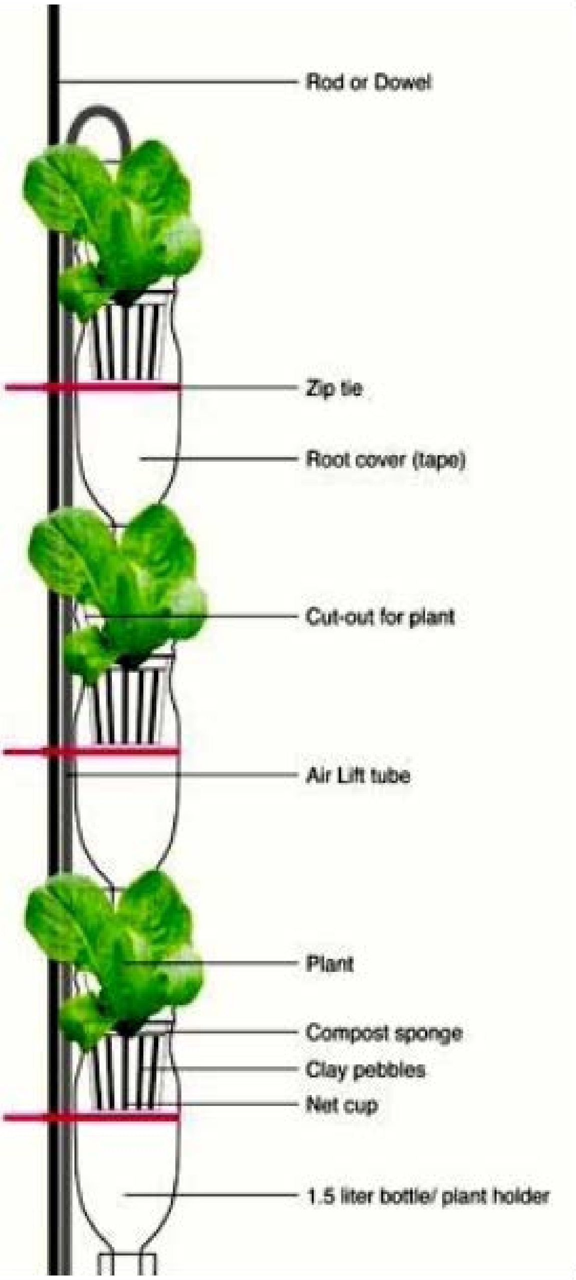
CLIMATE**SMART**

Design Guidelines



Handbook for Urban Poor Community in Cambodia

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MISEREOR

Contents

Introduction
What is climate-smart design?

Since more than three decade we know that human activities are affecting our climate. In the past century, the average temperature on our planet has increased by almost 1°C. It is envisaged that temperature could rise up to 3°C until 2050 if we continue like now. This increase of global temperature is called global warming or climate change. The main cause of global warming is the increased emission of so-called greenhouse gases like carbon dioxide (CO2), methane and others air pollutants. Human activities such as burning fossil fuels like coal, oil and natural gas are increasing the amount of carbon. For example, fossil fuels are burned in power plants to generate electricity. Other causes for climate change are deforestation, more agriculture activities and much more.

Climate-Smart = Carbon Mitigation + Climate Adaptation

Scientist have found out that higher global temperatures will lead to more extreme weather events and higher sea levels. The arctic sea ice is also shrinking and coral riffs are disappearing. Many ecosystems are in danger. In Cambodia the impact of global warming can be felt already today by more flooding events and longer droughts. This is affecting the livelihood of millions of people worldwide. If temperature rises above 2°C, our planet might become uninhabitable.

Therefore, we have to do something against climate change. We have to become climate-smart! What does climate-smart means? Climate-smart means on the one hand that we have to mitigate our impact on the environment and reduce the carbon emission of human activities. On the other hand, we know that changes are happening like for example more flooding. So we have to adapt to these changes. All this together is called becoming climate-smart.

The aim for this climate-smart design handbook is be a guide for urban poor communities to become more climate-smart. It shall help all organisations and actors working to improve the infrastructure of these communities to do climate-smart improvements. This handbook was developed within the context of Sahmakum Teang Tnaut (STT)'s Alternative Urban Housing and Planning (AHUP) Programme with the support of Misereor Germany.


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Chapter 1

Climate-smart Design Strategies

The here developed climate-smart design strategies follow the principle of sustainable development. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

A particular focus is set to protect the natural system upon which the society depends.

Furthermore, we considered all three dimensions of sustainability: the nvironmental, social and economic dimensions. That means climate-smart strategies are environmental friendly as well as rely on affordable low-cost measures. The social dimension is covered by a community driven approach. Most of the measure can be implemented by the community members alone or with very little technical support.

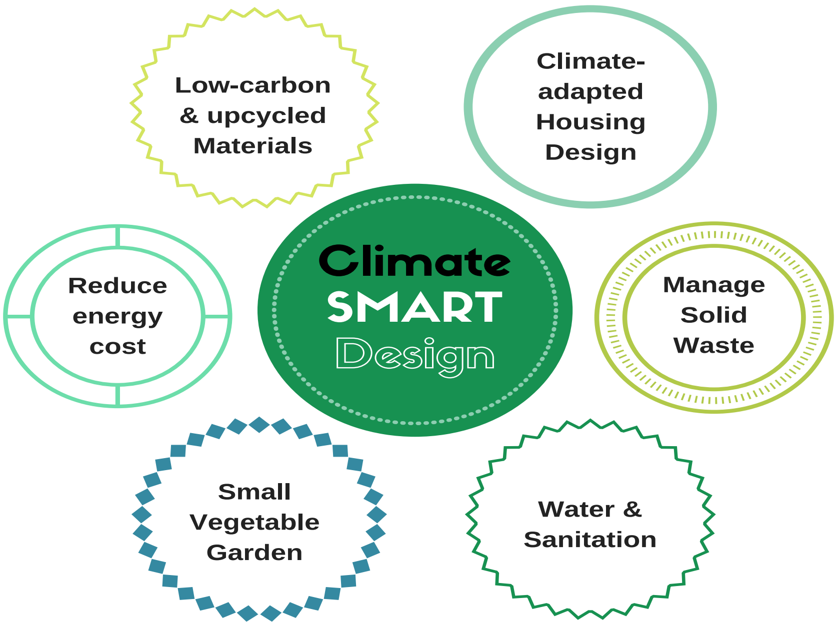
The involvement of the communities and its stakeholders was essential during the process of developing these strategies. In a total of eight communities, interviews were conducted to understand the major challenges of their inhabitant.

A need assessment workshop in two communities helped us to get information on the importance of the different proposed interventions.

Climate-smart design is aiming to improve the living condition of the urban poor communities in Cambodia. Our Guidelines are a comprehensive set of solutions covering the following areas:

1. Climate-adapted Housing Design
2. Reduction of Energy Cost
3. Low-carbon and upcycled Materials
4. Solid Waste Management
5. Water and Sanitation
6. Small Vegetable Garden

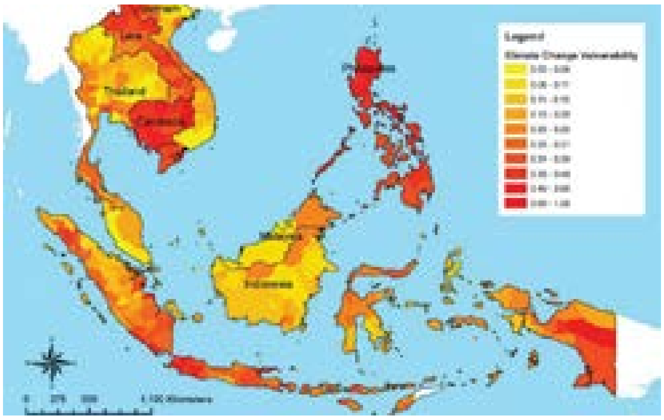
Each area contains a set of different measures. In the following chapter all measure are described in detail. Together with the Handbook different training material was developed to make the implementation easy and feasible.



Climate-adapted Housing Design

Why?

Global warming will increase air temperatures in our cities and our houses will become more uncomfortable. Urban poor people cannot afford to install expensive air-conditioning system. Therefore, we need low-cost climate-responsive design strategies to make their houses cooler. Cambodia is located in the tropical climate zone with mean temperatures between 27°C and 30°C. The climate is dominated by the annual monsoon cycle with its alternating wet and dry seasons. The main concern is to keep the house as cool as possible. Climate-adapted design should focus on reducing solar gains or protecting from the sun and enhancing natural ventilation.



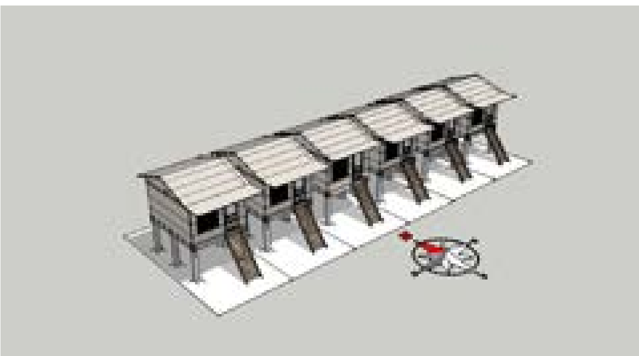
Climate Vulnerability Map for South-East Asia

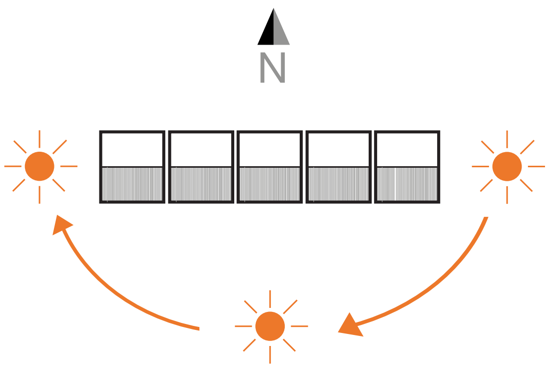
Building Layout and Orientation

The solar penetration of a building is highly dependent on the building layout and orientation. With an optimum building layout and orientation houses can stay cool all over the year.

If the house is located on an plot with open space around elongated building volumes with the long axis from east to west are best to reduce solar gain. Windows in the east and west facade should be avoided. Large roof overhangs will ensure all windows facing south or north are well shaded.

In the context of dense urban settlements in Cambodia, houses are often attached to each other or standing close to each other. The best orientation for this context is to orient the entry facade towards north or south. By doing so, the east and west facades of the building are always shaded by the neighbouring houses. An large roof overhang (0.5-1.0m) is always recommended for shading the facades and as protection against the strong monsoon rain.



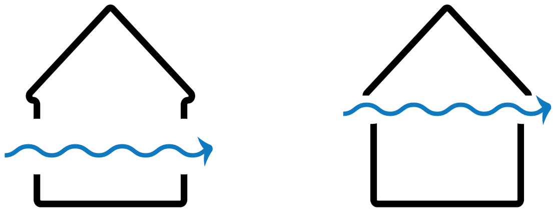


Optimum settlement pattern with sun path

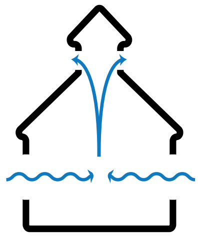
Natural Ventilation

Natural ventilation is a very effective, energy-efficient and often pleasant way to create comfortable homes in a hot and humid climate like Cambodia. Due to the evaporation effect of the skin, the human body can tolerate about 3°C higher indoor temperatures if air is moving slightly. Houses should be designed to enhance natural ventilation and air movement within the building and the settlement.

Natural ventilation in buildings is also needed to supply fresh air from the outside and to remove used air, moisture, odours as well as potentially harmful substances (e.g. smoke) from the inside. Therefore, it is highly recommended to improve the natural ventilation within the houses of urban poor communities. Effective natural ventilations can be achieved in several ways, e.g. using cross or stack ventilation effect. Openings should be oriented towards the prevailing winds. Windows should placed in oposite sides to enhance air movement inside the house. Stilted houses catch more winds and protects against flooding.



Cross Ventilation by placing openings (windows and doors) facing each other (left) or by placing a ventilation gap between roof and wall (right).



Stack Ventilation by placing an additional opening in the upper part of the roof

Large openings in building facade to ensure good ventilation in Roluos Cheung Aek Communiity

Windows

To ensure effective natural ventilation and daylighting of a room the window area should be at least 15% to 20 % of the total floor area. Building facades designed for enhancing air ventilation should have an opening area of al least 20 % and up to 40 % (of total facade area).

Windows should face rather south or north than east and west in order to reduce solar heat gains of the building. If east or west facing windows can not be avoided effective shading should be foreseen, e.g. shutters or vertical shading devices.

Very small window in house facade in Sen Reak Reay Community

Shading

Shading of the windows is one of the best options to avoid the house to heat up during the day. Traditional houses often have large roof overhang.

A roof overhang of at least 0.5 metres up to 1 metres is recommended. A porch or veranda can also shade the house and create an additional cool outdoor space.

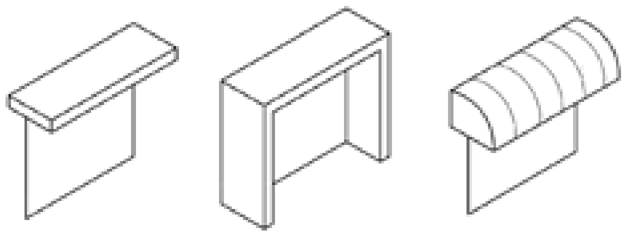
South-facing windows can be effectively shaded by an overhang with the length of at least one third of the window height. For east and west facing windows fins are more effective to shading. Shading can be also achieved by planting plants in front of the facade or the window. Vegetation in and around the houses brings also a cooling effect by evaporation.

Shutters can used for shading windows facing all directions and are also good for better security. However, they block all the daylight and forces to use lighting when shutters are closed.

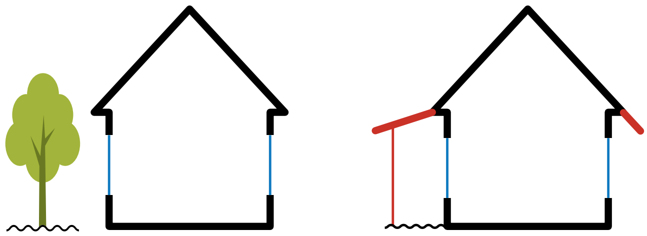
Traditional Khmer house with large roof overhang and porch

Opening with large window overhang in Sen Seak

For detailed calculation of roof and window overhangs your can use an easy online tool available at: http://susdesign.com/overhang_annual/index.php



Different designs of shading devices: overhang, overhang with fins, awnings (from left to right)

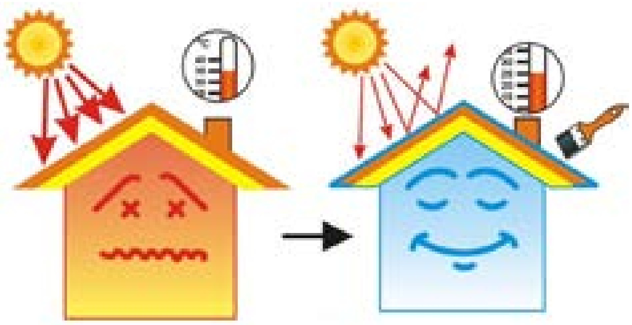


Vegetation (left) and porch (right) for shading

Large roof overhang in Roluos Cheung Aek

Window with shutters in Roluos Cheung Aek

Light coloured Materials



House with dark roof (left) heats up more than house with white roof (right)

Dark coloured objects absorb more sun light and heat than light coloured object. That is the reason why building in hot climate should be painted using a light colour, in the best case white. Particularly, crucial is the colour of the roof which is most exposed to the sun. Painting the roof white is a low-cost measure and can be done by the house owners themselves.

Painting manufacturers have also developed a special paint, called cool roof paints. Cool roof paint is a highly reflective paint that ensures a high albedo effective and can be applied on all kind of roof surfaces.

Red shingle roof in Phnom Penh is painted white

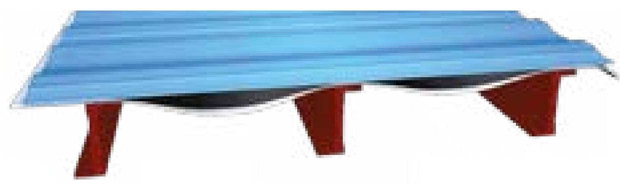
Roof Insulation

The major solar heat gain of the houses happens through the roof. Therefore, it is highly recommended to increase the insulation level of the roof using tradition methods or adding a low-cost insulation layer.

In traditional houses of Cambodia, palm matting was used as roofing materials. The limited durability of these roofs has led to the use of corrugates metal roof sheets instead. The thermal resistance of metal roof is very low. That means the metal roofing heat up very quickly during the day and radiates the heat into the house.

A very effective and low-cost option to keep the roof and the house cool is to add an reflective (bubble) foil insulation layer (also called radiant barrier) below the corrugated metal sheet. The temperature below the roof can be reduced by 3°C to 7°C.

The different methods to install such an insulation layer are illustrated in the pictures. If its possible a small air gap between the metal sheet and the insulation foil should be foreseen.



Roof insulation draped below metal sheet with air gap

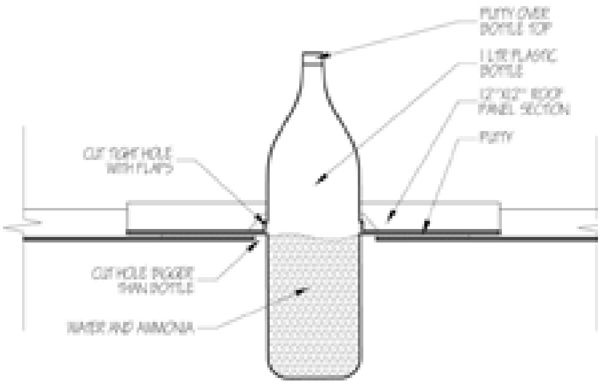
Roof insulation below metal sheet using battens

Roof insulation below rafters as retrofit solution

Reduce energy cost

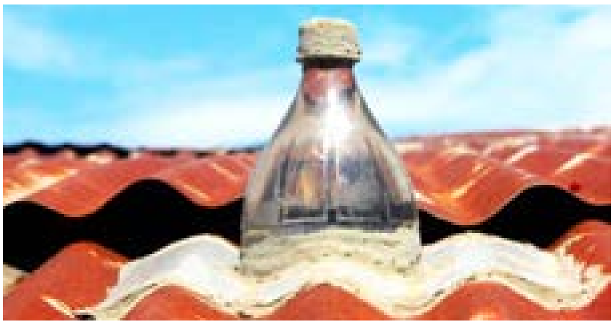
Why?

Energy use in building is a major contributor to climate change. Becoming climate-smart means also becoming energy-efficient. Reducing energy consumption will also reduce energy cost which can contribute to alleviate poverty in urban poor communities in Cambodia. In these communities energy is mainly used for cooking, lighting and fans. Only few households uses refrigerators. More energy-efficient household equipment will make sure that your monthly energy bill stays low. While selecting the right technology, health risks and the risk of fire should be considered



Solar Bottle Light

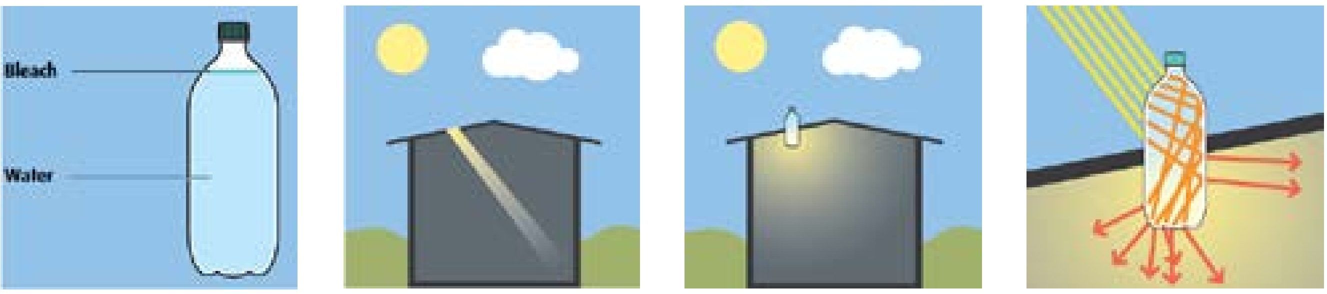
Following the principle of “Litter to Light”, the solar bottle bulb targets urban poor community in dense settlements, where even during the day, their dwellings are extremely dark. Instead of using a normal light bulb which consumes electricity that has to be payed at a high price, solar bottles bulbs can provide light for free during the day. Water inside the bottle refracts sunlight during the daytime and creates the same intensity as a 55 watt light bulb, making daylight affordable and easy.



Solar bottle light in metal roof

Materials needed:

1. Big PET Bottle
2. Galvanized iron sheet
3. Rubber sealant
4. 10ml bleach
5. 1000ml clear filtered water



4 Steps of how to make a solar bottle light

Energy-efficient Lighting

Electricity is expensive in Cambodia. Therefore, it is always cost-effective to use the most efficient lighting technology. For the same lighting level conventional incandescent lamps uses 60 Watt while more efficient CFL bulbs need only 14 Watt. The most efficient lighting are LED bulb which are not so much more expensive anymore. Compared to all other technologies LED bulbs have the longest life time of about 25,000 hours while CFL bulbs last only 8,000 hours. It is important to buy good quality LED lights with warranty from the shop.

Incandescent CFL LED

Efficient cook stove for wood & charcoal

LPG gas Cylinder with stove

Efficient Cooking

Many urban poor household still uses charcoal or wood for cooking because they cannot afford to purchase a LPG cylinder and a gas cooking stove. While cooking with charcoal the use of efficient cooking stove is recommended. Energy-efficient cooking stove are locally produced and easily available at low cost (between 5 to 20 US-Dollar).

Cooking with charcoal comes along with a high risk of fire hazard. It is also more expensive than cooking with LPG. It is necessary to set up a micro-finance scheme for the purchase of LPG cooking technology. This would enable urban poor households the access to modern and cheap cooking fuels.

Solar Energy

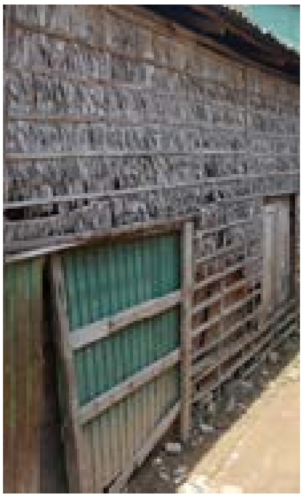
If a community cannot be connected to the public electricity grid or is only connected via a middle man who charges very high electricity prices (2000 Riel and above), solar energy can become an alternative option for lighting and other small energy uses in the houses.

The high upfront cost of solar energy systems can only be payed by urban poor household if a micro-finance scheme is in place. All electricity consuming devices have to run on direct current (DC). In the long run, solar Photovoltaic (PV) system can be very cost-effective because the sun light is free of cost. Nowadays solar power batteries have a very long life time (if well maintained) and have to be only replaced every 5 to 10 years.

Low-carbon and upcycled materials

Why?

Climate-damaging carbon emission are also produced during the manufacturing of building materials. The sum of all energy required to produce a material is called embodied energy or embodied carbon. Depending on the manufacturing process the embodied energy or carbon emissions can be lower or higher. Climate-smart buildings should use low-carbon materials. Another options for reducing the embodied carbon of a building is to use waste materials. Transforming a waste material into a new material of better quality is called upcycling. Therefore, these materials are called upcycled materials.



Palm Leave Walling

Corrugated Bamboo Roofing

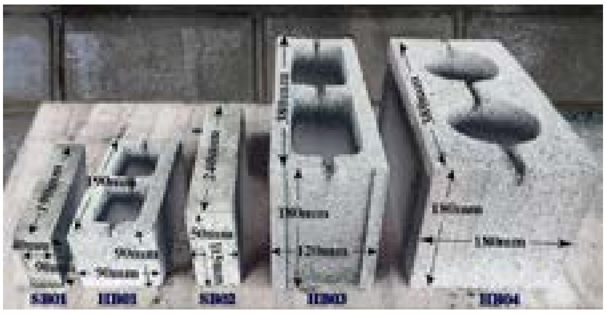
Natural Fibres and Bamboo

Light-weight materials like natural fibres and bamboo are best performing in hot and humid climates. They are also carbon-neutral. Bamboo being a fast growing renewable material is particularly suitable for low-carbon low cost housing.

Bamboo plays an important role in local economies in the Asia-Pacific region. Modern manufacturing techniques allow the use of bamboo in timber-based industries, to provide bamboo flooring, board products, laminates and furniture. Compressed bamboo roof sheets set an attractive option for replacing metal sheet roofs.

Hollow Concrete Blocks

Hollow concrete blocks have a lower embodied energy than traditional clay bricks. The reason for that is that clay bricks have to be burnt in a brick kiln at very high temperature. Brick kilns in developing countries often use out-dated in-efficient manufacturing technology and are responsible for huge amount of green house gas emissions and other air pollutants. Hollow clay bricks have lower embodied carbon than full clay brick. However, they are responsible for more carbon emissions compared to hollow concrete blocks. The construction cost of hollow concrete walls is also lower compared to clay brick walls because you need less mortar and less time (labour) as concrete blocks are bigger than clay bricks.



Types of Hollow Concrete Blocks in Cambodia

Compressed Earth Bricks (CEB) or Eco Bricks

Compressed Earth Bricks or Eco Bricks are unfired bricks manufactured in a mechanical press. The brick are made from an appropriate mix of fairly dry inorganic subsoil, non-expensive clay, and aggregate If the blocks are stabilized with a chemical binder such as Portland cement they are called compressed stabilized earth block (CSEB). The compression strength of a properly made Eco Brick can meet or exceed that of a typical cement brick. Eco Bricks are very climate-smart because they are not kiln-fired and use abundantly available local material. Furthermore, a house made of Eco bricks is 20 to 40% cheaper than a conventional brick houses.

More information available at: http://ourdreamhomes.biz

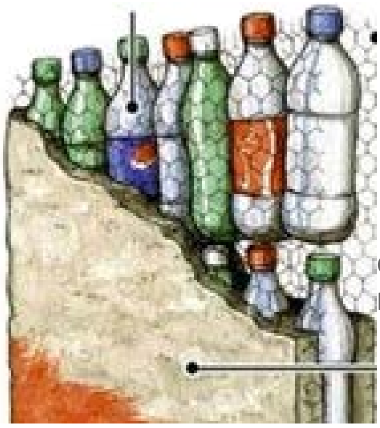


Eco Bricks made in Cambodia

Plastic Bottle Wall

Using plastic bottles for wall infill is not only climate-smart but can also reduce construction cost. Starting a community clean-up campaign together with the initiative of collecting plastic bottles and plastic waste for construction activities might be a good start to raise awareness and improve the living conditions in these communities.

The plastic bottles are filled up with plastic waste and then used instead of bricks or concrete block to build walls. Placing bottles right side up within a frame is known as a vertical bottle wall, while lying the bottles on their side is considered a horizontal bottle wall. The plastic bottle wall can be plastered like a normal brick wall after the application of metal wires or a mesh which holds the bottles together.



Layers of plastic bottle wall

Construction approach:

1. Build structural frame
2. Collect and fill bottles
3. Align bottles in wall cavity
4. Overlay frame with wires mesh to hold bottles together
5. Stuff loose plastic around bottle gaps
6. Plaster wall for clean finish



Installation of bottle wall in Kouk Khleang Youth Center

Manage Solid Waste

Reduce, Reuse and Recycle

Why?

Waste management is a challenging topic all over Cambodia. Typically, people pack all kinds of waste together in one plastic bag, making it difficult to separate for recycling and composting. In urban poor communities, it is not unusual to see flying plastic bags and other rubbish laying around. Hazardous waste is often burnt on the site with other kinds of waste releasing toxic gases. This not only pollute the environment but also leads to health problems of the inhabitants.

In Cambodia, there is no central system in place to reduce, recycle or compost the waste. All collected waste is disposed in a dumping site (also called land fill) in the outskirts of the cities. Landfills are emitting climate-damaging gases like carbon dioxide and methane. Therefore, there is an urgent need to reduce waste and avoid waste dumping in landfills.

About 70% of household waste is organic matter which could be easily composted or even used in a biogas plant to generate cooking gas. Awareness and education is needed to improve the waste management within the communities. The following actions can help to reduce the environmental pollution and keep the communities clean. Cleaner communities might also improve the reputation and the relationship with the whole neighbourhood.

Community Clean-up Day and Awareness Programme on Waste separationCons

Raising awareness about the environment is essential to dealing with the problem of rubbish outside the bin and improper rubbish packaging. When people truly understand the impact of their actions, they are more likely to change themselves. This kind of self-awareness is even more effective than rules and regulations because people will be willing to change without being forced.

Improper waste disposal pollutes our environment

Therefore, it is so important to start waste management activities with an awareness and educational programme. This event could be combined with a community cleanup day. The following topics should be included in the educational programme:

1. Impact of improper waste management for the environment and the communities
2. 3R Approach: Reduce, Reuse, and Recycle
3. Waste separation and value of waste (aluminium cans, paper, glass and plastic bottles)
4. Composting organic waste
5. Waste-to-energy: Biogas for urban areas
6. Upcycling of waste

Awareness Programme and Clean-up Day

How to separate household waste

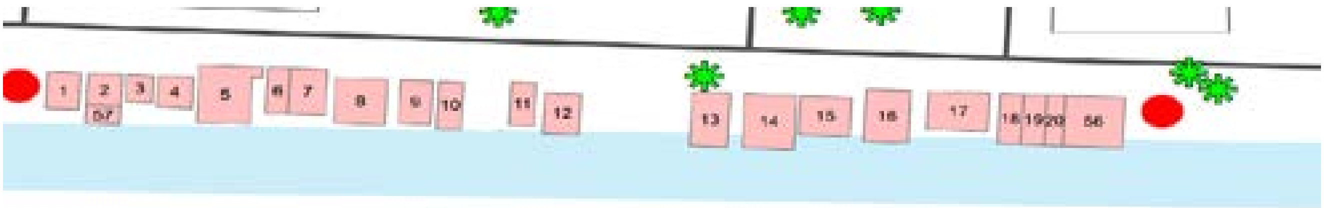
Central waste collection place

The waste in urban areas is generally collected by the rubbish collection firm CINTRI. Waste collection takes only place if a household or community pays for it. The payment is done through the electricity bill. That means if a community is not officially connected to the power grid, waste collection is also not payed and collected.

The waste is often collected a bit far from the communities along the next bigger road. The installation of one or several waste collection places in the community can avoid that rubbish bags are laying around the community. Such waste disposal places for the community would also help CINTRI because the garbage truck has only to stop at few places to collect the rubbish compared to the situation before.

It is important to involve CINTRI in the process of setting up the waste collection places to identify the best location. Furthermore, the community members need to become aware about the waste collection days.

Waste Collectors from CINTRI in Phnom Penh



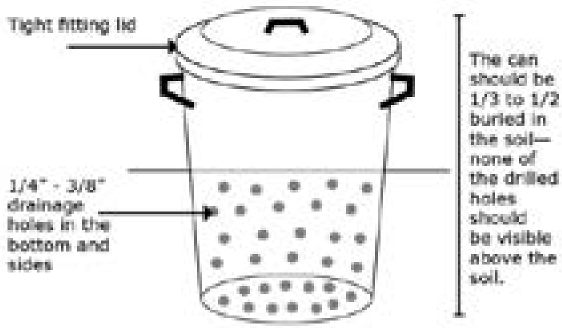
Possible Central Waste Collection Places (Red Circles) in Urban Poor Community

Composting of Organic Waste

Between 60% and 80% of household waste in Cambodia is organic material such as kitchen waste, food leftovers, etc. This waste can easily be composted on household or community level. Composting of waste is an aerobic (in the presence of air) method of decomposing solid wastes. The process involves decomposition of organic waste into humus known as compost which is a good fertiliser for plants. In rural areas of Cambodia composting is practise in a pile on the ground. The limited available space in urban areas make this technique not suitable for urban poor communities.

Instead a simple composting bin can be used on household level. During a practical composting workshop the community members are guided how make a low-cost composting. Moreover, they should learn how composting works and which waste is organic waste.

For smaller communities and where space in available, it might be also possible to install and community composting place. This can be operated by one community member as a business model. He or she could sell the humus to nurseries and generate some additional income.



Homemade Composting Bins

Biogas Plants

For Urban and Peri-urban Areas

A biogas plant or digester is a technology which uses waste food or dung/manure to generate biogas for cooking. Although many biogas plants are already installed in Camdodia's rural areas, it is not used in the urban context.

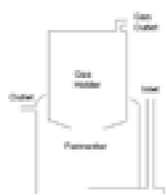
Compact Biodigester

The Indian Appropriate Rural Technology Institute (ARTI) has developed a small biogas digester that uses starchy or sugary wastes as feedstock, including waste flour, vegetable residues, waste food, fruit peelings, rotten fruit, oil cake, rhizomes of banana, and non-edible seeds. These household digesters have a small footprint and are made from cut-down high-density polythene (HDPE) water tanks. A heat gun can be used to make them and standard HDPE fittings can be used. While the conventional biogas system occupies about 4 cubic meters of space, the compact biogas system is about as large as a domestic refrigerator. It is an extremely user friendly system, because it requires daily only a couple of kg feedstock. For best results the feedstock (stuff you put in the fermenter) should be blended so that it is smooth. The starter mix can be cattle dung blended in water or some waste flour. The feeding of the biogas plant is built up over a few weeks until it provides a steady supply of gas. This is typically 250-500 grams of gas per day from 1-2 kg (dry matter) of feed. An inlet is provided for adding feedstock, and an overflow for removing the digested residue. The biogas digester should be set up in a sunny place close to the kitchen, so a short section of pipe can take the biogas to the kitchen.

This compact biogas plant is a suitable solution for small cooking businesses in the urban poor communities. This kind of business produces more organic waste than a usual household which makes the technology more feasible. The collection of organic waste from the neighbours or the whole community could add feedstock and increase the amount of produced cooking gas. Once it is installed and in operation, the biogas plant produces cooking gas for free and less waste is disposed in landfills. The upfront cost for installing the biogas digester is between 350 and 650 US-Dollar depending on size and technology. A micro-financing scheme should be set-up to make the installation in urban poor communities possible.

More information available at:
https://energypedia.info/wiki/Biogas_Plant_by_ARTI https://www.atecbio.com/

Compact Biogas Digester with Cooking Stove



Parts of a Biogas

Typical Kitchen

ATEC Biogas Plant in Cambodia

Tire-Tube Biodigester

Another small-scale biodigester was developed in Bangladesh using tire tubes. This kind of plant is even smaller and cheaper than the ARTI biogas plant.

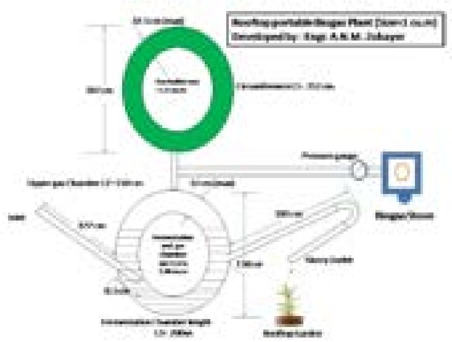
The developed tube-type rooftop biogas plant is best run with kitchen and food waste for methane production. Kitchen waste as feedstock has a higher energy density compared to manure and digestion takes place rapidly. So a smaller quantity of decomposing material needs to be held in the plant. 2-3 kg (dry matter) kitchen and food waste feedstock produces about 1 cubic metre of biogas. The wet organic material (kitchen waste and food waste) is collected in bins and containers brought to the rooftop. The waste is then mixed with water (twice daily 1kg of kitchen waste with 2 litres of water) and directly charged into the inlet of biogas digester, where bacteria breaks down the material and releases biogas.

A rubber pipe connects the biogas digester to the gas stove, where it is used for cooking. The outlet from the biogas digester lets out the very watery slurry, which can be used as organic fertiliser.

A pressure gage is used to monitor the pressure of the biogas that is available for cooking purposes. A hydraulic chamber is not applied. Instead the plant is pressurized through weight on the gas holder. The biogas plant has the capacity to hold 1.0 m3 gas and is able to provide enough biogas to cook for 1.5 hours (in total) per day and produces best quality organic fertiliser.

A big plus for this type of plant is the fact that the core parts can be made out of recycled materials. In this case rejected tractor tubes have been used for the digester and gas holder. Piping, gas valve, pressure gauge and stove had to be bought. The total cost of the plant material shown in the picture was around 70 US-Dollars.

More information available at:
https://energypedia.info/wiki/TyreTube_Biogas_Plant



Components of a Tire Tube Biodigester

Biogas plant in Bangladesh made of Tire Tubes

Cooking with Biogas in Cambodia

Water and Sanitation

Why?

Access to clean drinking water and proper sanitation is a huge challenge in urban poor communities. The public water supply and the sewage does often not reach these communities. Water supply is often provided by expensive private suppliers and implies high water cost for the urban poor families.

It is not unusual that open defecation is still practised due to the absence of toilets in the houses. Many communities are built above and along the water channel of Phnom Penh. Defecation directly into the water bodies is still a common practise. Consequently, inhabitant of the communities are exposed to highly polluted waste water that increases the risk of diarrhoea and other water-related diseases.

Rain water harvesting

Rainwater harvesting is an option that has been adopted in many regions of the world where conventional water supply systems have failed to meet peoples needs. Collecting the rainwater in urban poor communities is an easy way to reduce the cost for the purchase of water.

The rainwater harvesting system has a collection area (typically the roof of a house), a distribution system and a storage tank. Guttering is used to transport rainwater from the roof to the storage vessel. Guttering comes in a wide variety of shapes and forms, ranging from the factory made PVC pipe to home made guttering using bamboo or folded metal sheet. Guttering is usually fixed to the building just below the roof and catches the water as it falls from the roof.

In the context of urban poor communities rainwater harvesting can fulfil the whole water demand for one household only during the rainy season. For this a water storage tank of about 3,000 litres needs to be installed. This volume is equivalent to three traditional water jars used in the rural areas of Cambodia. Concrete ring tanks can be also installed at low-cost storage and with the help of community members. They have a higher storage capacity than traditional water jars, typically 3,000 to 5,000 litres.

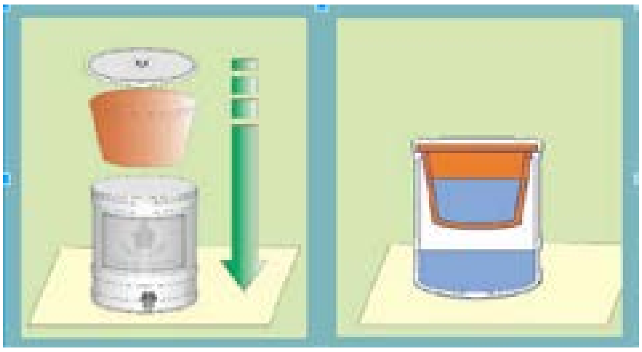
More information on rainwater harvesting can be found at:
http://www.rainwatercambodia.org/
http://rdic.org/rain-water-collection/

Rainwater Jar in Rural Cambodia

Ceramic water filters

Dwellers in Cambodian urban poor communities are much concerned about the safety of drinking water. In some communities ground water wells are located near to polluted waste water channel and the water is probably contaminated bearing a health risk for those using and drinking it.

Beside boiling the water, ceramic water filter can be a very effective and low-cost option to provide safe drinking water to urban poor households. The water filters are locally produced and can be purchased for about 20 US-Dollar. Ceramic water filters removes all germs and bacteria from water and works with rain water, surface and well water.



Components and Functioning of a Ceramic Water Filter

How does it work?

1. A specially constructed clay/ceramic pot is placed inside the top of a large water storage container.
2. Contaminated water is poured into the ceramic pot.
3. As the water seeps through the porous pot, nearly all of the impurities are removed.
4. Pure drinkable water is collected in the large water container.

Ceramic water filters cannot remove arsenic from water. As a result, this is not a good device for treating arsenic contaminated well water.

More information on water filters can be found at: http://rdic.org/ceramic-water-filters/

Ceramic Filter Production in Cambodia

Natural Sanitation Solution

Natural sanitation systems are an innovative solution to treat waste water locally, protect the environment and lower the health risk of water-related diseases in the communities. The technology is called **Constructed Wetlands** and uses the natural functions of vegetation, soil, and micro organisms to treat waste water naturally. The water produced from constructed wetlands is usually non-potable, but keeps the local environment healthy, and can be recycled for reuse, e.g. for irrigation purposes.

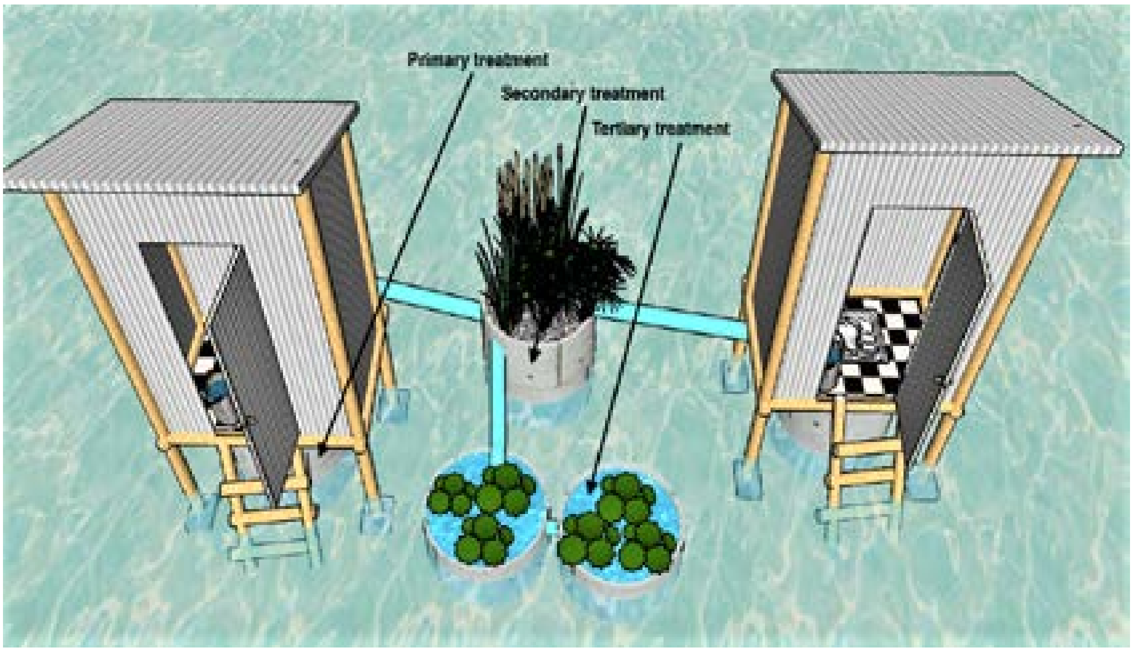
Constructed wetlands are not new in Cambodia. They are already installed in several flood-prone communities and in floating villages. Using constructed wetlands, household's wastewater can be contained and treated to a high grey water standard. The three stage treatment design for flood-resilient sanitation is the first appropriate system for poor, marginalised populations. The system needs little space and relies on gravity flow; no energy, electrical, or chemical systems are required.

In floating communities, a small water basin is inserted under a floating house's toilet, capturing the raw sewage and treating it using microbial and other ecological communities enabled by the plants and their root systems. The Pod was successfully tested in a floating village for over three years, leading to a product that isolates and treats wastewater efficiently with no aesthetic problems in terms of smell or 'visuals', no mosquitoes, no chemicals, and basically no maintenance.

More information can be found at:
http://wetlandswork.com

Handy Pod in floating Village in Cambodia

Visualisation of Handy Pod for floating Villages



Natural Sanitation Solution for flood-prone Communities

Stilt Houses in Roluos Cheung Aek Community

Flood Protection

Flooding events have increased in Cambodia's urban settlements as a result of climate change and urban development. Neighbourhoods are often not properly designed to ensure on site rainwater retention and to provide an effective sewer system to drain high peaks of water during the rainy season. Flooding disperses the wastewater from sewerage, which causes water pollution, epidemic diseases, as well as damage to houses and infrastructures. Urban poor communities are often more affected because of the absence of sewage connection and the proximity to the water channels.

Houses in the communities are often built as stilt houses as protection against the flooding. For upgrades or the construction of new houses, it has to be ensured that the distance from the ground is large enough to avoid flooding inside the houses.

Generally, the problem of flooding has to be tackled effectively on a larger scale (city and regional-scale) with a well-balanced strategy of different engineered options like the construction of dykes and embankments, or the protection of wetlands and flood plains. However, in the following some basic options are given on how to adapt to flooding at the scale of buildings and neighbourhoods (Hesse et al., 2011).

Examples for Basic Individual Flood Adaptation

1. Lifted Ground Level

2. Ramps and Stairs

3. Shafts for flooding protection (Hessse et al., 2011)

	Neighborhood Scale	Building Scale
Elevation above flood level	Raising the level of alleys and/ or building blocks	Levelling the basement/ ground floor of the house
Dry flood proofing constructions	Permanent (dykes) or temporary (flood walls) water defences	Permanent or temporary water proof floors
Wet flood proofing constructions	Water resistant streets with floodsafe escape routes	Water resistant ground floors with temporary uses
Other techniques		Dyke and drainage pipe Water pump

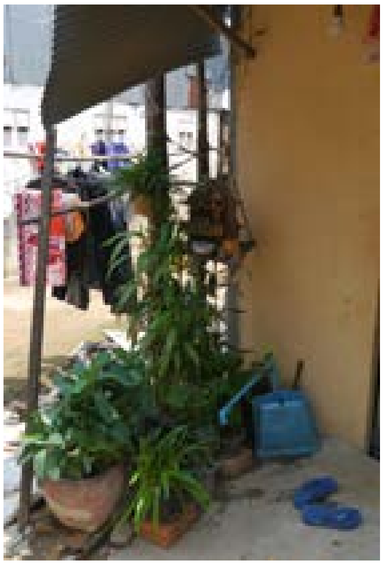
Flood Protection Options on Neighborhood Scale and Building Scale

Small Vegetable Garden

Creating green spaces in dense urban settlements

Why

Urban settlements have higher temperatures than its rural surroundings due to the so-called urban heat island effect. This effect is caused by the greater absorption, retention, and generation of heat by buildings, pavements, and human activities in the city. Studies have shown that cities can be up to 3°C warmer than the surrounding rural area. Vegetation can contribute significantly to reduce the urban heat island effect and make our urban settlements cooler.



Plants in front of house in Sen Reak Rey Community

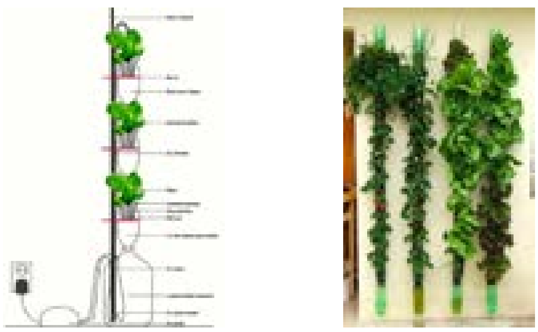
Vertical garden

The limited availability of space makes it difficult to plant fruit trees or other vegetation in urban poor communities of Cambodia. However, the building facades can be used to plant veggies and herbs in a vertical garden. The concept of vertical gardens arrived from the idea to use vertical space, for example along a building facade, to stack, hang and plant vegetables. Using freely available plastic bottles, pots or cups makes this solution available at a low cost. Hanging plants in front of the house wall also provide shading and makes the houses cooler.

Guiding workshop might be provided to support community members to set up a vertical or bag garden. These kind of workshop should be as practical as possible and can be combined with a waste and plastic bottle collection campaign.

Vertical Garden made of Plastic Bottles

Hanging Tomato plant in Sean Reak Rey Community



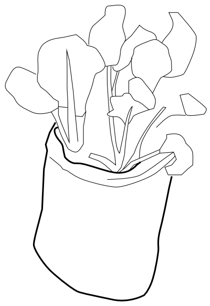
Vertical Garden with water-efficient Irrigation System

Bag gardening

Vegetable gardening does not need much space nor money. Rice or cement bags can be used instead of expensive flower pots to plant veggies like spinach, tomatoes, onions, etc. This so-called bag garden has a volume of about 1 square metre and represents a farmable surface area of 5 square metres. Bag gardening is very suitable for urban poor communities because they improve the micro-climate in these dense settlement and help people to enrich their food diet. Bag gardening need very little water and are very cheap to set up.

How to make a bag garden?

Step 1 | Necessary Materials: A woven burlap or plastic bag, such as a rice bag. Enough soil or dirt mixed with compost or animal manure to fill the bag. Enough small stones and metal cans with holes for the watering system. Seedlings of whatever plant life is desired. A knife or other device capable of cutting through the bag. Enough water to water the bag garden every day.



Step 2 | Create the Base: Fill the bottom of the bag or sack with soil. Place the metal cans with the holes in the centre of the bag and then fill it with rocks – this is used as the watering system for the bag garden. Water is poured over the rocks and it slowly filters through the stones, gradually watering the vegetables without flooding them.

Step 3 | Build Up: Fill the area around the can with soil up to about the top lip of the can. The can should now be pulled up, letting the stones fall out of the bottom so that the stones are in the middle of the dirt. Keep the can on top of the rock center and refill it again.

Step 4 | Fill the Bag: Repeat step 3 until the bag has been filled. The bag should now contain an uninterrupted core of rocks surrounded by earth all the way to the top.

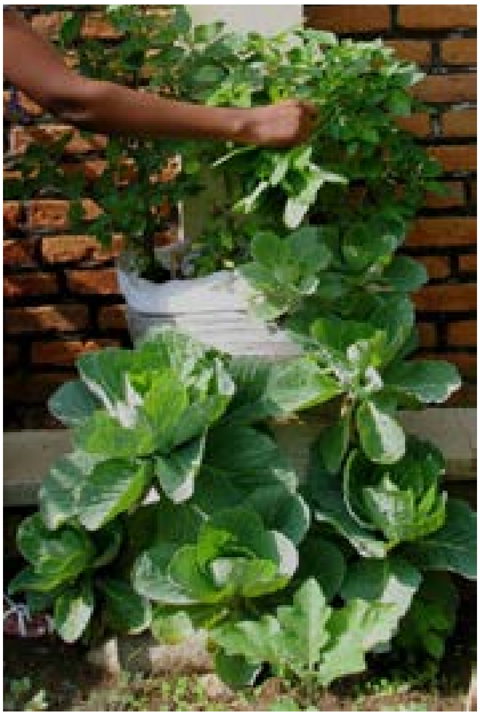
Step 5 |Cut Sites for Plant Growth: Make a number of holes in the side of the bag at an even distance apart. These holes are where most if not all of the seedlings are going to be transplanted to.

Step 6 | Transplant seedlings into the holes on the sides.

Step 7: Plant on the Top: Either plant seeds or transplant more seedlings into the open top of the bag. Since this is the only horizontal surface for growth on the bag, consider using the top for tubers.

Step 8 | Maintain, water, care for, and harvest; as necessary. Always water from above to utilise the rock irrigation channel.

Step 9 | Recycling: Bag gardens can be used to grow plants during one growing season. After the plants die, the dead plants and roots should be taken out of the dirt. Once the growing season is over, the bag should be emptied, with the stones and any dead roots taken out of the dirt. The bag garden can be made again for the next growing season



Example of Bag Garden

More information can be accessed at:

http://www.appropedia.org/Bag_gardens

Step-wise Process of making a Bag Garden

Chapter 2

The Communities

Introduction

The Phnom Penh Survey 2014[1] from STT identified a total of 340 urban poor settlements in Phnom Penh. With increasing pressure on more commercialized land use in the city center, there is a trend that urban poor families live in the outer Khans of the city. Compared to only 80 urban poor settlements in the inner Khans, three quarter of them, namely 260, are located in the outer Khans.

The majority of settlements (71%)[1] are not organized as communities, meaning that they do not have a community leader or saving group. The majority of settlements are rather small having not more that 50 building structures.[1]

People in urban poor settlement are mainly working as formal or public sector workers (18%), Construction Workers (17%), Factory Workers (17%),Motodop / Tuk Tuk drivers (16%), and Traders (small shop or street vendor; 13%). Women are predominately engaged in factory labour and men in construction, formal occupations, and motodop / tuk tuk drivers. [2]

Infrastructure and service provision is laking in the urban poor communities in Phnom Penh. The situation in the settlements located in the outer Khan is worse than in the inner Khan. The most important challenges are lack of adequate sanitation facilities, connection drainage, solid waste collection, electricity and water supply. The impact on health is particularly obvious in the case of water-related diseases. Twelve percent of household have no access to improved sanitation.[2]

Methodology

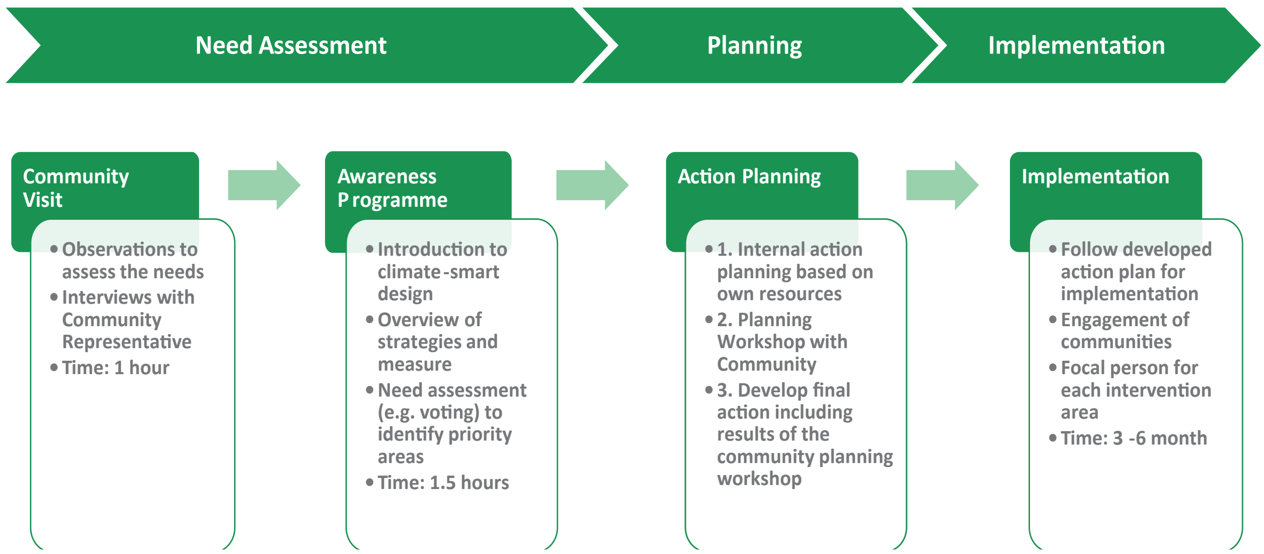
The here presented climate-smart design guidelines were developed based on the need of urban poor settlement in Cambodia. The figure below illustrated the methodology that was applied.

The first step to identify the needs and assess the current situation was a community visit. A total of 6 communities were visited and interview with the community representative and other members were conducted. Secondly, two communities, namely Rolous Cheung Ek and Samaki Rung Roeurng, were chosen as pilot communities and an awareness programme on climate-smart design was conducted. During this programme community member got the opportunities to express their need regarding the importance of climate-smart design options.

Consequently, the planning process started that aim to bring climate-smart design into reality. Also in this phase, it was important to involve the community by conducting a planning workshop.

Finally, based on the developed action plan the implementation could start. At this point, it is important to mention that the communities chose three priority areas our of the six climate-smart design clusters.

The following chapter highlights the results of the need assessment - the first step of climate-smart design interventions.



Methodology for Climate-smart Design Assessment and Implementation

[1] Sahmakum Teang Tnaut (STT), 2014: The Phnom Penh Survey - A Study on Urban Poor Settlements in Phnom Penh.

[2] People In Need (PIN) and UNICEF 2014: Phnom Penh Multiple Indicator Assessment of the Urban Poor.

Rolous Cheung Ek

Community profile

Rolous Cheung Ek is a community living under threat of eviction in Rolous village, Sangkhat Cheung Ek, Dangkor district, 10 km away from central Phnom Penh. The community first settled there in 1987 and have been living along the canal without decent housing and a safe and clean environment. Through research and mapping exercises carried out by STT, some information on this community has been recorded.

The community is currently made up of 56 households containing 89 families, 277 members (142 of which are female, 3 of which are disabled). The community was organised in 2009 and in the past it had a saving scheme, however due to a lack of trust in the committee members the scheme was not processed and following this the committee disintegrated.

The majority of residents are unskilled workers serving as construction workers, garment factory workers, motor doub (motor taxi drivers), tuk-tuk drivers and food hawkers or recycling vendors. The monthly income of these households is approximately \$100-\$150, and as such are considered to be amongst Phnom Penh's urban poor. This income is spent on the high cost of living associated with Phnom Penh for food, their children's education, utility fees, and other social activities.

The residents living in this community have reported a number of problems which affect their daily lives and standards of living of which poor infrastructure is their largest concern. This includes dilapidated housing structures, poor roads, electrical pillars in a state of disrepair and inadequate drainage systems. Other critical issues include poor sanitation and waste management including a lack of toilet facilities, an absence of social services, and financial limitations. The threat of eviction and lack of tenure security in the form of land titles remains a critical issue for the residents and can lead to families unwilling to invest in improvements.

The poor quality of house material and a lack of funds to repair housings are big challenges raised by the community in Rolous Cheung Ek. Most houses are constructed from low quality wood, with the roof and walls covered by a mix of old zinc, and either wooden or concrete columns. Many of the houses lack roofs, walls, and are in critical need of repair. Security is a large concern for many residents and as such many of the houses do not have windows.

Currently, the community has access to electricity and water (from a well) by a 'middle man' which leads to inflated costs that the residents struggle to pay. The latter is particularly concerning given that the area is prone to significant flooding as a result of living along the canal area. None of the residents have land titles, placing them at risk of land eviction. At present this community does not receive support from civil society organizations.

Opportunities

- Many houses in very bad conditions, intervention needed
- Construction of 17 new houses and toilets planned
- Location closed to Monument 'Killing fields', maybe we can showcase for tourists also to fund-raise money for more houses in other communities?

Challenges

- Financial resources of families limited
- Families are already displaced from evicted communities

Photos showing the existing condition of the community

Photos showing the existing condition of the community

Samaki Rung Roeurng

Community profile

Samaki Rung Roeurng community is located on state public land along a canal near Boeung Trabek. Residents received a formal eviction notice in 2010, but after they protested the Khan guaranteed they would not demolish their houses. However, in 2014 the Sangkhat numbered houses with spray paint, apparently in preparation for eviction. Other challenges facing the community include gambling, flooding, and hygiene problems from living by sewage. The Community has 67 houses and is home to 92 families, in total 446 people.

Housing and land tenure

The community has not undergone the Systematic

Land Titling process. No families have received land titles outside of this process. Khan Chamkarmon has informed the community they live on state public land.

The Municipality of Phnom Penh restored the canal in 2010. On 17 September 2010, Khan Chamkarmorn released a letter informing households along the canal and wider community to voluntarily leave within 10 days of receiving the announcement. After protesting in front of the MPP and the Prime Minister's cabinet, the Khan informally ask the community to keep silent, with the guarantee that they would no longer demolish their houses.

In 2012, STT has provided a mapping to community residents.

Access to services and utilities

The community is nearby Boeung Trabek Khang Thbong primary school (1km away), Boeung Trabek Khang Cheung secondary school (2km), Phsar Deum Thkov health centre (2km), Phsar Boeung Trabek market (0.5km) and Monivong Boulevard (0.5km).

Community infrastructure

The community is accessed by a small concrete alley, fitting one person or motorbike. The alley is at the end of street 97 and 99. There is only a partial drainage system. Households along the canal use the canal, and other houses have pipes that flow into the canal.

The community is connected to state electricity (720 Riel/kWh). Residents get water from the Phnom Penh Water Supply authority (550 Riel/m^3) and private suppliers. CINTRI collects rubbish. There is no communal street lighting.

Due to flooding, sometimes lasting over two week, some houses cannot accessed at all.

Community assets

There was previously a savings scheme, established in 2004. A year later they had saved more than 1 million Riel, keeping it in a UPDF account. It is UPDF policy that after a community deposit, they can request funds to improve living conditions. They requested funds to extend small businesses and repair houses. Unfortunately, the savings scheme no longer operates because residents' income has decreased and they have lost interest.

Hazards and risks

Hazards and risks include polluted/dirty water and air and living near a garbage dump. Gambling is also a significant concern. The top three challenges include threat of displacement; waste under homes and lack of hygiene living near sewage; and unsafe electricity connections.

Future plans

STT mapping identified that some residents wish to get a ID-POOR card to save money at the health centres.

During the need assessment, community representative and members were very motivated to improve the waste management in the community. They also stated that housing upgrades are needed to make them more comfortable because of poor ventilation and overheating.

Opportunities

- Motivation of community member to improve waste management
- Close to all basic infrastructure, can be developed to Green Community
- Well organized as community with recognized representative

Challenges

- Flooding problem might be outside of our project scope - Adaptation to flooding, dialogue with local authorities
- Possible eviction due to land use conflicts with local authority

Needs Assessment

Rolous Cheung Ek

Observations during first Community Visit

The community is accessed through a 2-lane dirt road in parallel to the canal and the houses. There is no sewage or draining system and some people built toilets above the canals. Open defecation is still practised by many community members due to the absence of toilets.

Most of the houses are in very bad conditions. They are built as stilt houses with wood structure and metal or wooden cladding. The houses are often very dark inside and are not well ventilated.

Some house are currently rebuild with the support from foreigners (private people). Those newly built houses have are standing on concrete columns. The house itself is a wooden structure with the pitched metal roof. Front walls are made of painted wooden cladding. Side and back walls is cladded by corrugated metal sheets.

Many household practice already rainwater harvesting which is not sufficient to fulfil all water needs. The community has installed 8 wells ($200 per well) which extract water from a depth of about 25 metres. It can be assumed that the ground water is polluted because the well is situated next to the highly polluted cannel. Community members also report often cases of diarrheal. Water can be also purchased from a commercial provider at 5000 Riel per jar.

Electricity is provided by a private supplier at a rate of 1600 Riel per Kilowatt-hour. All houses have lighting but only few have other household devices like TV and fridge. Most households in the community uses biomass for cooking. Charcoal or wood is used in efficient cook stoves. Only few uses still open three stone fire. Community member have stated that they would like to use LPG gas but have no money to purchase cook stove and gas cylinders.

During the visit it was noticed that the waste is not very well managed in the community. Waste can be seen all around the main road and below the houses. CINTRI collects rubbish from the main road, but not where the community is located. That means community member have to walk between 400 and 1000 meters to the main road for waste disposal (depending on the location of the house).

Community mapping carried out by STT

Awareness Programme with Community on Climate-smart Design

Date: 4 May 2017 from 3pm to 4:30pm

Location: Roluos Cheung Aek Community

The awareness programme was attended by about 25 adults (15 female) and 15 children. After a short introductory round Ms. Susanne Bodach gave a presentation on the climate changes, its impact on the livelihood, on climate-smart design and possible interventions to improve housing and infrastructure of the community. Mr. Soa Kosal was acting as a translator and guiding the discussion.

It was interesting to see that some participants are already aware about climate change issues. It seems that they have seen programmes on TV on this topic. The participants showed a great interest in the topic during the presentation. During the discussion round few comments were made by the participants which are listed in the following:

- Question: Can you use the solar bottle light contraption to run a TV?
- Comment: We do not have money to buy a gas cylinder and cooker.
- Comment: CFL light bulbs are used by almost all residents in the community.
- Comment: One community member mentioned that she had seen plastic bottles being upcycled before and used to construct houses.
- Comment: Some community members had heard of and were aware of composting.
- Comment: One community member mentioned she had heard about biogas before and she had seen it being used in another neighboring community.

At the end of the interaction, all participants could indicate their interest by voting for the 5 different clusters of climate-smart design measures (see Table 1).

The most important areas for intervention are:

1. **Waste management,**
2. **Improve thermal comfort of houses, and**
3. **Water management.**

Table 1: Results of voting for different climate-smart design clusters

No.	*Cluster*	*Number of votes*
1	Improve thermal comfort (Make the houses cooler)	16
2	Reduce energy cost	9
3	Waste management	17
4	Create green spaces and gardening	10

Needs Assessment

Samaki Rung Roeurng

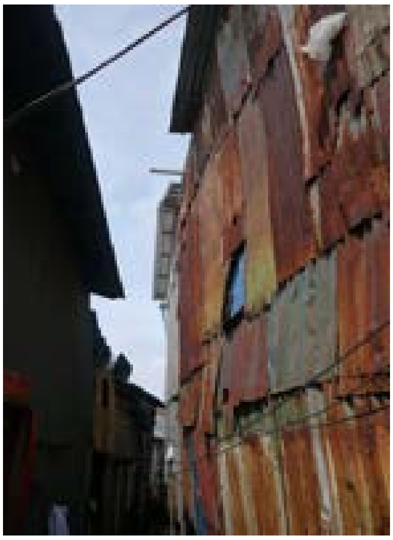
Observations during first Community Visit

The community is accessed through a small lane that ends in a concrete and wooden bridge over the canal. Almost all houses are built as stilt houses over the canal. Houses are generally attached to each other and very little space is left between them. It is a very dense settlement.

Most of the houses are built as wooden structure with metal cladded walls and metal roof. Many of them are in very bad conditions. Houses have very small opening which do not assure sufficient ventilation.

Community members have access to public electricity and also public water supply. However, they are not connected to the sewage system. That means black and waste water goes directly into the canal bearing a health risk for the community.

During the visit it was noticed that the waste is not very well managed in the community. Plastic and other waste can be seen at the entry to the community around the small alley and under most houses.



Community mapping carried out by STT

Awareness Programme with Community on Climate-smart Design

Date: 4 August 2017 from 8am to 11am

Locarion: STT Meeting Room

The awareness programme was attended by about 15 adults (11 female). Firstly, Mr. Sao Kosal welcomed the participants and gaves the open remarks. Then, Ms. Susanne Bodach gave a presentation on the climate changes, its impact on the livelihood, on climate-smart design and possible interventions to improve housing and infrastructure of the community. Mr. Sren was acting as a translator and guiding the discussion.

The participants showed a great interest in the topic during the presentation. During the discussion round the community representative stated that the community has already solved two big issues to improve their livelyhood. Firstly, they got access to the public electricity grid and, secondly, they get water from teh public water supply which is very cheap. However, particpants stated that waste is a big problem. Furthermore, the house are very hot during the summer.

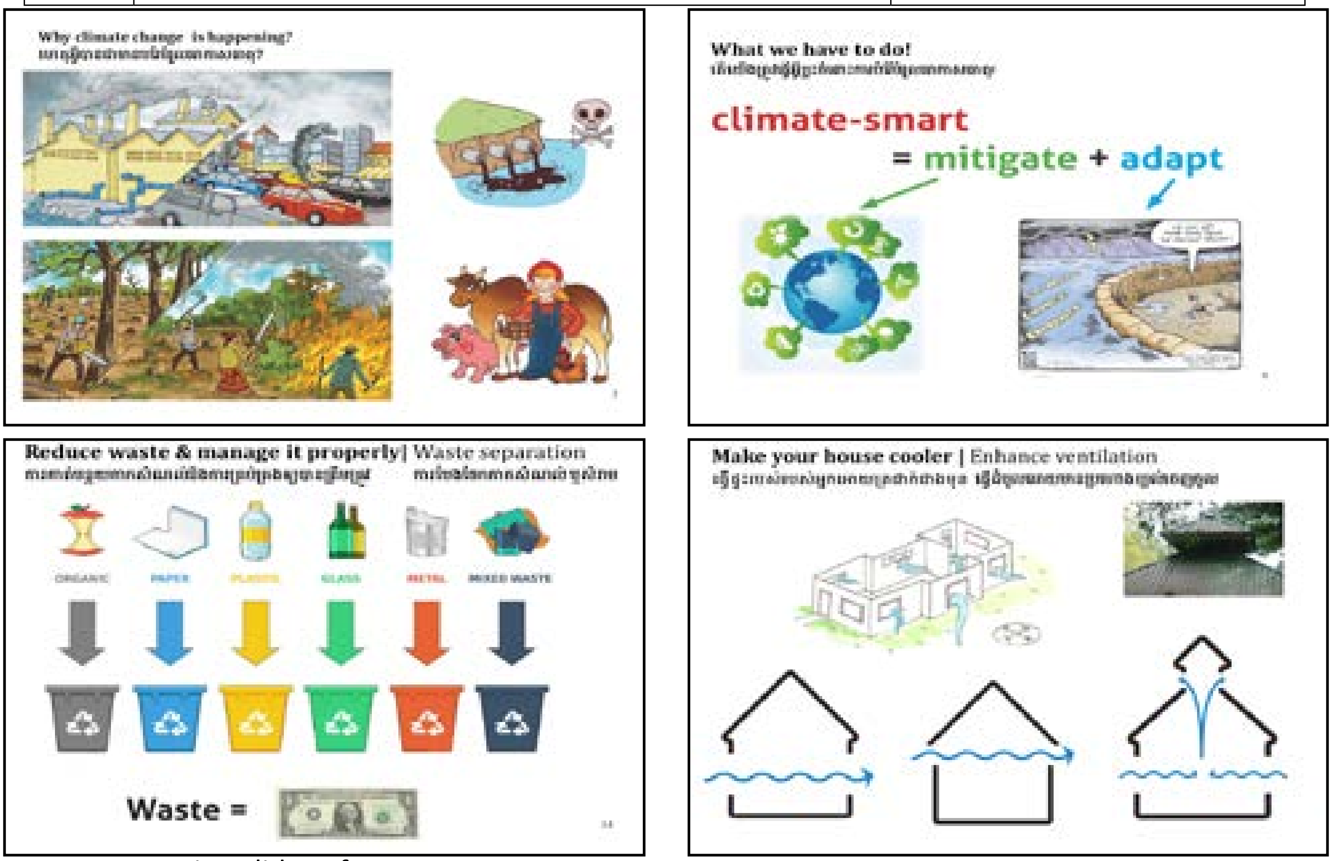
At the end of the interaction, all participants could indicate their interest by voting for the 4 different clusters of climate-smart design measures (see Table 2).

It was concluded that the most important areas for intervention are:

1. **Waste management,**
2. **Improve thermal comfort of houses, and**
3. **Water management.**

Table 2: Results of voting for different climate-smart design clusters

No.	*Cluster*	*Number of votes*
1	Improve thermal comfort (Make the houses cooler)	10
2	Reduce energy cost	1
3	Waste management and green spaces/gardening	16
4	Water management (Drinking water, rain harvesting/flood protection/ treat waste water)	4



Four presentation slides of awareness programme

Chapter 3

Case Studies

Climate-smart and sustainable design is not completely new in Cambodia. We have found a number of projects where climate-smart design strategies were implemented. The idea of this chapter was to show that these strategies and technologies can work in the local context.

Most of the example follow a community involved low-tech and low-cost approach. That make them so relevant for the replication in urban poor communities.

Each project is summarised in one page which contains the most relevant information on the location, type and year of the project as well as the applied strategies and materials. All examples are located in Cambodia and may serve as a collection of Best Practices on Climate-Smart and Sustainable Design for the country.

Coconut School

Ouk Vanday

www.coconutschool.org

Location: Ronas Village, Koh Dach (Silk Island)
Completed: 2013
Type: School for English, computer studies
Sustainable strategies: As well natural ventilation and lighting incorporated into the lightweight structure, there are future plans to incorporate solar panels.
Materials: The school is built almost entirely out of recycled materials- used coffee cups (roof), coloured plastic (mural), beer bottles (foundation for walls, pots for plants), coconut trees which are plentiful on the island, and old car tyres. Students are encouraged to provide plastic and other recyclable from their community.

The entrance roof is made of used coffee cups

Walls built using old car tires

Donated computers and recycled bottle light www.huskcambodia.org

Bottle buildings

Husk Cambodia

Location: Ronas Village, Koh Dach (Silk Island)

Completed: 2013

Type: School for English, computer studies

Sustainable strategies: As well natural ventilation and lighting incorporated into the lightweight structure, there are future plans to incorporate solar panels.

Materials: The school is built almost entirely out of recycled materials- used coffee cups (roof), coloured plastic (mural), beer bottles (foundation for walls, pots for plants), coconut trees which are plentiful on the island, and old car tyres. Students are encouraged to provide plastic and other recyclable from their community.

The Eco Blocks are bottles stuffed with plastic bags, polystyrene trays, straws.

The Eco Blocks are tied together to create blocks that build up the wall which is then covered with chicken net.

The walls of bottles are covered with plaster.

www.komitu.blogspot.com

KOMITU ARCHITECTS

Kouk Khleang Youth Centre

Komitu Architects with Cambodian Volunteers for Society, Khmer Kampuchea Krom for Human Rights and Development Association

Location: Kouk Khleang community

Completed: 2014

Type: School

Sustainable strategies: The structure incorporates rainwater harvesting tanks, eco-bricks and natural ventilation and light. Sustainable building practises were explored through workshops with local students of architecture and engineering. The future users of the building and surrounding community participated in the design and build process.

Materials: Low carbon materials such as bamboo, compressed earth blocks and recycled plastic bottles.

The main feature is the slatted bamboo facade, which creates a dynamic light and shadows

Eco-bricks constructed using plastic bottles are used to construct the walls

On the site adjoining water treatment plant, the Youth Centre provides a quiet space in the busy, built-up neighbourhood

IDEA School
Idea Project

www.ideaproject.org.hk

Location: Kampot
Completed: 2011
Type: Preschool and skill centre

Sustainable strategies: Openings in walls and roof for natural ventilation and daylight greatly improve conditions for studying. Local teachers and students were trained in design skills to empower sustainable living. Workshops with children through design development and construction, allow children to take an active role in constructing their school and create a sense of ownership.

Materials: Re-used everyday materials collected in neighbourhood.

Workshops with children to develop the design of the school and capture their needs for good lighting and ventilation. The children's artwork is integrated into the design of the school.

Rubbish reused for play: water pipes to transfer sound, car tires for jumping, dishes from the local market for decoration.

Framework House

Atelier COLE

with Building Trust International and Habitat for Humanity

www.ateliercole.com

COLE

Location: Phnom Penh

Type: Housing (9 low cost pilots)

Sustainable strategies: The homes are elevated atop pre-cast concrete pillars to protect against flood risk. A split-roof and operable shutters allow natural ventilation, while overhanging canopies mitigate solar heat gain. The build process was used as a tool for community engagement. Training was given on site-specific natural building techniques to allow low for future adaptation.

Materials: Sustainably grown timber, bamboo, natural materials, and recycled materials to reduce carbon footprint

Cost: Approx $2,500, funded through SELAVIP

The homes are adaptable and allow for expansion, for example families can choose to fill in the ground floor

Site specific wall and floor materials reduce the overall cost and carbon footprint

The design builds on traditional techniques and forms with a raised first floor for flood protection.

www.littledream.org

Thon Mun Community Centre

Project Little Dream

Location: Takeo

Completed: 2013

Type: Free elementary school, public gathering space

Sustainable strategies: The porous bamboo screens allow for natural ventilation while the ceiling bamboo screen extends between the two classroom volumes to create a natural shaded corridor.

Materials: Locally abundant bamboo used for walls and ceilings. The gabion wall was formed by wire cages filled up with rubble from local temples that had been destroyed in the past.

The school and public gathering space is formed by two structures on a raised platform and connected by a shaded patio area.

Bamboo: local craftsmen and volunteers used indigenous materials and tradition

Rubble was collected from local temples that had been destroyed to create the gabion walls for the sanitary facilities.

Wet + Dry House
Visionary Design Development

www.vdd.com.au

Location: Phnom Penh outskirts

Type: Low income housing

Sustainable strategies: Rather than elevating, the structure was constructed as a multi-stage response to flooding in mind, set at different heights to allow for more sustained use. The small building footprint reduces costs and allows for more green space. Raised roof for cross ventilation as well as openings in the brick wall. Roof gutter takes water into 1300L water tank for kitchen and bathroom.

Materials: Brick walls, trees for shading, recycled tyres, earth, open-able wall panels

Cost: Approx $2,000

Front wall swings down to extend common area and create an entry ramp to provide access to the disabled

Brick walls with ventilation openings provide increased resilience.

The dual-purpose porch serves as a store-front, and keeps the sense of community alive by opening the home to neighbours. Replaceable wall panels with open-able windows to allow for flexibility and privacy.

Open Embrace

Keith Greenwald and Lisa Ekle

Location: Phnom Penh outskirts

Type: Low income housing prototype

Sustainable strategies: The living quarters, set on clay brick piers, respond to the cyclical nature of the climate, protecting against floods while opening up space to socialize in the dry season. The corrugated zinc roof, indented slightly to let in natural sunlight and air, reduces heat gain and but captures rainwater in cisterns.

Materials: The materials are familiar and largely sourced locally including bamboo, timber, clay bricks and corrugated zinc.

Cost: Approx $2,000

Between the columns, an enclosure is wrapped in bamboo panels, with one end opening to a raised courtyard space via swinging partitions enabling a family to extend or reduce living quarters as needed throughout the day

Local techniques and materials: clay bricks and locally sourced timber

A new take on the traditional stilt house creates a shaded flexible space underneath to allow different uses during wet and dry season

Courtyard House
Jess Lumley and Alexander Koller

Location: Phnom Penh outskirts

Type: Low income housing prototype

Sustainable strategies: The stilt structure and bridged courtyard provides ventilation and breathing room on a confined 5x12m plot.

Materials: The house recasts traditional elements, such as a brick wall, timber posts, and palm leaf matting and bamboo shutters, which create playful patterns of light and allow for ventilation. The brick boundary wall creates a natural fire break, while also allowing another house to be built up against it in the future, saving cost.

Cost: Approx $2,000

The bridged courtyard connects the upper washing and cooking spaces and serves as a natural clothesline

The raised structure provides shade and space for motorbikes and hammocks underneath

The house incorporates differentiated areas for the family; for gathering, sleeping, washing, cooking, and playing, etc.

www.cookfox.com

Neeson Cripps Academy

COOKFOX Architects

with Cambodian Children' Fund and Velcro Companies

Location: Phum Damnak Thum, Phnom Penh (former garbage dump)

Type: Education facility

Sustainable strategies: Water and energy efficiency via natural lighting, integrated solar shading, low energy lighting, and low flow water fixtures. An energy recovery system to improve air quality inside classrooms by filtering outdoor air into the interior of the building, and on-site photovoltaic cells will provide a portion of the school's energy needs.

Materials: Natural materials such as bamboo and locally sourced terracotta

The roof top has a multi-purpose athletic court, and a teaching garden filled with local plants and vegetables, which will also help to reduce storm water runoff and minimize solar heat gain

The open-air learning spaces are shaded with a bamboo screen, while other parts of the building use terracotta fins

The flexible open ground floor creates a versatile gathering space and mitigates potential flooding

Waste management project

EXO foundation

with COMPED (Cambodian Education and Waste Management Organisation)

www.exofoundation.org

Location: Battambang

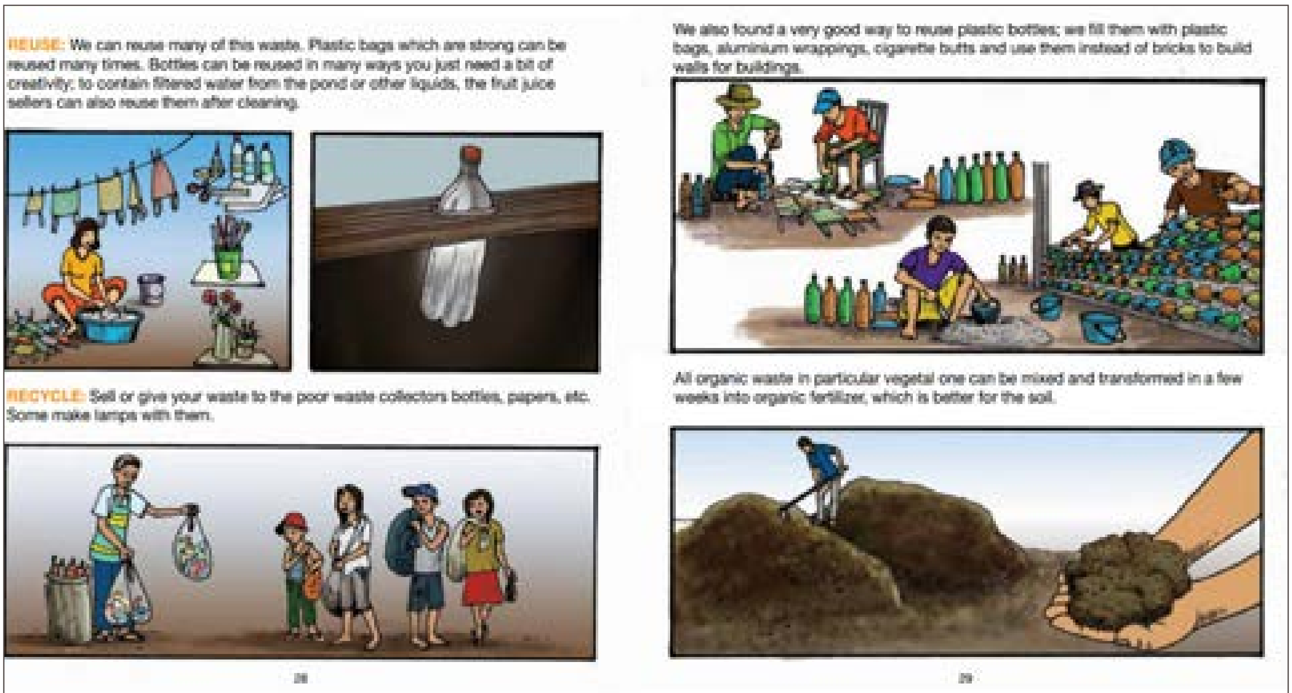
Type: House, education and training

Sustainable strategies: Social sustainability- education by sensitising locals through conferences, theatre plays and comic books. Creating new economic activities by training and paying local waste pickers to sort and create Eco-bricks (plastic bottles filled with clean non-organic rubbish)

Materials: Eco-brick

Cost: $14,000

The bottles are collected from the street and from local hotels. By clearing waste sites and providing a financial incentive to local waste pickers, the environmental impact caused by the production of bricks is greatly reduced.



Excerpt from comic strip distributed to locals explaining the risks of uncontrolled waste disposal on people and environment

Sra Pou Vocational School
Architects Rudanko + Kankkunen

www.rudanko-kankkunen.com

Location: Sra Pou Village

Completed: 2011

Type: Vocational training and community centre

Sustainable strategies: The whole school is hand-made. This allowed employing many people from the community, and keeping all techniques simple and transferable. The holes created within the walls allow for ventilation and light.

Materials: By teaching people how to make the most out of easily available materials, so that they can apply the same techniques in the future. The red soil on site was used to make sundried soil blocks.

The soil block walls are laid out with small holes, for indirect sunlight and gentle wind to cool the spaces

The colourful handicraft doors welcome visitors coming along the main road

The school building is made out of local materials with local workforce. The whole community space cant be opened, providing comfortable shaded outdoor space

Tmat Boey Ecolodge

Building Trust International

with Wildlife Conservation Society

www.buildingtrustinternational.org

Location: Kuen Promtep Wildlife Sanctuary, Tmat Boey

Type: Eco lodge facility for ecotourism project

Sustainable strategies: The angled roof structure helps to reduce solar gain, while the bamboo walls provides shading. Participatory approach through design and build with the local community provided skills for locals to become custodians for their natural habitats.

Materials: An adobe mix using earth on-site was placed on the external walls with lime plaster which created a cooling effect. Locally sourced bamboo was used to create the roof and walls. Recycled plastic bottles from the local community were used to create a staircase.

The overhanging split roof is angled to reduce solar gain on the walls.

The adobe and lime plaster has a cooling effect creating a natural airflow throughout.

Moveable swinging windows built from locally sourced timber can be positioned to allow guests to watch wildlife

Phnom Tamao Wildlife Centre

Building Trust International

with atelier COLE and Free the Bears

www.buildingtrustinternational.org

Location: Phnom Tamao, Phnom Penh

Type: Kiosk in sanctuary for rescued bears

Sustainable strategies: The building workshop and kiosk showcases natural building and construction techniques. The aim is to educate visitors on the benefits of renewable energy strategies such as solar power, harvesting rainwater and bio-gas as alternatives to mainstream energy sources.

Materials: The design makes use of natural materials such as locally sourced bamboo for the roof construction and adobe bricks (clay,sand) for the walls. Scrap metal was also collected from the site and re-purposed into the new building.

The on-site 'show' kiosk which educates visitors on conservation and how to build with natural materials promoting both new and traditional construction techniques for locals to apply to their own constructions in the future

Bamboo trusses are used to form the roof structure

Details: glass bottle lighting feature and adobe bricks www.buildingtrustinternational.org

Eco Hut

Building Trust International

with Hand in Heart Project

Location: Siem Reap

Type: Housing

Sustainable strategies: As much material as possible was sourced from the site to reduce carbon footprint. Earth bags were fill on site and adobe was used for walls. The type of adobe is called cobb and is a mixture of earth (sand and clay), rise husks and water. The thick mud was then applied directly to earth bags filled with material from the site to form the facade. Recycled glass bottle walls allow light into the interior spaces. Openings in the roof allow for natural ventilation.

Materials: Earthbags, adobe and recycled glass bottles.

Filling the bags with earth on site


Recycled glass bottles walls can create interesting light effects in interior spaces


Mixing traditional Khmer features of the palm tree leaf weave roof with the earthbag technique

Conclusion

Becoming climate-smart is the challenge of the 21th century and it is necessary to act at local level. Any upgrade interventions in urban poor settlements should be climate-smart to ensure that this marginalized group of our cities is not left behind.

Climate-smart design include climate change adaptation as well as mitigation measure. Aiming the poorest strata of the urban population, affordability of implementation has to be considered. Therefore, the set of climate-smart design measure presented in this book is focusing on low-tech and low-cost solutions. However, awareness raising activities have to conducted before implementation and the involvement of the community during the planning phase is essential to ensure ownership and successful implementation.

The collection of examples presented in Chapter 3 - Case Study shows that climate-smart and sustainable design is not new to Cambodia. However, there is a urgent need to scale up these activities and convince more decision makers to consider climate-smart design in the development of our cities.


COMMUNITY
Cleanup