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**CTCN TA: SALINE WATER PURIFICATION TECHNOLOGY AT HOUSEHOLD LEVEL  
AND LOW-COST DURABLE HOUSING TECHNOLOGY  
FOR COASTAL AREAS OF BANGLADESH**

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# Capacity Training Workshop Report

12-13 November 2018

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By

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## 1. INTRODUCTION

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### 1.1 OVERVIEW

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A two days “Capacity Training Workshop” was held on 12-13 November 2018 at Dhaka in Bangladesh. The capacity training workshop is a part of the activities of “CTCN Technical Assistance for Saline Water Purification Technology at Household level and Low-cost Durable Housing Technology for Coastal Areas of Bangladesh”. The main objective of the training workshop is to i) discuss and ensure that identified technology solutions by the TA activities are appropriate for local beneficiaries and reflect local condition, and ii) build capacity of key stakeholders in Bangladesh on proposed technologies, climate change issues, and financing opportunities.

The Green Technology Center (GTC), Korea Institute of Civil Engineering and Building Technology (KICT) and Glory & Tech Co., Ltd. (GAT) jointly organized the workshop in collaboration with key stakeholders in Bangladesh which include Bangladesh Unnayan Parishad (BUP) and the Department of Environment (DoE), Ministry of Environment, Forest and Climate Change (MoEFCC) (Bangladesh NDE). During the workshop more than 50 trainees from various institutes (including government, academia, NGO, local community, and etc.) were trained and shared their opinion. (Please see ‘Annex II’ for the list of participants)

Overall, the workshop was successfully conducted with active participation of the trainees in close cooperation with Palli Karma-Sahayak Foundation (PKSF) and the Bangladesh NDE.

**Figure 1-1** the capacity training workshop



## 1.2 WORKSHOP AGENDA

The workshop consisted of opening remarks and three (3) technical sessions on water purification and low cost housing technologies. The high level representatives from MoEFCC (Bangladesh NDE) and PKSf (TA request proponent) opened the workshop with remarks. The technical sessions were i) Low cost domestic climate-resilient housing technology solutions, ii) Saline water purification technology solutions, and iii) Identifying finance opportunities for the technology deployment. The detailed contents of the sessions are as below table and followings.

**Table 1-1** the workshop agenda

|                                                                                                                                 |                                                             |
|---------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| <b>Opening Remarks</b>                                                                                                          |                                                             |
| <ul style="list-style-type: none"> <li>- Dr. Nurul Quadir, Secretary, MoEFCC</li> <li>- Dr. Q K Ahmad, Chairman PKSf</li> </ul> |                                                             |
| <b>[Session 1] Low cost domestic climate-resilient housing technology solutions</b>                                             |                                                             |
| Session Chair: Dr. Rezaul Karim, Chairman, BUP                                                                                  |                                                             |
| Moderated by Mohammad Abu Sadeque, Former Director, HBRI                                                                        |                                                             |
| <b>Title</b>                                                                                                                    | <b>Presenter</b>                                            |
| 1.1 Field survey results of southern coastal areas in Bangladesh                                                                | Dr. Chang U CHAE, KICT & Mr. Kazi Amdadul Hoque, Friendship |
| 1.2 Review of building materials and component alternatives for southern coastal housing                                        | Dr. Tae Hyeob SONG, KICT                                    |
| 1.3 Design guideline for housing construction in southern coastal areas of Bangladesh                                           | Mr. Mohammad Abu Sadeque, HBRI                              |
| 1.4 Proposals of housing model for southern coastal areas of Bangladesh                                                         | Dr. Chang U CHAE, KICT & YoungWan Kim, BOF, Korea           |
| <b>[Session 2] Saline water purification technology solutions</b>                                                               |                                                             |
| Session Chair: Dr. Fazle Rabbi Sadeque Ahmed, Director, PKSf                                                                    |                                                             |
| Moderated by Md. Mahmudul Hasan, DG, WARPO                                                                                      |                                                             |
| 2.1 General water purification techniques using membrane technologies                                                           | Prof. Sangho Lee, Kookmin University                        |
| 2.2 Investigation of local water use in the village of Satkhira, Bagerhat Region                                                | Dr. Dongjin Yang, GAT                                       |
| 2.3 Implementation and technical part of managing desalination water treatment plant in south east coastal region of Bangladesh | S.M Mahabub Alam & Sarder Ziauddin, NGF                     |
| 2.4 Low-cost desalination applications to solve water problems in coastal areas of Bangladesh                                   | Dr. Yunchul Woo, KICT                                       |
| <b>[Session 3] Finance opportunities for the technology deployment</b>                                                          |                                                             |
| Session Chair: Mr. Abdul Karim, Managing Director, PKSf                                                                         |                                                             |
| Moderated by Dr. Sultan Ahmed, DG, DoE                                                                                          |                                                             |
| 3.1 Access to Climate Finance                                                                                                   | Ms. Rywon YANG, GTC                                         |
| 3.2 Climate Technology Cooperation through CTCN and Korea's Technology Cooperation activities                                   | Mr. Chang Sun JANG, GTC                                     |
| 3.3 Technology cooperation and its potential linkage with carbon market                                                         | Dr. Sue Kyung LEE, GTC                                      |

## **2. WORKSHOP PRESENTATIONS AND DISCUSSIONS**

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### **2.1 OPENING REMARKS**

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Dr. Nurul Quadir, Secretary, MoEFCC thanked the Korean Govt. appreciating the initiative of undertaking such a project. He said that the coastal region of Bangladesh is very much vulnerable to the impact of climate change. The local communities have to face series of natural disasters including cyclone, storm surges, salinity intrusion, etc. that cause huge damage of assets and property to the community people of the coastal area of the country. In such situation, this project is a very useful and time demanding.

Dr. Q K Ahmad, Chairman PKSF and Special Guest of the workshop welcomed the initiative and appreciated the objectives of the project. It is now proved that climate change is the reality not the anticipation. He said that the people of our coastal community are facing the disasters induced by the impact of climate change every year. They have developed their own capacity to adapt with the adverse situation. We should collect their local knowledge and fit it into the framework of the pilot project to update the technology and make it more feasible and acceptable for the coastal community people of Bangladesh. There should be enough scope of research to scale up the technology and deliver those to the community for getting optimum outcome.

### **2.2 LOW COST DOMESTIC CLIMATE-RESILIENT HOUSING TECHNOLOGY SOLUTIONS**

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#### **2.2.1 FIELD SURVEY RESULTS OF SOUTHERN COASTAL AREAS IN BANGLADESH**

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The purpose of the field survey study is to understand the characteristics and problems of local housing structures, investigate residential environmental conditions such as local temperature, humidity, soil etc., investigate infrastructure for building improvement, and provide direction of residential improvement through this study. The following table summarizes the field survey information and sources:

Table 2-1 Field survey

| Objective                                              | Information area/Indicators                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Source                                                                                                                                                                                                                                                        |
|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Understand, analyze, and report the field survey study | <p>Main structural type of housing (wood, masonry, soil erection etc.)</p> <ul style="list-style-type: none"> <li>• Analysis of the major causes of aging housing (analysis of causes e.g. Salt and weathering etc.)</li> <li>• Analysis of aging type (size and shape of cracks, size and shape of exfoliations etc.)</li> <li>• Current status and maintenance of old structure</li> <li>• Status of internal space division (average area and number of rooms)</li> <li>• Presence of floor and ceiling (ceiling finish)</li> <li>• Difference in heights between the main building and the ground (presence of canopy)</li> <li>• Average number of residents (survey on family composition)</li> <li>• Fuel usage patterns for meals</li> <li>• Exhaust and ventilation methods</li> <li>• Configuration and materials of windows and doors</li> <li>• Sleeping type (floor, bed, etc.)</li> <li>• Indoor finishing (cement, soil, wood, tree branches, etc.)</li> <li>• Indoor floor finishing (soil, cement, wood, board, tile, etc.)</li> <li>• Use of water (water supply or direct use of underground water)</li> <li>• Electricity supply (voltage and main use electrical appliances)</li> <li>• Location and type of toilet (indoor, outdoor)</li> </ul> | <ul style="list-style-type: none"> <li>✓ Villagers (who belongs there more than 10 years)</li> <li>✓ Local leaders like elected public representative</li> <li>✓ Expert on Housing of Southern Bangladesh (academician, researcher, engineer etc.)</li> </ul> |

This field survey used mainly quantitative techniques and better triangulation qualitative technique also used in some cases. The field survey carried out based on a review of housing guideline, data and observations gathered during field visits and interviews with villagers as well as relevant personnel from Government and other agencies. The data were gathered through different methods, including survey, focused group discussions, document and program component review.

Three locations (three villages) on each district of Bagerhat and Satkhira, were pre-visited by the KICT team along with Friendship team in September (These areas belong to southern coastal part of Bangladesh). Every location was tracked through GPS. However, locations were finalized in consultation with KICT.

The field survey reveals that most of the existing houses are not of durable in nature having

characters of emergency and transitional shelters. Space and inhabitant ratio vary from 25:1 to 100:1. Main structure type of housing are of wooden and bamboo skeleton. Roofing elements are made of straws, CGI sheet, Golpatha, Asbestos, etc. and not in good condition. Deterioration of roof, wall and other elements of the houses are mainly due to decay and damages caused by saline effect and cyclone wind respectively. Fifty eight percent houses were not repair or rebuilt during last five years. Façade elements are of straws, bamboo mat, CGI sheet etc. It has been noticed that over 70% dwellings are having one room and only 20% households having two rooms in their houses. About 30% houses have no ventilations and only less than one percent households have their electric fan. Most of the dwellings are having detached kitchen (62%) and toilet (100%). 66% houses are south facing. Fuel uses in most houses (93%) are wood with insufficient natural ventilation in the kitchen. Over 20% houses have no window. Majority inhabitants sleep in elevated platform made of wood. Floor of houses are mostly mud and 88% houses have their yards. Sources of water are mainly rainwater and surface water. Fifty percent houses are out of electricity supply.

Average household size are 4.14 persons per household. Approach road length varies from 2km to 7 km from the main road of Upazila headquarter and width of the approach road varies from 1.2m to 4m.

Main source of potable water is from rain which is more than 63% and other source of drinking water is surface water from pond and river. Sources of water other than drinking comes mainly from pond and river. More than 89% households use Ring-slab toilet but 4.7% uses open field.

About 63% of households constructed their house from their own and other with the help of mason, contractors or others. Regarding the financial support, only less than 2% households received from the Government, 12.5% from NGOs and societies and about 84% houses constructed with one's own finance.

Inclusion of Rainwater harvesting and renewable energy like solar panel with the housing package is also most important. Use of wood as fuel should be replaced by alternative sustainable and renewable energy like bio-gas. Cow dung, kitchen waste and other organic waste might be the source of bio-gas generation.

**Table 2-2** Summary of the survey results

| Village Name                      | Uttar Japa            | Durgabati             | Hurka    | Kamalkathi            | Keyabunia             | Selabunia             |
|-----------------------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|-----------------------|
| <b>Union</b>                      | Poddopukur            | Buri Goyalinoi        | Hurka    | Poddopukur            | Chila                 | Burirvanga            |
| <b>Upazila</b>                    | Shyamnagar            | Shyamnagar            | Rampal   | Shyamnagar            | Mongla                | Mongla                |
| <b>District</b>                   | Satkhira              | Satkhira              | Bagerhat | Satkhira              | Bagerhat              | Bagerhat              |
| <b>GPS_E</b>                      | 89.21326              | 89.22946              | 89.63467 | 89.21326              | 89.61796              | 89.57381              |
| <b>GPS_N</b>                      | 22.33638              | 22.28128              | 22.56600 | 22.33638              | 22.42070              | 22.54982              |
| <b>Households</b>                 | 450                   | 469                   | 230      | 420                   | 150                   | 153                   |
| <b>Population</b>                 | 2600                  | 2700                  | 1060     | 2450                  | 650                   | 1000                  |
| <b>Shelter</b>                    | Yes                   | Yes                   | No       | No                    | No                    | Yes                   |
| <b>Shelter Capacity</b>           | 500                   | 400                   |          |                       |                       |                       |
| <b>Mobile Accessibility</b>       | No                    | Yes                   | No       | No                    | No                    | No                    |
| <b>Mode of easy Accessibility</b> | By Road and water way | By Road and water way | By Road  | By Road and water way | By Road and water way | By Road and water way |
| <b>Distance from main road</b>    | 3 km                  | 3 km                  | 7 km     | 2 km                  | 5 km                  | 3 km                  |
| <b>Road Pavement</b>              | Yes                   | Yes                   | Yes      | Yes                   | Yes                   | Yes                   |
| <b>Approach road width</b>        | 3 m                   | 4 m                   | 3.7 m    | 1.8 m                 | 1.2 m                 | 1.8 m                 |
| <b>Average width of main road</b> | 20 m                  | 20 m                  | 8 m      | 20 m                  | 10 m                  | 15 m                  |

## 2.2.2 REVIEW OF BUILDING MATERIALS AND COMPONENT ALTERNATIVES FOR SOUTHERN COASTAL HOUSING

### ► Proposal of construction materials to secure economic efficiency and durability




Durable housing applicable to the southern coastal areas of Bangladesh must follow the eight-item guidelines established by the HBRI, as described above. Among the eight items, this proposal focuses on the supply of construction materials considering the possibility of material utilization, and the necessity of easy sourcing of materials and maintenance and management for 30 years of durability.

In addition, in view of the economic growth of Bangladesh, we propose the following industrialized products considering expansion to small and metropolitan cities in the

southern coastal region.

- Aerated inorganic blocks: the main raw materials are cement, fly ash, soil, sodium silicate, and hydrogen peroxide
- Cellulose lightweight block and boards: the main raw materials are straw, cement, and clay
- Cement extrusion panels: the main raw materials are cement, silica powder, sand, and fiber mortar construction

**Table 2-3** Building materials suitable for the southern region of Bangladesh

| Aerated inorganic blocks                                                                                                                                                                                                                                  | Cellulose lightweight block and boards                                                                                                                                                                                                                                                                               | Cement extrusion panels (exterior)                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                          |                                                                                                                                                                                                                                     |                                                                                                                                                                                        |
| <ul style="list-style-type: none"> <li>- Uses small amounts of cement; made using fly ash and clay</li> <li>- Manufactured by room temperature curing</li> <li>- Lightweight, high processability</li> <li>- Can be made using local materials</li> </ul> | <ul style="list-style-type: none"> <li>- Uses rice straw as the main material and the adhesive is applied differently depending on the application</li> <li>- The exterior material is cement-bonded, and the interior material is resin adhesive</li> <li>- Uses the abundant supply of local rice straw</li> </ul> | <ul style="list-style-type: none"> <li>- Requires examination of the use of exterior materials to ensure durability</li> <li>- It is expensive and has low field processability</li> <li>- Optimal for 30 years of durability, as it is a high-density product</li> </ul> |

### ► Aerated Inorganic Blocks

It is a material similar to the lightweight aerated concrete block proposed by the HBRI. The HBRI produces classic ALC (autoclaved lightweight concrete) blocks using cement and aluminum powder. This proposal outlines the use of a small amount of cement of less than 5%, and forms aerated blocks using fly ash or clay. Since the strength of this block is less than 3MPa, it may be insufficient in durability and its compressive strength is insufficient for self-assembly. Therefore, this block can be best used as a filler material for timber and bamboo frames.

The production method comprises general room temperature curing and autoclave curing. While autoclave-curing products have relatively high density and strength, they are not quite

applicable to housing, considering the infrastructure of southern Bangladesh. This type of product is suitable as building material for the southern coastal region of Bangladesh because of its humidity control function resulting from its many air bubbles. In other words, it is highly usable as a functional building material as it maintains a pleasant indoor environment. However, it may cause problems such as mold and contamination during prolonged periods of high humidity due to its low water resistance.

**Table 2-4** Composition of aerated inorganic blocks

| Raw material                | Additive                                    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Specifications                                                                                                                                                                                                  |
|-----------------------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cement,<br>Fly ash,<br>Soil | Sodium<br>Silicate,<br>Hydrogen<br>peroxide | <ul style="list-style-type: none"> <li>- Uses inorganic mineral wastes, such as fly ash, which has high CaO content, as raw materials</li> <li>- Uses alkali stimulants such as cement to improve reactivity</li> <li>- It is lightweight and has excellent heat insulation as more than 50% of it is comprised of air bubbles</li> <li>- Superior process ability in the field through the use of a saw</li> <li>- Finishing mortar applied to improve surface water absorption</li> </ul> | <ul style="list-style-type: none"> <li>- Density: <math>&gt;0.5\text{g/cm}^3</math></li> <li>- Compressive strength: <math>&lt;3\text{Mpa}</math></li> <li>- Water absorption: <math>&gt;15\%</math></li> </ul> |

### ► Cellulose Lightweight Block and Boards

Rice can be planted up to 3 times per year in the southern region of Bangladesh because of its mild temperature during the year, allowing abundant production of rice straw. Rice straw is an organic material that has the disadvantage of rotting when it is exposed to moisture. However, when rice straw is used to strengthen inorganic materials, it is possible to use it to produce building materials with high durability because of its high tensile strength. In addition, it enables the use of eco-friendly materials as it allows humidity control. Once the rice straw is sufficiently dried, it is possible to produce plates and blocks by applying pressure molding using a certain amount of binder, such as cement.

Various types of products can be produced depending on the type of straw and pressure

molding method. In the case of a sheet material in which rice straw is the main material, there is a method of forming a sheet material to expose the shape of the rice straw directly using a binder such as urethane, or a method of making a sheet of a gray system using cement as a binder. The basic molding method is pressure molding.

The general manual work is limited depending on the product size. It can mold products that have a board size of 500x500x15mm or smaller. For automolding, it can handle up to 2000mm in length, 500mm in width, and 15 to 50mm in depth. It is also possible to produce products capable of both humidity control and insulation due to the fine cellulose pores.

However, as cellulose is highly absorbent and can lead to mold and contamination when continuously exposed to moisture, it is considered to be suitable only for interior use. In particular, as the southern coastal region of Bangladesh can reach humidity levels of above 80% and has a rainy season, cellulose is believed to be excellent for use in interior materials that have humidity control functions.

**Table 2-5** Composition of cellulose lightweight block and boards

| Raw material | Additive      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Specifications                                                                                                                                                                                           |
|--------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Straw        | Cement, Resin | <ul style="list-style-type: none"> <li>- Method of drying the straw, cutting it to a certain size, and then molding it under pressure</li> <li>- Can be used as either interior or exterior material depending on the type of adhesive used</li> <li>- Various applications depend on the pressure applied</li> <li>- Utilization as various interior and exterior materials by controlling the thickness of the straw</li> <li>- For use as exterior material; necessary to establish measures to improve water resistance</li> </ul> | <ul style="list-style-type: none"> <li>- Density: 0.3~1.0g/cm<sup>3</sup></li> <li>- Flexural strength: &lt;2Mpa</li> <li>- Water absorption:<br/>Cement base: &gt;20%<br/>Resin base: &gt;5%</li> </ul> |

### ► Cement Extrusion Panels

Moisture is the most important cause of factors that inhibit the durability of buildings. The water penetrates the material and expands its interior, or corrodes the rebar used as the reinforcing material. Therefore, the durability of a material can be greatly improved if moisture penetration can be minimized.

Cement extrusion panels are products that perform vacuum extrusion molding using cement, sand, and reinforcing fiber. In theory, their absorption rate is low because they are completely absent of internal voids. In addition, these panels are characterized by little shrinkage change despite being composed only of fine powder.

Polypropylene fiber is used as reinforcing powder in cement extrusion panels. Considering the characteristics of the Bangladesh region, pulverized fiber of rice straw can be used instead of this fiber. This allows the incorporation of more eco-friendly factors and has the advantage of lowering the production cost.

Cement extrusion panels can be produced in various thicknesses ranging from 25mm to 60mm depending on the type of mold, and have excellent durability as they are high-density products (over 30 years – more than 30 years of Korean buildings, such as KICT exterior materials). They are excellent for securing airtightness by space due to their excellent sound insulation properties, in addition to having excellent fire resistance performance.

However, as high-density products, they have the disadvantages of requiring the use of a separate processing apparatus to be processed in the site and requiring an initial investment to build production facilities.

**Table 2-6** Composition of cement extrusion panels

| Raw material                | Additive                                                      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Specifications                                                                                                                                                                 |
|-----------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cement, Silica powder, Sand | Hydroxypropyl methylcellulose powder (HPMC), Cellulose Fiber, | <ul style="list-style-type: none"> <li>- High-density as it is a vacuum extrusion molding product</li> <li>- No surface deterioration due to excellent moisture resistance and length stability</li> <li>- Enhanced image with exposed concrete</li> <li>- Varied use as interior material, exterior material, flooring material, and roof material, among others, by various assembly methods</li> <li>- Can use pulverized straw as reinforcing fiber; currently uses Polypropylene and pulp</li> </ul> | <ul style="list-style-type: none"> <li>- Density: &lt;1.5g/cm<sup>3</sup></li> <li>- Flexural strength: &lt;14Mpa</li> <li>- Water absorption: Cement base: &gt;15%</li> </ul> |

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### 2.2.3 DESIGN GUIDELINE FOR HOUSING CONSTRUCTION IN SOUTHERN COASTAL AREAS OF BANGLADESH

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Bangladesh is an over populated, hungry country having population over 160 million. Total area is 147,570 square kilometers causing population density 1,100 per square kilometer. Per capita agricultural land is only 14 decimal which is one of the lowest among the agrarian countries in the world. Besides, Bangladesh is losing one percent of agricultural land every year out of which 80% are due to unplanned rural houses and 17% are the causes of manufacturing burnt bricks using top soil from agricultural land. Study reveals that projected population size of Bangladesh will be 240 million in 2040 and 50 million people will suffer from food shortage. For conservation of agricultural land with increasing population and development we have to go for planned rural house as well as adoption of unburned building blocks using no agricultural top soil. Moreover, every year 25 billion clay burnt bricks emits 20 million tons of greenhouse gases causing 20% of total national emissions. About 25 million dwelling units are there in the country and most of them are not disaster resilient. Till today, fully damaged houses due to disaster are approximately 300,000 and partially damaged more or less 500,000.

As per 'Standard Guideline for Rural Housing in Disaster Prone Areas of Bangladesh', 'Durable Houses' are those which can withstand load coming from natural disaster and sustain at least for 30 years. Similarly, 'Transitional Houses' and 'Emergency Houses' are those which can sustain unto 15 years and 1 year respectively. The Standard Guideline also states 'Design Standards for Rural Housing' as below:

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

Since 1970, at least four cyclones and tidal surges had a devastating impact on the villages

and houses in the coastal area of Bangladesh. This is mainly due to current housing practices that are not durable since the main materials used are bamboo, straw, wood, CGI sheet, etc. People are building their houses in the agricultural land area, and some of them are using clay burnt bricks made from top soil.

Some of the NGOs and INGOs provided houses to the poor people. Some of those houses caused destroying the agricultural land. Reason is the prevailing policy of providing housing support only for those who have a piece of land even if it is at the middle of agricultural field. Those who can afford, build their houses using CGI sheet roof as well as wall. Due to the insufficient roads to enter the villages, vehicles could not approach the houses. Means of communication does not allow any vehicle to enter into most of the villages. Because of houses either built temporary in nature or not durable against cyclone and tidal surge, almost all houses undergo collapse or damages.

Another important issue needs to be considered during design and construction of coastal housing is saline effect. Salinity is a slow killer of building materials, especially concrete. Saline intrusion is deeper from inland to the west coast of Bangladesh such as Satkhira, Khulna and Bagerhat districts. Salinity affects construction in many ways. It is very difficult to make suitable water available for construction. Also salinity makes hostile environment for concrete and other building elements which reduces the durability and sustainability. Reinforced Concrete structure suffers from short life which is more or less ten to fifteen years due to saline environment as well as unwise or injudicious use of aggregates and water.

Considering grave issues of our country like conservation of agricultural land, protection of forest & environment, durability & sustainability of houses, saline tolerant housing, etc. some of the government policy statements are established as follows:

1. 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.
2. Prime Minister's Directives to HBRI - a) Appropriate planning has to be drafted for proper utilization and application of the research outcomes. b) Ferro cement must be introduced in house building and rural settlement. c) Research initiatives must be undertaken regarding construction of hollow blocks from river dredged sand and d) Measures must be taken to produce environment-friendly bricks (Non-fire) from river dragged soil.

3. Bangladesh and COP-21 - In the Intended Nationally Determined Contributions (INDC) Bangladesh pledged an unconditional 5% greenhouse gas emission cut by 2030, adding that financing and technology support will cut emissions by 15%.

Standard Guideline also stated the design guidelines for coastal housing of Bangladesh. Climatic factors considered during design and construction of coastal houses are - cyclone, tidal surge, high wind, salinity, nor-western, driving rain, riverbank erosion and solar radiation. Besides, following design guidelines need to keep in mind:

1. Resilience Against the Impacts
2. Climate responsive design approach
3. Introduction to low impact building material and construction technology
4. Development of standardized and labor-friendly pre-fabricated mode of construction using minimum/ economic building elements
5. Addressing contextual issues

Basic principle of housing design and construction is a) agro-friendliness b) environment friendliness c) durability d) sustainability and e) affordability. National standard also specifies facade and roofing elements of houses such as a) Ferro-cement b) Concrete blocks c) Sandwich panel d) CSEB d) Thermal block e) Interlocking block, etc.

Existing houses are not safe against load coming from wind and tidal surge. Therefore, those is a need of upgrading to safer or more durable ones. Techniques stated in the Standard Guideline can be followed for improving unsafe houses.

Considering above facts, following recommendation may be considered for construction of new durable houses and also upgrading of existing houses:

1. Ferro-cement is the most suitable technology for coastal areas
2. Pre-cast, pre-fabricated technology is the most preferred one
3. Concrete must be durable and minimum compressive strength shall be 4000psi
4. Brick chips should not be used as coarse aggregate for concrete
5. Present transitional houses need to be upgraded as safer shelters
6. New shelter should be of durable type
7. Multi-story foundation for conservation and expansion of agricultural land needs to be promoted
8. Updated wind velocity data and inundation data from BNBC and IWM respectively need to be considered for shelter design

9. Epoxy coated bar may be used for RC construction

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#### 2.2.4 PROPOSALS OF HOUSING MODEL FOR SOUTHERN COASTAL AREAS OF BANGLADESH

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The main goal is to design several optimum houses which can be affordable and durable for southern coastal areas of Bangladesh. Through this TA, KICT has outlined 3 different types of housing proposals in consideration with income level, building area, resident's living area, price, etc. of the residents of southern Bangladesh. To minimize the maintenance cost of residential living environment, all 3 housing proposals are recommended to apply the rainwater recycling system and solar system.

##### **Housing type**

- A type: Durable housing design for low income class residents in southern coastal area of Bangladesh
- B type: Durable housing design for middle income class residents in southern coastal area of Bangladesh
- C type: Durable housing design for middle income class residents in southern coastal area or urban area of Bangladesh

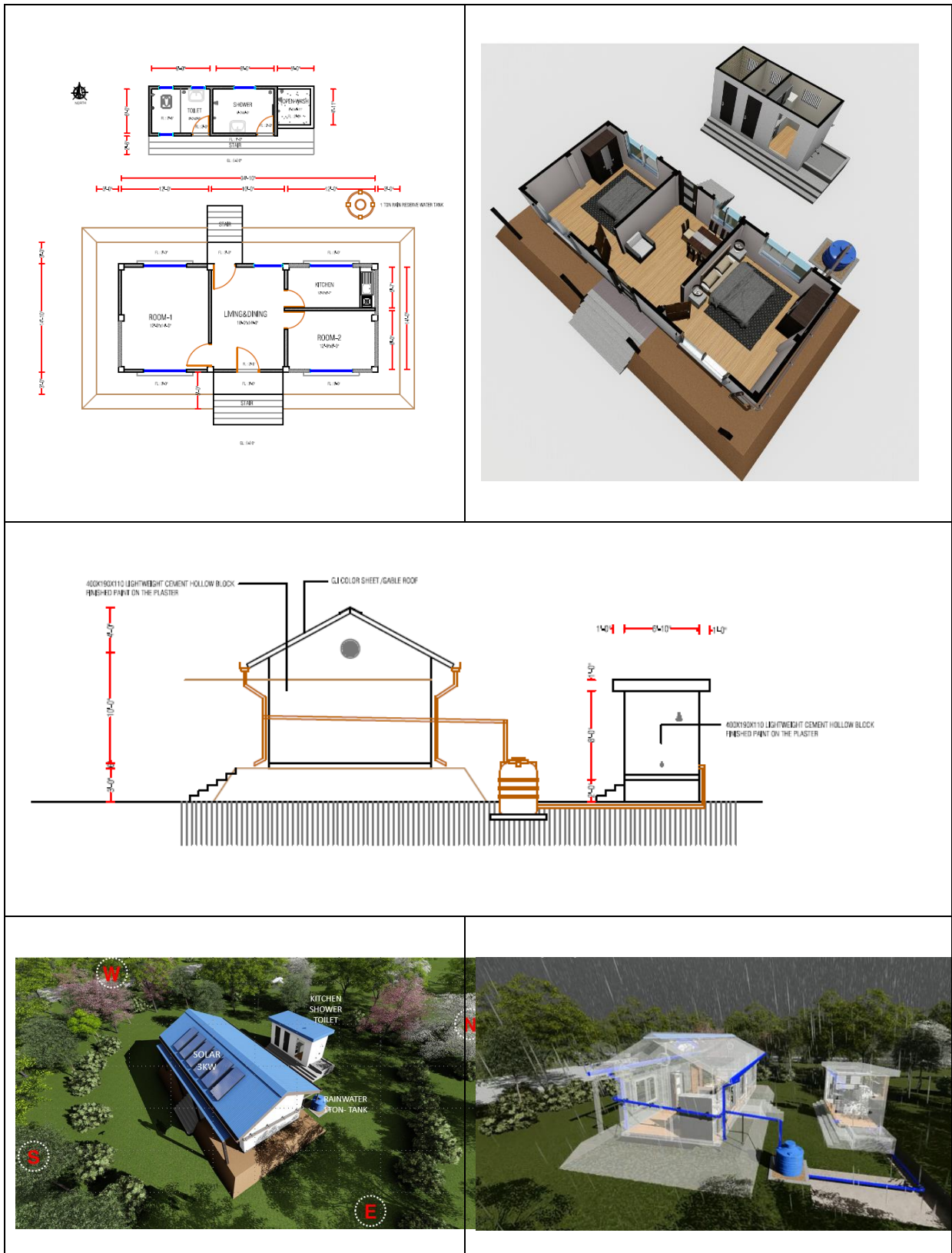
##### **Main materials**

- Low income class in southern coastal area of Bangladesh (A type):
  - Local materials (Gol-pata, Bamboo, lightweight foam blocks, etc.)
  - Utilization of solar system
  - Utilization of rainwater storage
  - Lightweight foam blocks and general cement brick
- Middle income class in southern coastal area of Bangladesh (B type):
  - Lightweight foam blocks, general cement brick and extruded concrete panel (Byucksan)
  - Utilization of solar system
  - Utilization of rainwater storage
  - Lightweight foam blocks and general cement brick
- Middle income class in southern coastal area or urban area of Bangladesh (C type):
  - Extruded concrete panel (Byucksan)
  - Utilization of solar system
  - Utilization of rainwater storage

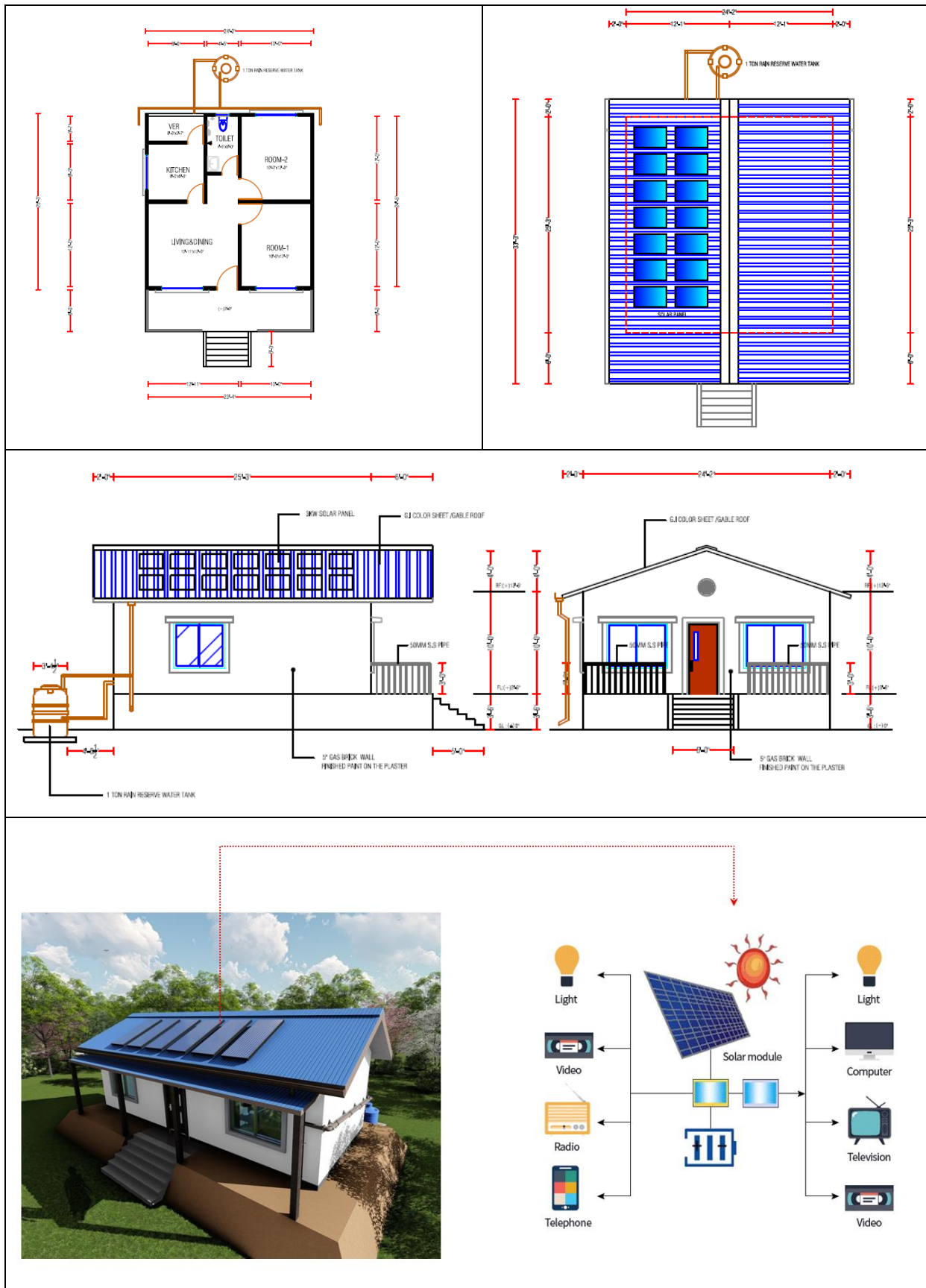
**Table 2-7** Summary of 3 housing proposals

|                              | <b>A type</b>                                             | <b>B type</b>                                             | <b>C type</b>                                                                        |
|------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Number of floors</b>      | 1 floor                                                   | 1 floor                                                   | 1 floor                                                                              |
| <b>Area</b>                  | 572sft/53 m <sup>2</sup>                                  | 572sft/53 m <sup>2</sup>                                  | 758sft/70.1 m <sup>2</sup>                                                           |
| <b>Main Material</b>         | Light weight foam block/Local brick                       | Light weight foam block/<br>Cement brick                  | Extruded concrete panel                                                              |
| <b>Wall structure</b>        | Cement hollow Block                                       | Cement brick                                              | Concrete panel                                                                       |
| <b>Roof structure</b>        | G.I steel gable roof                                      | G.I steel gable roof                                      | G.I steel gable roof                                                                 |
| <b>Division</b>              | ROOM(1,2)<br>LIVING&DINING<br>KITCHEN<br>TOILET<br>SHOWER | ROOM(1,2)<br>LIVING&DINING<br>KITCHEN<br>TOILET<br>SHOWER | ROOM(1,2)<br>LIVING&DINING<br>KITCHEN<br>TOILET<br>SHOWER<br>VERANDA<br>OPEN TERRACE |
| <b>Price / household</b>     | USD 10,990                                                | USD 12,570                                                | USD19,770                                                                            |
| <b>Price / m<sup>2</sup></b> | USD 207                                                   | USD 237                                                   | USD 283                                                                              |
| <b>Solar system</b>          | 3KW                                                       | 3KW                                                       | 3KW                                                                                  |
| <b>Rainwater tank</b>        | 1TON                                                      | 1TON                                                      | 1TON                                                                                 |

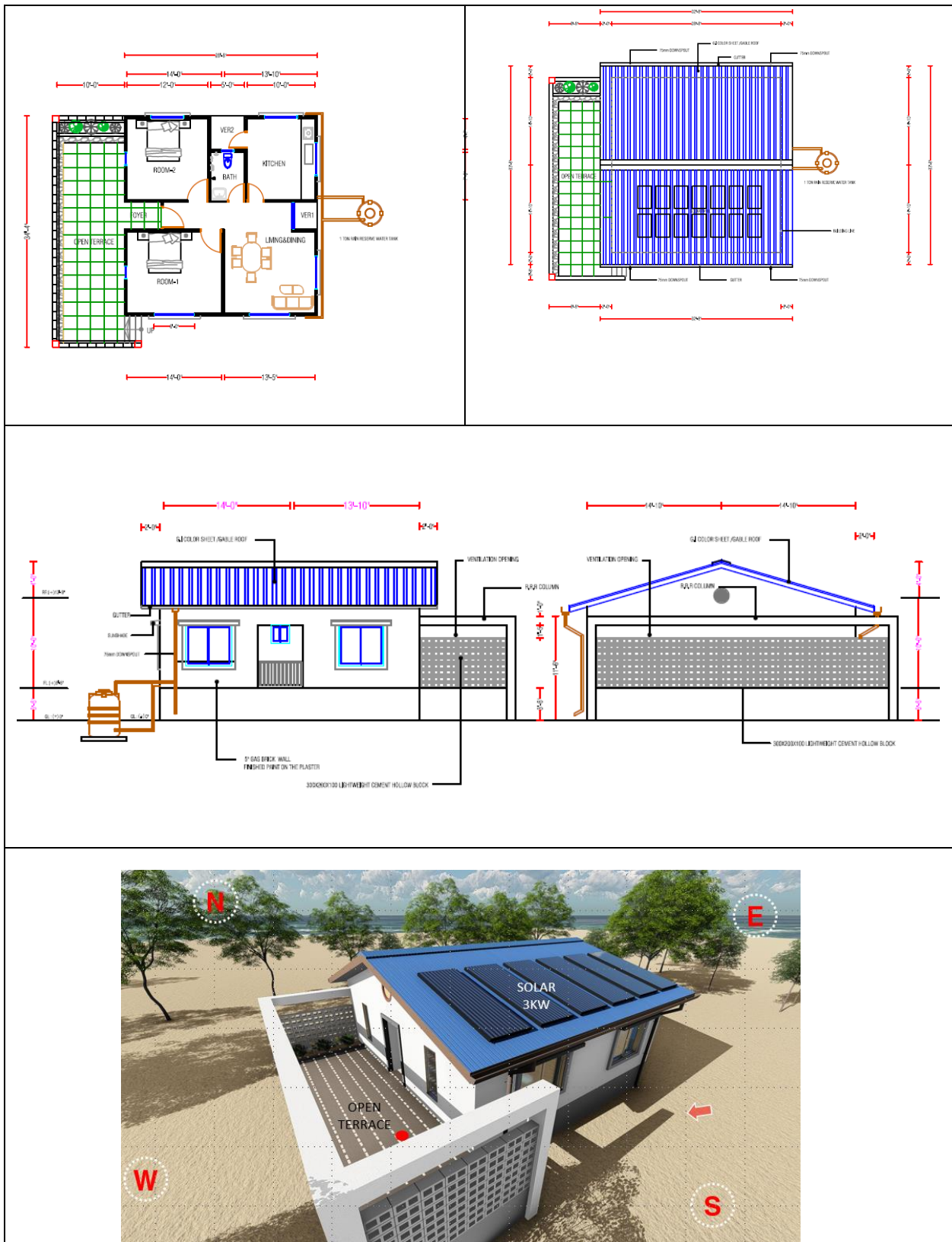
→ Proposal -A type



→ Proposal -B type



→ Proposal -C type



## 2.3 SALINE WATER PURIFICATION TECHNOLOGY SOLUTIONS

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### 2.3.1 WATER PURIFICATION TECHNIQUES USING MEMBRANE TECHNOLOGIES FOR BANGLADESH

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#### 1) Capacitive Deionization (CDI)

Capacitive deionization units are small and portable and require no consumable resins or sorbents. For the operation, any type of DC power source, such as batteries, solar panels and generators, can be used. It can deliver potable water from various sources (wells, lakes, and streams) through the removal of contaminant ions such as arsenic, perchlorate, nitrate, and other toxic inorganics. It removes both cations and anions and charged particles.

#### Principle of CDI

##### a. Ion Removal

CDI electrostatically removes dissolved cations and anions from contaminated water. The CDI unit has a stack or spiral wound of a high surface area carbon electrodes. The electrodes are porous and electrically conductive, and the ions are removed when the DC voltage is applied. The voltage should be less than or equal to 1.2 volts ( $V \leq 1.2$ ) to prevent electrolysis of water. The ions adsorb and are held in the electric double layers on the electrodes. Cations migrate to the negative electrode while anions migrate to the positive electrode. The required current rapidly decays as ions are removed so it is inherently efficient and needs low-power supply.

##### b. Regeneration

In the regeneration process, the electrodes are shorted, or polarity is briefly reversed to force desorption and flush in reverse direction with product water. This is one of the efficient processes as captured salt concentration is highest at the inlet. The uses of the produced water during flush are minimal and the resulting effluent can be sent to the drain. Regeneration can briefly reverse polarity to speed up desorption. Stored capacitance can be re-captured during discharge to improve the efficiency of the process (more relevant when treating brackish water).

Some of the **advantages** of the CDI are it doesn't require high pressure/high voltages and uses less equipment and operational cost. Moreover, the energy from the CDI can be recovered by utilizing energy storage devices (CDI is a capacitor).

## 2) Reverse Osmosis

Reverse Osmosis is a technology which employs a pressurized semi-permeable membrane to remove ions, molecules and large particles from polluted water sources. High-pressure pump (over 20 bars) and high-pressure re-circulation pump are required for the process. Relatively, its unit cost is quite expensive; however, it is possible to reduce the required energy by renewable solar and wind energy. The high-pressure RO application can be used for seawater of 30,000 mg/L salinity or brackish water of more than 15,000 mg/L.

Some of the advantages of RO are:

- High separation efficiency without phase change.
- Small size particles cannot penetrate the RO membrane, while they can pass through other membranes such as nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF).
- RO eliminates 95% to 99% of TDS, which is currently the most suitable technology for obtaining pure water.
- It is also applicable for wastewater reclamation, and treatment of shale gas/ coal bed methane produced waters.

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### 2.3.2 POTENTIAL APPLICATIONS FOR THE VILLAGE OF SATKHIRA, BAGERHAT REGION

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#### **Water supply for a village**

**A hand-pumped water purification process:** A hand-pressured water purification process using RO technology is one of the low-cost brackish water treatment processes. It doesn't need any electricity to produce water. In terms of maintenance, small amounts of chemicals are needed to clean membranes. It is the safest and easiest process to supply water for a village in the coastal area

**Solar-assisted water purification process:** In order to reduce energy consumption, solar energy is one of the options which needs to be considered. A solar panel is one of the alternative techniques to produce electricity for water purification processes. It can also mitigate problems pertinent to disconnection of power source at the water purification plant.

### 2.3.3 WATER PURIFIERS USING MEMBRANE TECHNOLOGIES FOR SOUTH EAST COASTAL REGION OF BANGLADESH

Although CDI and RO purifiers, which are suggested in this report, are a little bit expensive than other RO purifiers sold in Bangladesh, they can produce better water qualities than others. In terms of maintenance costs and water qualities, RO purifier has a comparative advantage compared to CDI purifier. Thus, the present report prefers to apply RO purifier for coastal areas in Bangladesh. However, RO still seemed to be precious processes so that it could be reduced a cost of energy via several alternative energy harvesting processes like a solar panel. The solar energy connected with RO can reduce 1.0 ~ 3.5 kWh/ton, which meant that an RO with solar energy purifier achieves a power consumption of 2.0 ~ 3.0 kWh/ton. The RO with solar energy is, therefore, a suitable integrated system to make an energy efficient water purifier for water supply to coastal areas in Bangladesh.

**Table 2-8** Comparison of CDI and RO device costs and maintenance costs

|                            | <b>CDI device</b>                                                                                                                                                                 | <b>RO device</b>                                                                                                                                                                                                                                       |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Key components</b>      | 1 <sup>st</sup> stage device<br>- CDI device (CDI module+Circuit board)<br>- Pump<br>- Water Tank(30L)<br>2 <sup>nd</sup> stage device<br>- 2 set of 1 <sup>st</sup> stage device | 1 <sup>st</sup> stage device<br>- Filters: Sediment + Ion-Exchange + Carbon + UF + RO<br>- Booster Pump<br>- Water Tank(30L)<br>2 <sup>nd</sup> stage device<br>- 1 <sup>st</sup> stage device + RO filter + Booster Pump<br>- Water storage tank(30L) |
| <b>Device cost</b>         | 1 <sup>st</sup> stage device: \$500<br>2 <sup>nd</sup> stage device: \$1000                                                                                                       | 1 <sup>st</sup> stage device: \$450<br>2 <sup>nd</sup> stage device: \$800                                                                                                                                                                             |
| <b>Cost of maintenance</b> | 1. Power consumption per drinking water production: 10.0~25.9 kWh/ton<br>2. Cost of replacing consumables per device<br>- CDI module: \$250<br>- Pump: \$50                       | 1. Power consumption per drinking water production: 3.1~5.8 kWh/ton<br>2. Cost of replacing consumables per device<br>- Filter set: \$120<br>- Booster Pump: \$200                                                                                     |

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### 2.3.4 FIELD STUDY FINDINGS

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GAT introduced the results of a survey on water use in the villages of Satkhira and Bagerhat districts. The following are the contents of the announcement.

GAT and KICT water team conducted the first local survey in late June 2018 and the second in mid-September 2018. In particular, officials from the Nowabnki Gonomukhi Foundation (NGF) and Friendship, which are carrying out drinking water projects in Sathkira, Bagerhat districts, as proposed by PKSf, participated in the survey schedule and acted as guidance in the area.

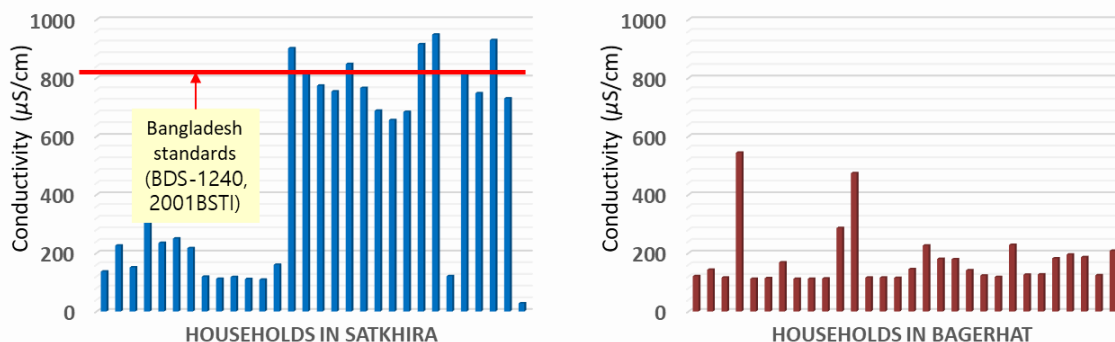
**Figure 2-1** Meeting with the residents of a village in Satkhia District



In the first local survey 30 households each of Satkhira, Bagerhat Districts were visited, to survey the drinking water sources and water facilities, analyze the water quality per household, and hear opinions from residents and representatives on drinking water usage. In particular, even though the investigation period is during the rainy season, the concentration of salts exceeding the Bangladesh standard was shown in the village of Satkhira, where arsenic, iron, manganese and ammonia components that are dangerous to the human body were also found to exceed the standard.

It was confirmed that desalination technologies should be applied in Satkhira region more preferentially, as the Satkhira region was found to have poorer drinking facilities and worse water quality, and residents in the Satkhira region also had more demand for safe drinking water.

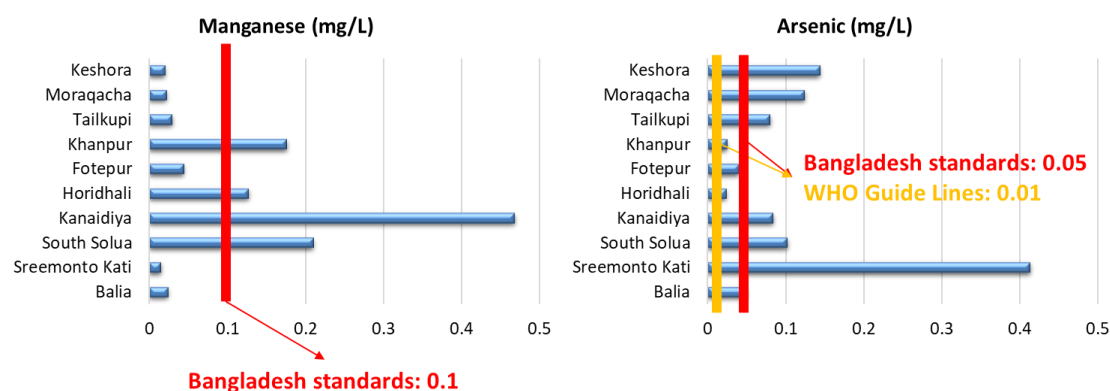
**Figure 2-2** Electro conductivity of underground water in households in Satkhira, Bagerhat districts



The second local survey was conducted in September 11-12, 2019, in the end of the rainy season in Bangladesh. During the second survey, GAT surveyed 10 villages in Tala upazila and KICT carried out survey from 3 villages in Shyamnagar upazila. Each team was accompanied by NGF and Friendship, the Bangladesh’s local NGOs.

All the families of the 10 villages in Tala upazila were using drinking water directly through the Shallow Tube Well. There was a pond near the water source and the water looked bad and there were cattle cages seemed to be a potential source of smelly groundwater and microbial contamination. Electrical facilities were installed in the village of Tala upazila, where electricity was supplied to each household. Some households were using solar panels intermittently. However, the electricity supply was cut off from time to time, so it needed a stable supply of electricity and a backup system using renewable energy such as solar energy.

**Figure 2-3** Analysis of Manganese and Arsenic Concentration in 10 Villages of Tala upazila



In a water quality analysis of 10 villages in Tala upazila, pH, and concentrations of boron, fluoride, and nitrate showed a safe level within the Bangladesh water standards. However, hardness, turbidity, electrical conductivity and concentrations of arsenic, manganese, iron and ammonia, exceeded the drinking water standard in Bangladesh. In addition to removing salt from groundwater, it has been found that it is also necessary to remove other ionic compounds that are hazardous to the human.

Also, during KICT's visit to three villages in Shyamnagar upazila, it was confirmed that underground water and rainwater were used for drinking water together with filtered water supplying from RO facilities. The North Jhapa village used the RO system to provide water to about 200 households. The residents were coming to get their own water. However, the power supply is unstable and can sometimes be interrupted. Therefore, it seemed necessary to secure a stable power supply system and a water supply network using piping etc.

**Figure 2-4** RO water supply system in village of North Jhapa

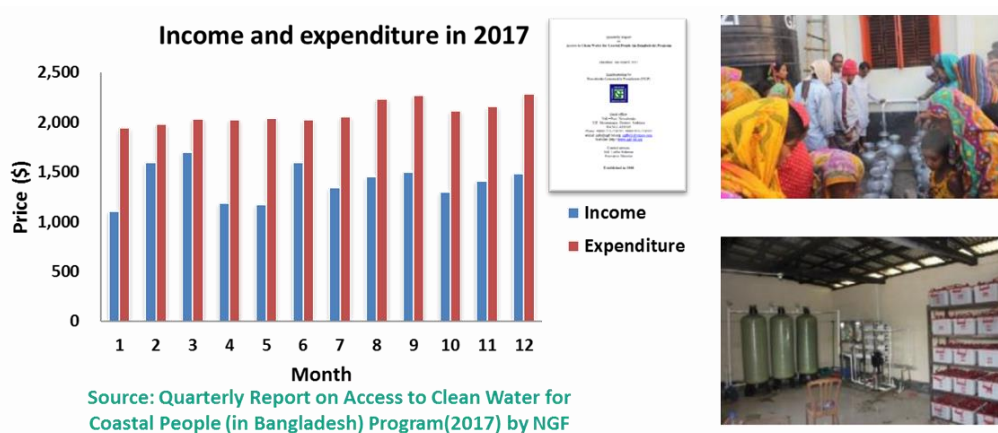


Based on the results of a field survey, Dr. Yang made the following suggestions:

The first consideration is the applicability and sustainability of the technology. This means that solutions for the desalination technology of the TA project should be realistically applicable in Bangladesh, and should be continuously operated to provide clean drinking water to residents of the area where groundwater is affected by saline water intrusion. For example, NGF's 2017 Quarterly Report found problems in local water supply facilities, namely problems in power supply, water supply systems and revenue structures, preventing the sustainability of water supply facilities. In the case of home water purifiers, it will also be necessary to anticipate and replace the factors that hinder this sustainability.

The second is about cooperation and sharing information. Bangladesh has been working hard to deal with climate change and a variety of water support projects are underway. For example, on the homepage of the Department of Public Health Engineering (DPHE), various drinking water support projects are identified to be under way by government agencies and financial institutions such as PKSF, and NGOs. The TA team wants to work together as appropriate partners rather than interfere with these projects in Bangladesh. In response, Fazzle Rabbi Sadeque Ahmed, PKSF Director and the chairperson, agreed with the proposal and hoped to be reflected.

**Figure 2-5** Operational reporting of drinking water supply facilities in NGF's 2017 Quarterly Report



The several personal suggestions on locally applicable water purification technology were proposed as well. The first suggestion is diversification of drinking water. In addition to poor water underground water, it is recommended that rainwater be used as a drinking water source in rainy season. This will also reduce the burden of maintaining water purifier.

The second is to find various renewable sources to stabilize power supply. In Korea, many studies have recommended to use various alternative energy sources such as solar, wind, and hydrogen energy. In Bangladesh, a variety of auxiliary power supplies should be selected and applied locally to stabilize the power supply.

The third is a combination of community water systems and household water purifiers. As mentioned earlier, underground water in the southern coast of Bangladesh contains not only saline ingredients but also harmful ion substances, which can be quite overloading filters for household water purifiers. Therefore, the public water supply facilities at the village level could be installed to increase the

service period of household water purifiers by first treating water supplying to the household (e.g. suspended solids, iron, manganese, ammonia, etc).

**Figure 2-6** Example of local water treatment facilities configurable in Bangladesh



### 2.3.5 IMPLEMENTATION AND TECHNICAL PART OF MANAGING DESALINATION WATER TREATMENT PLANT IN SOUTH EAST COASTAL REGION OF BANGLADESH

NGF professionals have participated in the study team of CTCN, South Korea and involved in conducting a feasibility study on water purification model at household level in the coastal areas of Bangladesh.

In particular, in relation to the CTCN-TA project, NGF introduced one desalination water treatment plant using both electricity and generator at Atulia since 2013. They introduce the way the local people came to get their own drinking water or received it by delivery.

**Figure 2-7.** Solar based desalination water treatment plant and water delivery activities



NGF introduced three additional desalination water treatment plants which are functioning from three different locations in Shyamnagar Upazila, aiming to understand the present status on plant operation & management practices and technological viability and explore

the business model that helps to make a decision in future scaling up. And they showed the results of the interviews with the key focal points of respective industries such as desalination water treatment plant supplier & set up engineer, plant manager and technician and community mechanism plant management body.

NGF had shared their organizational experience and knowledge on low cost desalination water supply technologies at both household and community levels in the coastal region of Satkhira, Bangladesh. Also, they have explained the journey including access to safe water and story behind the success.

## **2.4 FINANCE OPPORTUNITIES FOR TECHNOLOGY DEPLOYMENT**

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The experts from GTC presented and identified finance opportunities for the technology deployment.

Firstly, the presentation titled 'Climate Technology Cooperation through CTCN and Korea's Technology Cooperation activities' was introduced to give basic information of the CTCN TA and background of Korea's participation in climate technology cooperation. The other TA cases which Korean experts have contributed to share.

As a key part of this session, the GTC experts presented on 'what is Green Climate Fund (GCF) and how to develop a GCF concept note'. The purpose of the presentation is make Bangladesh stakeholders understand GCF project development process mainly who are participating in drafting the GCF concept note for the Bangladesh TA. The participants obtained and learned a key information needed to access GCF including GCF program overview, GCF project area, process of developing GCF concept note, key criteria, and contents of concept note and a case study. In addition, 'Technology cooperation and its potential linkage with carbon market' was shared to the participants specially focusing on carbon market and the Clean Development Mechanism (CDM) which is one of the market mechanisms of UNFCCC.

## **2.5 DISCUSSIONS**

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**Dr. Abu Talib Mohammad Shahjahan** (Assistant Professor, BUET) raised the point about considering the environmental survey as there is an issue of high air temperature in the coastal area. Generally, in the coastal area of Bangladesh, houses are found small in size due to high air force especially during the disasters. The windows need to be included for ventilation and thermal comfort. He also pointed out including the area and price of the land

involved in implementing the housing technology in the study area. The issue of individual house configuration is a very much sensitive one that needs to be considered during designing low cost housing technology.

**Dr. Apurba K Podder** (Assistant Professor, BUET) mentioned the design of the housing pattern. He commented that it is needed to add windows in housing design, which are considered as the most important component of the house in the rural area especially in the coastal region of Bangladesh. He added that geometric aspect should be involved while designing a building, and a house should not be made without verandas and windows. He pointed out that there will be a massive economy shift which needs to be considered. More research should be done before introducing the technology.

**Md. Yusuf Mehedi** (Assistant Director, MoEFCC) said about the issue of refilling the tank during dry season. The rainfall decreases considerably during the dry season in the country. If the stored purified water is used by the house members in every purpose then the water will be exhausted within a short time. In that situation refilling the water tank will be a big issue and there should be alternatives.

**Dr. Fazle Rabbi Sadek Ahmed** (Director, PKSf) strongly opined on integrating indigenous knowledge on building houses of local people in the climate vulnerable areas of Bangladesh. He suggested to collect and analyse different documents from concerned departments and organizations for better solution and scaling up the technologies.

**Dr. Md. Samsul Alam** (Professor, Jahangirnagar University) pointed out the issue of considering local socio-economy and livelihood of the coastal community of the Bangladesh while designing low cost durable houses. He opined that cultural tradition and the economy is an integral part of development and communities where housing technology plays a vital role which should not be undermined. He suggested to take into account those issues before promoting the pilot of the technology in the coastal region of Bangladesh. Success of the pilot project will determine the replication of the technology to the other parts of the country and other countries as well. He also recommended to use local materials available in the project areas in building houses that has been demonstrated in the training workshop.

**Mr. Palash Kanti Haldar** (Coordinator, Concern Worldwide) opined that there should be the use of traditional materials in building houses in the remote areas of the coastal zone. It will be a matter of great threat to the unprivileged people of the coastal community if their houses collapse which will be made of foreign materials. Materials need to be available and affordable for the community people when considering low cost durable housing. Regarding

the water purification technology, he raised the question of affordability of the technology to the community people. He also raised the issue of maintenance of the water treatment plants.

**Dr. Nilufar Banu** (Executive Director, BUP) opined on involving young people and developing young entrepreneurship for making future leadership. She also mentioned using the renewable energy such as solar energy in the water purification technology. She opined on increment of coverage of distributing fresh water to nearer villages through pipelines.

**Mr. Abdul Karim** (Managing Director of PKSf) chaired the closing session. He mentioned the kind support and assistance of Korean government during and after the Bangladesh Liberation War. Mentioning the Korea as a friend country of Bangladesh he expressed his gratitude for the initiative of the technology transfer through the project. Wishing for the success of the pilot project he showed his expectation of large-scale programme support from Korea.

### 3. OUTCOMES OF THE WORKSHOP

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There was a very active interaction among the participants, resource persons and technical experts from Korea in the training workshop. After an intensive discussion the workshop was completed successfully with the following outcomes:

- ✓ There should be provision of scaling up the technology through incorporating traditional indigenous knowledge of the community people.
- ✓ There should be provision of financial support for the community people to adapt the technology at household level as the cost of the technologies is higher than that of the local available technologies.
- ✓ The issue of local socio-economy and traditional culture needs to be considered in developing and implementing low cost housing technologies in coastal area and it was suggested that further research is needed.
- ✓ Locally available materials should be used in housing technology especially in the areas which are located far remote of the coastal zone.
- ✓ New technology should be introduced with a scope to fulfill the demand of the community people for whom the technologies are going to be imported.

## ANNEX

### ANNEX 1. WORKSHOP PHOTOS



[CTCN TA] Capacity Building Workshop: Group Photo








**[CTCN TA] Capacity Building Workshop: Technical sessions**






**[CTCN TA] Capacity Building Workshop: Discussion and Q&A**

**ANNEX 2. LIST OF PARTICIPANTS**

| <b>National Capacity Training Workshop</b>                                    |                                      |                         |                                                   |                       |                                                                                       |
|-------------------------------------------------------------------------------|--------------------------------------|-------------------------|---------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|
| 12 November 2018, Dhaka, Bangladesh                                           |                                      |                         |                                                   |                       |                                                                                       |
| Venue: Seminar Hall-2, Palli Karma-Sahayak Foundation (PKSF), Agargaon, Dhaka |                                      |                         |                                                   |                       |                                                                                       |
| Monday, 12 November 2018                                                      |                                      |                         | Time: 08:30AM                                     |                       |                                                                                       |
| Sl. No.                                                                       | Name                                 | Designation             | Name & Address of Organization                    | Phone / Cell / E-mail | Signature                                                                             |
| 1.                                                                            | Mehsuh U2 Rahim                      | Sr. Research Specialist | Friends of Bangladesh, Dhaka, AB                  | 01720171543           |    |
| 2.                                                                            | Md. Zia uldin Sarkar                 | H/O M&E                 | NGF, Satkhira                                     | 01711231184           |    |
| 3.                                                                            | SM Mahabub Abu.                      | Project Coordinator,    | NGF Satkhira.                                     | 01718775575           |    |
| 4.                                                                            | Palash Kanti Haldar                  | Project coordinator     | Concern worldwide<br>H#15 SW(D), R#7<br>Gulshan-1 | 01713-330951          |  |
| 5.                                                                            | Dr. Abu Taib<br>Mohammed<br>Shofiqan | Assistant<br>Professor  | Dept. of<br>Architecture<br>BUET                  | 01730436953           |  |






Monday, 12 November 2018

Time: 08:30AM

| Sl. No. | Name                          | Designation                                  | Name & Address of Organization              | Phone / Cell / E-mail                      | Signature                                                                             |
|---------|-------------------------------|----------------------------------------------|---------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------|
| 6.      | MD LUTFOR RAHMAN              | ED                                           | Nowabentki Gonna<br>mullik Foundation (NGO) | 01711218197                                |    |
| 7       | Md. Shomser ALI               | Executive<br>engineer (ENV)                  | LGED, Agargaon.                             | 01711-453679<br>enr.shomserali@yahoo.com   |    |
| 8.      | Mohammad Abu<br>Sadeque PEng. | Expert.                                      | Former Director<br>HBRI                     | abussadeque<br>@gmail.com<br>01819220223   |    |
| 9.      | Kazi Amdadul<br>Hoque         | Director &<br>Head of Climate<br>Change & DM | FRIENDSHIP<br>Baridhara<br>Dhaka            | 01713030124<br>Kazi_ameddul@friendship.ngo |   |
| 10      | K.M. Marufuzzar<br>man        | Manager                                      | PKSF                                        | 01712021627<br>maruf82314@gmail.com        |  |

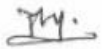

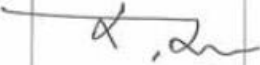

Monday, 12 November 2018

Time: 08:30AM

| Sl. No.             | Name                                                    | Designation                     | Name & Address of Organization | Phone / Cell / E-mail             | Signature                                                                             |
|---------------------|---------------------------------------------------------|---------------------------------|--------------------------------|-----------------------------------|---------------------------------------------------------------------------------------|
| 16                  | Dr. Fazle Rebbul Kabir<br>Ahd.                          | Director.                       | PKSF                           | 01552310099                       |    |
| 17                  | M. AR. Robson                                           | Managing<br>Editor              | BLITZ                          | 01720522909                       |    |
| 18                  | Somas Krishna Das                                       | Assistant Director              | DOE                            | 01817585440<br>skdasdoe@gmail.com |    |
| <del>19</del>       | Md. Feriğ Alam                                          | Assistant<br>Program<br>manager | PROYAS                         | 01712579463<br>ferig@proyas.org.  |   |
| <del>20</del><br>20 | <del>Md. Tahirul Karim</del><br>Md. Hasem Hossain Kabir | D.D.                            | DOE                            | 01712-304222                      |  |

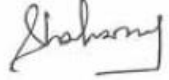

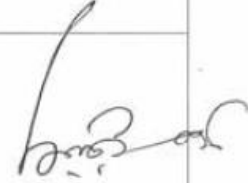


Monday, 12 November 2018

Time: 08:30AM

| Sl. No. | Name                   | Designation        | Name & Address of Organization                | Phone / Cell / E-mail               | Signature                                                                             |
|---------|------------------------|--------------------|-----------------------------------------------|-------------------------------------|---------------------------------------------------------------------------------------|
| 21      | Md. Yusuf Mehedi       | Assistant Director | BCCT.                                         | 01770604829<br>Sumam.ju71@gmail.com |    |
| 22      | Dr. Mohd. Shamsul Alam | Professor,         | Dept. of Curg. & Env.,<br>Jahangirnagar Univ. | 01816704748                         |    |
| 23      | Dr. Jahangir Alam      | VC                 | UGV<br>Barisal                                | 01714204910                         |    |
| 24      | Md. Arjun Akbar Muzgar |                    | CR1                                           | 01712-062525                        |                                                                                       |
| 25      | M. Z. Ali.             | Ch. Rep            | NSRD                                          | 01747988708<br>zakrobin@gmail.com   |  |



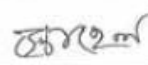

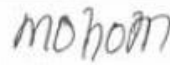
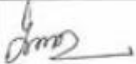
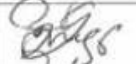
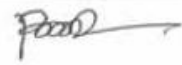
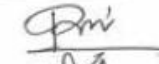

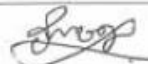

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|---------|------------------------|---------------|-------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|
| 26      | Shahamaj Fahman        | Asst Director | Department of Environment                             | 01885071557           |    |
| 27      | Soufial                | O (IT)        | PKSF                                                  | 01614396542           |    |
| 28      | Ma. Azhawl<br>Sstampha | SRO           | Bangladesh<br>Institute of<br>Development<br>Studies. | 01710211765           |    |
| 29      | Fatehaduzzaman         | DM,<br>PKSF   | PKSF                                                  | 0170804757            |   |
| 30      | Md. Shchian<br>Mahmud  | DM,<br>PKSF   | PKSF                                                  | 01713028761           |  |

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| Sl. No. | Name              | Address of Organization                         | Phone / Cell / E-mail | Signature                                                                             |
|---------|-------------------|-------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|
| ১       | মোঃ মেহেদী হাসান  | মোল্ল্যা পাড়া, নওয়াবেকী, শ্যামনগর, সাতক্ষীরা। | ০১৭৭৬১৪৩৪৩৭           |    |
| ২       | মোঃ আবু হাসান     | বিড়লাক্ষী, নওয়াবেকী, শ্যামনগর, সাতক্ষীরা।     | ০১৭৫৬.৬৫৩০১১          |    |
| ৩       | মোঃ সোহেল রানা    | শ্যামনগর, সাতক্ষীরা।                            | ০১৭৩৭ ২২১৪১৭          |    |
| ৪       | মোঃ আকবর হোসেন    | শ্যামনগর, সাতক্ষীরা।                            | ০১৭০৭ ৪৯০৫৩১          |    |
| ৫       | মোঃ মোহন          | বিড়লাক্ষী, নওয়াবেকী, শ্যামনগর, সাতক্ষীরা।     | ০১৭২৭-৪৭৬৩২৭          |    |
| ৬       | মোঃ আব্দুল্লাহ    | বিড়লাক্ষী, নওয়াবেকী, শ্যামনগর, সাতক্ষীরা।     | ০১৭১১৭৭১৪৭৬           |    |
| ৭       | মোঃ ইদ্রিস আলী    | নওয়াবেকী, শ্যামনগর, সাতক্ষীরা                  | ০১৭২১৭২৭৭৭৭           |    |
| ৮       | মোঃ রাউফুল প্রধান | আটুলিয়া, নওয়াবেকী, শ্যামনগর, সাতক্ষীরা।       | ০১৭০৭ ৪৯০৫২৪          |   |
| ৯       | মোঃ আশ্রাফ আলী    | দৈবজ্জহাট, মোরেলগঞ্জ, বাগেরহাট                  | ০১২৭৩২২৭২৬৫           |  |
| ১০      | দুলাল মিত্রি      | জিউধরা, মোরেলগঞ্জ, বাগেরহাট                     | ০১৭২৭-৫৫ ১৬১২         |  |
| ১১      | মোঃ কবির হোসন     | বারইখালী, মোরেলগঞ্জ, বাগেরহাট                   | ০১৬২১-৭৭১৭১০          |  |
| ১২      | মোঃ আলমগীর হোসেন  | সানকিভাঙ্গা, মোরেলগঞ্জ, বাগেরহাট                | ০১৪১২-৭৪০৭২৭          |  |





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|---------|------------------|-----------------------------|--------------------------------|---------------------------------------------|-----------|
| 1       | Sayeed ulah      | Bangladesh<br>Befar         |                                | 01922763888                                 | Sayy      |
| 2       | Md Mahbobul Alam | Deshi news<br>s.s. Reporter | Deshi news                     | 01641113404<br>mahbobulalam<br>71@gmail.com | For.      |
| 3       | A. S. M. Akad.   | Asst. Producer              | Delac.                         | 01747.995962                                |           |
| 4       | Suro Khan        | Reporter                    | Somoy TV                       | 01964444039                                 |           |
| 5       | Jobayer          | Reporter                    | Somoy                          | 01910-801678                                | Jy        |

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| Sl. No. | Name                                            | Designation  | Name & Address of Organization         | Phone / Cell / E-mail | Signature                                                                             |
|---------|-------------------------------------------------|--------------|----------------------------------------|-----------------------|---------------------------------------------------------------------------------------|
| 6       | S. M. Biplob                                    | Reporter     | ১১/১১/১১                               | 01834114115           |    |
| 7       | Ahad Hassain                                    | Sr. Reporter | Deepto. TV<br>ahad_tutul@yahoo.com     | 01716027665           |    |
| 8       | Marsheda Yesmin<br>Peau<br>Staff Reporter<br>Da |              | Daily Ittefaq<br>yesmin.peau@gmail.com | 01712-046108          | Peau                                                                                  |
| 9       | Ashraful Alam<br>Asst. Editor                   |              | ash ashraful sharif<br>49@gmail.com    | 01913-102599          |   |
| 10      | MD. Azim                                        | S.R.         | Shipon 90 @<br>gmail.com               | 01670024092           |  |

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|---------|------------------|--------------------------|--------------------------------|-----------------------|--------------------------------------------------------------------------------------|
| 11      | Faibul Islam     | cameraman                | G-TV                           | 01927674341           |   |
| 12      | Rashed Kamal     | Reporter                 | Bmoy Song Kal                  | 01670157852           |   |
| 13      | Mamunur<br>Ahmed | Special<br>correspondent | MD. Mustafa                    | 014102744<br>63       |   |
| 14      | Muntassis        | SR                       | Alokta<br>Bangladesh,          | 01819437718           |  |
| 15      |                  |                          |                                |                       |                                                                                      |