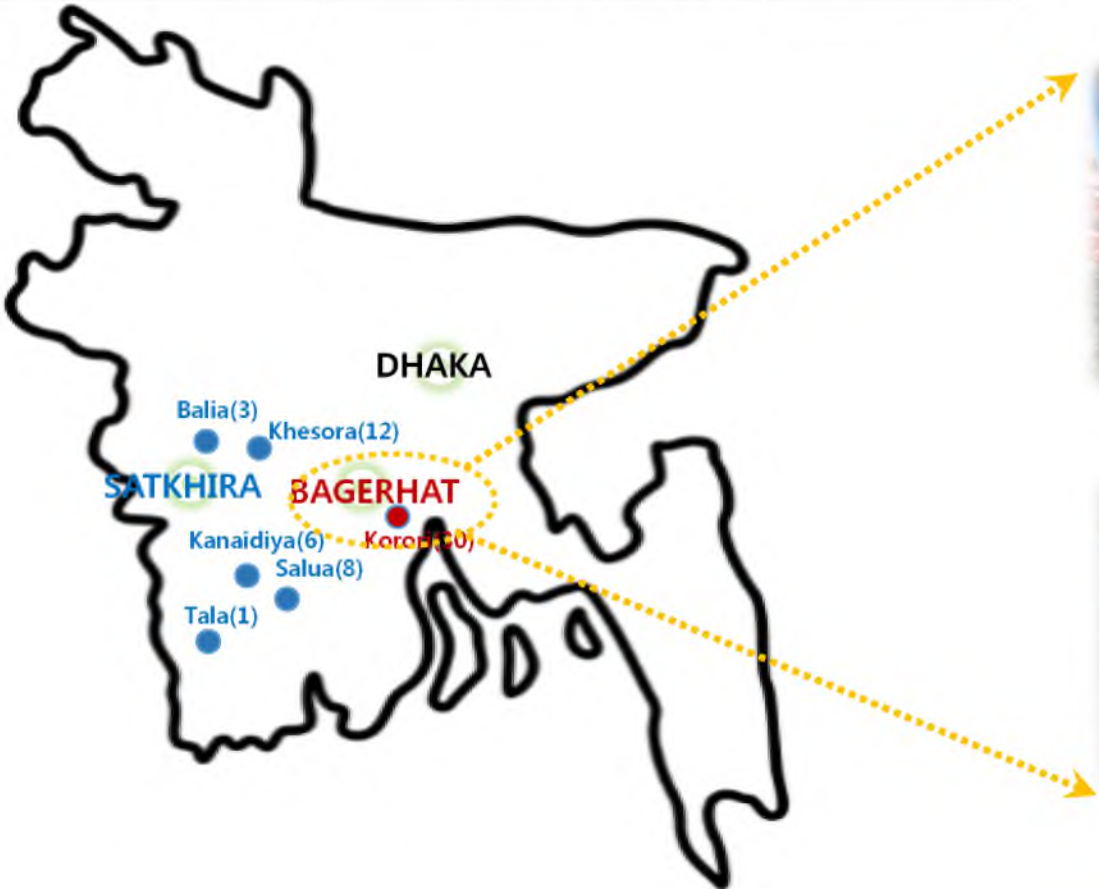
- Most of the plants are RO plants and their operational conditions are almost similar and alternative technology options will be sought with this project.

- Although RO is a dominant application to produce drinking water in the world, a cost-effective desalination process will be selected to apply for target areas.

Water usage survey in Satkhira and Bagerhat

❖ **Water supply at present in both areas**

Area	Water Source		Well stocked house	Drinking tank stocked house
	Ground water	Ground water with Rain water		
Satkhira	29	1	3	1
Bagerhat	30	0	27	5



Rainwater Tank

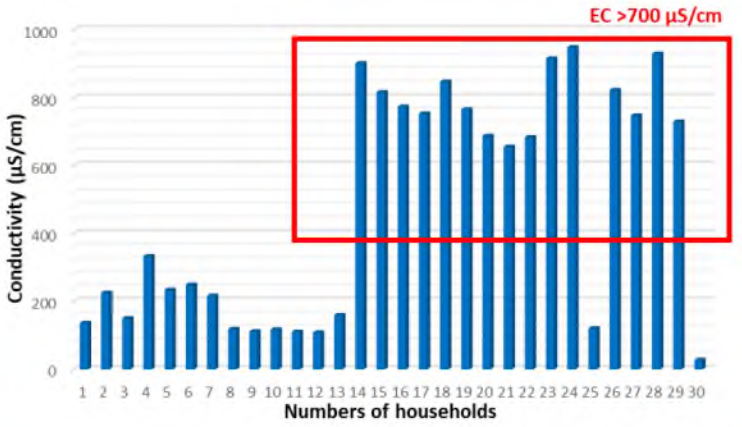
Shallow Tube Well

Drinking Tank

Characteristics of water qualities in target areas

❖ **Satkhira vs Bagerhat regarding water qualities**

Water Quality Parameter (unit)	Groundwater in Bagerhat	Groundwater in Satkhira	Bangladesh standards	WHO Guide Lines
Hardness as $CaCO_3$ (mg/L)	400	1,400	200-500	-
Potassium permanganate consumption (mg/L)	3.8	10.1	-	10
Manganese (mg/L)	0.342	0.136	0.1	-
Boron (mg/L)	0.04	n.d.	1.0	-
Fluoride (mg/L)	0.27	n.d.	1	1.5
Arsenic (mg/L)	0.032	n.d.	0.05	0.01
pH	7.2	7.3		6.5-8.5
Ammonia (mg/L)	0.08	2.57	0.5	-
Chloride (mg/L)	55.5	1,727.9	150-600	-
Total Dissolved Solids (mg/L)	642	4,309	1000	-
Nitrate (mg/L)	0.1	0.1	10	50 as N
Iron (mg/L)	0.19	n.d.	0.3-1.0	-
Turbidity (NTU)	4.41	0.73	10	-



(Unit: µS/cm)

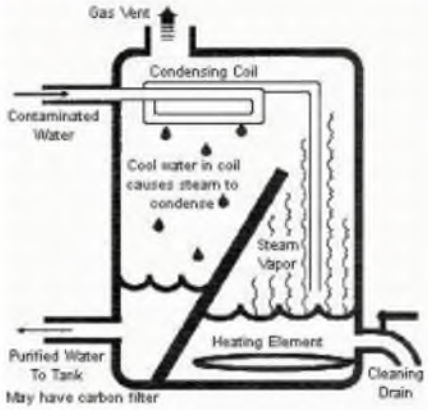
	Max.	Min.	Average
Satkhira	949	28	480.4
Bagerhat	574	112	175.0

In terms of water qualities, Satkhira is worse than Bagerhat

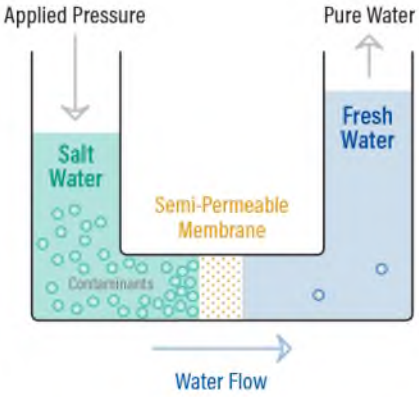
4. Potential applications at household levels

Potential applications

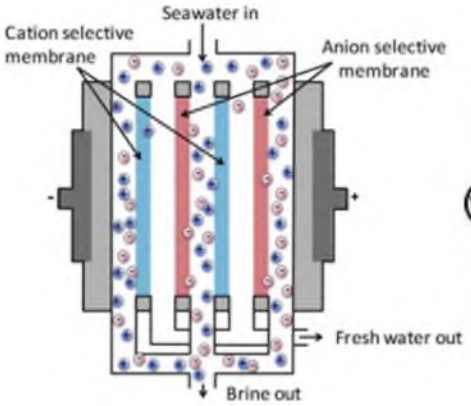
❖ Low-cost desalination processes



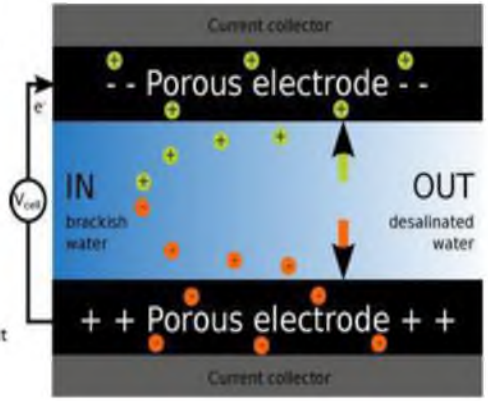
Membrane Distillation



Reverse Osmosis



Electrodialysis



Capacitive Deionization

	Membrane Distillation	Reverse Osmosis	Electrodialysis	Capacitive Deionization
Driving Force	Thermal Energy	Mechanical Pressure	Electrochemical Potential Difference	Electrochemical Potential Difference
Applicable Feed Water TDS Concentration (ppm)	35,000 (seawater)	SWRO: 35,000 (seawater) BWRO: 4,000	6,000 (brackish water)	3,000 (brackish water)
Energy Requirement (kWh/ton)	~ 16.4	SWRO: 2 ~ 3 BWRO: 0.5 ~ 1.0	~5.5	~ 0.45
Cost of Water Purification($/ton)	7.5~9[1)]	**1.51**[2)]	**0.85**[3)]	**0.3**[4)]

Source: R. Zhao et al. / Desalination 330 (2013) 35 – 41, P. G. Youssef et al. / Energy Procedia 61 (2014) 2604 – 2607, M.A. Anderson et al. / Electrochimica Acta 55 (2010) 3845–3856

1) International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 10, Number 1 (2017),

2), 3) http://aquaewp.com/제-content/uploads/Why-EWP-vs-RO.pdf, 4) http://aqwatec.mines.edu/produced_water/treat/docs/Capacitive_deionization.pdf

1. Capacitive Deionization (CDI)

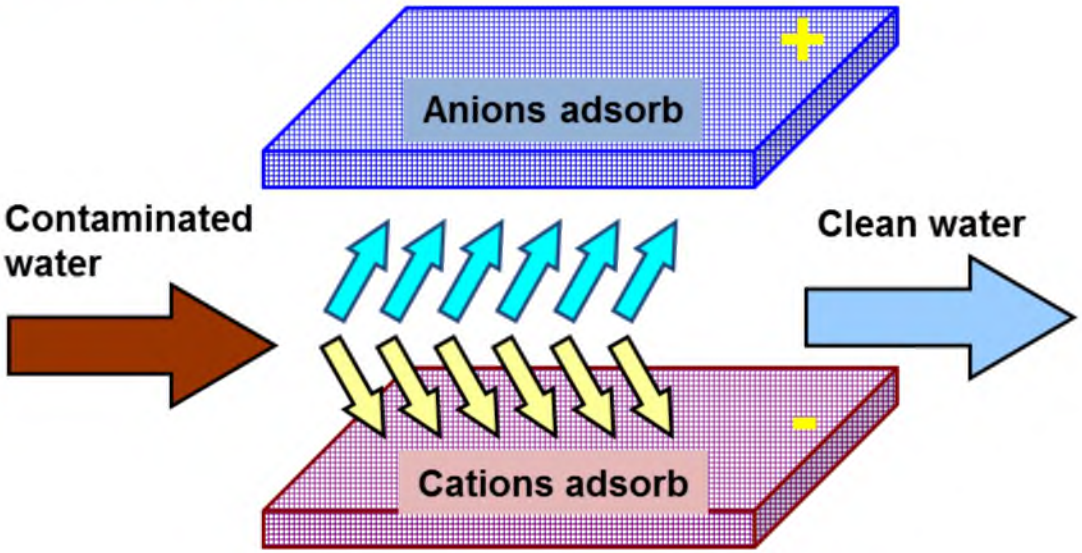
- **CDI for De-contaminating Drinking Water**

  - Eliminates ions such as arsenic (III), perchlorate, nitrate, and other toxic inorganics
  - Removes both cations and anions
  - Removes charged particles
  - Units small and portable
  - Requires no consumables (resins, sorbents, etc.)
  - Can use any DC power source (batteries, solar panels, generators, etc.)
  - Low voltage 1.2 VDC (safe); current scales with total dissolved solids (TDS)
  - Low power at typically low TDS concentrations in drinking water
  - Can deliver potable water from many sources (wells, lakes, streams, etc.)

Ref. https://slideplayer.com/slide/2813275/

1. Capacitive Deionization (CDI)

Ion Removal

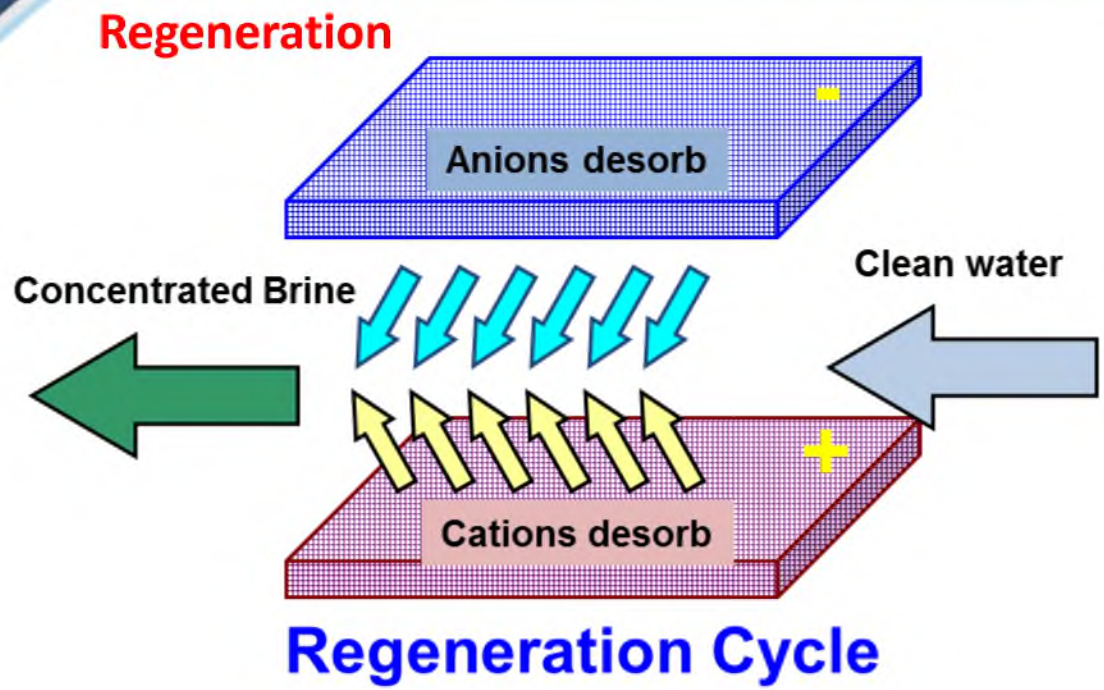


Deionization Cycle

- Cations migrate to negative electrode
- Anions migrate to positive electrode
- The required current rapidly decays as ions are removed so it is inherently efficient and needs low-power supply

- CDI electrostatically removes dissolved cations and anions from contaminated water
- TDA CDI unit
  - Stack (or spiral wound) high surface area carbon electrodes
  - Electrodes are porous and electrically conductive
  - Ions are removed when DC voltage is applied
  - $V \leq 1.2$ volts to prevent electrolysis of water
  - Ions adsorb and are held in the electric double layers on the electrodes

1. Capacitive Deionization (CDI)

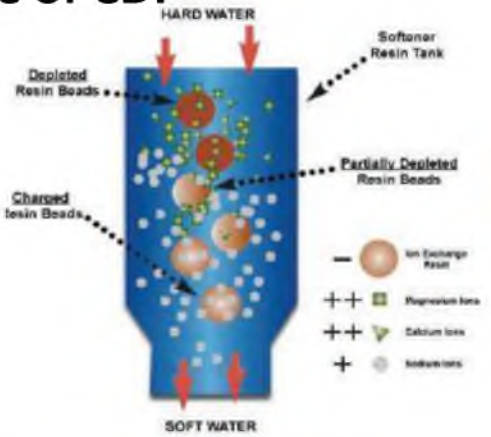


- Electrodes are shorted or polarity briefly reversed to force desorption
- Flush in reverse direction with product water
  - One of the efficient processes because captured salt concentration is highest at the inlet
  - Uses of the produced water during flush are minimal and resulting an effluent can be sent to the drain

- Can briefly reverse polarity to speed up desorption
- Flush <u>counter-current</u> with clean product water
- Stored capacitance can be re-captured during discharge to improve an efficiency of the process (more relevant when treating brackish water)

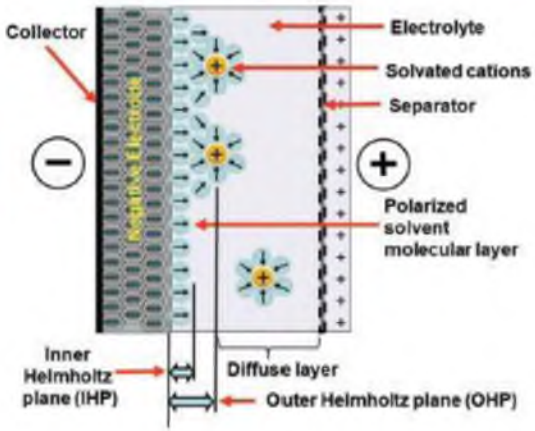
1. Capacitive Deionization (CDI)

Principle of CDI

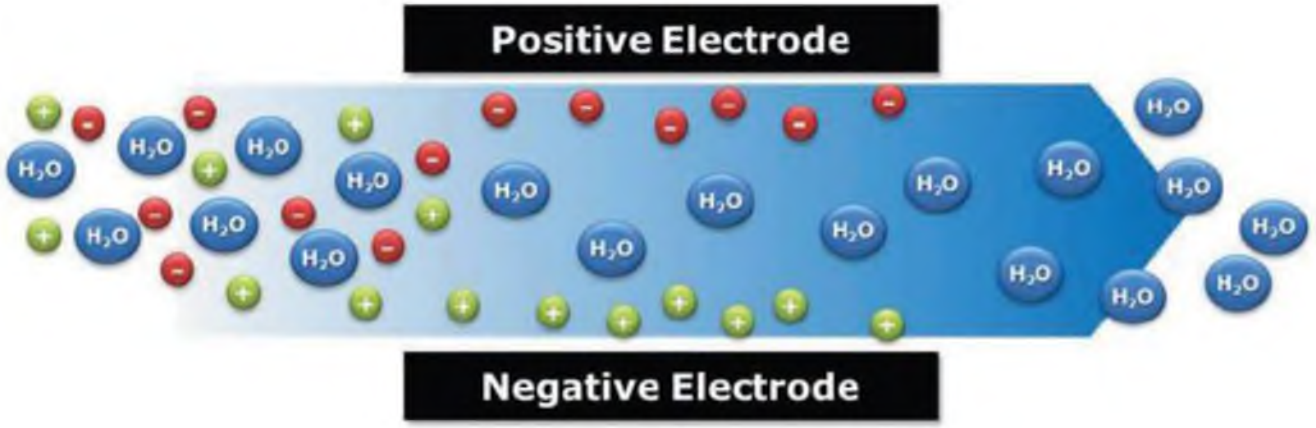


Water Purification

Convergence Technology



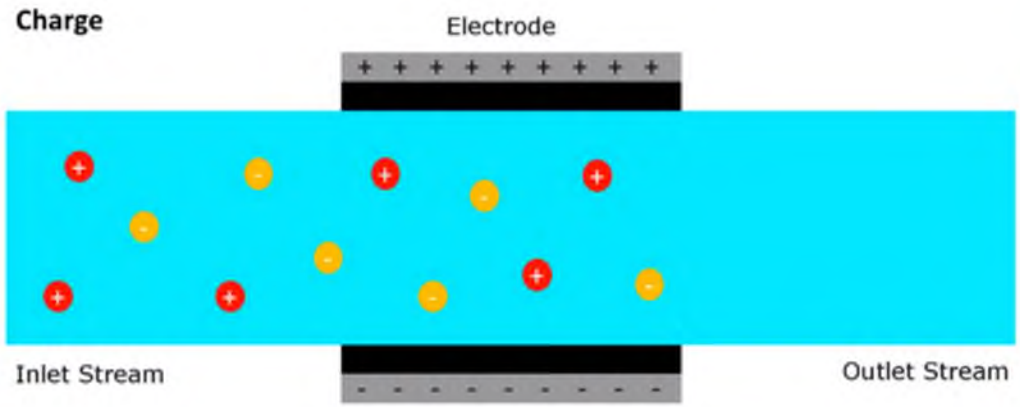
Supercapacitor



CDI is a desalination process to remove ionic species from aqueous solutions by applying electric potential to porous electrodes.

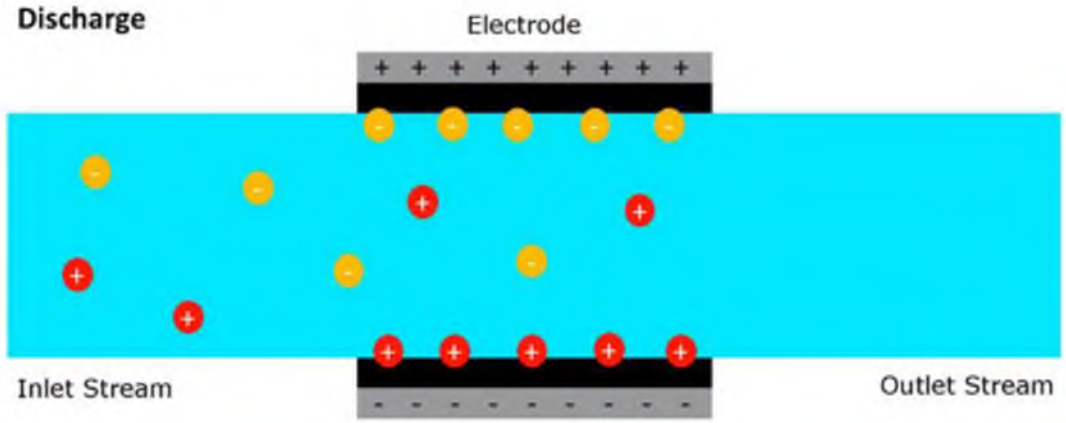
1. Capacitive Deionization (CDI)

Principle of CDI



- Recovery: 75-90% recovery possible

- Operation power: comparable or lower than ED technology



1. Capacitive Deionization (CDI)

Advantages of CDI

Comparison of several water purification technologies

Desalination Technology	Energy Requirement
Mechanical Vapor Compression (MVR)	6,6 kWh/m^3 (~ 25 Wh/gal) – Sea Water
Multiple Effect Distillation with Mechanical Vapor Compression (MED-MVR)	7,9 – 10,8 kWh/m^3 (30-41 Wh/gal) – Sea Water
Multiple Effect Distillation with Thermal Vapor Compression (MED-TVR)	56,8 – 83,2 kWh/m^3 (215-315 Wh/gal) Sea Water
Multi Stage Flash Evaporation (MFE)	~ 84,5 kWh/m^3 (~320 Wh/gal) – Sea Water
Reverse Osmosis (RO) (Depending on energy recovery)	6,6 – 9,3 kWh/m^3 (25-35 Wh/gal)– Sea Water 2,3 kWh/m^3 (8,5 Wh/gal)- Brackish Water
Electrodialysis	2,03 kWh/m^3 (7,7 Wh/gal) – Brackish Water
CDT (Includes Energy Recovery)	~ 4.2 – 8.5 kWh/m^3 (16-32 Wh/gal) – Sea Water 0,05-0,1 kWh/m^3 (0,2 – 0,4 Wh/gal) – Brackish Water

- Does not require high pressures
  - Equipment and operational costs are reduced
- Low voltages
  - Safe
  - Low power (low energy cost)
  - Small units can be used in remote locations and run by solar panels
- Used energy from the CDI can be recovered by utilizing energy storage (CDI is a capacitor)

1. Capacitive Deionization (CDI)

E-Carbon Filter for CDI

E-CARBON FILTER

Name : E-CARBON FILTER (Ion removal filter)

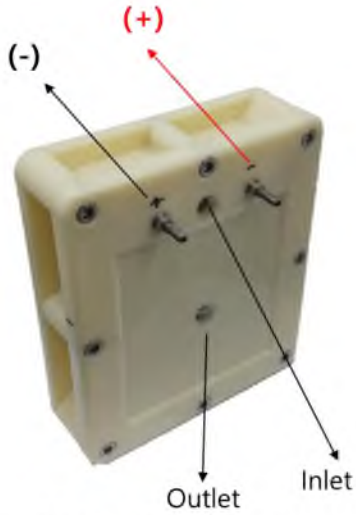
Materials : Activated carbon, Ion exchange membranes

Operating temperature : 4 ~ 60 ℃

Maximum flow rate : 720L / day

Operation pressure : 3 ~ 42 psi

Cleaning : Please assemble after living water for about 5 minutes cleaning



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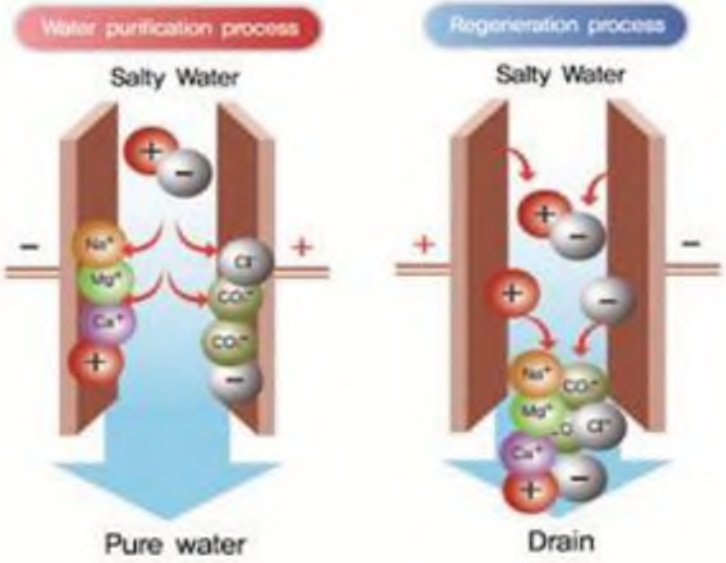

2. Reverse Osmosis (RO)

- **High pressure RO**

  - The technology employed a pressurized a semi-permeable membrane to remove ions, molecules and large particles for drinking water.
  - Recovery: More than 90% possible.
  - Unit cost: Quiet expensive
  - Operating power: Lower than electrodialysis (ED) technology for > 5000 ppm.
  - Design: High pressure pump 20 – 30 bar and high pressure re-circulation pump required
  - Ability to prototype: The RO unit can be easily re-configured.
  - Reducing energy by a renewable solar and wind energy.
  - The high pressure RO application can be used for seawater more than 30,000 mg/L or brackish water with a salt concentration of more than 15,000 mg/L, depending on TDS of a feed water.

2. Reverse Osmosis (RO)

- **Advantage of RO**

  - **A separation efficiency of the RO shows good performances without a phase change.**

  - **The RO system can make a small size compared to other applications.**

  - **The RO eliminates 95% up to 99% of total dissolved solids(TDS), which is the best technology currently for obtaining pure water.**

  - **To apply many other applications such as seawater desalination, wastewater reclamation, and shale gas and coal bed methane produced waters.**

2. Reverse Osmosis (RO)

- **Drawbacks of RO**

  - The small pores can prevent penetrations of large molecule substances although smaller molecules such as pesticides and chlorine are passing through the RO membrane.

  - To prevent penetrations, a carbon filter must be used to the RO process.

  - As most minerals like iron, magnesium, and calcium solutions are larger molecular size than water molecules. The RO membrane prevents passing through other side against them.

  - Thus, the permeate water exhibits de-mineralized.

  - The systems needs professional for cleaning.

2. Reverse Osmosis (RO)

Removal elements of filters

FILTERS	Removal elements
Sediment filter	Removal of large particle dust, sand, rust, etc.
Cation exchange filter	Eliminates calcium, magnesium, pomegranate, rusty, suspended solids, and residual chlorine
Carbon filter	Eliminates organic chemicals and odors
Ultrafiltration membrane filter	Removal of microorganisms and impurities below 0.1 μm
Reverse Osmosis filter	Eliminates organic inorganic pollutants, bacteria, viruses, heavy metals, etc.

Examples of potential applications

❖ Water purifier for household levels

Water purifier
by solar-assisted reverse osmosis (RO)

Water purifier
by Capacitive deionization (CDI)

- To supply safe drinking water for household level
- To reduce total energy consumption via low-cost desalination potable processes

KICT

Thank you for your attention

GTAT Glory And Technology

GREEN TECHNOLOGY CENTER

CTCN CLIMATE TECHNOLOGY CENTRE & NETWORK

GREEN TECHNOLOGY CENTER

Ministry of Science and ICT

Korea NDE's Cooperation Approach under UNFCCC

(The case of Network, Capacity Building and Technical Support)

< CTCN Technical Assistance – Capacity Building Workshop >

2018.11.13

Changsun Jang

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Ministry of Science and ICT

Agenda

I Korean NDE's Platform for Climate Technology Cooperation

II Korean NDE's Climate Technology Cooperation Case

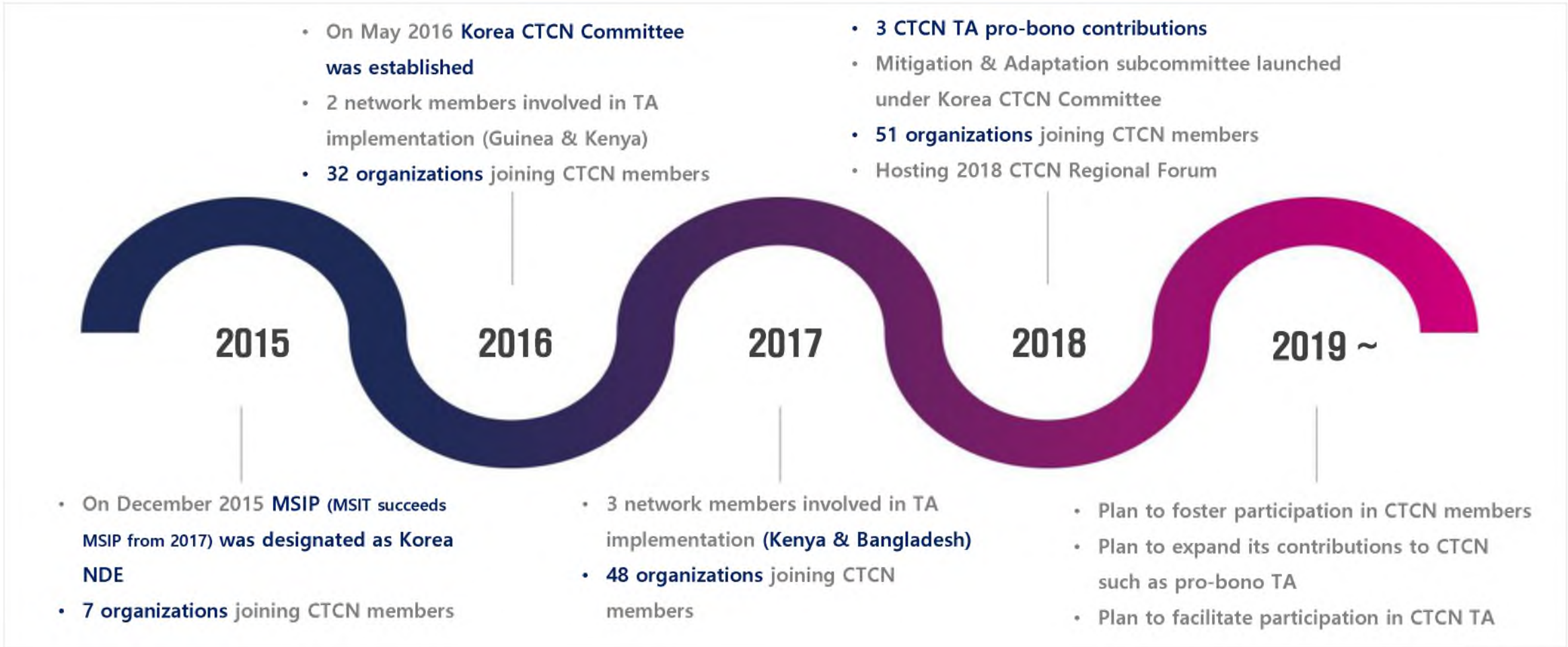
III Korean NDE's Vision and Way Forward

The ministry of Science and ICT focuses on accelerating innovation across the whole society through promoting R&D activities, securing source technologies and growth engines, and converging science and technology with ICT

The Korea NDE's History

Ministry of Science and ICT

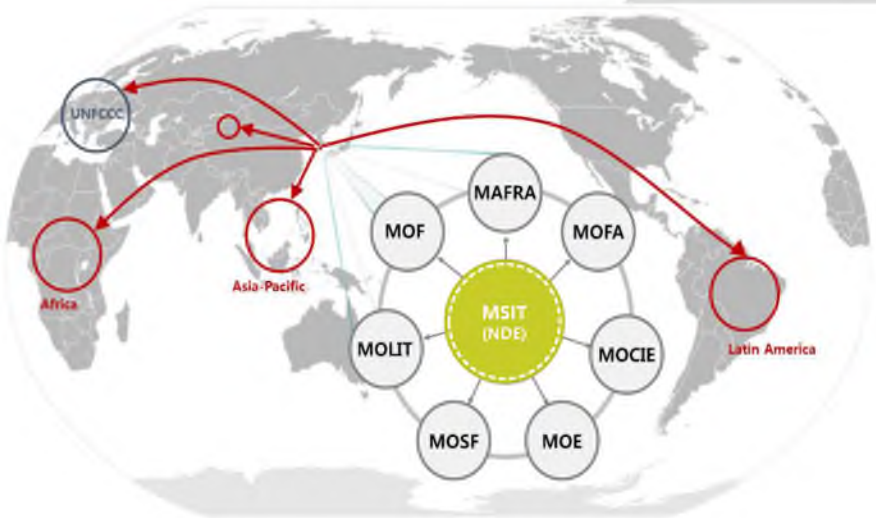
In 2015, the Ministry of Science and ICT (MSIT) **was designated as Korea National Designated Entity** (NDE) **for fostering the development and transfer of technologies and interacting with the Climate Technology Center and Network** (CTCN)



The MSIT aims to become a hub for global climate technology cooperation – linking Korean technology holders to needs of partner countries around the world

Vision Hub & Sherpa for Global Climate Technology Cooperation

Target Develop Global Cooperation Model to support for Industrialization of Climate Techs



Five Strategic Directions

① Climate Tech Pilot Projects

② Expand Global Cooperation Resources

③ Strengthen Global Climate Tech Cooperation channels

④ Establish Support System for Domestic Climate Tech Cooperation

⑤ Support Korean Institutions CTCN Involvement

Korea NDE's Cooperation Areas

Ministry of Science and ICT

The NDE currently offers support on cooperation development in three channels: ① networking with climate technology stakeholders; ② strengthening the capability; and ③ providing technical supports

NETWORK

Climate Technology Stakeholders including CTCN Members & NDEs

Providing a diverse network activities for forming a broad community of climate technology stakeholders

Set-up

CAPACITY BUILDING

Climate Technology Knowledge, Best Practice Model, Lessons Learned

Strengthening the capacity to identify technology options and adapt proper technologies

Design

TECHNICAL SUPPORT

Pro-bono TA, Technology Transfer,

Providing technical supports for partner countries to achieve their NDC (Mitigation & Adaptation)

GREEN TECHNOLOGY CENTER

Ministry of Science and ICT

Agenda

Ⅰ Korean NDE's Platform for Climate Technology Cooperation

Ⅱ Korean NDE's Climate Technology Cooperation Case

Ⅲ Korean NDE's Vision and Way Forward

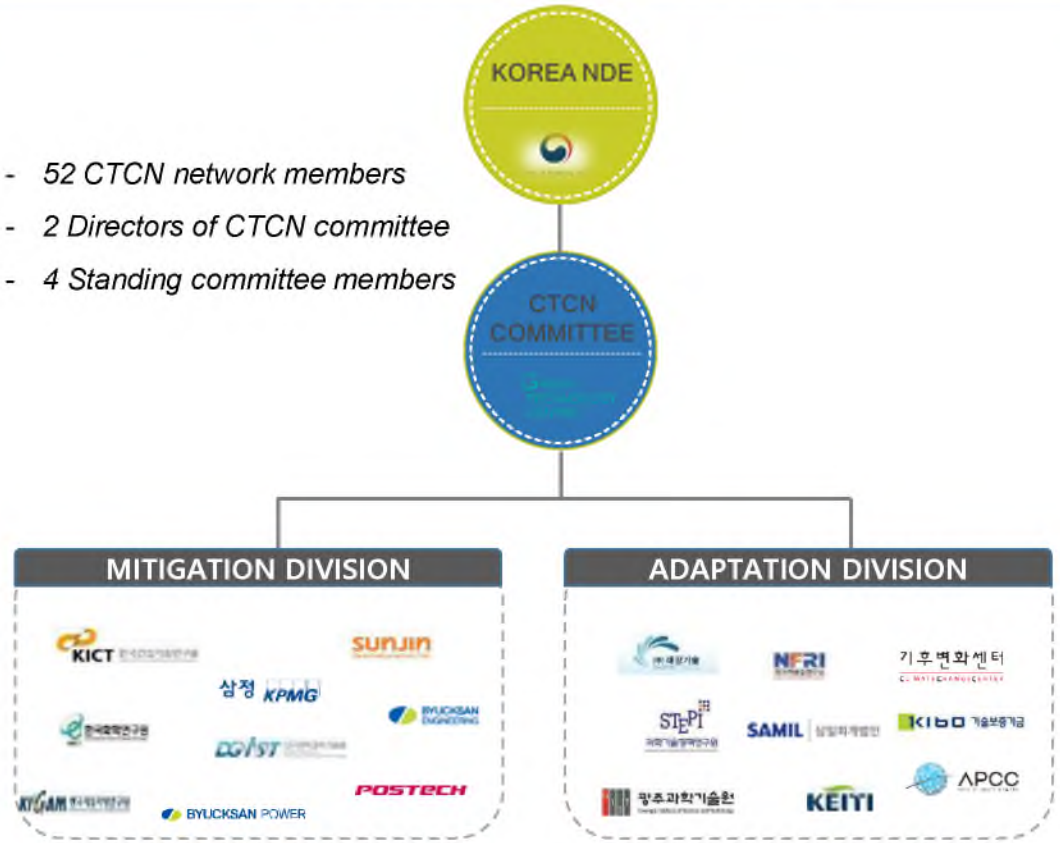
[Network/Capacity Building] *Korea CTCN Committee*

Ministry of Science and ICT

To facilitate climate technology transfer through CTCN platform, Korean NDE launched Mitigation & Adaptation subcommittees in 2018 under the umbrella of the Korea CTCN Committee established in 2016

Korea CTCN Committee Structure

- *52 CTCN network members*
- *2 Directors of CTCN committee*
- *4 Standing committee members*



Roles of Korea CTCN Committee

Korea CTCN Committee Members

- **52 organizations** Total Network Members participated in Korea CTCN Committee
- **34 organizations** under Mitigation Division in Korea CTCN Committee
- **18 organizations** under Adaptation Division in Korea CTCN Committee

Korea CTCN Committee Activities

- **Network:** providing access to a diverse climate technology stakeholders of climate technology users, providers and financiers under the umbrella of the CTCN committee
- **Information exchange:** sharing CTCN activities including TA tracks, TA process, case studies and lessons learned
- **Capacity building:** facilitating the provision of information, training and support to build the capacity of CTCN members to utilize CTCN programme

[Network/Capacity Building] *Korea CTCN Committee Activities*

Ministry of Science and ICT

1st 2016

Launched CTCN Committee & 1st CTCN Committee Workshop

2nd 2016

2nd CTCN Committee Workshop & Capacity Building on application of CTCN TA

1st 2017

3th CTCN Committee Workshop & Capacity Building on application of CTCN TA

2nd 2017.

4th & 5th CTCN Committee Workshop & Capacity Building on application of CTCN TA

1st 2018.

6th & 7th CTCN Committee Workshops & 1st CTCN subcommittee meeting

[Network/Capacity Building] *Global NDE Cooperation Activities*

Ministry of Science and ICT

Korean NDE provides a diverse network activities for sharing climate technology information and strengthening the capacity to identify technology options and adapt technology through global CTCN networks

'16 November
(2016 SEOUL Science & Technology FORUM)

'17 September
(Workshop on Strengthening the Cooperation)

'17 October
(KOREA CLIMATE TECHNOLOGY 2017)

'18 July
(2018 CTCN Regional Forum)

To help partner countries to develop and enhance endogenous capabilities and technologies based on their potential and resources, Korean NDE is seeking to transfer innovation technologies to partner countries

Facilitating an innovative environment through concrete cooperation with partner countries

(in the areas of renewable energy, climate resilience, smart cities and big data application)

[Technical Support] *CTCN TA Pro-bono contributions*

Ministry of Science and ICT

To promotes the accelerated transfer of climate technologies, Korean NDE has been mobilizing its financial resources for providing technical assistance (TA) pro-bono basis to three partner countries in 2018

Federal Democratic Republic of Ethiopia

- **Project Overview**
  - Devise an effective funding strategy for the realization of the pilot TOD investment in Ethiopia
- **Period :** 12 months

Financing Strategy for Transit Oriented Development

Democratic Socialist Republic of Sri Lanka

- **Project Overview**
  - Formulate a Climate-smart city framework for the City of Kurunegala
- **Period :** 12 months

Development of Framework for climate-smart City

Republic of Serbia

- **Project Overview**
  - Identify potential projects of renewable and/or waste heat supply to the City's district heating network.
- **Period :** 12 months

Incorporating renewable and waste heat technologies

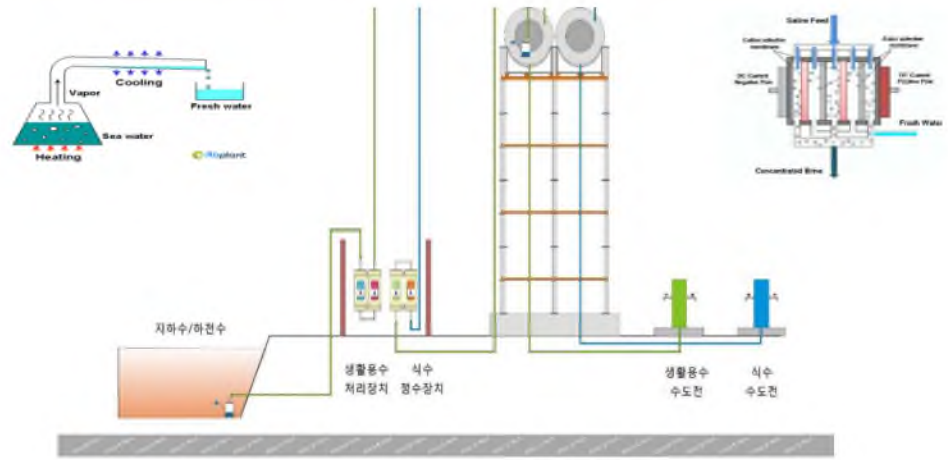
Based on CTCN TA activities, Korean NDE has been providing demonstration programs to develop and characterize prototypes and capable of providing performance measurements in operational environments

Bangladesh, CTCN Technical Assistance

CTCN TA RFP *CTCN TA TOR* *CTCN TA Proposal*

- **Project Overview**
  - Identify and introduce household level desalination technique(s) as well as low-cost salinity proofed housing option(s) in coastal areas of Bangladesh
- **Period :** 8 months

Bangladesh, Demonstration of Desalination Technology



- **Project Overview**
  - Install 10 water treatment facilities customized to raw water condition considering the economic efficiency and scale of the business
- **Period :** June 1, 2018 ~ November 30, 2019 (18 months)

Based on bilateral cooperation including feasibility studies and technology demonstrations, Korean NDE supports to design and develop green projects (GCF, MDB projects) **in collaboration with partner countries' NDE or NDA**

Bhutan, Bilateral Cooperation

Feasibility Study on Green Transport System

BIS Technology Demonstration

Linkage to GCF PPF resources

- **Project Overview**
  - Mobilizing its financial resources for a feasibility study, BIS technology demonstration, and PPF preparation to facilitate the Bhutanese government's access to GCF resources
- **Period :** From 2016 ~

Bhutan, Development of Green Transport Program

- **Project Overview**
  - Design and develop the Green Transport Program in collaboration with Bhutanese NDE & NDA and the World Bank
- **Period :** From 2017 ~

GREEN TECHNOLOGY CENTER

Ministry of Science and ICT

Agenda

Ⅰ Korean NDE's Platform for Climate Technology Cooperation

Ⅱ Korean NDE's Climate Technology Cooperation Case

Ⅲ Korean NDE's Vision and Way Forward

GTC's Vision and Way Forward

Ministry of Science and ICT

- Under the new climate regime with Paris Agreement, Tech mechanism has emerged as a key tool of Promoting, facilitating and financing the transfer of, or access to, climate technologies as know-how to our partner countries

- MSIT (Korean NDE), window for climate tech cooperation, is playing a leading role in the areas of green climate technology policy and a bridge builder of global climate tech cooperation on behalf of Republic of Korea

- Through transfer of climate technologies to our partner countries, MSIT is strongly committed to the reduction of carbon emission and enhanced climate adaptation, and therefore, minimizing the adverse effects of climate change

GTC's Vision and Way Forward

Ministry of Science and ICT

Korea NDE

Ministry of Science and ICT

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

Design technology cooperation activities in response to partner countries' requests

Operating Entity

Ministry of Science and ICT

GREEN TECHNOLOGY CENTER Korea

Develop technology cooperation activities with NDEs and CTCN

CTCN Committee

Mitigation Facility

Adaptation Facility

Korea CTCN Members

NFRI
KIGAM 한국지질자원연구원
KICT 한국건설기술연구원
KIBO 기술보증기금
광주과학기술원
STEPI
DGIST
KEITI
BYUCKSAN ENGINEERING
BYUCKSAN POWER
기후변화센터 CLIMATECHANGECENTER
SAMIL 삼일회계법인
POSTECH
(주)해강기술
삼정 KPMG
SUNJIN
한국화학연구원
APCC APEC CLIMATE CENTER

Int'l Organizations

Central American Bank for Economic Integration
CABEI
IDB Inter-American Development Bank
GREEN CLIMATE FUND
THE WORLD BANK IBRD · IDA | WORLD BANK GROUP
UNDP
UNIDO
UNEP
ADB Asian Development Bank

Korea Gov't Agencies

기획재정부
한국수출입은행
외교부
KOICA Korea International Cooperation Agency
환경부
KEITI
산업통상자원부
KIAT Korea Institute for Advancement of Technology

Identification | Development | Matchmaking | Implementation | Scaling-up

Thank You

GREEN TECHNOLOGY CENTER

Ministry of Science and ICT

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GREEN TECHNOLOGY CENTER

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

Developing GCF Project – GCF concept note

2018.11.13

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GREEN TECHNOLOGY CENTER

Agenda

Ⅰ Climate Finance and Green Climate Fund(GCF)

Ⅱ Developing GCF project – Concept Note

Ⅲ The Bhutan Green Transport Program Case

GREEN TECHNOLOGY CENTER

WORLD BANK GROUP

Agenda

Ⅰ Climate Finance and Green Climate Fund(GCF)

Ⅱ Developing GCF Project – Concept Note

Ⅲ Kenya Sustainable Water Project – Case Study

Technology Mechanism and Financial Mechanism

GCF Overview

- Fund created to support the efforts of developing countries to respond to the challenge of climate change
- Established in Dec. 2013 at Songdo, the Republic of Korea

objective

- Strive to maximize the impact of its funding by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change

Role

- Main fund for global climate change finance in the context of mobilizing USD 100 billion by 2020
- As an operating entity of the UNFCCC Financial Mechanism, it is accountable to and functions under the guidance of the COP(Conference of Parties)

Features

- Private Sector Facility(PSF) to catalyze private finance
- Promote direct access of National Implementing Entities

The GCF currently offers support on pipeline development in two channels: ongoing efforts through readiness activity area four, which supports countries on pipeline development and through PPF

GREEN TECHNOLOGY CENTER

WORLD BANK GROUP

Agenda

Ⅰ Climate Finance and Green Climate Fund(GCF)

Ⅱ **Developing GCF project – Concept Note**

Ⅲ Case Study - Kenya Sustainable Water Supply Project

Main challenges in developing the GCF project concept

1. **Designing the project or programme in the right way to meet investment criteria; and**

2. **Providing the required information concisely and in sufficient detail and quality**

Source : Internationale Zusammenarbeit (GIZ) GmbH

GCF Project Areas

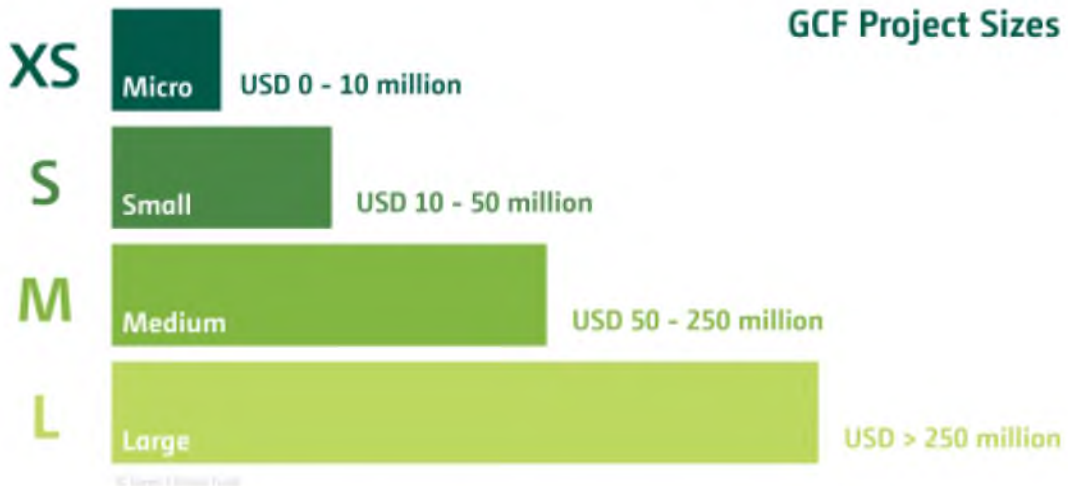
Considering the investment strategy, GCF selected 8 impact areas which will deliver major mitigation and adaptation benefits

GCF Project Areas	
Mitigation	**Adaptation**
▪ Low-emission energy access and power generation	▪ Enhanced livelihoods of the most vulnerable people, communities, and regions
▪ Low-emission transport	▪ Increased health and well-being, and food and water security
▪ Energy efficient buildings, cities and industries	▪ Resilient infrastructure and built environment to climate change threats
▪ Sustainable land use and forest management	▪ Resilient ecosystems

Deciding Project Size and Accredited Entity

Deciding the right project size and identifying the right accredited entity is key to build a successful GCF funding proposal.

Consideration of a project size category



- *Micro proposals would have a total size of up to and including US$ 10 million;*
- *Small proposals would have a total size of above US$ 10 to 50 million;*
- *Medium proposals would have a total size of above US$ 50 to 250 million; and*
- *Large proposals would have a total size of above US$ 250 million.*

Identification of an accredited entity

GCF encourages national entities to access to the fund through direct access modality which is designed to help countries exercise ownership of climate change funding and better integrate it with their national climate action plans.

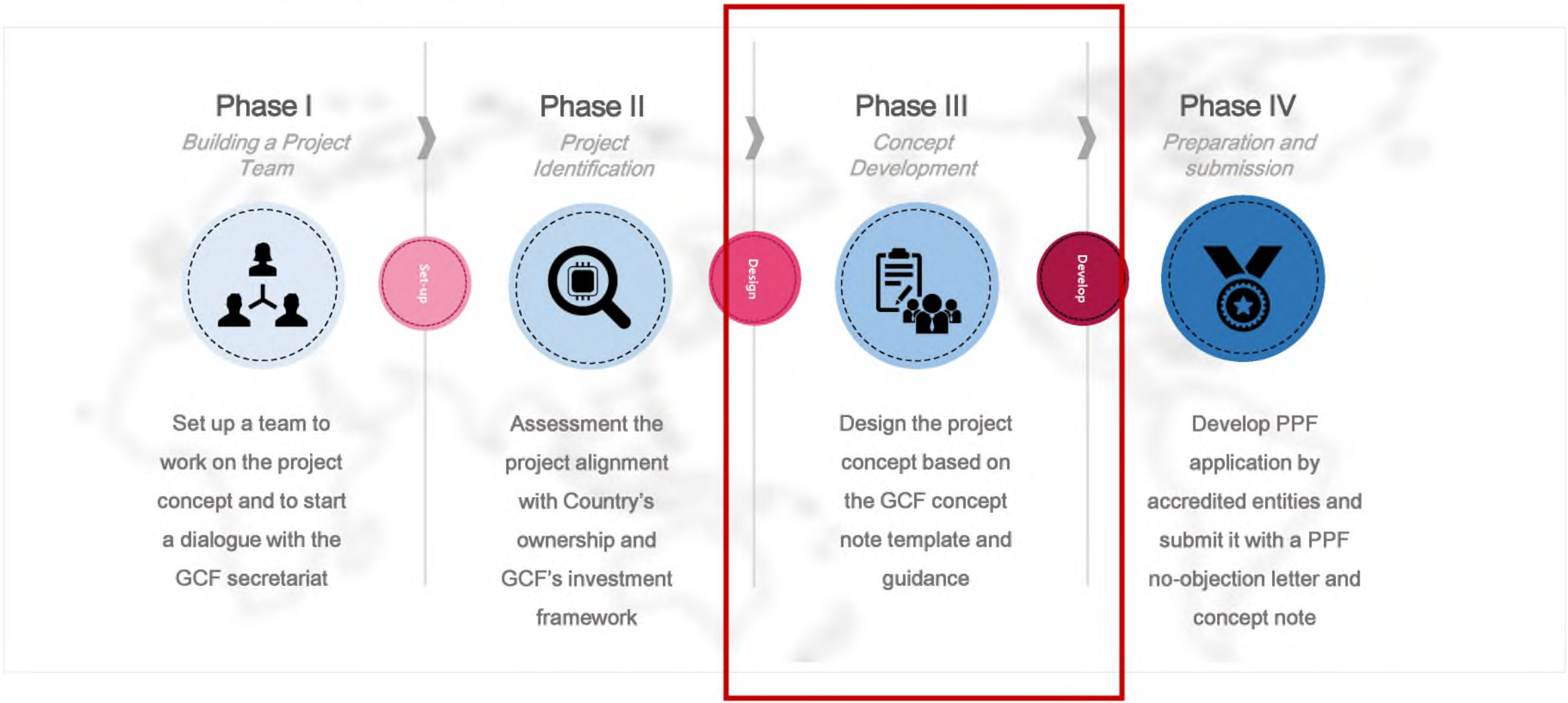
Concept Note Development

Initial Considerations

- **Concept note development is optional**
- **Concept note requires less detail and allows in-depth feedback and recommendations from the secretariat within one month after submission**
- **Advantages of developing a concept note:**
  - Assess chances for success, i.e. whether to prepare a full proposal or not.
  - Provide guidance on potential improvements in project/programme design.
  - Provide guidance on how to present the project/programme in the proposal.

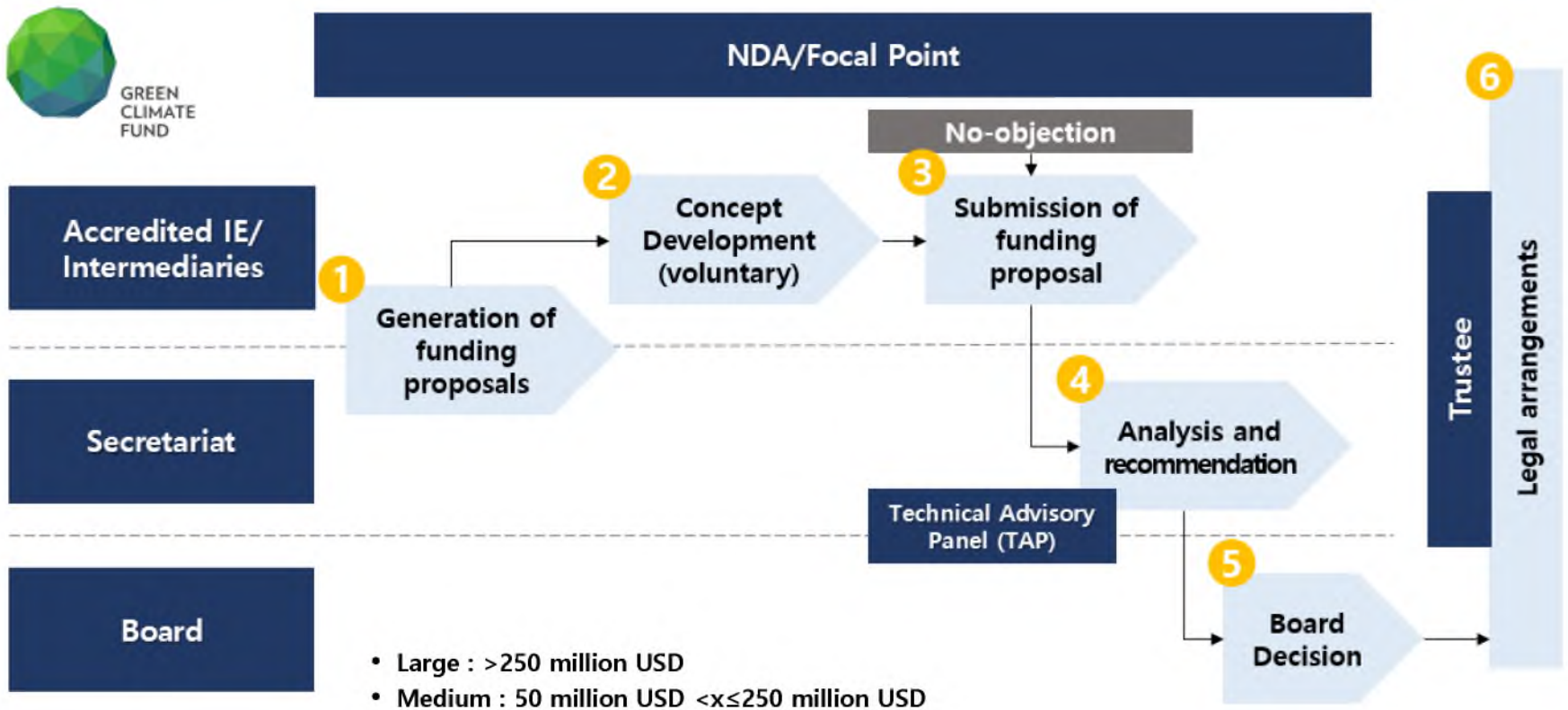
How to get started

Requests for support from the PPF should be submitted at the same time or following submission of a GCF Concept Note for a project or programme



GCF Proposal Approval Process(adopted at 7th Board Meeting)

GCF project approval process

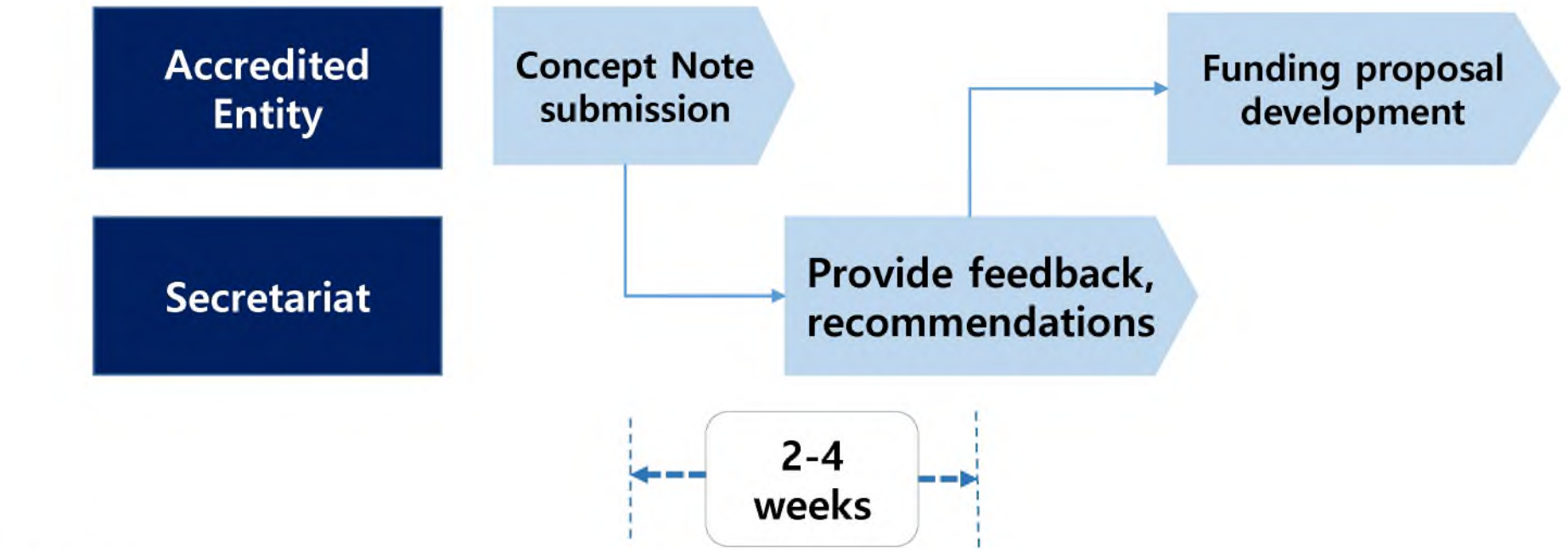


- Large : >250 million USD
- Medium : 50 million USD <x≤250 million USD
- Small : 10<x≤50 million USD
- Micro : ≤10 million USD

Source: Green Climate Fund

GCF Proposal Approval Process(adopted at 7th Board Meeting)

GCF project approval process



Source: Green Climate Fund

GCF Concept Note – Overall Structure

4 Sections:

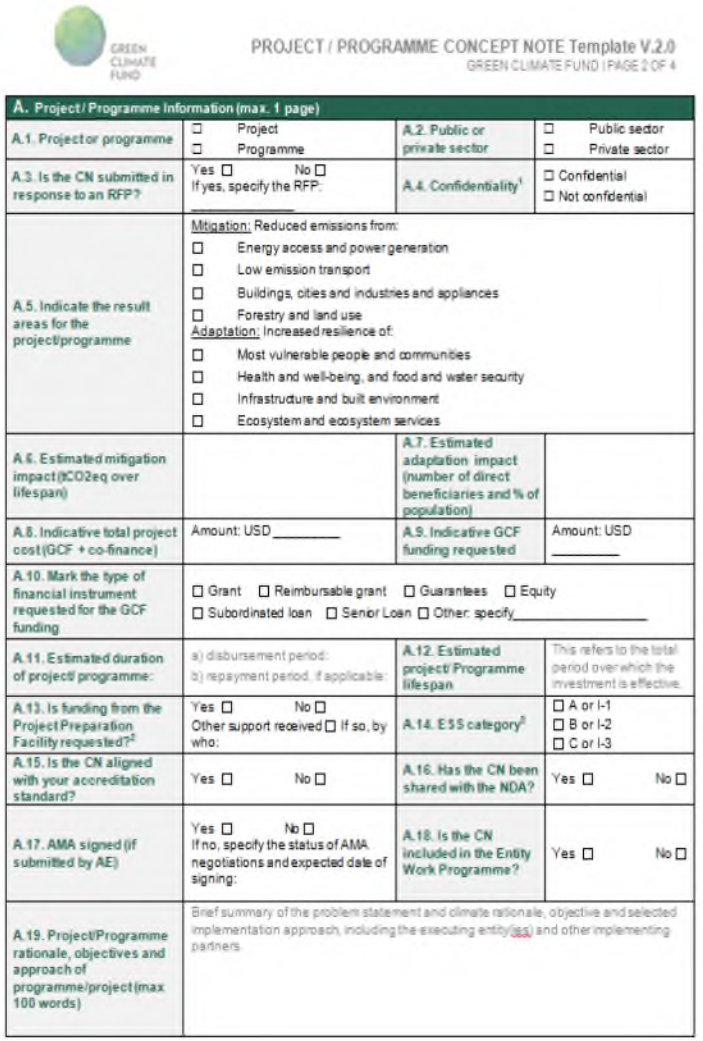
A. Project / Programme Information

B. Project / Programme details

C. Indicative financing / Cost information

D. Supporting documents submitted (OPTIONAL)

The maximum number of pages should not exceed 12 pages



PROJECT / PROGRAMME CONCEPT NOTE Template V.2.0
GREEN CLIMATE FUND | PAGE 2 OF 4

A. Project / Programme Information (max. 1 page)			
A.1. Project or programme	☐ Project ☐ Programme	A.2. Public or private sector	☐ Public sector ☐ Private sector
A.3. Is the CN submitted in response to an RFP?	Yes ☐ No ☐ If yes, specify the RFP: _____	A.4. Confidentiality[1]	☐ Confidential ☐ Not confidential
A.5. Indicate the result areas for the project/programme	Mitigation: Reduced emissions from: ☐ Energy access and power generation ☐ Low emission transport ☐ Buildings, cities and industries and appliances ☐ Forestry and land use Adaptation: Increased resilience of: ☐ Most vulnerable people and communities ☐ Health and well-being, and food and water security ☐ Infrastructure and built environment ☐ Ecosystem and ecosystem services		
A.6. Estimated mitigation impact (tCO2eq over lifespan)		A.7. Estimated adaptation impact (number of direct beneficiaries and % of population)	
A.8. Indicative total project cost (GCF + co-finance)	Amount: USD _____	A.9. Indicative GCF funding requested	Amount: USD _____
A.10. Mark the type of financial instrument requested for the GCF funding	☐ Grant ☐ Reimbursable grant ☐ Guarantees ☐ Equity ☐ Subordinated loan ☐ Senior Loan ☐ Other: specify_____		
A.11. Estimated duration of project/ programme:	a) disbursement period: b) repayment period, if applicable:	A.12. Estimated project/ Programme lifespan	This refers to the total period over which the investment is effective.
A.13. Is funding from the Project Preparation Facility requested?[2]	Yes ☐ No ☐ Other support received ☐ If so, by who:	A.14. ESS category[3]	☐ A or I-1 ☐ B or I-2 ☐ C or I-3
A.15. Is the CN aligned with your accreditation standard?	Yes ☐ No ☐	A.16. Has the CN been shared with the NDA?	Yes ☐ No ☐
A.17. AMA signed (if submitted by AE)	Yes ☐ No ☐ If no, specify the status of AMA negotiations and expected date of signing:	A.18. Is the CN included in the Entity Work Programme?	Yes ☐ No ☐
A.19. Project/Programme rationale, objectives and approach of programme/project (max 100 words)	Brief summary of the problem statement and climate rationale, objective and selected implementation approach, including the executing entity(ies) and other implementing partners.		

Section A : Project / Programme Information

Outlines the basic elements of the project/ programme

Concept note template

A.6. Estimated mitigation impact (tCO2eq over lifespan)		A.7. Estimated adaptation impact (number of direct beneficiaries and % of population)	
A.8. Indicative total project cost (GCF + co-finance)	Amount: USD _____	A.9. Indicative GCF funding requested	Amount: USD _____
A.10. Mark the type of financial instrument requested for the GCF funding	☐ Grant ☐ Reimbursable grant ☐ Guarantees ☐ Equity ☐ Subordinated loan ☐ Senior Loan ☐ Other: specify_____		
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A.17. AMA signed (if submitted by AE)	Yes ☐ No ☐ If no, specify the status of AMA negotiations and expected date of signing:	A.18. Is the CN included in the Entity Work Programme?	Yes ☐ No ☐

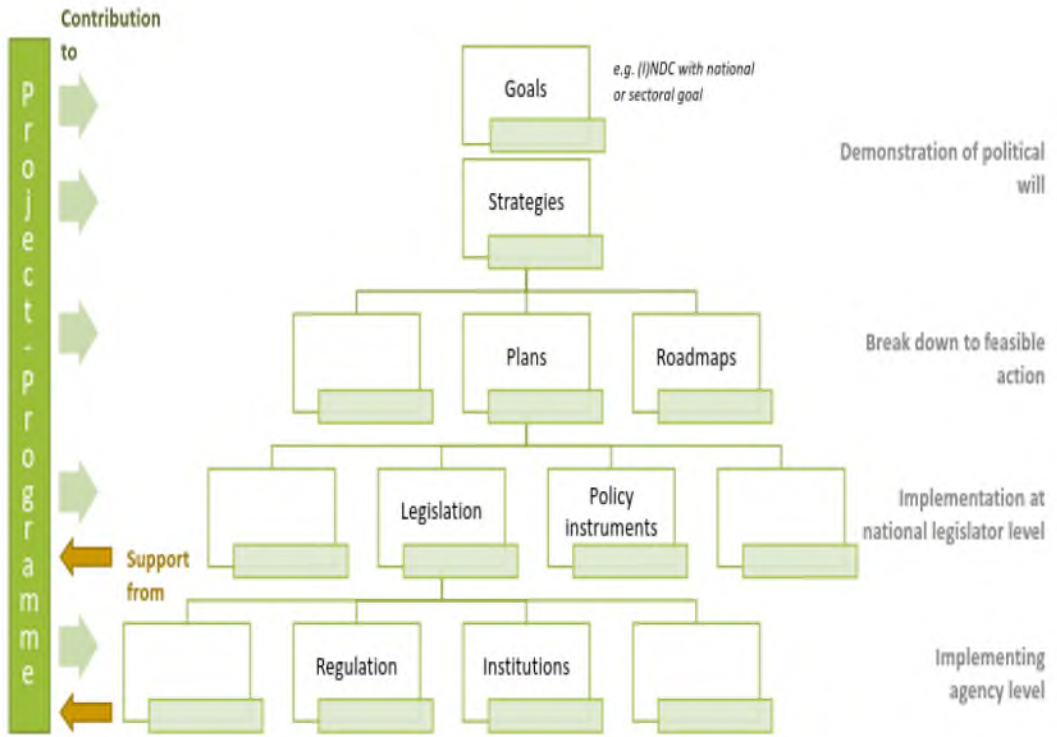
- **Estimated mitigation impact**
- **Estimated adaptation impact**
- **Indicative total project cost (GCF funding, co-financing)**
- **Type of Financial instrument**
- **Project duration / estimated project lifespan**
- **Environmental and social safeguards(ESS) category**

Context and Baseline (B.1)

- Climate vulnerabilities and impacts, GHG emissions profile, and mitigation and adaptation needs
- Fit with the country's national priorities and ownership of the concept
- Main root causes and barriers to be addressed
- For private sector project/programme: key characteristics and dynamics of the sector or market

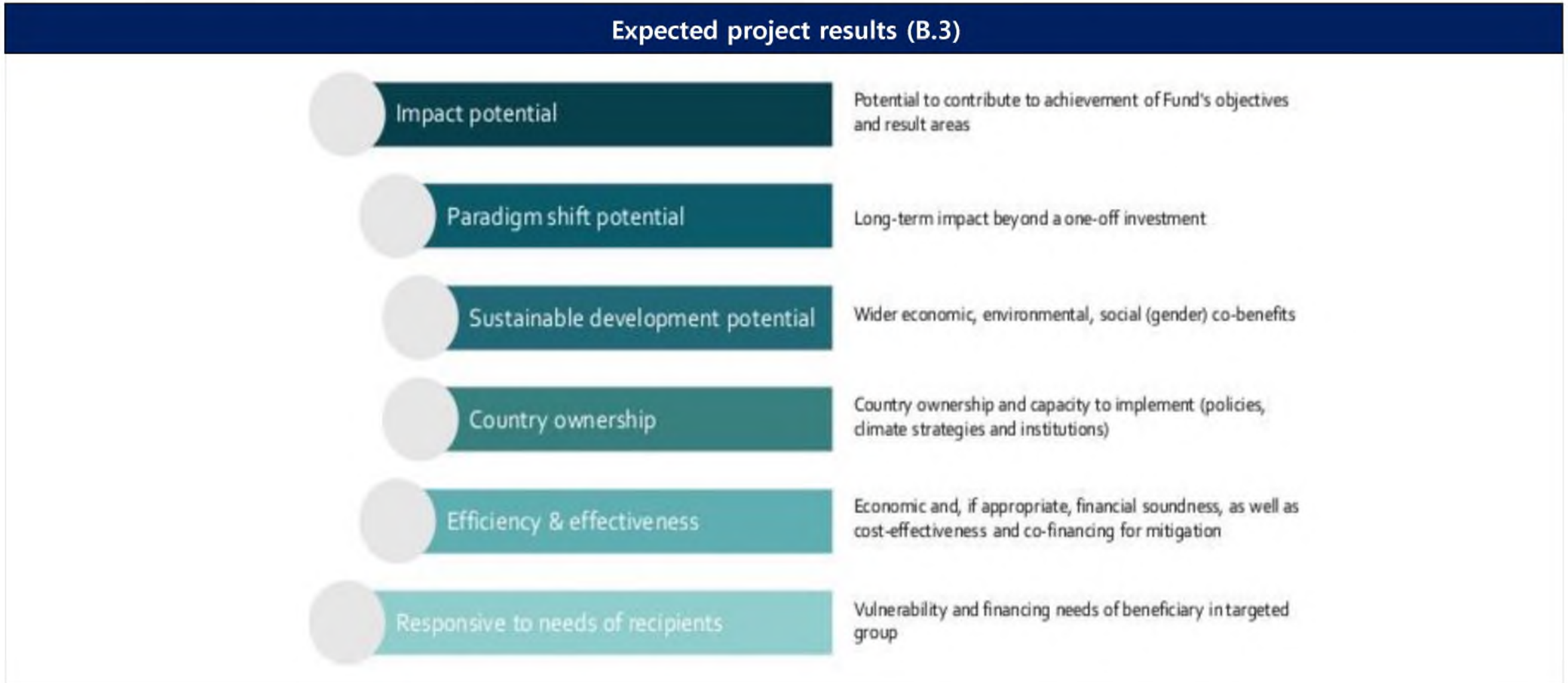
Project Description (B.2)

- **Theory of Change** in line with the Fund's goals and objectives
- **Consistency of activities** with **national regulatory and legal framework**
- **Capacity of Accredited Entity(ies)** to undertake planned activities and **implementation arrangements**
- Brief overview of the **key financial and operational risks** and **mitigation measures**



Source: GIZ, 2017. Guidebook: Writing a Green Climate Fund Funding Proposal (p. 42)

Provide an estimate of the expected impacts aligned with the GCF investment criteria



An estimate of the total cost per component and disaggregate by source of financing

Financing by components (C.1)

Component	Indicative cost (USD)	GCF financing		Co-financing		
		Amount (USD)	Financial Instrument	Amount (USD)	Financial Instrument	Name of Institutions
Indicative total cost (USD)						

A Financial Model needs to be added as an annex to the concept note including a projection covering the period from financial closing through final maturity of the proposed GCF financing with detailed assumptions and rationale

Explain why the Project/Programme requires GCF funding

Justification of GCF funding request (C.2)

- **Why the Project/ Programme requires GCF funding?**
- Describe **alternative funding options** for the same activities including an **analysis of the barriers to access to finance**
- **Justify the rationale and level of concessionality of the GCF financial instrument(s)** and describe **how this will be passed on to the end-users and beneficiaries.**

Exemples :

- Absence of alternative sources of financing
- Potential for crowding-in alternative sources of financing
- High potential for replication and scaling-up
- Target highly vulnerable population

Explain how the project/programme sustainability will be ensured in the long run and how this will be monitored, after the project/programme is implemented

Sustainability and replicability of the project(exit strategy) (C.3)

- Will there be activities which will **create the enabling environment** for sustainability?
  - Capacity building, knowledge sharing
  - Policy framework
- If there is an organizational structure in place how is it funded in the long-term
- How is infrastructure expected to be maintained?
- Why are business models becoming competitive over the course of the project/programme?

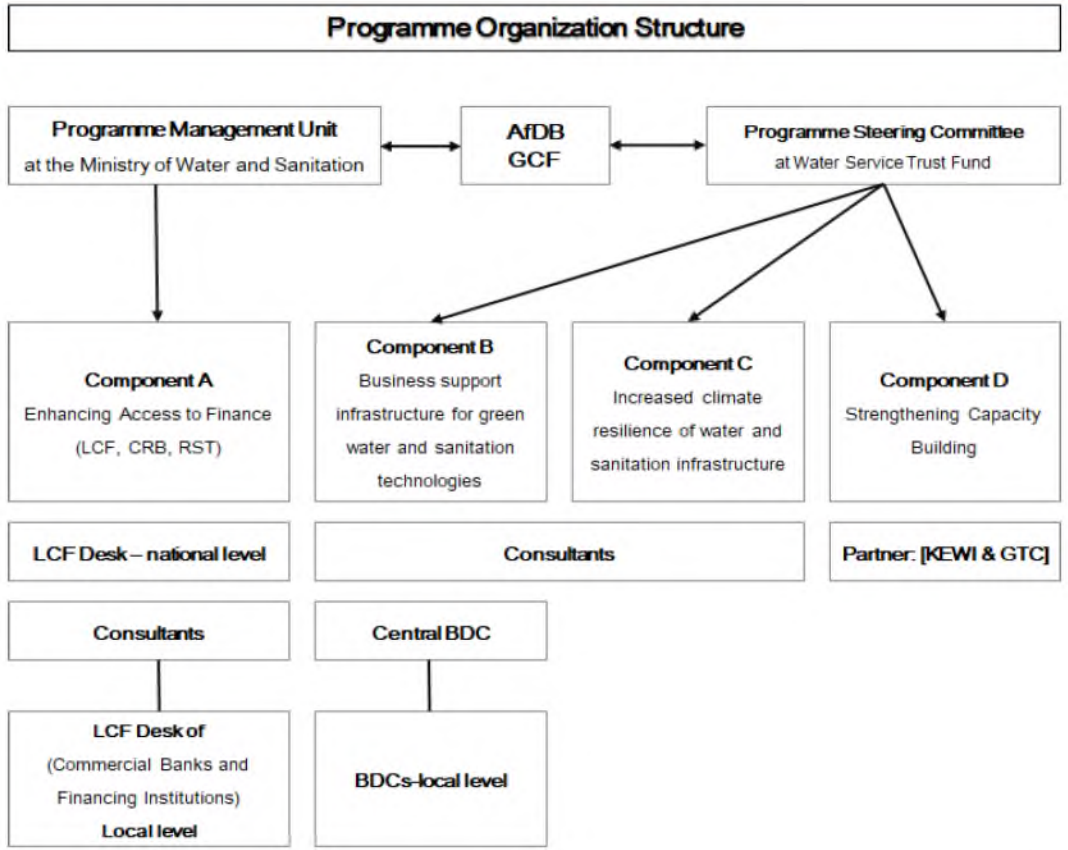
Three approaches :

- **Phasing down**. A gradual reduction of project activities
- **Phasing out**. A withdrawal of involvement in a project
- **Phasing over**. The transfer of project/programme activities to local institutions or communities,

Explain how engagement among the NDA, AE and/or other relevant stakeholders in the country has taken place and what further engagement will be undertaken

Engagement among the NDA, AE, and/or other relevant stakeholders in the country (C.4.)

- Multi-stakeholder engagement and consultations are seen as important tools to ensure country ownership.
  - Design a consultative process to discuss national climate change priorities and strategies
  - Organize it on a regular basis
  - Be inclusive by engaging all relevant actors in the sector



Even though it is optional, it is advised to submit the documents if prepared for comprehensive and constructive feed back from GCF

Supporting documents

D. Supporting documents submitted (OPTIONAL)

- ☐ Map indicating the location of the project/programme
- ☐ Diagram of the theory of change
- ☐ Financial Model
- ☐ Pre-feasibility Study
- ☐ Evaluation Report of previous project

GCF Simplified Approval Process(SAP)

In October 2017, the GCF adopted Simplified Approval Process specifically targeting direct access entities to reduce the time and effort needed in the preparation review, approval and disbursement procedures

SAP requirements	SAP examples
Simplification: • The documentation to be provided with the Funding Proposal is reduced • The review and approval processes are streamlined. **Requirements:** • Project that is ready for scaling up, and has the potential for transformation to adapt to and/or mitigate climate change. • Requiring a GCF contribution of up to USD 10 million. • With minimal environmental and social risks and impacts. GCF Secretariat will assess concept note or funding proposal to determine if eligible under SAP	• Early warning and other monitoring systems • Household-level facilities such as rainwater harvesting and small-scale renewable energy • Small-scale rural and urban community-based projects such as village water supply and drainage, and climate resilient agriculture

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WORLD BANK GROUP

Agenda

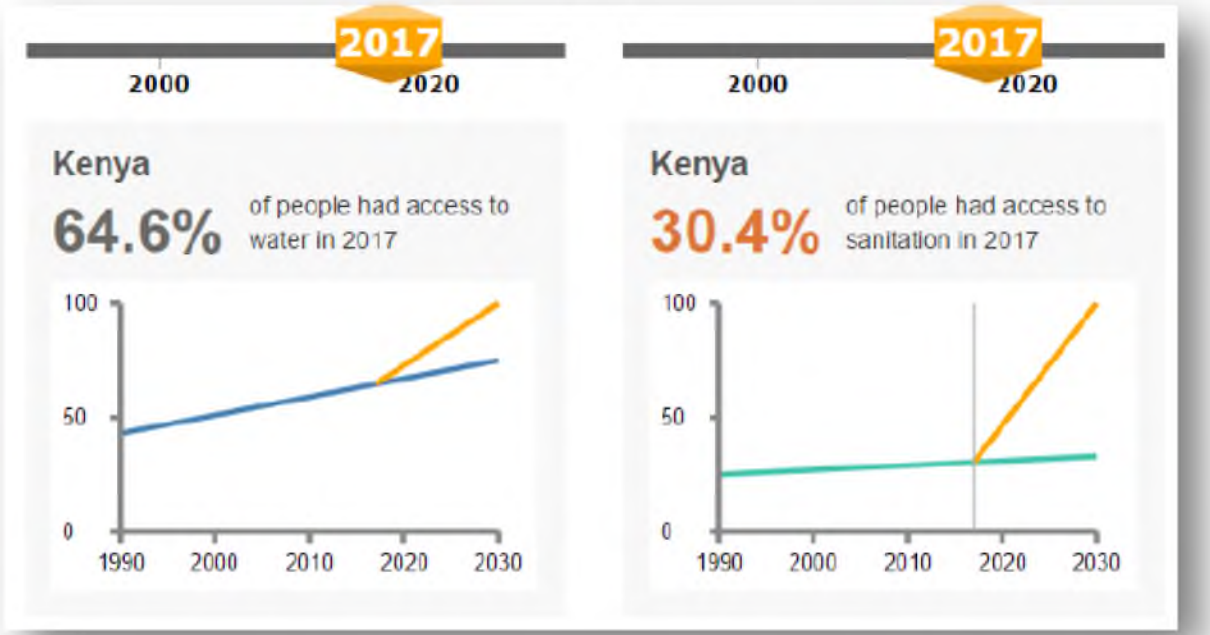
Ⅰ Climate Finance and Green Climate Fund

Ⅱ Developing GCF Project – Concept Note

Ⅲ Case study – Kenya Sustainable Water Supply Project

Kenya –Sustainable water service delivery

- Kenya has set the goal to achieve universal access to water and sanitation by 2030.
- Climate change impacts on water resources is slowing down the process, with emphasis on the rural area

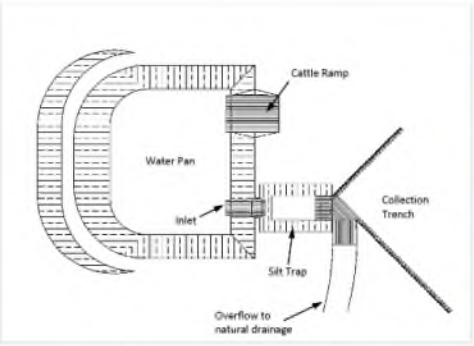


Access to water in 2017

Access to Sanitation in 2017

Kenya CTCN TA – Phase 1 (2017)

Basic water pan



Improved design

Solar/Wind pumping

Kenya's water challenges

- Water resource available but not well stored
- Most severe in ASAL, peri-urban areas
- Bottom of Pyramid Market
- Many projects but broken technologies go unrepaired
- Need for sustainable revenue models
- Kenyan government seeking cost-recovery through user fees

Request to CTCN

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

WATER SERVICES TRUST FUND, KENYA
Financial support for improved access to

GTC Actions

- Evaluation/suggestion of PPP models for water service technologies
- Stakeholder consultation in Nairobi (April 2017)
- Capacity Building Workshop

Kenya CTCN TA – Phase 2 (2018)

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Based on the finding from Phase 1, GTCK developed GCF Project "Enhanced Access to Financing for Green water and Sanitation Technologies in Kenya" in cooperation with the Kenyan national stakeholders.

Concept Note

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Concept Note

The Green Climate Fund (GCF) is seeking high-quality projects or programmes.

The Accredited Entity is encouraged to submit a concept note, in consultation with the National Designated Authority, to present a project or programme idea and receive early feedback and recommendation.

Project/Programme Title:	Enhanced Access to Financing for Green Water and Sanitation Technologies in Kenya
Country(ies):	Kenya
National Designated Authority(ies) (NDA):	The National Treasury
Accredited Entity(ies) (AE):	*African Development Bank (AfDB)*
Date of first submission/ version number:	*[YYYY-MM-DD] IV.01*
Date of current submission/ version number:	*[YYYY-MM-DD] IV.01*

Please submit the completed form to fundingproposal@gcfund.org
Please use the following naming convention in the subject line and file name: *the accredited entity or country/ supported*

PROPOSAL | 2017

GREEN CLIMATE FUND

PROJECT / PROGRAMME CONCEPT NOTE Template V.2.0

GREEN CLIMATE FUND | PAGE 6 OF 9

and raise public awareness. Figure 1 (below) articulates how these components will lead to achieving the desired outputs and outcomes of this programme.

[Figure 1: Logical framework for Enhanced Access to Financing for Green Water Technologies in Kenya]

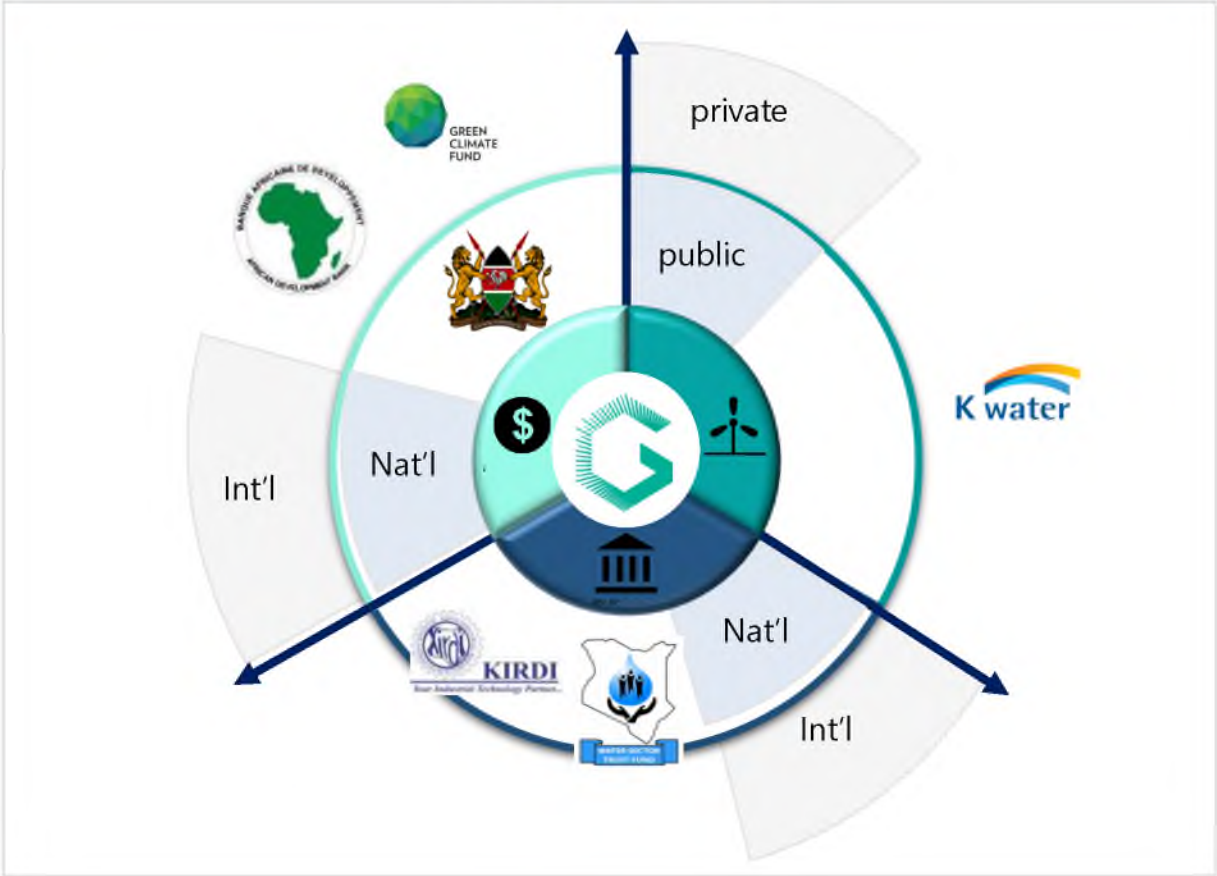
Component A: Improved access to financing for green water and sanitation technologies. This component will improve potential beneficiaries' access to finance through Line of Credit Facility (LCF) to meet credit demands. It will extend Credit Reference Bureau (CRB) to improve quality of information and reduce credit risk, and also upgrade newly established Registry for Security Right providing information on fixed and movable assets. The specific outputs for this component will be as follows.

Output 1: Line of Credit Facility established. An LCF will be set up for potential public, private sector and civil society implementers in the target areas, with low interest, less restrictive collateral requirements and innovative cash-flow-based financing. The Government will borrow from Accredited Entity (AE) and bear the foreign exchange risk of the loan. Under this facility, the National Treasury, on behalf of the Republic of Kenya, will on-lend the loan to identified *Commercial Banks* and financial institutions with experience in financing in the water and sanitation sector, and enter into a subsidiary loan agreement with the commercial banks and financing institutions. The banks and financial institutions will handle inviting of application and appraisal in coordination with BDCs. This output will require (i) detailed loan selection criteria including a list of eligible green technologies in water supply and sanitation; (ii) training for the involved financial institutions to enhance credit appraisal skills, project technology assessment and project finance skills including cash-flow forecast, viability parameters, sensitivity analysis, financial modelling, technical and economic risk analysis; and (iii) gender-related training to address different needs of women and men, and potential risks associated with investments for both of them. Banks that have expressed interest during the preparation of this concept include the Cooperative Bank of Kenya and Family Bank. Other commercial banks to be targeted include the Kenya Commercial Bank and Sidian Bank.

Output 2: Credit Reference Bureau strengthened. The CRB is a central repository of credit histories (positive and negative) of borrowers. Implementation agencies facilitating exchange of information among member banks which are users as well as information providers for the system, will be profiled and identified for strengthening to provide credit referencing services for the programme. The output will focus on (i) expanding CRB membership; (ii) providing consultancy on analysing current status and barriers, on improving reporting and credit scoring products, including customized products to meet individual member information needs; (iii) sensitizing financial institutions on the use of credit information; and (iv) raising public awareness about the need for building and maintaining a credit track record, explaining the role of the CRB in banks' lending decisions, and emphasizing the importance of developing a positive credit reputation. This output is aimed at enhancing credit referencing services in order to efficiently facilitate access to credit under output 1. This support will be demand driven and only institutions requesting for such will be capacitated. Awareness creation will however be undertaken for the private sector borrowers and the public to impress on them the value of positive credit. Any interaction with the CRB will be through the properly established regulatory framework and the relevant financial institutions.

Output 3: Registry for Security Right enhanced. Kenya's recently adopted *'The Movable Property Security Rights Act of 2017'* establishes in its Section 19 the registry for security rights. This provides a credible mechanism for securing the interests of lenders on borrowers' assets provided as security for a loan. It helps potential beneficiaries with sound business financials to secure credit against their assets and facilitate access to finance even when they do not have adequate collateral. This will require (i) as-is and

Network Scheme



Project Concept

The project concept is to enhance access to innovative financing and private sector participation towards deployment of green water and sanitation technologies.

Logframe

PARADIGM SHIFT

The proposed programme will lay down the foundation for wide private participation which will ensure sustainable water and sanitation services of ASAL areas and allow shifting to low emission pathway by deploying green water and sanitation technologies.

Activities	Outputs	Outcomes	Impacts
(1) Enhance access to financing for green water and sanitation technologies (2) Increase climate resilience of water and sanitation infrastructure for the vulnerable area (3) Build business support infrastructure (4) Strengthen capacity building program and raise public awareness	• Improved Access to Finance: - Line of Credit Facility established - Credit Information Bureau strengthened - Registry for Security Rights enhanced • More resilient Water and sanitation infrastructure: - Capacity building for the vulnerable communities - Results based subsidy • Business support infrastructure: - Project implementation capacity strengthened - Business Development Centers established - Website for knowledge sharing • Capacity building and public awareness: - Training programs for professional experts - Public awareness raising	• Enhanced access to finance for sustainable food and water resilience • Strengthened institutional capability to manage financial resources • Strengthened technical capability to operate and maintain water and sanitation infrastructure	• Mitigation - Reduced emissions of 17,060 tCO2eq/year through increased low-emission energy access • Adaptation - Increased resilience of water and food security of 1.8 million people in ASAL areas - Increased resilience of infrastructure and the built environment to climate change threats

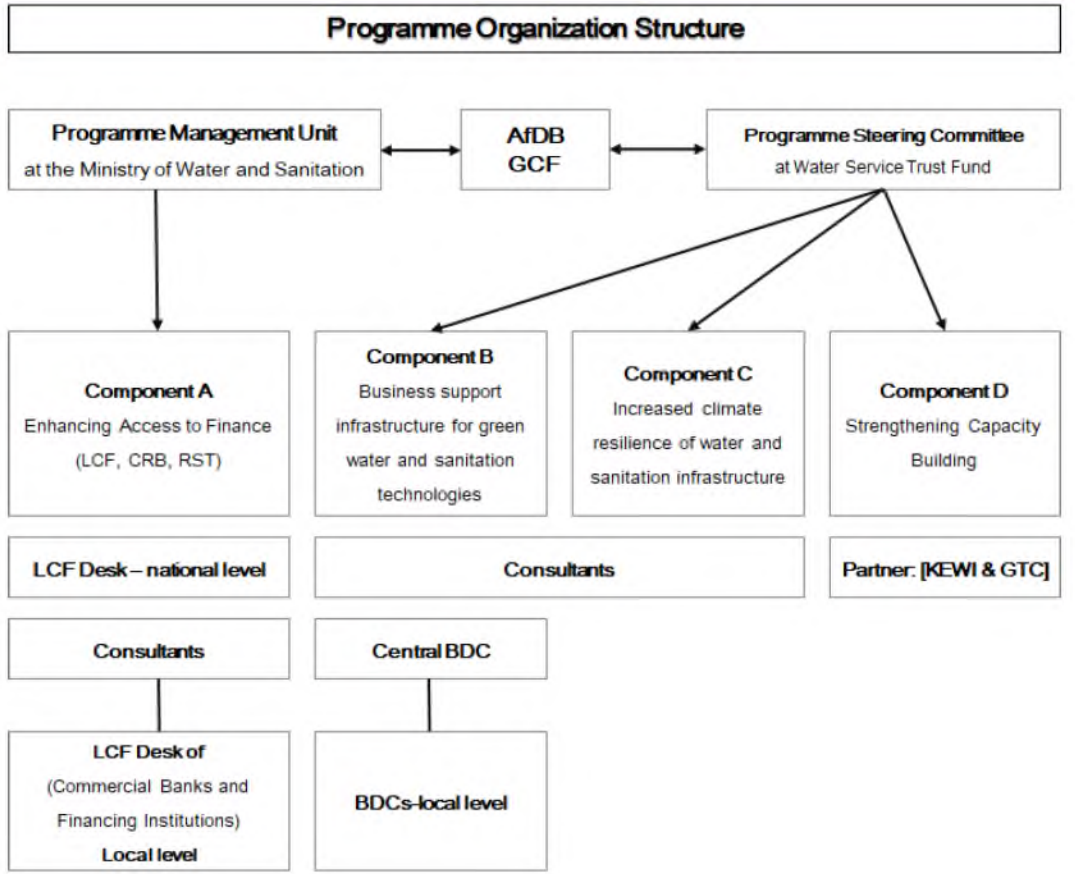
Assumptions

- Current financial resources for water and agriculture sectors are underserved
- Current capability of domestic financial institutions to develop and expand lending market for green water and sanitation technologies is insufficient
- Given support, financial institutions are able to address the shortcomings
- Given access to finance, private actors are expected to invest in sustainable water and sanitation technologies

- Increased investments in sustainable water and sanitation sectors will lead to:
  - reduced carbon emissions
  - enhanced quality of people's life
- Increased investments in climate resilience will lead to:
  - reduced vulnerability incurred by climate change

Assumptions

Organizational structure



The program includes three interlinked interventions: (i) improve access to financing for green water and sanitation technologies; (ii) establish business support infrastructure established; (iii) Strengthen capacity building programme

Component 01

Enhanced access to financing for green water and sanitation technologies

Establish a Line of Credit Facility for the private sector to deploy green technology on water related technology such as water efficiency and renewable energy technology

Component 02

Business Support Infrastructure

increase access to new business opportunities for potential participants in the water and sanitation sector, by providing institutionalized support for designing water and sanitation projects with suitable business model

Component 03

Capacity Building

Strengthen the capacity of water related public institutions and County governments, raise awareness of the public, and develop professional training programs in cooperation with local partners

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Thank You

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Ministry of Science and ICT

The Application of the Project Preparation Facility (PPF)

(The Bhutan Green Transport Program Case)

< CTCN Technical Assistance – Capacity Building Workshop >

2018.11.13

Changsun Jang

Researcher
Green Technology Center Korea

GTC 녹색기술센터
GREEN TECHNOLOGY CENTER

GREEN TECHNOLOGY CENTER

Agenda

Ⅰ About Project Preparation Facility (PPF)

Ⅱ Project Preparation Facility Approach

Ⅲ The Bhutan Green Transport Program Case

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Ⅰ About Project Preparation Facility (PPF)

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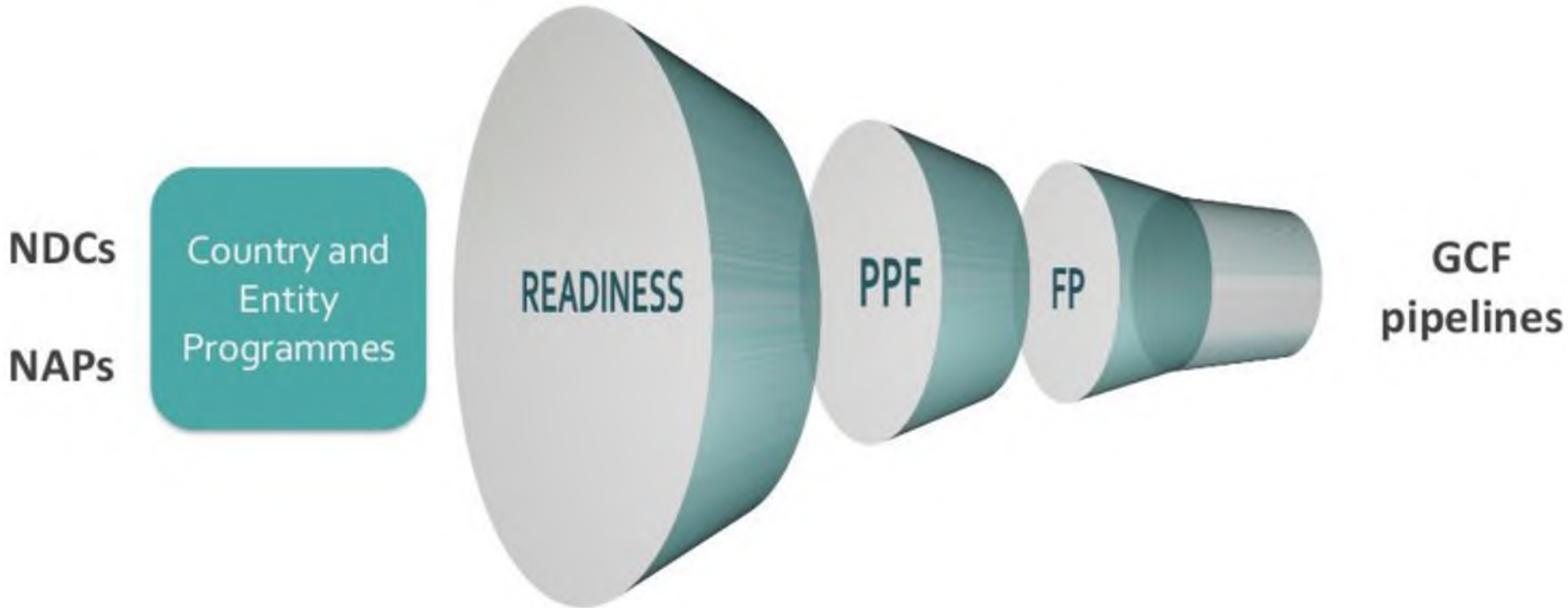
The GCF currently offers support on pipeline development in two channels: a PPF established at B.11 as well as ongoing efforts through readiness activity area four, which supports countries on pipeline development



Key Features of the PPF and Readiness Activity area Four

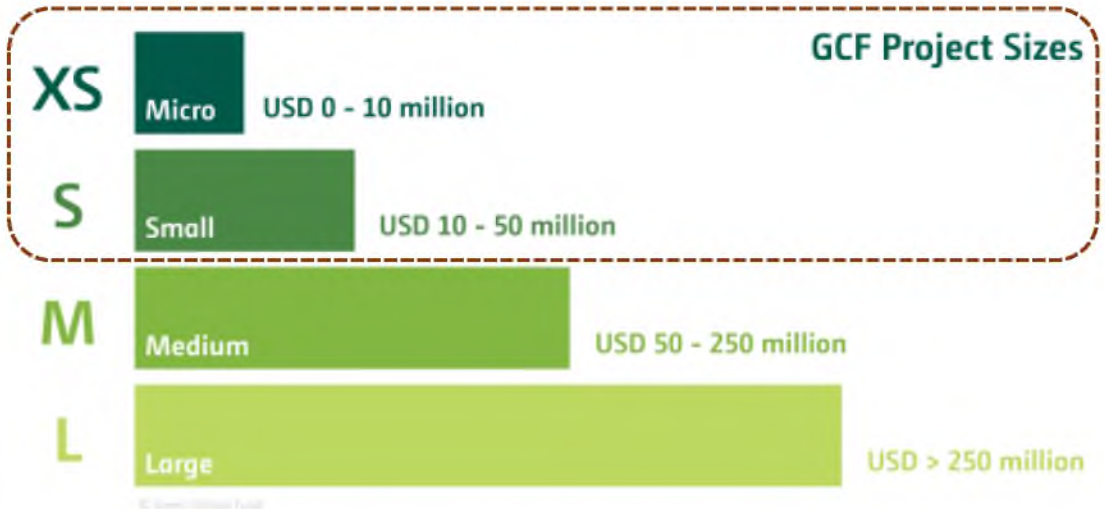
The PPF and readiness activity area four are two options that support NDAs and accredited entities, particularly direct access entities, to access GCF resources for pipeline development

Key features of the project preparation facility (PPF) and readiness activity area four		
Design feature	**PPF**	**Readiness activity area four (pipeline development)**
Submission by	Accredited entity	National designated authority (NDA) or focal point
Eligibility	Targeted to small-scale activities and direct access entities	NDA or focal point
Financing limit	Up to 10% of requested GCF financing with a limit of USD 1.5 million for any single proposal	Subject to the readiness funding limit of USD 1 million per calendar year
Approval by	Secretariat	Executive Director or designate

The Main Objective of the PPF

The PPF is designed to support project and programme preparation requests from all accredited entities, especially direct access entities and micro-to-small size category projects

Consideration of a project size category



- *Micro proposals would have a total size of up to and including US$ 10 million;*
- *Small proposals would have a total size of above US$ 10 to 50 million;*
- *Medium proposals would have a total size of above US$ 50 to 250 million; and*
- *Large proposals would have a total size of above US$ 250 million.*

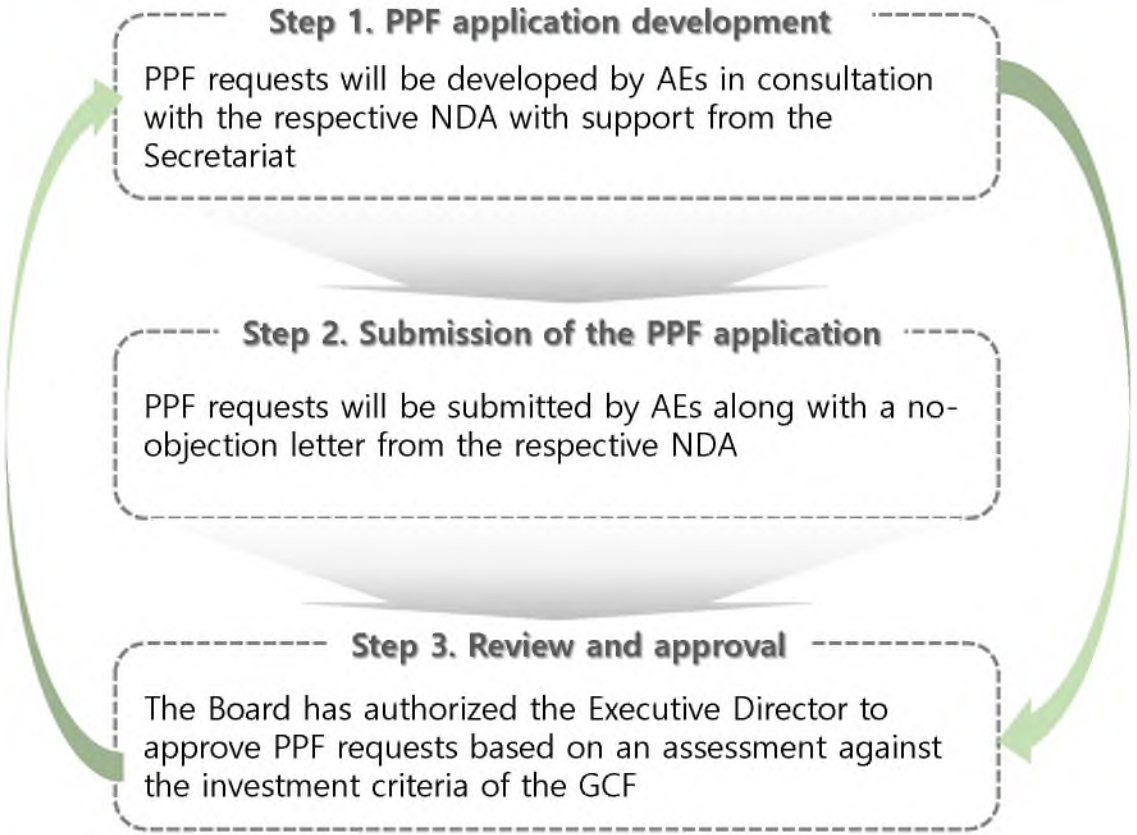
Identification of an accredited entity

- *The PPF is designed to especially support Direct AEs (National & Regional) for Projects in the micro-to-small size category*
- *International AEs are encouraged to do so for LDCs, SIDS and African counties where no Direct AE is accredited*

Process & Eligible Activities

Accredited entities (AEs) can submit an application providing due justification of their need for project preparation funding with information on the proposed project

Process



Eligible Activities

The PPF will support the following activities:

- ✓ Pre-feasibility and feasibility studies, as well as project design;
- ✓ Environmental, social and gender studies;
- ✓ Risk assessments;
- ✓ Identification of programme/project-level indicators;
- ✓ Pre-contract services, including the revision of tender documents;
- ✓ Advisory services and/or other services to financially structure a proposed activity; and
- ✓ Other project preparation activities, where necessary, provided that sufficient justification is available.

With each preparation phase having different needs, it would be important to review the main outstanding requirements of project development

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Agenda

Ⅰ About Project Preparation Facility (PPF)

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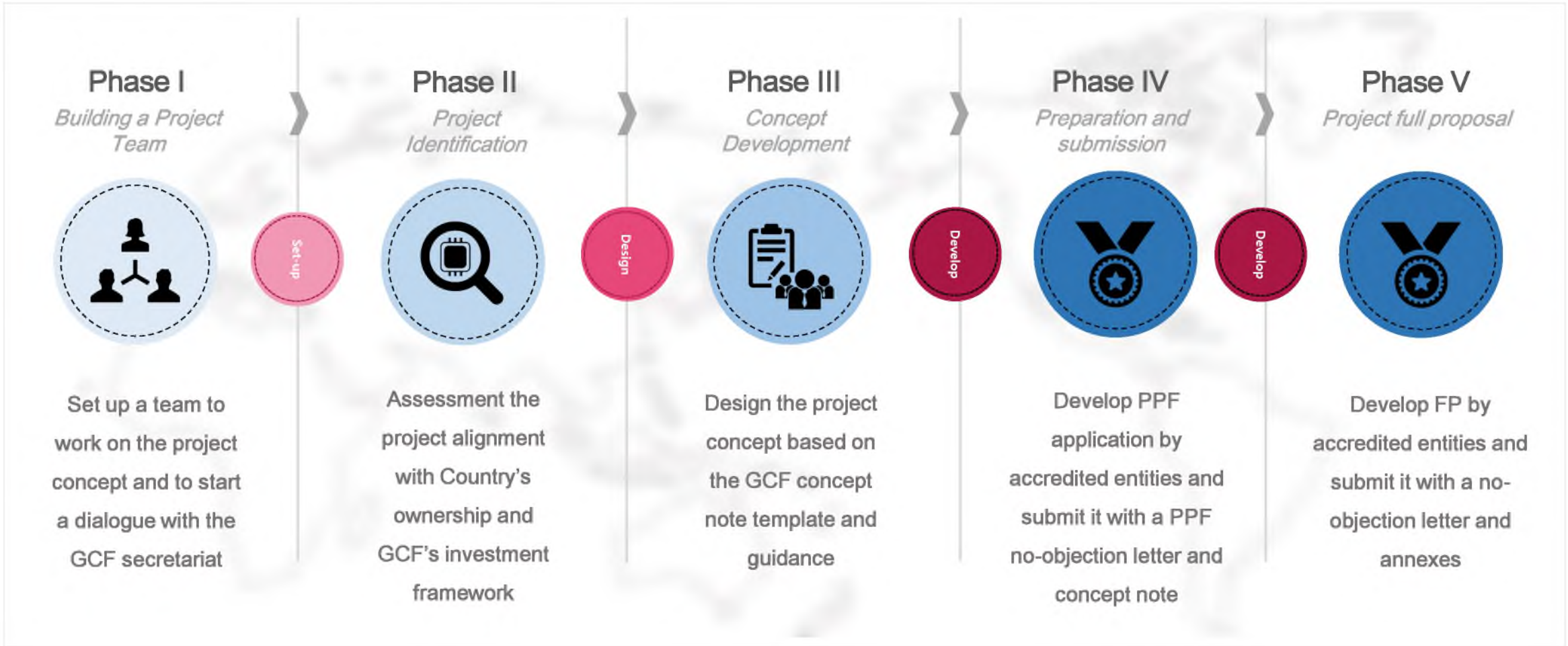
Ⅲ The Bhutan Green Transport Program Case

How to get started

Requests for support from the PPF should be submitted at the same time or following submission of a GCF Concept Note for a project or programme



Phase 1: Building a Project Team

It is highly recommended that the accredited entities consult with the respective national designated authority (NDA) or focal point on the project or programme concept at an early stage

▶ **National Designated Authority (NDA)**

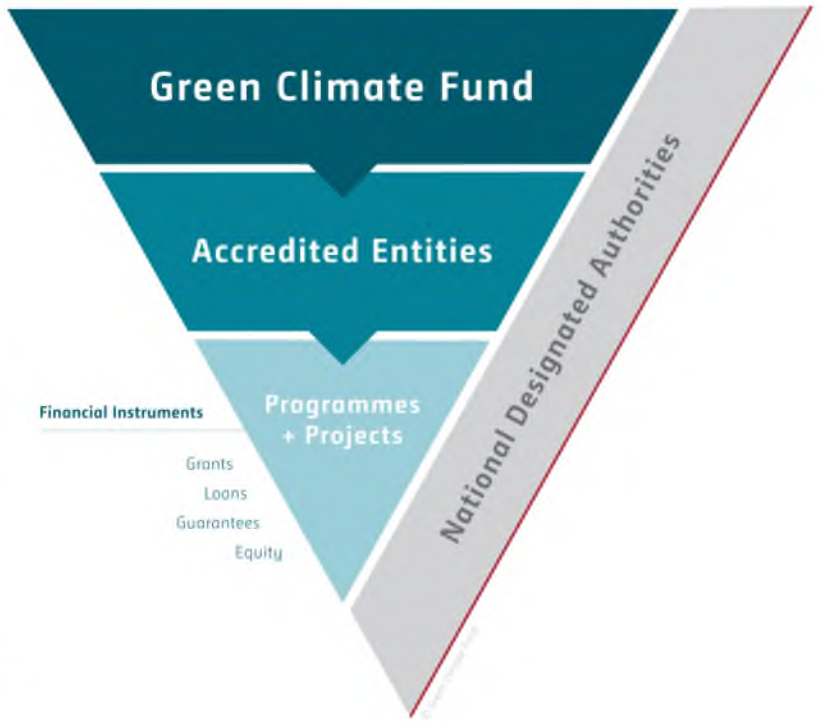
National Designated Authority, a focal point for GCF in the recipient country, is the core interface between a country and the Fund. NDA is a designated entity in the country with the authority and mandate to officially communicate and liaise with the Fund.

▶ **Accredited Entities (AEs)**

The Green Climate Fund works through a wide range of Accredited Entities to channel its resources to projects and programme. Accredited Entities carry out a range of activities that usually include the development of funding proposals and the management and monitoring of projects and programme.

▶ **COUNTRY OWNERSHIP.**

An entity through which GCF proceeds are channelled for the purposes of a funded activity or part thereof; and/or any entity that executes, carries out or implements a funded activity, or any part thereof. An accredited entity may carry out the functions of an executing entity, though it is preferable if local and national actors execute projects/programmes.



Phase 2: Project Identification (GCF 8 Strategic Results Areas)

The GCF seeks to have an impact within eight mitigation and adaptation results areas identified by GCF's Board, achieving a balance between its funding for mitigation and adaptation initiatives

GCF 8 STRATEGIC RESULTS AREAS

GCF 8 STRATEGIC RESULTS AREAS

Mitigation Strategic Impacts

- ✓ Energy generation and access
- ✓ Transport
- ✓ Buildings, cities, industries, and appliances
- ✓ Forests and land use

Adaptation Strategic Impacts

- ✓ Health, food and water security
- ✓ Livelihoods of people and communities
- ✓ Infrastructure and built environment
- ✓ Ecosystems and ecosystem services

With a focus on (1) impacts; (2) paradigm-shift potential; (3) crosscutting adaptation-mitigation benefits; and (4) sustainable development co-benefits

Phase 2: Project Identification (GCF 6 Investment Criteria)

The Accredited Entity will develop its funding proposal with due consideration of the investment criteria and the applicable and relevant activity-specific sub-criteria and indicative assessment factors

GCF 6 Investment Criteria

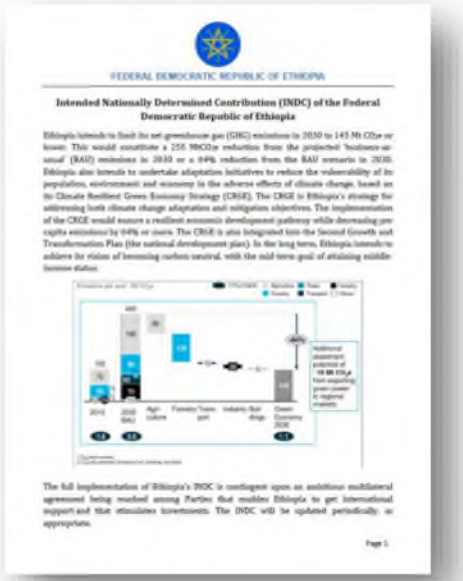
GREEN CLIMATE FUND

Impact potential	Potential to contribute to achievement of Fund's objectives and result areas
Paradigm shift potential	Long-term impact beyond a one-off investment
Sustainable development potential	Wider economic, environmental, social (gender) co-benefits
Country ownership	Country ownership and capacity to implement (policies, climate strategies and institutions)
Efficiency & effectiveness	Economic and, if appropriate, financial soundness, as well as cost-effectiveness and co-financing for mitigation
Responsive to needs of recipients	Vulnerability and financing needs of beneficiary in targeted group

Phase 2: Project Identification (Partner Country's Ownership)

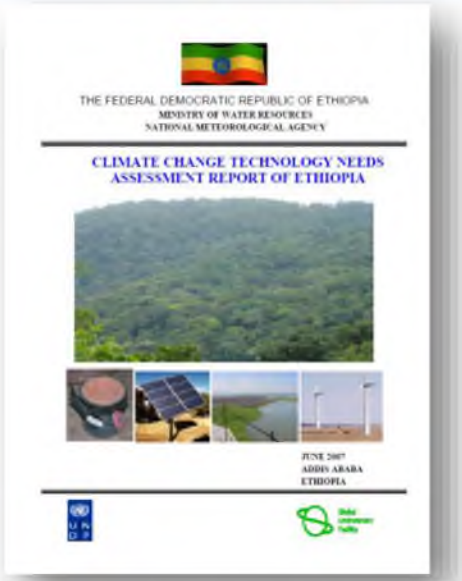
The PPF application must include a clear paragraph explaining how the proposed project fits in with the country's national priorities and ensures full country ownership, in particular with national climate strategy

Nationally Designated Contribution (NDC)



- NDCs reflect each country's ambition for reducing emissions, taking into account its domestic circumstances and capabilities.
- Some countries also address how they'll adapt to climate change impacts, and what support they need from, or will provide to, other countries to adopt low-carbon pathways and to build climate resilience.

Technology Needs Assessment (TNA)

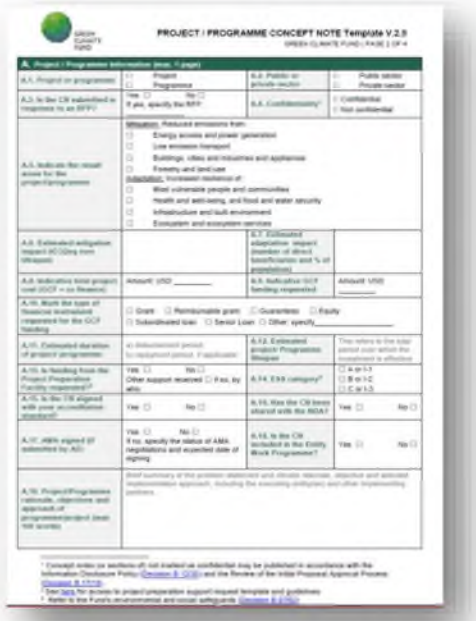


- To determine how to reduce greenhouse gas emissions and adapt to the adverse impacts of climate change, countries undertake technology needs assessments.
- Since 2001, more than 80 developing countries have conducted TNAs to address climate change. More recently, many countries have identified climate technology needs in their nationally determined contributions (NDCs).

Phase 3: Concept Development

As a voluntary step, AEs may use the concept note to present a proposed project to the Fund in order to receive feedback and recommendations from the Secretariat on whether it is aligned with the Fund's objectives

GCF Concept Note Template



- *The recommendation will clarify whether the concept is endorsed, not endorsed with a possibility of resubmission, or rejected*
- *Any feedback or recommendations are intended to provide non-binding guidance to enable the accredited entity to initiate the next phase*

Concept Note Contents

A. Project/Programme Information (max. 1 page)

B. Project/Programme Details (max. 8 page)

C. Indicative Financing/Cost Information (max. 3 page)

D. Supporting Documents Submitted (OPTIONAL)

- ✓ Map indicating the location of the project/programme
- ✓ Diagram of the theory of change
- ✓ Financing Model
- ✓ Pre-feasibility Study
- ✓ Evaluation Report of previous project

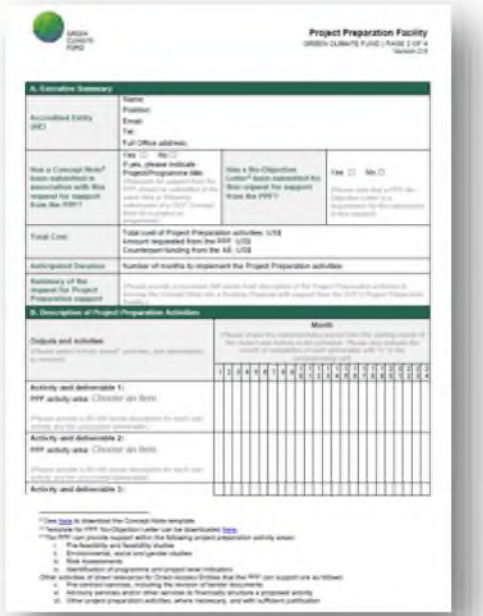
Prior to the submission of the concept note, the accredited entity shall:

- *Inform the NDA about the proposed activity to be implemented in their country and commence consultations with a view to confirming it is in accordance with the country's strategic framework and priorities; and*
- *Inform the Secretariat that it has commenced consultations with the NDA*

Phase 4: Preparation and Submission of PPF application

The PPF is designed to especially support Direct AEs for Projects in the micro-to-small size category, but international AEs are encouraged to do so for LDCs, SIDS and African counties where no Direct AE is accredited

PPF Application Form



- Requests for support from the PPF should be submitted at the same time or following submission of a GCF Concept Note for a project or programme

PPF Form Contents

A. Executive Summary
B. Description of Project Preparation Activities
C. Justification of the Project Preparation Request
D. Implementation Arrangement
E. Budget Details and Disbursement Schedule

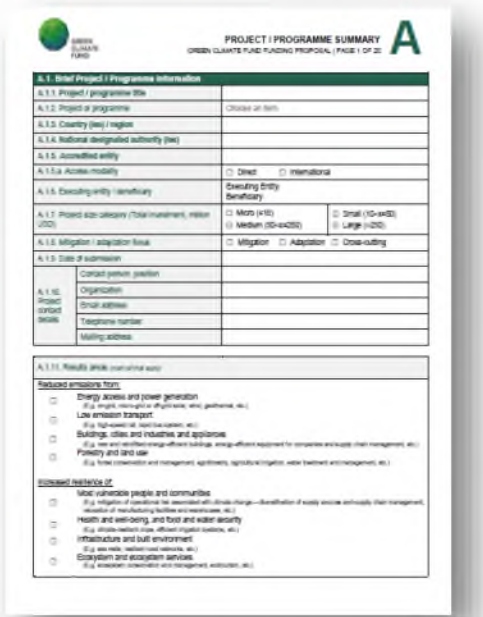
When submitting the PPF application, the AE shall:

- *A PPF submission should include (1) PPF request; (2) PPF No-Objection letter; and (3) Concept Note*
- *Copy the National Designated Authority when submitting the PPF request*
- *Submit the completed form to ppf@gcfund.org using the following naming convention in the subject line and the file name "PPF-[Accredited Entity]-[country]-yyyymmdd"*

Phase 5: Preparation and Submission of Funding Proposal

The funding proposals should demonstrate how the proposed projects or programme will perform against the investment criteria and achieve part or all of the strategic impact results

GCF Funding Proposal Form



- Accredited entities are expected to develop their funding proposals, in close consultation with the relevant national designated authority, with due consideration of the GCF's Investment Framework and Results Management Framework.

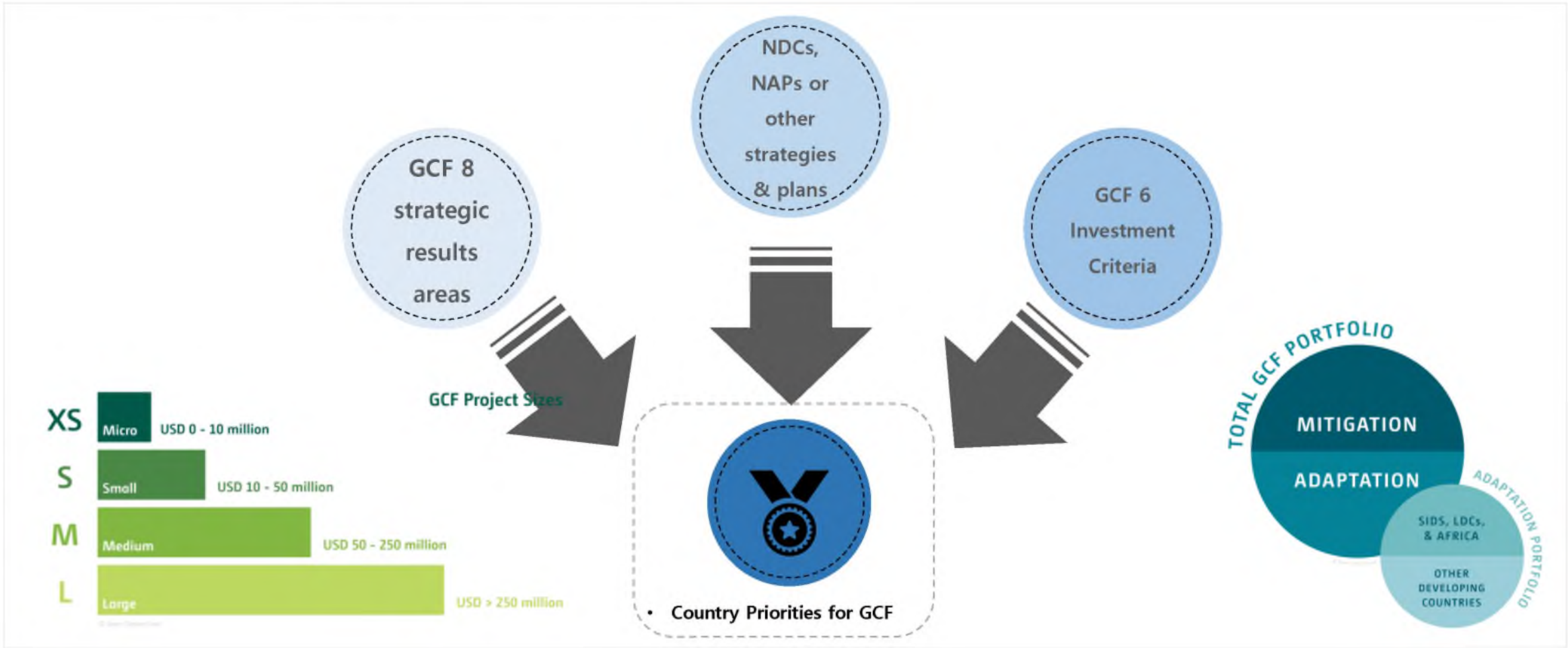
Funding Proposal Form Contents

A. **PROJECT/PROGRAMME SUMMARY**
B. **FINANCING/COST INFROMATION**
C. **DETAILED PROJECT/PROGRAMME DESCRIPTION**
D. **RATIONALE FOR GCF INVOLVEMENT**
E. **EXPECTED PERFORMANCE AGAINST INVESTMENT CRITERIA**
F. **APPRAISAL SUMMARY**
G. **RISK ASSESSMENT AND MANAGEMENT**
H. **RESULTS MONITORING AND REPORTING**
I. **ANNEXES**

- *NDA No-objection letter*
- *Feasibility study*
- *Integrated Financial Model*
- *Letter of commitment for co-financing commitment*
- *Environmental and Social Impact Assessment (ESIA)*
- *Map indicating the location of the project/programme*

Identification of the GCF Pipeline

The GCF recognizes the need to ensure that developing country partners exercise ownership of climate change funding and integrate it within their own national action plans.



GREEN TECHNOLOGY CENTER

Agenda

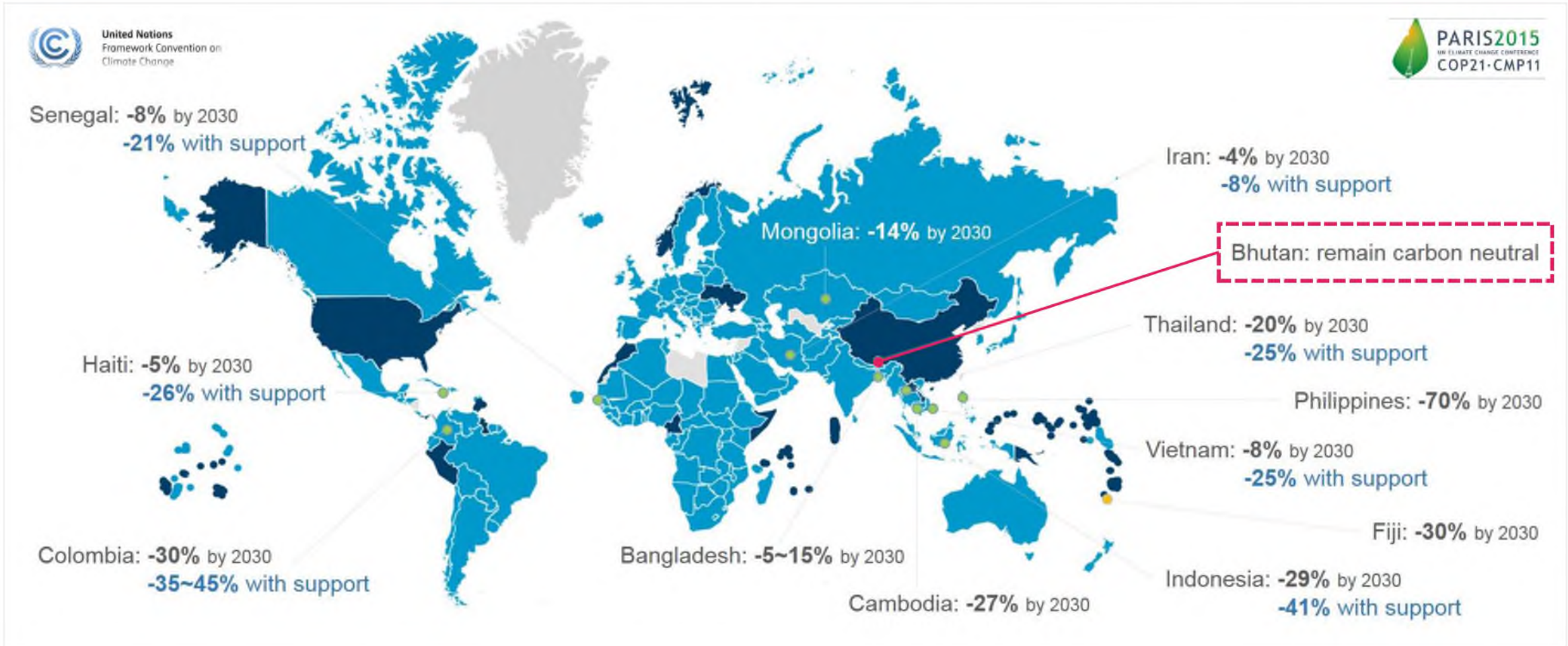
Ⅰ About Project Preparation Facility (PPF)

Ⅱ Project Preparation Facility Approach

Ⅲ **The Bhutan Green Transport Program Case**

Bhutan's Nationally Determined Contribution (NDC)

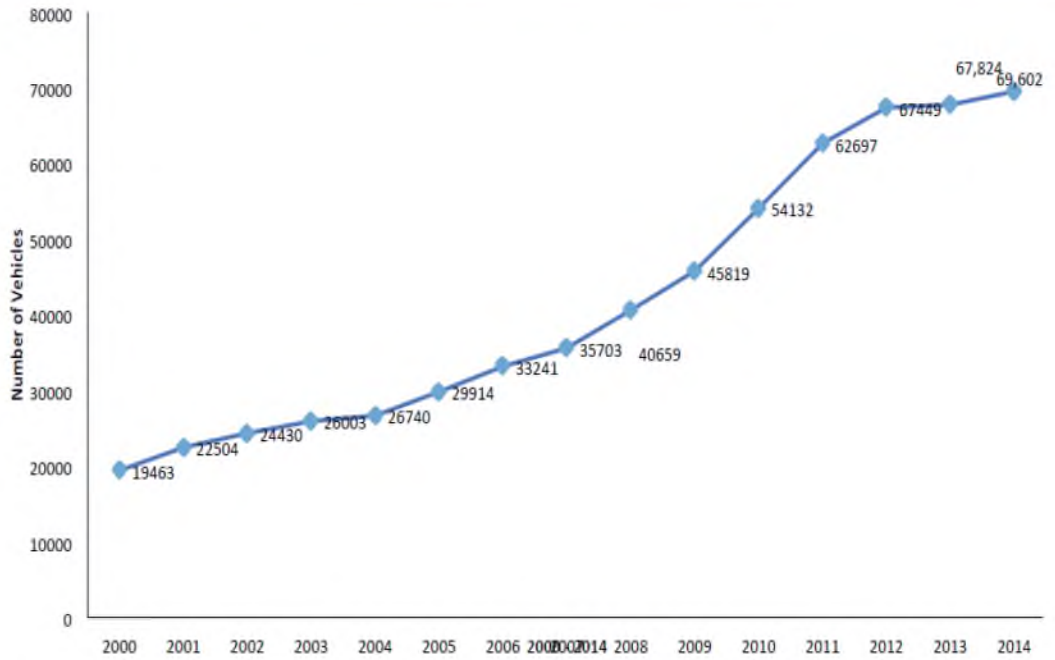
Considering the historical and current emissions from Bhutan and its imperatives for sustainable development, Bhutan declared to remain carbon neutral by pursuing low emission development pathways across all sectors.



Carbon Emission in Bhutan's Transport Sector

Bhutan's NEC noted in its 2011 communication under the UNFCCC that between the first GHG inventory year in 1994 and the second year of 2000 emissions from energy grew at 21.4% a year mostly due to transport growth

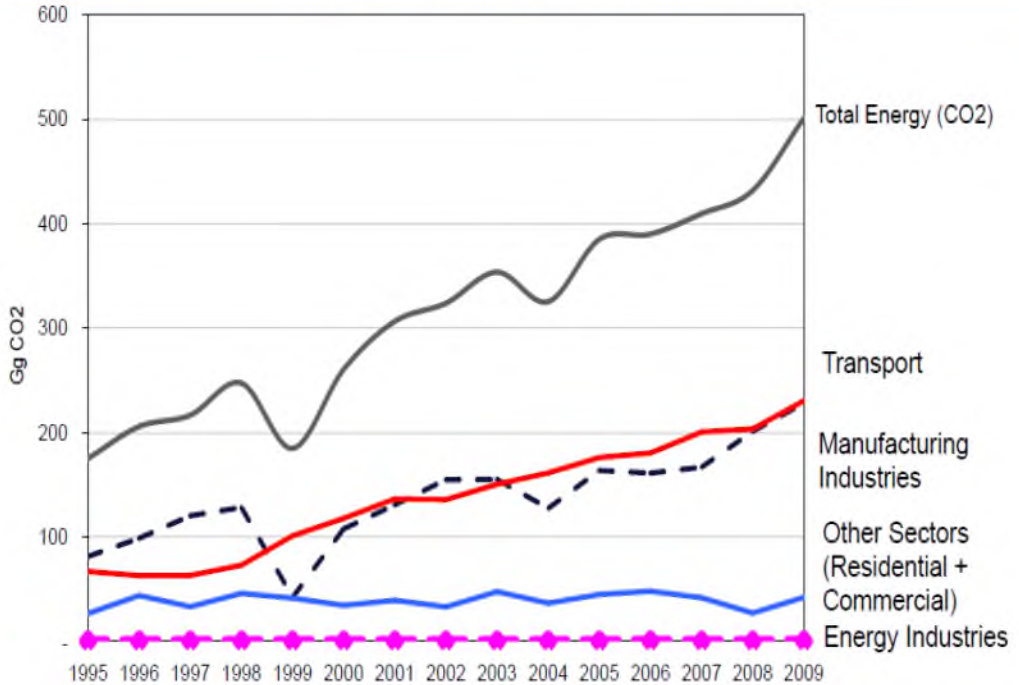
Bhutanese motorization trend



- *Between 1990 & 2010, the number of Bhutanese living in urban areas nearly tripled*
- *The number of vehicles has been increasing at roughly 9-10% per annum*

Source: Bhutan national strategy and action plan for low carbon development

Transport sector emission



- *Emissions from energy grew at 21.4% a year due to transport and industry growth*
- *Roughly 1% of total vehicles in Bhutan (75,190) are public passenger buses*

Source: Bhutan national strategy and action plan for low carbon development

The Concept of the Bhutan Green Transport Program

The objective of the Green Transport Program for Thimphu is to improve mobility for Thimphu's population while reducing dependence on fossil fuels *(three broad components to the Program)*

Bhutanese GCF Concept Note

GREEN CLIMATE FUND

Concept Note

The Green Climate Fund (GCF) is seeking high-quality projects or programmes.

Accredited entities may choose to submit a concept note, in consultation with the relevant national designated authority, to present the proposed project or programme idea in order to receive early feedback and recommendation.

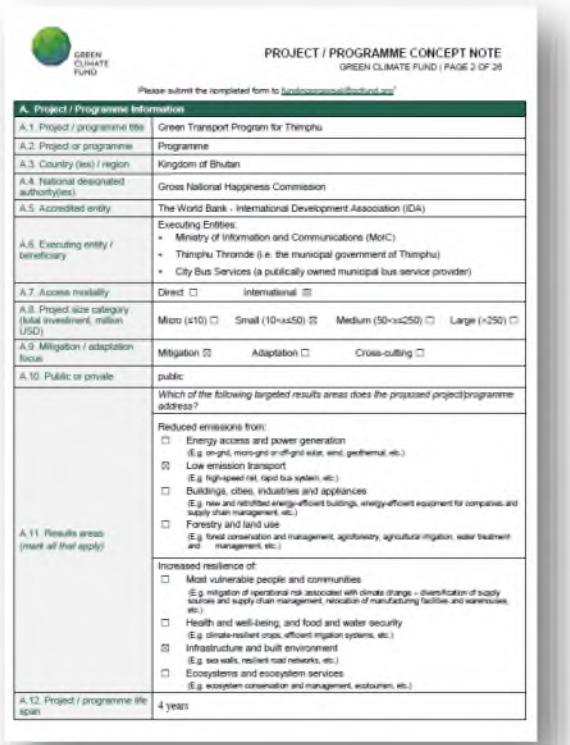
Project/Programme Title: Green Transport Program for Thimphu

Country/Region: Kingdom of Bhutan (South Asia Region)

Accredited Entity: International Development Association (World Bank)

National Designated Authority: Gross National Happiness Commission

PROPOSAL | 2015



GREEN CLIMATE FUND

PROJECT / PROGRAMME CONCEPT NOTE

GREEN CLIMATE FUND | PAGE 2 OF 26

Please submit the completed form to fundingproposal@greenfund.org

A. Project / Programme Information	
A.1. Project / programme title	Green Transport Program for Thimphu
A.2. Project or programme	Programme
A.3. Country (ies) / region	Kingdom of Bhutan
A.4. National designated authority(ies)	Gross National Happiness Commission
A.5. Accredited entity	The World Bank - International Development Association (IDA)
A.6. Executing entity / beneficiary	Executing Entities: • Ministry of Information and Communications (MoIC) • Thimphu Thromde (i.e. the municipal government of Thimphu) • City Bus Services (a publically owned municipal bus service provider)
A.7. Access modality	Direct ☐ International ☒
A.8. Project size category (total investment, million USD)	Micro (≤10) ☐ Small (10<x≤50) ☒ Medium (50<x≤250) ☐ Large (>250) ☐
A.9. Mitigation / adaptation focus	Mitigation ☒ Adaptation ☐ Cross-cutting ☐
A.10. Public or private	public
A.11. Results areas *(mark all that apply)*	*Which of the following targeted results areas does the proposed project/programme address?* Reduced emissions from: ☐ Energy access and power generation (E.g. on-grid, micro-grid or off-grid solar, wind, geothermal, etc.) ☒ Low emission transport (E.g. high-speed rail, rapid bus system, etc.) ☐ Buildings, cities, industries and appliances (E.g. new and retrofitted energy-efficient buildings, energy-efficient equipment for companies and supply chain management, etc.) ☐ Forestry and land use (E.g. forest conservation and management, agroforestry, agricultural irrigation, water treatment and management, etc.) Increased resilience of: ☐ Most vulnerable people and communities (E.g. mitigation of operational risk associated with climate change – diversification of supply sources and supply-chain management, relocation of manufacturing facilities and warehouses, etc.) ☐ Health and well-being, and food and water security (E.g. climate-resilient crops, efficient irrigation systems, etc.) ☒ Infrastructure and built environment (E.g. sea walls, resilient road networks, etc.) ☐ Ecosystems and ecosystem services (E.g. ecosystem conservation and management, ecotourism, etc.)
A.12. Project / programme life span	4 years

Proposed uses of a PPF grant

- ***Component 1 – investments in physical infrastructure***

(i) Pedestrianization of Norzin Lam which is the main 1.3 kilometre road;

(ii) Development of a North-South cycle path network

(iii) Safe road crossings for pedestrians and cyclists; and

(iv) Investments in a BRT system for Thimphu along north-south corridor.

- ***Component 2 – investments in operating assets***

(i) Procurement of approximately 15 advanced emissions performance buses to serve BRT route and other high demand routes; and

(ii) Procurement of spare parts to facilitate maintenance of advanced emissions buses.

- ***Component 3 – technical assistance and institutional development***

(i) Funding analytics, policy advice, marketing assistance;

(ii) Support to improve operational performance of City Bus Services, Implementation support, and project management

The Concept Development of the Bhutan Green Transport Program

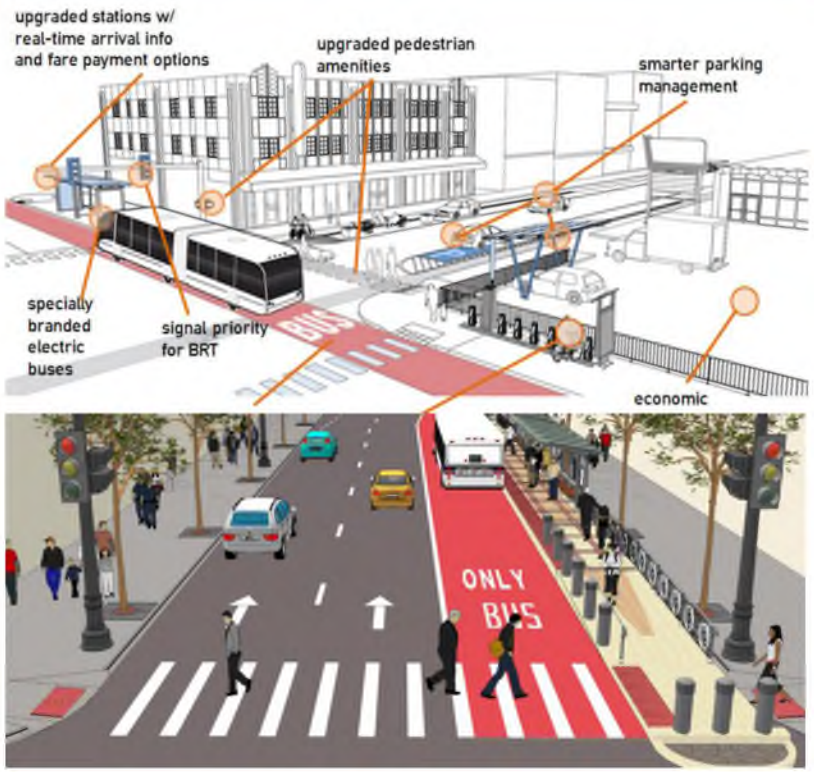
GREEN TECHNOLOGY CENTER

The program includes four interlinked interventions: (i) a master plan for low emissions transport; (ii) sustainable public transport services; (iii) green transport systems; and (iv) knowledge development and transfer

Component 1

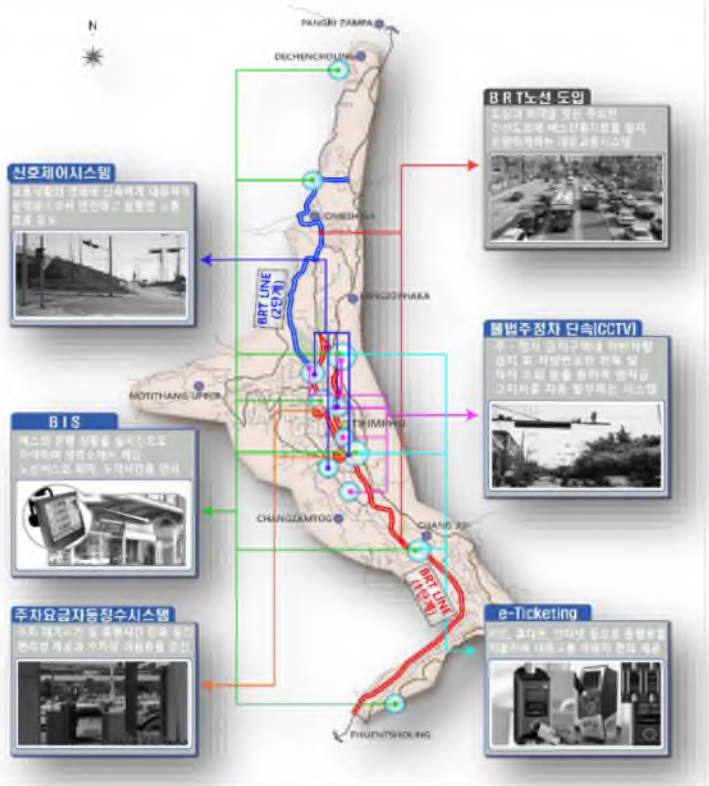
Master plan for low emissions transport

Component 2



Sustainable Public Transport Services
(BRT & complementary infrastructure)

Component 3



Green Transport Systems
(ITS & BIS)

The Preparation of the Project Preparation Facility

Completing the large amount of technical preparations required to achieve the readiness required for GCF consideration is a primary reason for applying to the Project Preparation Facility (PPF)

Bhutanese PPF Proposal


Project
Preparation
Funding
Application


Project Preparation Facility

Accredited Entity	The World Bank
Contact Details	Name: Yoichiro Ishihara / Dominic Powlis Position: Resident Representative / Senior Transport Specialist Email: yishihara@worldbank.org / dpowlis@ worldbank.org Tel: +975 77 102 122 / +1 202 458 4619 Full Office address: World Bank Bhutan Country Office Bhutan Development Bank Building Norzin Lam, Chubachu, PO Box 244 Thimphu, Bhutan
Concept Note Title (reference number)	Green Transport Program for Thimphu
Country/Region	Kingdom of Bhutan / South Asia Region
Request Summary (in 200 words)	1. This request seeks US$ 1,500,000 from the Project Preparation Facility (PPF) to develop a full proposal to the Green Climate Fund in support of a Green Transport Program for Bhutan's capital city of Thimphu (hereafter the "Program"). The Program will focus on low-emissions transport solutions that will enable Bhutan to achieve its sustainable development targets and Intended Nationally Determined Contribution (INDC) as submitted in September 2015. This follows on Bhutan's 2009 re-commitment to remain carbon neutral. The Program comprises three interlinked interventions: (i) a master plan for low emissions transport; (ii) investments in sustainable public and non-motorized transport services; (iii) green transport systems; and (iv) knowledge development and transfer. *PPF resources would support the following:* 1. A master plan for low emission transport in Thimphu; 2. Technical preparations for Program investments including a BRT system, Bus Information System, e-ticketing technology, pedestrianization works, an upgraded city bus depot, an upgraded city bus terminal, non-motorized transport infrastructure, a signal control system, a parking management system, and an integrated traffic control centre; 3. Knowledge development and transfer activities to strengthen the institutions that manage transport in Bhutan; 4. Environment and Social Impact Assessment (ESIA) of Program works; 5. Gender analysis and a Gender Action Plan for Program activities; 6. Financial and Economic Assessment; and 7. A Program management plan to coordinate the execution of various activities. 2. Outputs will support a final application for GCF funding of Thimphu's Green Transport Program and will also serve to coordinate the activities of development partners who would co-finance alongside the GCF.
Anticipated Duration	July 1, 2017 – September, 30/2018 (15 months)
Estimated cost	Total Cost: US$ 1,500,000 Funding amount requested from PPF: US$ 1,500,000

Proposed uses of a PPF grant

PPF resources would be used to fund the following required preparation activities:

- ***Activity 1. Development of a master-plan for low emission transport in Thimphu.***
- ***Activity 2. Technical preparations for Program investments***
- ***Activity 3. Knowledge development and transfer to prepare RGoB institutions for Program implementation.***
- ***Activity 4. Preparation of an Environmental and Social Impact Assessment (ESIA) of Program works.***
- ***Activity 5. Gender analysis and preparation of a Gender Action Plan.***
- ***Activity 6. Development of a financial model and accompanying economic model to assess the Program's merits.***
- ***Activity 7. Development of a Program Management Plan to coordinate the all activities under the Program***

Proposed Activities of the Project Preparation Facility

The Outputs from required activities will inform a final GCF funding application for the Green Transport Program for Thimphu City to be proposed for GCF consideration during Bhutan's 2018/2019 fiscal year.

Activity 1 (Development of a master-plan)	Activity 2 (Technical Preparations)	Activity 3 (Knowledge development and transfer)
(i) travel demand management; (ii) policy and pricing interventions in the market for transport services: (iii) coordination of the international community to assist RGoB institutions; (iv) identification of short, medium, and long term expenditures in services and infrastructure solutions; (v) development of policy targets and measurement / reporting methodologies to capture results.	(i) preparation and vehicle specification for a BRT system; (ii) specification of Intelligent Transport System (Bus Information System, e-ticketing technology, signal control system, parking management, integrated traffic control centre); (iii) preparation for pedestrianization and other non motorized transport infrastructure works; (iv) preparations for an upgraded city bus depot and terminal.	(i) institutional support to the City Bus Company to improve operation of existing and future assets; (ii) assistance to the Ministry of Information and Communications to develop policy interventions including travel demand management; and (iii) support to the Road Safety and Transport Authority for governing subsidy funding and service delivery targets for the City Bus Service.
Activity 4 & 5 (ESIA & Gender analysis)	**Activity 6 (Development of a financial model)**	**Activity 7 (Development of Program Management Plan)**
(ESIA) Necessary to ensure that Program investments comply with World Bank and other development partner safeguards policies. **(Gender)** To aim the benefits of improved public and non-motorized transport at women in particular and to prepare the gender action plan	These tools will help to plan Program investments for optimal returns and sustainability. Results will also serve to present envisaged benefits to the GCF when the Program is proposed for investment support.	Development of a Program Management Plan to coordinate the all activities under the Program and to frame a reporting methodology both for preparation work and subsequent implementation of physical works.

Expected Performance against GCF's Investment Criteria (1/3)

The Green Transport Program for Thimphu city is designed to respond to GCF's all six of the investment criteria but only the applicable and relevant sub-criteria and indicative assessment factors

Climate impact potential

○ **Mitigation Impact**

- The carbon mitigation potential of the Program by 2020 is **approximately 11,782 metric tones** per annum

Paradigm shift potential

○ **Scalability**

- This program can **serve as a roadmap** for the staged and systematic implementation of actions needed to improve the traffic and transport situation in Thimphu.
- The Action Plan for Bhutan's transport system developed in this program will be approved by the Royal Government of Bhutan (RGoB) and used as a mandate for implementation **eventually in other urban areas in Bhutan**

○ **Replicability**

- One objective of this Program is to demonstrate the benefits on offer by avoiding a typical path towards high rates of private vehicle ownership and use so that **neighbouring governments in the South Asia region begin to see the value of alternative policy approaches**.
- The proposed project therefore offers **opportunities for both demonstration impact and potential replication**.

Expected Performance against GCF's Investment Criteria (2/3)

The Green Transport Program for Thimphu city is designed to respond to GCF's all six of the investment criteria but only the applicable and relevant sub-criteria and indicative assessment factors

Sustainable development potential

○ **Environmental co-benefits**

- By reducing carbon emission from the transport sector accounting for about 45% of all energy emissions, possible to improve air quality in Thimphu city and achieve its commitment to remain carbon neutral

○ **Social co-benefits**

- For lower income households with proper travel options, the provision of quality alternatives to private transport expands their access to economic opportunity and social services.

○ **Economic co-benefits**

- The projected modal shift due to the Program would save Bhutan **approximately 6.15 million liters of petrol** imports in 2020 for the cost of an additional **256,887 liters of imported diesel**

○ **Gender-sensitive development impact**

- Increasing the density of supply of bus services can offer a more attractive, affordable alternative to meet the latent trip demand of female population.

Needs of recipient

○ **Economic and social development level of the country**

- The proposed Program targets beneficiaries by mode of transport which effectively targets poor and low income segments of Thimphu's population.

○ **Absence of alternative sources of financing**

- Hydropower related debt currently amounting to approximately 190% of one year's GDP for Bhutan, this constraint limit the RGoB's ability to invest in preparation activities and subsequent investments in Thimphu's urban transport infrastructure / services.
- Considering rapidly increasing trend of GHG emission in transport sector, GCF contribution to preparation activities is critical to enabling Bhutan to meet its international commitments.

○ **Need for strengthening institutions and implementation capacity**

- While upfront capital investments are limited, RGoB has showed willingness to cover public transport service costs as well as delivering a high quality of the service to customers.

Expected Performance against GCF's Investment Criteria (3/3)

The Green Transport Program for Thimphu city is designed to respond to GCF's all six of the investment criteria but only the applicable and relevant sub-criteria and indicative assessment factors

Country ownership

○ Existence of a national climate strategy

-Bhutan's TNA and NDC include proposals for low-emission transport systems including BRT and ITS as a dedicated way of mitigation solution.

○ Coherence with existing policies

-The RGoB has already taken action aligned with "*Bhutan Transport 2040 Integrated Strategic Vision*" policy to try and stem rising dependence on private conventional vehicles and fossil fuel.

-The most priority of outcome for Bhutan's *11th Five Year Plan* seeks to enhance "*access to adequate, sustainable and inclusive public transport*".

○ Engagement with civil society and other relevant stakeholders

-The implementation of the program would sit under the RGoB's multi-sectoral "Task Force" created by Executive Order C2/172 in 2016, in response to traffic congestion and urban transport challenges in Thimphu.

-Ministry of Information and Communications, Gross National Happiness Commission, Ministry of Finance, Thimphu Thromde, City Bus Service, ect.

Effectiveness and efficiency

○ Cost-effectiveness and efficiency

- An initial economic assessment suggests that the project would yield an Economic NPV of US$ 19.0 million at a 6% discount rate with an Economic Rate of Return of 13.0%.

○ Bhutan's governance environment and size

- Bhutan's Governance indicators are among the best in South Asia and well above the average for IDA-eligible countries and low income countries
- The scale of Thimphu makes it possible for moderately sized investments to have large impacts with clearly attributable cause and effect.

Present value of benefit (cost)	NPV of costs / benefits [US$]	% of NPV of benefits	% of NPV of costs
Fuel Savings	$62,220,246	92%	
Emissions Savings	$5,104,719	8%	
Time Savings	($1,775,365)		4%
Capital investment	($43,328,487)		89%
Operational & other expenses	($3,220,754)		7%
NPV of project @6% discount	$19,000,358		
IRR of project	13.0%		

Additional Activities for Bhutan's green transport system

To meet their commitment to the international community to remain carbon neutral, Bhutan has undertaken a diverse of activities in collaboration with international organizations in the transport sector.

Expanding a City Bus Services

(increasing a fleet of two buses to 32 buses that carry approximately 6,000 people per day)

Piloting green transport systems

(piloting the use of pre-paid e-tickets & new designs for bus shelters and devising a system for handling customer grievances)

Pre-feasibility study on BRT and ITS

(confirming the economic viability of a BRT type solution, The WB and RGoB are seeking to expand on the analysis with further engineering due diligence)

Undertaking TNA and TAP

(In the transport sector, intelligent Transport System (ITS) has been identified as a potential technology of the sustainable transport solution in Bhutan)

Bilateral Exchange Activities between Korea and Bhutan

Korean NDE and GTC have invited Bhutanese delegation including the Minister of Agriculture and Forests to foster a more future-oriented and multi-faced partnership in low-carbon transport sector from 2016 to 2018

'16 March

'16 June

'17 November

'17 March

'18 September

From May to December in 2017 GTC installed BIS pilot *(1 center, 10 OBEs, 2 BIT and Mobile service)* **in Thimphu city, which will be the base information to design detailed engineering and specifications for ITS**

Pilot of ITS Pilot

Bus Information System (BIS) pilot for Thimphu city

The Bhutan Green Transport Program

The World Bank and Green Technology Center Korea have been supporting the Royal Government of Bhutan to pursue low emission development pathways in the transport sector and achieve their goal of NDC *(Carbon Neutral)*

Thank You

GREEN TECHNOLOGY CENTER

Ministry of Science and ICT

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