Study of Climate Change Adaptation Measures Lacking Funding in Sri Lanka

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Abbreviations

Asian Development Bank	ADB
Asian Development Fund	ADF
Batticaloa Municipal Council	BMC
Carbon Dioxide	CO_2
Clean Development Mechanism	CDM
Climate Change Thematic Research Programme	CCTRP
Climate resilient action Plans for Coastal urban areas of Sri Lanka	CCSL
Conflict Affected Regional Emergency Projects	CARE
Divisional Secretariats Divisions	DS divisions
Farmer Organizations	FOs
GIS-based Rapid Response System	RRS
Global Environment Facility	GEF
Government of Sri Lanka	GOSL
Gross Domestic Product	GDP
International Organization for Migration	IOM
Intergovernmental Panel on Climate Change	IPCC
Iranamadu Irrigation Development Project	IIDP
Japan International Cooperation Agency	JICA
Kankasanthurai	KKS
Mekong Asia Pacific/Community Based Adaptation	MAP/CBA
Methane	CH4
Million cubic metres	MCM
National Building Research Organization	NBRO
National Climate Change Adaptation Strategy	NCCAS
National Water Supply and Drainage Board	NWSDB
National Federation for Conservation of Traditional Seeds and Agricultural Resources	NFCTSAR
Negombo Municipal Council	NMC
Nordic Climate Facility	NCF
Nordic Development Fund	NDF
Nordic Environment Finance Corporation	NEFCO

Norwegian Institute of Water Research	NIVA
Practical Action	PA
Reverse Osmosis	RO
Rice Research & Development Institute	RRDI
Salt Water Exclusion Bunds	SWE Bunds
Sri Lankan Rupee	LKR
United Nations Framework Convention on Climate Change	UNFCCC
United Nations High Commissioner for Refugees	UNHCR
United States Dollar	USD

1. INTRODUCTION

Sri Lanka is an island situated off the Southern tip of India and separated from India by the Palk Strait. Due to the location of Sri Lanka, within the tropics between 5^o 55' to 9^o 51' North latitude and between 79^o 42' to 81^o 53' East longitude, the climate of the island is characterized as tropical. The maximum length of the country is 435 km and maximum width is 240 km. Thus, Sri Lanka is considered as a small island. Despite the small size, the 2012 census[1] reports a total population of 20,277,597 in Sri Lanka. According to Central Bank data 2012, the per capita GDP is USD 2,923.

The coastal line which is about 1,585 km comprises sandy beaches, extensive lagoons, and estuaries with mangroves, coastal marshes and dunes. The South Central parts of the island consist of mountainous areas. This mountain region is the origin of the major river systems which flow across the lowlands into the Indian Ocean. This major river system is the life wire of North Central and Eastern province agriculture irrigation system. The topography of the southwest is characterized by long parallel ridges that are cut by these rivers. The northern and north-central parts of the island form one great plain, and the coast.

Sri Lanka has traditionally been divided into three climatic zones: a wet zone in the southwestern region including central hill country, a dry zone covering predominantly, northern and eastern parts of the country, and an intermediate zone, skirting the central hills except in the south and the west (Department of Agriculture[2]). Contribution of Southwest monsoon rains, soils, land use and vegetation have been widely used for above classification. The wet zone receives relatively high mean annual rainfall of over 2,500 mm without pronounced dry periods. The dry zone receives a mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September. The intermediate zone receives a mean annual rainfall between 1,750 and 2,500 mm with a short and less prominent dry season. According to the Department of Meteorology of Sri Lanka, "Rainfall in Sri Lanka has multiple origins. Monsoonal, Convectional and Expressional rain account for a major share of the annual rainfall. The mean annual rainfall varies from under 900 mm in the driest parts (southeastern and northwestern) to over 5,000 mm in the wettest parts[3]."

The climate experienced during 12 months period in Sri Lanka can be characterized into four climate seasons as follows:

1. First inter-monsoon season - March - April
2. Southwest monsoon season - May - September
3. Second inter-monsoon season - October - November
4. Northeast monsoon season - December - February

[1] http://www.cbsl.gov.lk/pics_n_docs/10_pub/_docs/statistics/other/econ_&_ss_2013_e.pdf
[2] http://www.agridept.gov.lk/index.php/en/crop-recommendations/903
[3] http://www.meteo.gov.lk/index.php?option=com_content&view=article&id=106&Itemid=81&

Traditionally Sri Lanka has been considered as an agricultural country although at present the agricultural sector is the smallest out of three main sectors of the economy: agriculture 11%, industry 30% and services 59%. However, it is important to note that agriculture is the sector that provides the highest percentage of employment and livelihood opportunities to the Sri Lankan labor force. The highest 33% of employment of the labor force is created by the agriculture sector. Agriculture is done in almost all the regions in the country. Tea and rubber are mainly grown in wet zones, and paddy and coconuts are cultivated in intermediate and dry zones. The dry zone agriculture is mainly determined by seasonal rainfalls and the irrigation systems.

Global warming, driven by the rising greenhouse gas concentrations especially CO_2 in the Earth's atmosphere, could cause many changes to ecosystems of the world. One of the most important changes is climate change which is a long-term shift or alteration in the climate. Temperature and precipitation are the most important climatic parameters that have the highest impacts on human life. Therefore, scientists have used available climatic data and information into several large-scale models of the atmosphere. These models are used to predict changes in temperature, precipitation, radiation, and other climate variables caused by increased greenhouse gas concentrations in the atmosphere. Climate change is a global problem that affects all countries despite their relative economic development. It is commonly known that intensive industrialization is the main cause of climate change.

The Intergovernmental Panel on Climate Change (IPCC) estimated that the mean global temperature might be increased by 1.4°C-5.8°C (2.52°F –10.44°F) during the 21st century (IPCC 2007[4]). In Sri Lanka, the highest mean temperature is predicted in Anuradhapura by 2.1°C (A2) and 1.6°C (B2). During the Southwest monsoon period (May to September) the overall increase in mean annual air temperature across the island is predicted to increase by 1.6°C (A1) and 1.2°C (B2) (de Silva, 2006[5]). Further, the Northeast monsoon rainfall is also predicted to decrease in selected dry zone stations. Therefore, the decreased rainfall and increase in temperature will increase the evapotranspiration and soil moisture deficits. Agricultural activities in the dry zone may be affected by predicted climate change impacts on water resources in Sri Lanka.

Temperature-related extreme indices have increased over most locations in Sri Lanka. Annual average rainfall over Sri Lanka has been decreasing for the last 57 years at a rate of about 7 mm per year. The coefficient of variation of rainfall distribution between 1931 and 1960 is greater during the Northeast monsoon and Second inter monsoon period (*Maha* season) when compared to the period from 1961 to 1990. Southwest monsoon rainfall has not shown any significant change during these two periods. However, variability has decreased between 1961 and1990 compared to the 1931-1960 period.

According to National Climate Change Policy of Sri Lanka, the Sri Lankan state has identified Sri Lanka as a country highly vulnerable to climate change although it is a low-emission

[4] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html
[5] http://wedc.lboro.ac.uk/resources/conference/32/DeSilva.pdf

country with relatively less addition to climate change. “Being a developing island nation subject to tropical climate patterns, Sri Lanka is highly vulnerable to climate change impacts. Extreme weather events such as high intensity rainfall followed by flash floods and landslides, and extended dry periods resulting in water scarcity are now becoming common occurrences in Sri Lanka. Any adverse changes in already volatile weather patterns are likely impact adversely on the socio-economic activities in the country” (UN Habitat[6])

A recent report by Oxfam[7] explains that “Climate change in Sri Lanka is expected to lead to a rise in sea level, higher temperatures, more frequent and prolonged droughts, high intensity rainfalls and increased thunder activity. Climate change impacts could include: inundations, flooding, storm damage, and coastal erosion affecting human settlements and wetlands; decreases in agricultural crop yields; pollution of waterways and wells, leading to increases in waterborne diseases; and increased soil erosion from heavy rainfall events. These anticipated changes represent a significant threat to the coastal areas, as well as to different sectors of the national economy and human health.” Thus, climate change can be identified as a cross cutting issue in Sri Lankan society.

Although Sri Lanka has been identified as highly vulnerable to climate change, no adequate interventions to mitigate or to adapt to adverse impacts of climate change have been made so far. Although many studies have been done to grasp the impact of climate change, no serious studies have been implemented to understand the reasons for the above inadequacies. Holding the assumption that climate change funding is one of such causes, this report is an effort to identify such gaps and to recommend what has to be done to mitigate climate change vulnerability of the country. This report mainly looks at climate change adaptation policies and measures implemented so far in the country. Based on already implemented projects, the study tries to identify different areas of adaptation interventions that are immediately required, resources they are lacking and their funding needs in particular. The objective of this report is to give an overall picture of crucial climate change adaptation measures lacking funding which will help funders in the field to strategize how to make effective contribution to Sri Lanka.

6 http://www.unhabitat.lk/downloads/Climate_Change_Policy.pdf

7 Review of Climate Change Adaptation Practices in South Asiahttp://www.oxfam.org/sites/www.oxfam.org/files/rr-climate-change-adaptation-south-asia-161111-en.pdf

2. LITERATURE REVIEW

2.1. Climate Change and Challenges to Development in Sri Lanka

Sri Lanka has launched into an unprecedented development drive, the success of which is critical for the nation. 'The Mahinda Chinthana: Vision for the Future', 'A New Sri Lanka, a Brighter Future', the 'Mahinda Chinthana, Vision for a New Sri Lanka' and 'A Ten-Year Horizon Development Framework' outline the overarching development strategy Sri Lanka is pursuing. Investments of approximately Rs. 4.3 trillion (EUR 8,045,977,011) are planned under this framework for the 2006-2016 period (Ministry of Finance and Planning 2006[8]). One of the main strategies according to this plan is to make Sri Lanka self-sufficient in agriculture. Both paddy cultivation and export crops have been provided subsidies worth millions.

However, some of such investments are at risk due to climate change—a global phenomenon which we cannot avoid and must prepare to face as a nation. Urgent and constructive action is needed to address the challenges climate change will pose to Sri Lanka's development trajectory. A Climate Change Thematic Research Program (CCTRP) is formulated to be a key part of this process. It will provide policy and decision makers with the research-based recommendations they will need to address the challenges ahead.

Human-induced climate change has emerged as a major concern of our times. Having initially emerged as an environmental issue, it is now regarded globally as an overarching development challenge that can seriously affect economic growth, food security, public health, and social stability. Developing countries are especially vulnerable (Jayathunga 2011[9]).

According to the Ministry of Environment and Natural Resources, "The full extent of climate change impacts on Sri Lanka is still being studied, but there is growing recognition that climate change may threaten the significant achievements the country has made in the last 20 years in increasing incomes and reducing poverty" (MoENR 2011[10]). Sri Lanka's development framework as articulated in the 'Mahinda Chinthana' documents outline the overarching development strategy Sri Lanka is pursuing. All of the key thrusts of Sri Lanka's development framework show vulnerabilities to climate change, and adaptive measures will be necessary to ensure their long term resilience and sustainability[11]. Research and projections indicate that Sri Lanka is highly vulnerable to effects of climate change and could be affected in different ways:

- Raised temperatures and unpredictable monsoon rains are already affecting the country's food production and water resources;
- More frequent and intense droughts, as well as extreme weather events like floods, can disrupt public life and damage property and crop harvests;

[8] http://www.treasury.gov.lk/depts/npd/publications/MahindaChintanaTenYearDevelopmentPlan.pdf

[9] https://googlegroups.com/group/climate-change 2011/attach/7943668269574671/Final%20IPW%20Report.pdf?part=6

[10] http://www.environmentmin.gov.lk/web/images/pdf/english_aannual_report.pdf

[11] http://www.climatechange.lk/adaptation/Files/Strategy_Booklet-Final_for_Print_Low_res(1).pdf

- In the longer term, rising sea levels can impact the island's highly-populated coastal areas, threatening human settlements, infrastructure and coastal/marine ecosystems

2.2. National Level Measures Taken So Far

Addressing the adverse impacts of climate change is highlighted in the government's 'Green Lanka Program 2009' and the 'Caring for the Environment: Path to Sustainable Development Action Plan 2008-12' (MoENR, 2008[12]) as priority areas requiring action. Several government departments and research institutions are engaged in studies to understand and manage climate change impacts, and to discern the optimal policy, technical and grassroots interventions. Sri Lanka is an active participant in international responses addressing both:

- **Mitigation**, which involves reducing the emission of greenhouse gases that cause man-made global warming; and

- **Adaptation**, or living with the climate change impacts that are inevitable in the upcoming years.

As part of its obligations in accordance with the UNFCCC, Sri Lanka submitted its Initial National Communication in 2000 and work on the Second National Communication was completed by the end of 2010. Although not required to do so under its UNFCCC obligations, Sri Lanka has voluntarily taken measures to engage in climate change mitigation activities, including involvement in carbon trading through the Clean Development Mechanism (CDM). This initiative is currently also being supported by JICA through a technical assistance.

In addition to ongoing mitigation activities, the Government of Sri Lanka (GOSL) recognizes that working towards mitigation alone will not protect Sri Lanka's national interests, and that given the scale of the threat Sri Lanka faces, a **focus on adaptation is critical**. With this in mind, the Ministry of Environment launched an ambitious planning process, involving a cross section of sector agencies, to develop Sri Lanka's first National Climate Change Adaptation Strategy (NCCAS). The NCCAS lays out a framework that is specific for Sri Lanka for moving stakeholders across the economy systematically towards building climate resilience.

2.3. Impacts of Climate Change on Agriculture

Definitions and explanations of the following concepts have been quoted from the web site of the Intergovernmental Panel on Climate Change[13].

Precipitation

Precipitation is the main driver of variability in the water balance over space and time and, changes in precipitation have very important implications for hydrology and water resources. Hydrological variability over time in a catchment is influenced by variations in precipitation

[12] http://www.environmentmin.gov.lk/web/pdf/Harita_Lanka_Book_small.pdf
[13] http://www.ipcc.ch/

over daily, seasonal, annual, and decade time scales. Flood frequency is affected by changes in the year-to-year variability in precipitation and by changes in short-term rainfall properties (such as storm rainfall intensity). The frequencies of low or drought flows are affected primarily by changes in the seasonal distribution of precipitation, year-to-year variability and the occurrence of prolonged droughts.

Evaporation

Evaporation from the land surface includes evaporation from open water, soil, shallow groundwater and water stored on vegetation, along with transpiration through plants. The rate of evaporation from the land surface is driven essentially by meteorological controls, mediated by the characteristics of vegetation and soils and constrained by the amount of water available. Climate change has the potential to affect all of these factors—in a combined way that is not yet clearly understood—with different components of evaporation affected differently: the primary meteorological controls on evaporation from a well-watered surface (often known as potential; evaporation) are the amount of energy available (characterized by net radiation), the moisture content of the air (humidity—a fraction of water vapor content and air temperature), and the rate of movement of air across the surface (a function of wind speed). Increasing temperature generally results in an increase in potential evaporation, largely because the water-holding capacity of air is increased. Changes in other meteorological controls may exaggerate or offset the rise in temperature, and it is possible that increased water vapor content and lower net radiation could lead to lower evaporative demands. The relative importance of different meteorological controls, however, varies geographically. In dry regions, for example, potential evaporation is driven by energy and is not constrained by atmospheric moisture contents, so changes in humidity are relatively, unimportant. In humid regions, however, atmospheric moisture content is a major limitation to evaporation, so changes in humidity have a very large effect on the rate of evaporation.

Soil Moisture

The amount of water stored in the soil is fundamentally important to agriculture and is all influenced by the rate of actual evaporation, groundwater recharge, and generation of runoff. Soil moisture contents are directly simulated by global climate models, albeit over a very coarse spatial resolution and outputs from these models give an indication of possible directions of change. The local effects of climate change of soil moisture, however, will vary not only with the degree of climate change but also with soil characteristics. The water-holding capacity of soil will affect possible changes in soil moisture deficits; the lower the capacity, the greater the sensitivity to climate change. Climate change also may affect soil characteristics, perhaps through changes in water logging or cracking, which in turn may affect soil moisture storage properties. Infiltration capacity and water-holding capacity of many soils are influenced by the frequency and intensity of freezing.

Changes in Hydrological Drought Frequency

Droughts are considerably more difficult to define in quantitative terms than floods. Droughts may be expressed in terms of rainfall deficits, soil moisture deficits, lack of flow in a river, low groundwater levels, or low reservoir levels; different definitions are used in different sectors. A

'hydrological' drought occurs when river or groundwater levels are low, and a 'water resources' drought occurs when low river, groundwater, or reservoir levels impact water use. Water resources droughts depend not only on the climatic and hydrological inputs but also critically on the characteristics of the water resource system and how droughts are managed.

Water Quality

Water in rivers, aquifers, and lakes naturally contain many dissolved materials, depending on atmospheric inputs, geological conditions and climate. These materials define the water's chemical characteristics. Its biological characteristics are defined by the flora and fauna within the water body, and temperature, sediment load and color are important physical characteristics. Water 'quality' is a function of chemical, physical and biological characteristics but is a value-laden term because it implies quality in relation to some standard. Different uses of water have different standards. Pollution can be broadly defined as deterioration of some aspect of the chemical, physical, or biological characteristics of water (its 'quality') to such an extent that it impacts some use of that water or ecosystems, within the water.

Research studies have been conducted on the effects of climate change on water resources and agriculture in Sri Lanka. Most of these studies refer to climate projections from the Hadley Centre for Climate Prediction and Research and the UK-developed *Hadley General Circulation Model* HadCM3. When projections are derived based on the Inter-governmental Panel of Climate Change Special Report on Emission Scenarios A2 and B2 for 2050s and compared with the rainfall data of baseline (1961-90), the impact of climate change on the Southwest monsoon (May to September) rainfall across the country is predicted to increase by 38% (A2) and 16% (B2). Further, it is predicted that higher volume of rainfall will cause runoff during Southwest monsoon season and will cause severe floods and landslides in Southwestern regions of the country. The Northeast monsoon (December to February) is predicted to decrease by 34% (A2) and 26 % (B2) in 2050s. Temperature is predicted to increase by about 1.5°C to 2°C. The maximum potential soil moisture deficit is predicted to increase by 11% (A2) and 4% (B2) in 2050s across the country compared to the baseline and subsequently the annual runoff is predicted to decrease in certain dry zone locations. Paddy irrigation requirements are predicted to increase on average across Sri Lanka by 23% and 13%, for the A2 and B2 scenarios respectively (de Silva *et.al,* 2007). The highest proportional increase is predicted to occur in Batticaloa by 45% (A2) and 15% (B2). This increase is mainly due to the decreased rainfall during January and February.

Agricultural crops are affected by climate change due to the relationship between crop development, growth, yield, CO_2 atmospheric concentration and climate conditions. When temperature exceeds the optimum for biological processes, crops often respond negatively with a steep drop in net growth and yield (Rosenweig and Hillel, 1995[14]). Some reports show that an increase in temperature by a single degree above normal can lead to a significant reduction in growth and yield (Pastori and Foyer, 2002[15]).

[14] http://www.gcrio.org/CONSEQUENCES/summer95/agriculture.html
[15] http://jxb.oxfordjournals.org/content/56/411/417.full

Since there will be water shortage due to the unreliability of the rainfall and increased temperature, adaptation measures should be focused on efficient use of water resources such as:

- Water saving irrigation methods (i.e. drip and sprinkler irrigation systems)
- Conservation of water by collecting in wells and ponds when rainfall is available
- Rainwater harvesting for drinking purposes

Furthermore, farmers involved in agricultural activities should focus on the following adaptation measures:

- Use of mulch and other material to conserve soil moisture without evaporating due to high temperature stress
- Using short duration, less-water-use crops such as leafy vegetables
- Using compost and organic fertilizers to hold adequate soil moisture

In general, it is identified that adaptation measures should focus on storage of excess runoff water during the Southwest monsoon for dry months and if possible store and divert this excess water to the dry zone areas for agricultural activities. In addition, land filling in the wet zone areas should be banned and allowed free drainage of runoff water. This could also encourage farmers in the wet zone to cultivate paddy in low lying areas. Rainwater harvesting should be introduced in all areas to collect excess water during the monsoon season. Further, for agricultural activities, farmers should be encouraged to use mulching by any sort of material to reduce the evaporation losses and use water saving methods such as drip or sprinkler irrigation systems to increase water use efficiency.

3. CLIMATE CHANGE ADAPTATION MEASURES IN SRI LANKA: CASE STUDIES TO IDENTIFY IMPACTS AND GAPS

This section takes into consideration various projects on climate change adaptation measures that have been implemented at grassroots level in Sri Lanka. This is an effort at understanding the level of change such projects have made in rights holders' perspective and to identify most crucial areas of future intervention. Case studies locate the areas discussed in the context of climate change, reveal how it has affected the people through their narratives, assess how the implemented projects have benefited people and minimized their vulnerabilities and identify areas of replications required. The overall objective of the case studies is to identify funding needs for climate change adaptation measures that are crucial to be implemented in the future.

Case studies of this preliminary report mainly look at projects of climate change adaptation implemented in the fields of agriculture, water and infrastructure. Climate change is a cross cutting issue. It is useful to look into individual projects to capture the impacts to come up with a set of recommendations which are useful for a broader intervention in the future. Under agriculture and water, the study looks at projects implemented in the dry zone of the country. Under infrastructure the wet zone is selected referring mainly to the increasing rainfalls which result in floods and landslides.

3.1. Adaptation Measures in Agriculture

For this study, areas in dry zones which are severely affected by climate change-induced seasonal variation of rainfall and high temperature which affects the agricultural activities were considered. The studies were done in order to capture the perception of farmers on climate change and the adaptation measures they use to cope with temperature and water scarcity. Furthermore, information on the assistance given to farmers to cope with climate change impacts and how they could be replicated for other farmers is presented. Study areas were Thellipallai in Jaffna district, Weerawila/Panaganuwa areas of Hambantota district and Thabbowa in Puttalam district. Some of the case studies were done in the form of in-depth interviews and some were done in the form of small surveys by considering the population of the areas.

3.1.1. Sprinkler Irrigation Project in Thellipalai, Jaffna: Implemented by Sewalanka Foundation

Jaffna is the northernmost district of Sri Lanka and is a peninsula. The climate of Jaffna peninsula is considered to be tropical monsoonal with a seasonal rhythm of rainfall. The temperature ranges from 26^0 C to 33^0 C. Annual precipitation ranges from 696 mm to 1,125 mm. The Northeast monsoon rain (October to January) accounts for more than 90% of the annual rainfall. Dryness causes extreme temperatures during the southwest monsoon and the heat wave of India affects the area during the months of April and May. In the months of April

- May and August - September, when the sun is overhead, the temperature stands at maximum. The coolest period occurs in December - January coinciding with the lowest sun.

The annual rainfall varies from one place to the other and also from year to year. The western part of the peninsula enjoys the mean annual rainfall of less than 1270mm whereas the eastern part has between 1,270mm to 1,905mm.The total average rainfall for 1932 was 1,874mm and for 1936 was 824mm. It is also calculated that rainfall during the Northeast monsoon forms 82% of the total annual fall.

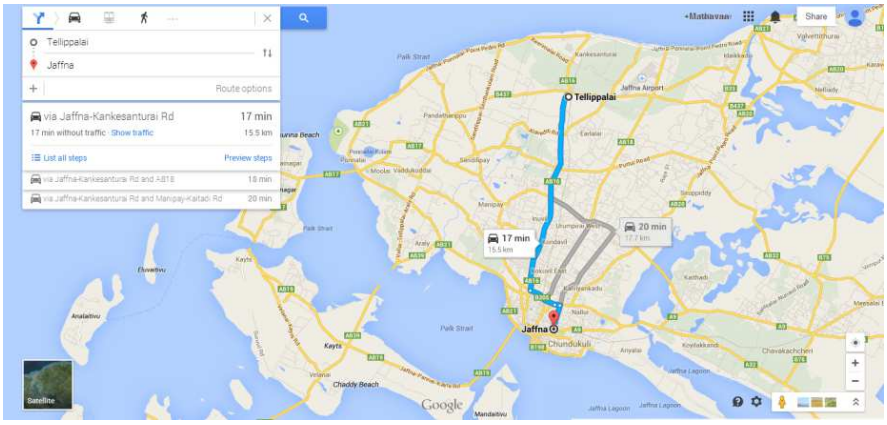
The city is surrounded by Jaffna lagoon to its west and south, Kokkuvil and Thirunelveli to the north, and Nallur to the east. Jaffna peninsula is made of limestone as it was submerged under the sea during the Miocene period. The limestone is grey, yellow and white porous-type. The entire land mass is flat and lies at sea level. Palmyrah groves can be seen where land has not been used for construction. Other notable vegetation is a leafless shrub called talai (alae africana) and koddanai (oleander).

According to a recent article in the *Sunday Times*[16], a research study conducted by Jaffna University has reported alarming information on severe water shortages in the future in Jaffna highlighting the need for immediate interventions to manage water extractions. The newspaper article quoting the above study states that "the groundwater in the limestone aquifer is the main source of water for the area. Aquifers are underground layers of rock that are saturated with water that can be brought to the surface through natural springs or by pumping. The extracted water must be replaced by new water to replenish or recharge the aquifer. But in Jaffna, this recharge rate is 0.57 million cubic meters (MCM) of water, while the extraction rate is 0.66 MCM, according to research done by M. Thushyanthy and C.S. de Silva. So, Jaffna's limestone aquifer will become depleted over the years." The above two researchers fear that the changing rainfall patterns due to climate change will impact Sri Lanka's groundwater aquifers. Not only the drought, but intense rain during a short period of time, will also disturb groundwater recharging cycles, as it will not allow rain water to leach down, but runoff quickly into rivers. The presence of buildings prevents rainwater from leaching, hence, leaching in urban areas is severely reduced, which slows down groundwater recharge, while groundwater extraction for commercial purposes is increasing. Hence, a solution needs to be found for the future.

Rapid development of agriculture, economy and increase of population due to resettlement, creates greater withdrawal of water. Especially, water extraction for agricultural purposes will impact Jaffna's water resources.

Sevalanka Foundation is a national NGO working on sustainable development projects in Sri Lanka. The ongoing sprinkler irrigation project in Jaffna is a sub-project under the ongoing program 'Building the Reliance of Returnees' funded by USAID as a strategy for efficient water usage in agriculture and a method of conserving ground water levels of the Jaffna peninsula by minimizing as an alternate method for the open field–surface irrigation system practiced by Jaffna farmers.

[16] http://www.sundaytimes.lk/130922/news/severe-water-shortage-looms-in-jaffna-63294.html



Map: Direction to Tellipalai from Jaffna: 15.5 km, 17 minutes of driving along the KKS road (Google Map)

The sprinkler irrigation project commenced in April 2014 as a pilot project in Thellipalai area, located 15.5 km north from Jaffna town along the Kankesnthurai (KKS) road. Sevalanka Foundation has identified the most marginal farmers in this area and has provided sprinklers for 0.25 acres on grant basis. There are altogether 125 farmers involved in this project covering 31.5 acres of crop. The main livelihood of the people in this area is farming and they grow onions, chillies and other tropical vegetables.

Farmers' Experience with the Project:

A field visit to the area and interviews were conducted with farmers who benefited from the project:

Mr. Sepamalai Klaiman (Age 30) and R.R.Rasalingam (Age 63) were mainly interviewed about their experiences with the sprinkler system and the impact of climate change on their livelihoods.

Both of the farmers have been interviewed separately at their homes and the following key questions were asked:

- How have you been experiencing the effects of climate change in your area?
- Why do you need this modern irrigation system?
- What are your new experiences with this project?
- Did you know about this system before this project?
- From where do you get the information for your farming and training?
- What are the others' perceptions on the new system?
- What are your ideas for introducing such a system to other farmers?
- Are there any disadvantages with this system?
- Will you and other farmers accept if this system is given in a long term recovery revolving loan system?

Mr. Sepamalai Klaiman, Age 30 (Left) and R.R.Rasalingam (Right) Age 63 with their sprinklers-installed fields in the background.

Both of them answered in almost the same pattern. The general and common statements provided by both are:

"We have been facing a bad water crisis in our irrigation, household water usage and for drinking purposes. We had enough water throughout the year 12 years back and we observed that the water levels in the wells were going down and sometimes the wells have only few inches of water in dry seasons from April to October. We have taken this system as an experiment to face the water crisis. Earlier we used water pumps and irrigated on the surface by flooding the cultivation grounds. We needed more water when we irrigated on the surface. This was not a problem in the past as we had enough water".

According to the farmers and the field officer of Sevalanaka Foundation, Mr. Sutha, they are experiencing unexpected drought and pest damages. Many of the farmers in this area are giving up farming and going to other work. Also in the years 2012 and 2013 the people who obtained loans from the banks (Hatton National Bank) and from the Development Project implemented by the Ministry of Economic Development are not in the position to pay back their loans. Many farmers have obtained Rs. 50,000 to Rs. 200,000 for onion farming and other crops. Some farmers have completely given up their farming (they couldn't present the exact numbers) and others have reduced the area of farming because of the water crisis and the risk of pest damages. They have clearly stated that degree of pest damages to the crop also occurs with the climate change and drought. Altogether, approximately more than 700 farmer families in this area have been affected by these adverse climate conditions.

"We heard about this sprinkler irrigation system from the Department of Agriculture, but we could not get this because of the non-availability and financial shortages. Although the Department of Agriculture was interested in implementing this system in our area, they said they didn't have money and experts to assist us. But now once it has been provided by Sevalanka Foundation we are able to manage the irrigation with very less water, low labor, fuel and less effort. It is also easier to operate. Our wives and children also can operate this

system since it is an automated method of irrigation. Although this is very new to us, we did not experience any trouble with this system. The only inconvenience we have with this system is that the whole system has to be dismantled during the ploughing process and re-fixed after. Now other farmers are also interested in this system after we have adopted this technology. They are visiting and inquiring about the project and our experience with this. Other farmers will also accept such systems if introduced on long term loan basis through the Farmer Organizations. Therefore, if some organization or the government can introduce a long-term loan system, more farmers will start to invest in this technique".

Mr.R. Rasalingam (Age 63) stated these points as well: He has farming experience since he was 8 years old.

"We had enough water from our wells. We had rainfall during October to January and in April in the past years about 10 years back. But we only have few weeks of rainfall now. Last time in 2013, we had rainfall for about 20 days only. Gradually the wells are getting low water levels and in summer times some wells tend to dry off completely. Therefore, people are going for deep-wells/tube wells and this is not a good system because the groundwater levels will go further down because of the tube wells. He stated "when I was a child, we had live fences and more trees in this area. Now all the fences are replaced with concrete walls and this is the main cause of climate change in this area. We need to revitalize the vegetation and trees in this area to get our climate back. I am doing this as an example to demonstrate to other farmers the advantage of sprinkler irrigation to manage water".

Project Implementer's Perception:

Mr. Ramesh is the Agriculture Officer, who is managing the field activities of this project. He holds a degree in agriculture from the University of Jaffna. He stated "we did not get much positive response when we proposed to introduce this system to their area at the beginning of the project. Because, the farmers in this area are used to flood their fields with water and it was very difficult to change their minds towards this system." However, Mr. Rasalingam and Mr. Klaiman have come forward to take up the challenge and they started gaining their positive experiences soon after installing the sprinklers in their fields.

Impact of the Project:

Although the project is very new to the farmers and the area, the sprinkler irrigation technology has shown tangible impacts on saving water, fuel/energy for the irrigation, time, labor and effort.

From a sociological point of view, this project has attracted the other farmers in the area to follow the same irrigation technic, thus the possibility of adopting this technology for water crisis is very positive. Furthermore, the positive attitude of Mr. Rasalingam that he functions as an experiment indicates signs of leadership for a future revolution in the irrigation technology to conserve water.

Cost of the Project:
Budget for the Sprinkler Irrigation Project done by Sevalanka Foundation in Jaffna for **125** affected farmers covering **31.5 Acres**

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Sprinkler units for 0.25 acres	50,000.00	Units	125.00	6,250,000
Water pumps	35,000.00	Units	125.00	4,375,000
Project management overheads	225,000.00	Months	24.00	5,400,000
Training and extension	650,000.00	Period	1.00	650,000
TOTAL				**16,675,000 (EUR 95,833)**
Average Project cost per farmer - LKR 133,400 (EUR 766)				

Funding Needs for Replication:
Introducing this sprinkler system to another 125 farmers of Kopai and Nallur DS divisions where the main livelihood of the people is agriculture. (However, in total, in both DS divisions, another 675 farmers were identified as vulnerable and need assistance of this type).

These two areas have been identified as the second highest vulnerable areas to drought by the Department of Agrarian Services (Mr. Sivananthan – Senior Technical Officer, Department of Agrarian Services-Jaffna). However, in order to ensure sustainability, the technology should not be provided on a grant basis directly to the beneficiaries. Instead, the project implementer can grant the allocated amount to the farmer organizations, where the farmer organization will lend money as a long term interest free loan to the affected farmers/most vulnerable people. Thus, the beneficiaries can pay back the loan to the farmer organization within the given period. Once the investment is accumulated, the farmer organization can use the money to lend again to the farmers. This will ensure a revolving loan system within the community.

Assistance could be provided through the farmer organizations (FOs) in a revolving loan system for 5 years upon an agreement with the farmers. The steps are as follow:

1. The Project Implementer will identify the Most Vulnerable farmers for water crisis and who are economically marginal through a baseline assessment.

2. The project implementer will identify the farmer organizations and provide the sprinkler system to the identified beneficiaries with an agreement to pay back the cost within 5 years.

3. All the procurement processes and bid evaluation could be conducted by the Project Implementer together with the farmer organizations in procuring and installing the sprinkler system.

4. Upon the provision of the system on credit basis, the monitoring and the pay back process by the beneficiary to the farmer organization/s has to be governed by the Project Implementer under the governance of the Local Governmental Authorities. After the project period, the farmer organization together with the Local Authorities (Divisional Secretaries/Department of Agrarian Services) can continue the monitoring process.

Forecasted implantation period: 2 years (24 months).

Required project funds for 2 years of implantation for 125 farmers is **LKR 16,675,000 (EUR 95,833)** (based on Sevalanka Foundation's budget)

New Project as Adaptation Methods to Conserve Water in this Area:

By considering the water scarcity of the Jaffna peninsula, this study proposes the following methods/systems to be implemented as adaptation measures. By the time of drafting this report, these techniques were not in existence in this area:

1. Groundwater Recharging System

This system refers to restoring the groundwater from the rainwater collected in the household/farming premises.

Hydrological concept of groundwater recharging:

$$Ri + R_c + R_r + R_t + S_i + I_g = E_t + T_p + S_e + O_g + \Delta W$$

where,

Ri	=	recharge from rainfall
R_c	=	recharge from canal recharge
R_r	=	recharge from field irrigation
R_t	=	recharge from tank
S_i	=	influent recharge from rivers
I_g	=	inflow from other basins
E_t	=	evapotranspiration
T_p	=	draft from ground water
S_e	=	effluent recharge to rivers
O_g	=	outflow to other basins
ΔW	=	change in ground water storage.

Source: Indian Institute of Science:
http://ces.iisc.ernet.in/energy/water/proceed/section7/paper5/section7paper5.htm

Therefore, the groundwater level has to be balanced through increasing the factors of: recharge from rainfall, recharge from field irrigation where the irrigated water penetrates the soils and recharges the water table, preventing outflows and limiting the draft from the groundwater.

(Rivers and channels are not applicable to Jaffna since there are no such structures existing in the peninsula).

Left to Right: 1- Ditch and furrow system practiced as a ground water recharging method in agriculture; 2- Deep cut perimeter ditches to stop the outflow of the flood; 3- Household model sample - rainwater harvesting tank. These kinds of structures will retain the water in the rainy season without allowing the water to run off as flood.

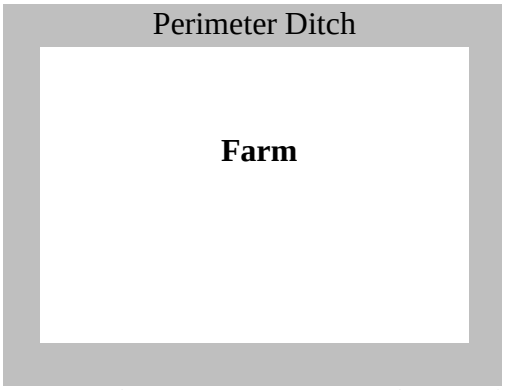
2. Soil Water Conservation Methods:

This involves conserving the water in the soil by different techniques to prevent it from drying off. Therefore, the moisture content in the soil will remain even in the drought period which is favorable to cultivation. The commonly used methods are:

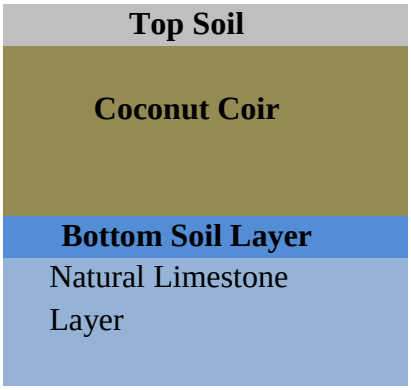
1. Mulching: covering the soil by different materials or turf layer in order to prevent the exposure of soil to the sun and wind.

2. Keeping soil organic matter: soil organic matter is the bio origin substances derived / expelled from the vegetation and animals. Crop residue, coconut husk, household waste, home yard waste and animal dung are the ideal bio substances which can be used to preserve water by functioning as a sponge by absorbing and keeping the water.

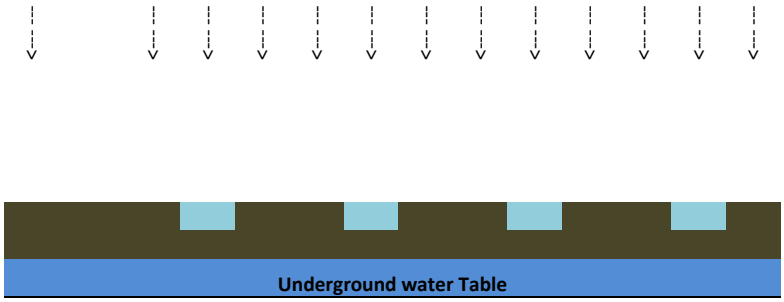
Concepts of perimeter deep cut ditch, coconut husk pits, ditch and furrow and water table recharging systems from the rain water collection from roof:
(Source: http://agrotechno-park.blogspot.com/2011/10/flood-and-furrow-irrigation.html



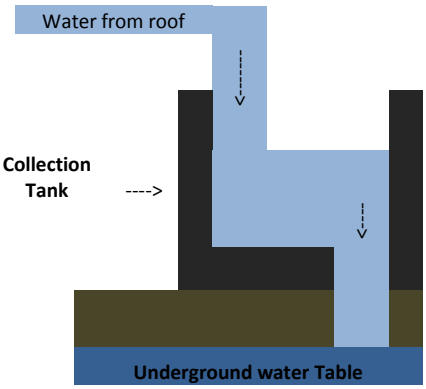
Layout plan of perimeter deep ditch to trap in-farm water from out flow



Cross section of Coconut husk pits



Cross section of Water Retention mechanism through ditch & furrow system



Cross section of Underground Water recharging system through rain water harvesting

Advantages of these systems:

a) Easy to construct / practice
b) Retains soil moisture in the farmland / premises
c) Prevents development of floods in the area by capturing the water in the household premises/farm

Reasons for people not practicing this method in Jaffna:

1. No awareness/lack of technical knowledge transmission to the people from agricultural professionals.
2. Less availability of coconut husk in the veritable farming areas. (Coconut doesn't grow well in the vegetable farming soils and environment).
3. Cost and labor intensive.

Proper technical training provided to farmers and new resources channeled to make coconut husks available (transporting from other districts) will help to counter these constraints.

Therefore these practices are proposed to be introduced to the Jaffna farmers as most suitable methods of conserving soil water as an adaptation method during drought seasons.

Estimated Budget for Ridge and Furrow System with coconut husk for 2,500 cubic meters

Activity / Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Excavation	2,500	Cubic Meters	2,000	5,000,000
Coconut Coir	13,000	Lorry load	40	520,000
Transport	12,000	Trip	40	480,000
Total				**6,000,000.00 (EUR 34,482)**

Estimated Budget for Rainwater Recharging System for 50 farmers

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Plastic tanks	116,000	No. of units	50	5,800,000
Pipes and fittings	850	No. of units	50	42,500
Gutters and fittings	1,200	Set	400	480,000
Sub total				6,322,500
Labor and contracting charges (30%)				1,896,750
TOTAL BUDGET				**8,219,250 (EUR 47,237)**

3.1.2. Rice Chain Project Implemented by Practical Action (PA) in Thabbowa, Puttalam District

Puttalam district is situated in the Northwestern province of Sri Lanka. According to the climate classifications it belongs to the dry zone of the country. Sharing the costal line of the country along the western parts, Puttalam has been identified as one of the most vulnerable districts in Sri Lanka in terms rising sea levels and declining fresh water resources. The main livelihood of the people in this district is agriculture. Fishery also accounts for a significant number of employments. Scattered small irrigation tanks and few water streams running from upper catchment areas of large scale irrigation projects are the main water sources of agriculture. Due to the decreasing annual rainfall, agriculture is highly dependent on these irrigation systems. Large scale irrigation systems that feed many of the small irrigation canals flow from the North Central province (which belongs to the dry zone) where water is used for intensive agriculture. In such a setup, water resource in Puttalam district has a high dependency on the weather of the adjoining districts and whatever small amount of rainfall the district receives.

According to Asian Development Bank, despite short term increasing trends, the total annual rainfall distribution for 1962-2009 has shown a decrease in Puttalam district. According to the Meteorology Department of Sri Lanka, the decade 2001-10 shows a decrease of 0.0009 mm rainfall decrease per year in this district. The ADB report of 2013[17] records that the maximum temperature of Puttalam district has increased by 0.0331°C per year during 1962-2009. According to agriculture research, there is a negative correlation between the air temperature and paddy rice yield. All the above facts provide implications of adverse agricultural impacts of the changing climate in Puttlam.

[17] http://oar.icrisat.org/6545/1/Policy%20Brief%2020.pdf

Practical Action has been implementing the Rice Chain project in Thabbowa area in the Puttalam district. The target group is about 300 paddy farmers whose cultivation is dependent on rainfall and the Thabbowa tank water. Traditionally, farmers have been doing paddy cultivation twice a year in Yala and Maha harvesting seasons. However, due to decreasing rainfall and droughts over the years, this pattern has changed and in some years they have been compelled to do farming only in one season. This has caused both monetary and social losses for the farmers whose main income source is paddy farming.

W. Nikulas, a farmer from this area shared his experienced with us:

"For more than twenty years, I have been writing down the weather conditions and rainfall data almost every day in my diaries. When looking at those raw data itself, we can realize how the rainfall has been gradually decreasing in our area. Moreover, the temperature has also been significantly increasing. For example, according to my estimates, during the dry seasons, hot winds may evaporate more than 25.4mm of water every day from the Thabbowa tank. We used to have small irrigation systems around big tanks in the past to control evaporation from the big tanks, but due to development projects, now they are no more there. Under the Thabbowa tank, about 400 farmers could cultivate paddy in the past in both seasons. But, now, due to frequent droughts and less rainfall, we have been able to cultivate only in one season. Even during that season farmers have to undergo lots of competition channeling water to their fields. So far about 100 farmers have been fully affected and have given up paddy cultivation".

Practical Action (PA) with similar experience in Hambantota has identified this as a crucial issue which requires intervention and has launched its Rice Chain project in this area targeting initially about 300 farmer families. Rice Chain project has three main components:

1. To introduce alternative ways of paddy cultivation to survive in the conditions of decreasing water levels. This includes promoting dry soil sowing of paddy as an economic way of agriculture water use and introduction of traditional varieties of paddy which can withstand water shortages and increasing air temperature. Further, with the water saved through these methods, they also promote cultivation of short-term crops like yams in between two seasons.

Paddy fields in Thabbowa: On the left side of the road, the fields which used dry soil sowing technique. Due to this, harvesting has already been done in these fields. On the right side of the road, the fields which have not followed the above methods and are still waiting to harvest while the water levels are going down.

2. Introducing alternative livelihood opportunities for traditional farmers to reduce their dependency of vulnerable paddy farming. For example PA has given training and capital to farmers to start poultry farms in this area. So far about 70 farmers have been given training equipment and they have started their business activities. To make sure the availability of a good market for the poultry products they produce, the farming is done organically using the resources available in the area. PA has realized that organic food has a better market demand than other products.

3. Linking the new livelihood activities of the farmers with the big market chains in Colombo. This is again a way to ensure the sustainability of these activities. Through these, farmers and farmer societies are directly linked with well-established companies as long-term buyers of these farmers' products.

Waruna, the Project Manager of Rice Chain project in Thabbowa shared his experiences with us:

"This is an area where lands were distributed by the government more than 60 years back to the poor people in the area to improve their livelihood by using uncultivated lands for agriculture. The whole project consists of more than 500 acres of land. Paddy cultivation has been the sole livelihood support system of more than 400 families. Due to the long-term droughts and high temperature, water has been becoming scarce every day. This has destroyed many cultivations as the irrigation water is not adequate. Many people are now giving up paddy cultivation and looking for manual jobs in the cities. Moreover, the water scarcity and damages to agriculture had resulted in severe poverty levels among the communities. As a consequence, you will find that almost all the families have at least one member working abroad--mainly in Middle-East countries. More than 60% of them are women. This has created a vicious cycle of poverty in this area. When the women are not in the house, whole family institution breaks up and it affect the education of children and thereby the future economy as well. Due to high numbers of migrant workers travelling back and forth, this area is highly affected by HIV Aids. I see the spread of it very fast although it has not yet been identified as an issue by the health officials due to their ignorance."

Under the first component of the project, already 200 acres of paddy fields have been introduced with the dry soil sowing technique. Farmers who have practiced this have been able to use minimum amount of water and have collected the harvest more than one month in advance compared to sowing according to traditional seasons. According to Waruna, the biggest problem created by climate change is the difficulty to predict the rainfall. The patterns have all changed. There has not been any advanced system to scientifically make accurate rain

forecasts and to communicate them to the farmers to make maximum use of the rain. Due to this gap, farmers cultivate based on their own inaccurate predictions. In such a situation, sowing in dry soil before the expected rainy seasons has been a relatively better adaptation method than sowing after the rain because by the time of rain, the plants are bigger and within a short time they can be harvested. Savings of the water and time with this system have been invested in cultivating short-term crops. Farmers who have not yet followed this system are now planning to use it in the next season.

Following are the Rice Chain Project costs budgeted by Practical Action to serve 100 families (300 farmers) who have been using about 500 acres of paddy land.

Component 1- Introducing new techniques of farming and new varieties		
Activity	Number of beneficiaries (farmers)	Cost (LKR)
Training and advocacy	300	500,000
Seeds	300	1,000,000
One tractor for the area to be managed by the farmers society	300	2,000,000
Communication for updating on rainfalls based on data from meteorological department	300	200,000
Total Cost		**3,700,000 (EUR 21,264)**
Component 2- Alternative livelihood programs		
Training on poultry farming	100 families	1,000,000
Equipment or initial capital	100 families	15,000,000
Total		**16,000,000 (EUR 91,954)**
Component 3- Connecting with Market chains		
Marketing training	100 families	500,000
Connecting meetings	100 families	500,000
Total		**1,000,000 (EUR 5,747)**

Thus, the total budgeted cost of Rice Chain Project that benefits 100 families (300 paddy farmers) in the area is **Rs. 20,700,000** or **EUR 118,065**

When inquired from a PA officer about the possibility of replicating this project, he emphasized the importance of immediately replicating this type of a project targeting 100 families in Kalpitiya in the same district. He also identified two areas in Hambantota (Weerawila and Thissamaharama) and two areas in Mannar district (Musali DS division and Manthai West DS division) each district consisting 200 families by referring to similar weather and climate conditions and problems in those areas. Therefore, if a project of this kind is replicated in five areas catering to 500 families, the total estimated cost (based on the ongoing PA project budget) would be approximately Rs.**103,500,000 (EUR 594,827).**

However, proper feasibility analyses have to be conducted before implementing such projects due to area specific socio-economic dynamics. Such a replication process is supposed to

improve the lives of 2,000 people directly and about 7,000 people indirectly as an adaptation measure to climate change.

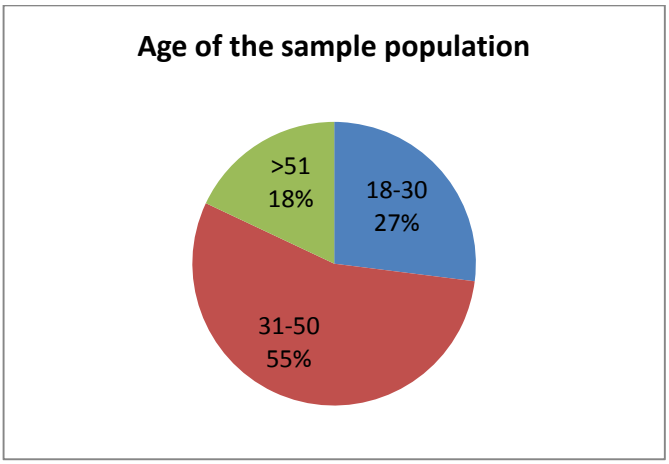
3.1.3. Vegetable Farming Support Project Implemented by Care International in Weerawila/ Pamunugama Areas in Hambantota District

This study was conducted using a survey methodology which covered a sample of 100 farmers in the two villages: Weerawila and Pamunugama in Hambantota district. Hambantota district is situated in the South East of Sri Lanka. According to the Hambantota District Secretariat[18], "Climatically, Hambantota District can be said to be a dry semi-arid region that has hot dry weather characterized by bright sunshine. This applies to the majority of the district, but does change somewhat toward the highland area of the West and Northwest. These sections have a pleasant wet and cool climate. The mean temperature range is between 26^{o}C in January, the coolest month, to 30^{o}C + in April, the hottest month. The monsoons are the most significant factor in the wind system of the region and the major rainy season is the Northeast monsoon that stretches from October to January. The district's annual rainfall is between 1,000 and 1,250 mm in the dry areas, between 1,000 and 1,500 mm in the intermediate parts and between 1,500 and 2,000 mm in the wet parts. During the year the wind speed varies from 15 km/h during the Northeast monsoon to 23 km/h during the South-West monsoon.

According to the ADB report of 2013, the maximum temperature in Hambantota has been increasing by about 0.0272°C/ year during the period of 1961-1990 but does not show a significant trend during the recent two decades (1900-2007). However, the incidents of droughts in the past decade have been many. Hambantota district is also undergoing a huge infrastructure development program of the government with the construction of an international airport and a harbor which were opened recently. It is obvious to see the level of deforestation that has been taking place at a massive scale in this area. Weerawila and Pamunugama are situated 30 km North to Hambantota city.

The most representative age group of the sample population is 31-50 year olds (55%). The age group of 18-31 years represents 27% of the sample population and 51 years and above is only 18%. It shows that the younger generation in this case study area is actively involved in agricultural activities as their main livelihood and it is possible to convince these populations on new adaptation measures for climate change and improve their living standards through proper guidance.

[18] http://www.hambantota.dist.gov.lk/index.php?option=com_content&view=article&id=4&Itemid=63&lang=en



Agricultural Activities:

Farmers in this case study area are mainly involved in agricultural activities throughout the year. Mainly they cultivate paddy when the irrigation water is issued during Maha (wet season). In other periods they cultivate other field crops such as Brinjal, Okra, Tomato, Cucumber and mainly leafy vegetables such as Mukunuwanna, Nivithi, Kankun and Gotukola. They also cultivate banana and papaw with intercrops such as Chili.

Banana and Chili intercrop

Okra cultivation

Water Sources

The main water source for agricultural activities of 80% of the sample population is from tanks (wewa) or canals (ela) nearby, whereas only 20% depend on their agro well or domestic wells. Almost 100% of the sample population experience crop damage due to adverse climatic conditions. Nearly 80% of the sample population indicated that water is the main constraint for agricultural activities and 20% indicated that they do not have the technology to use the available water efficiently. During the rainy seasons, and for 3-4 months after the rainy season, they get enough water for their agriculture. But after a few months, the sources dry off and water becomes extremely scarce. Due to climate change effects, during some years, prolonged

droughts were experienced. Therefore, adaptation measures should focus mainly on preserving excess water during rainy seasons, introducing efficient methods of water use for agriculture with minimum wastage and building the capacity of the farmers to manage water resources sustainably.

Agro Well

Pathaha

Canal

Irrigation System:

Most of the famers are not using proper irrigation systems to apply water. Water gets wasted and farmers complain that they do not have the knowledge or technology to improve the irrigation system to reduce the wastage of water. Most of them use 2 inch PVC pipes to apply water and make the plots like ponds. Usually they pump water from an Agro well or Pathaha or wewa to the cultivated plots. Some farmers are using a locally made sprinkler irrigation system. Therefore, farmers are looking for suitable irrigation systems as an adaptation measure to cope with predicted water shortage due to climate change.

Irrigation using 2 inch PVC pipe

Irrigation using locally made sprinkler irrigation

Projects:

CARE international, an international NGO has given 2 H.P. water pumps to 24% of the sample population and these farmers are using it for irrigation purposes. One farmer received an Agro well through CARE. Other than that, there were no projects or assistance given to farmers either by NGOs or government agencies to irrigate their farming lands.

Water pump given by CARE International

Knowledge on Climate Change:
None of the farmers know about climate change or had any idea about what will happen due to climate change. They feel the increase in temperature but do not have knowledge on global warming. No awareness programs have been conducted by the government or NGOs. The whole sample population eagerly wants to gain knowledge on climate change and how to adapt to it.

Knowledge on Agricultural Technology:
Farmers have very poor knowledge on very basic agricultural technology such as mulching to reduce the evaporation of soil moisture resulting from high temperature due to global warming. Only 5% of the sample population use mulching and even then, they do not know the reason for using mulch.

Mulch used in cucumber cultivation

Need for the Farmers:
Farmers' main problems regarding agricultural activities are lack of water sources and lack of suitable water saving irrigation systems. Almost 97% of the sample population need sprinkler irrigation systems and only 3% needs rainwater harvesting systems. For proper agricultural cultivation, 100% of the sample population needs knowledge on agricultural technology such as mulching, new seed and fertilizers, compost etc.

Conclusions and Recommendations:
The sample population does not have any knowledge on climate change or even the proper agro technology. Most of the farmers cultivate paddy during the wet season and field crops and vegetables in the dry season using water from agro wells, wewas and elas. They have very poor knowledge on water saving irrigation systems to reduce water losses. Only CARE international has given 2 H.P. water pumps to only eight (24%) farmers and the farmers did not receive any assistance from any other NGOs or government organizations. Some farmers use locally made sprinkler irrigation systems. Given the success of using sprinkler irrigation systems, all the farmers need assistance to obtain that system.

Recommendations and Replication Needs:

1. Awareness program on Climate Change: Farmers in this area have not undergone any training or awareness programs on climate change. Virtually none of them know what climate change is and its impacts on agriculture and water. Therefore, farmers in this area should be educated on the impacts of climate change and how to cope with its impact urgently. A one or two-day residential program will help give them knowledge.

2. Awareness program on new agro technology and processing methods: Farmers are not aware of the basic agricultural techniques to improve the agricultural activities to gain more profit. Farmers do not know the basic land preparation techniques and soil moisture conservation techniques, water application or irrigation methods which could increase the productivity and improve living standards. They are using traditional irrigation methods such as a 2 inch PVC pipe to apply water to the basins which causes wastage of water. Further, farmers do not know how to process their harvested product to catch the market prices. When they do not get the correct price for their product they just leave it to rot due to frustration. Therefore, farmers should be trained to get hands-on experience to process their harvested produce to get a good market price which will enhance their living standards.

3. Provide a sprinkler irrigation system which will cost about Rs. 70,000 and could be made locally. With training on the above two areas farmers will be able do successful cultivation which will improve their living standards. It will reduce the labor cost and the time to be in the field under hot temperature which will affect their health. When sprinkler irrigation is introduced they have to operate it at least three times depending on the crop. It will ensure uniformity of water application and higher water use efficiency. By using sprinkler irrigation they could double the extent of cultivation compared to the present situation.

4. Provide agro wells/Pathahas wherever necessary which cost about Rs. 200,000. Some farmers do not have access to water sources. Therefore if the farmers have agro wells they will be able to do meaningful cultivation rather than worrying about the uncertainty of the water source. These agro wells and Pathahas will store the runoff water when there is heavy rainfall and could be used when there is no rainfall. It is a small water storage system.

5. Provide rainwater harvesting systems for drinking water which cost about Rs. 50.000 each. Rainwater harvesting is important as a source of drinking water as the water quality in the tanks and wells are not very suitable evidenced by complaints about kidney diseases etc. Lanka Rainwater Harvesting Forum gives training for farmers to construct their own rainwater harvesting system. Therefore Rs 50,000 will be adequate to construct a household rainwater harvesting system.

6. Farmers also need assistance on seed materials which can survive in the changing climate conditions.

Budget for different projects required to reduce the vulnerability of 100 farmers in the two areas

Project	**Cost per unit and no. of recipients in need of assistance**	**Total cost**
1. Awareness raising program on climate change	2000 X 100 farmers	200,000
2. Awareness raising training on new agro technology and processing methods	3500 X 100 farmers	350,000
3. Providing sprinkler water systems	70,000(per farmer for 0.25 acre) X 50 farmers	3,750,000
4. Providing agro wells for a selected number of farmers	200,000 X 15	3,000,000
5. Providing rain water harvesting systems to farmer families	50,000 X 80 farmers	4,000,000
6. Providing seeds that can cope up with increasing temperature and water scarcity	1500 per farmer X 100 farmers	150,000
Total		**11,450,000** **(EUR 65,804)**

During the field visits, Thissamaharama and Sooriyawewa in Hambantota district were identified with similar or more adverse climate impacts, poor irrigations infrastructure and poor knowledge among the farmers on effective irrigation systems and climate change. It is noteworthy to consider these two areas covering another 200 farmers (100 from each area) as requiring replication of the projects described above. If the number of recipients remains the same, each replication should be able to be done within the same budget.

3.2. Adaptation Measures on Water

This section identifies two case studies of projects which have been implemented as adaptation measures in the sector of water. The projects described below give examples of different measures taken for issues related to drinking water, agriculture water as well as sea water inundation. The projects are mainly on the infrastructure facilities developed to adapt to the climate change related water issues in the above sectors. Both case studies were done in Jaffna district as it was identified as the most affected in terms of climate change-driven water issues in the country. However, the projects described will also benefit other dry zones such as Mannar, Hambantota and Monaragala districts if replicated.

3.2.1. Drinking Water Supply Projects/Activities Implemented in the Delft Island

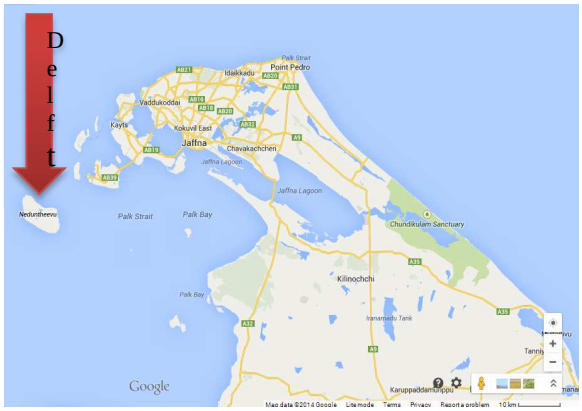
This case study provides examples of different strategies and the projects implemented by the National Water Supply and Drainage Board (NWS&DB) and the Delft Navy to overcome the drinking water problem. There are four main activities/projects done in Delft:

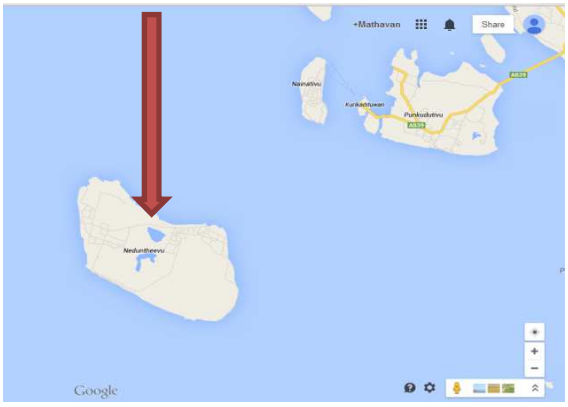
1. Network Improvement Project by the National Water Supply and Drainage Board (NWS&DB)
2. Rain Water Harvesting Tank Project by the National Water Supply and Drainage Board (NWS&DB)
3. Water delivery through tankers from the west coast wells by Delft Navy
4. Reverse Osmosis Plant Project at Delft Island by Delft Navy

All of these projects/activities are discussed below as one case study.

Delft (Tamil: Neduntheevu) is one of the islands situated in the Palk Strait of the Indian Ocean west of the Jaffna peninsula and belongs to Sri Lanka having a flat shaped 50 square km area. It has 8 km of maximum length and 6 km of maximum width. Delft is a single Divisional Secretariat with six Grama Niladhari divisions. According to the Divisional Secretariat, Delft has a total population of 4,458 people as at May 2014. The major livelihood of the people is fisheries.

Delft has been selected for the study of water crisis and effect of the rise in sea water level since the island is commonly spoken of in the media and among the general public for these two issues.





Left: Location of Delft Island: Source (Google Map)
Right: Location of the Vettukulam, the biggest inland freshwater tank (pointed by the arrow)

Present Sources of Water in Delft Island:

The National Water Supply and Drainage Board and the Sri Lanka Navy are implementing water supply projects in the island. Even though almost every home has a well to obtain water for the general household use (for bathing and cleaning), the well water in the island except the western part of the island is not suitable for drinking because of the high level of brackishness.

Projects of NWS&DB:

1. At present, drinking water is obtained from wells from the western part of the Delft Island, which is suitable for drinking. A water supply network is in action by pumping directly to 17 tanks in the island through underground pipelines.

2. NWS&DB is constructing 24 rain water harvesting tanks in certain common places at a unit cost of Rs.300,000 each. The main funding source of these projects is Asian Development Bank (ADB).

Left: Two of the wells in the west part of the Delft Island at Sarapitty (there are altogether 8 wells).
Right: One of the water distribution tanks out of 17 tanks presently used to deliver drinking water.

Water Supply Activities of Delft Navy:

1. The drinking water from the wells of the west part of the island is distributed by the Sri Lankan Navy to the village level water tanks.

2. A Reverse Osmosis (RO) Plant[19] is utilized by the Delft Navy to purify the brackishness from the well water obtained from the west part. An average of 10 cubic meters/day of filtered water is provided to the general public at the Navy Base in Delft. Water is provided only for 1 hour and 30 minutes a day (30 minutes in the morning, noon and evening).

Although people find this project helping their day-to-day life, many of them are concerned of their situation of being highly dependent on the Navy as it indirectly justifies a higher level of military presence in the area.

Proposed Projects in the Near Future by the National Water Supply and Drainage Board:

1. Improvement of the present water supply network in the Delft Island. A new water tank is being built at the west part of the Island (Sarapitty) where the drinking water wells are located.

2. Two 50 cubic meters (50,000 liters) of Reverse Osmosis Plants have been planned to be installed in the Island by the beginning of the year 2015 in order to deliver the total drinking/consumable water requirement to the general public.

[19] Reverse Osmosis is a hi-tech process of filtering the unpurified water for drinking purposed. It is commonly used in ships to purify sea water for drinking water to the sailors.

Left: A navy tanker pumping water from the drinking water wells for distribution.
Right: One of the village level 5,000 Liter tanks mounted aside a road provided where the water is pumped by the tankers of Delft Navy.

Left: People waiting to obtain the filtered water from the Reverse Osmosis Plant of Delft Navy.
Right: The time of the water delivery is displayed at the back of the water tap

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Project Implementer's Perception:

The Divisional Secretary Mr. Alvappillai Sisri, Management Assistant Mrs. J.E Edward, the Technical Officer of the Divisional Secretariat Mr.Janarthanan, Development Assistant of the Water Supply and Drainage Board Mr.Aruljeevan, Officer-in-Charge Senior Technical Officer for the Delft Island Mr.J.E.Rajanayagam have been interviewed about the ongoing water projects during the visit to Delft. The Project Coordinator of Sevalanka Foundation Mr. Roni who is working with the National Water Supply and Drainage Board in Delft also gave certain facts for this study. In addition, few inhabitants of the area were also interviewed to get the real situation of the water availability in the Island.

According to all of them, the general finding is that the island has been experiencing heavy drought gradually for the last 25 years. However, there is no measurable data on climate change and rainfall patterns because there is no metrological station situated in the Island. The experiences of the people are the only evidence of the climate change in Delft. Due to the decreasing rainfall and long summer days with heavy sunlight, the internal water bodies (approximately 25) are almost completely dried. These water bodies are made traditionally by the local inhabitants to capture rain water to recharge the underground water levels. However, the largest internal lake (Vettukulam) of approximately 1 sq km area is completely dried. Inland farming of cash crops such as chili and small amounts of vegetables were the main livelihood of the people which is no more in practice because of the heavy drought.

A part of the main dried basin of the inland lake Vettukulam . The size of the lake and the degree of the caqapacity to hold water can be seen in these pictures.

People's Perception on the Water Crisis in Delft:

Mr. Fernando Ramesh Kumar (34 yrs.), J. Santirakumar (37 years), Mrs. Hancy (25 years) Mrs. Fatima Rajeswary (56 Years) were interviewed to find out the real impact of the drought and the present water projects in the Delft Island.

The following questions were asked:

How about the availability of water for drinking, household purposes and agriculture in this area?

"The entire drinking water source of the people in Delft Island is from the Sarapity wells located in the west part of the Island. The water is more fresh and tastes good during January to May following the rain. Then the water turns a bit salty in the other parts of the year. We did not have much crisis for drinking water 25 years back. I can still remember the quality of the drinking water from the Sarapity wells when I was a child. The Vettukulam lake and other lakes were filled with water 25 years back. But gradually it started drying and now all the lakes are dried completely. People were dependent on water from the Vettukulam for agriculture and

now they have given up their cropping because of the non-availability of water. The farming communities recognized the salinization of water in the Vettukulam tanks in 1960s and they started to move to the Kilinochchi and Mullaitivu districts under the "Educated Youth Colonization Program". About 350 families have completely migrated to these districts. However, there are another 250 families continuing farming in the west coast where the water is obtained for drinking. In the west coast, the wells contain fairly fresh water which is suitable for farming. They are cultivating vegetables for their home consumption and the surplus is sold in the Delft market, but the main supply of vegetable to Delft is from Jaffna. Now we get the rainfall only for few weeks in November and December and in the rest of the year we do not have rain. The people in Delft have their own wells in their homesteads, but the water is not suitable for drinking except the west coast area. We use the water from our own wells for bathing and washing. For cooking and drinking Sarapity wells are the only sources.

Left: Mr. Ramesh Kumar (right) is working as a Book Keeper at the Delft Multipurpose Cooperative shop and Mr. J Santhirakumar (left) were interviewed. together. Mr. Ramesh Kumar answered many of the questions and explained the present situation of water availability in Delft.
Right: The water tank which is under construction as part of the water supply enhancement project implemented by National Water Supply and Drainage Board.

Do you experience climate change with respect to the availability of drinking water?

The availability of drinking water is getting lesser and the quality of the water from these wells is going down because of the sudden increase of the population from 1,500 to more than 4,000 in the Island: resettled families after the end of the war and the Navy and Police personnel counting for about 400. So the total number of affected people is approximately 3,600 people currently living in this area. The Forces are using the Sarapity well water for their general purposes as well. Because of these reasons water has become more and more limited. However, the services provided by the Delft Navy in distributing drinking water through tankers throughout the Island and the provision of filtered water from the Reverse Osmosis (RO) plant are good efforts.

The RO project is very desirable since the water is very pure and clean and not salty. Nevertheless, the availability is very low and there is high competition for the RO filtered water

among the Delft people. It is only delivered at the site of the Delft jetty at the Navy Base and the people have to go to the site and wait in queue, but the water is provided only for 30 minutes at a time (morning, noon and evening). People of other parts of the Island do not have access to this water because of the mode of delivery and less availability. The proposed RO Project by the NWS&DB is desirable since we have experienced the pure water from the RO Plant of Delft Navy. The Delft people are waiting to get the benefit of this project in the near future".

Are you aware of the health hazards of drinking salty water?

"Yes. The people are well aware of the problem in drinking salty water. Bottled drinking water is available in shops. The people who have money buy the bottled water. But it is very expensive to buy water for drinking purposes. Since we do not have any options at the moment, we are dependent on the available water at present".

Are you satisfied with the water projects implemented in the area?

"We are not convinced with the ongoing project on building rain water harvesting tanks by the NWS&DB, because a similar project implemented by UNHCR in 2004 is not functioning".

He showed a rain water harvesting tank built at the office of Fisheries Cooperative Society Union of Delft, just opposite St. Fatima's Church where a new rain water harvesting tank is built which is mentioned in the above picture.

What is your perception of the failure of this rain water project implemented by UNHCR?

"The tank is too big to collect the water from the roof since the rainfall in the Island is very less. There is also no maintenance since it is located in a common place. There is also a crack in the tank and it doesn't hold water".

What are your suggestions for improving the ongoing water projects in Delft?

"We need durable and sustainable solutions and technology".

One of the rain water harvesting tanks (8 cubic meters / 8,000 liters) under construction at St. Fatima Church, Delft Island.

The picture of the abundant rain water harvesting tank built by UNHCR in 2004 at the office of Fisheries Cooperative Society Union, Delft just opposite to St. Fatima's Church where one of the rain water harvesting tanks (8 cubic meters/8,000 liters) which is under construction at the St. Fatima (mentioned in the above picture).

What do you mean by that?

Then he showed the effort of the next door inhabitant Mr. Nagalingam (who was absent on that day at his house) to build a rain water collection system. Mr. Nagalingam is in the process of developing a sump to collect the roof water. The sump is just dug and the measure has not been done yet.

But you have mentioned that such a rain water collection system is not a successful method in this area?

"Yes. That is because of the way of implantation. The bigger tanks are built at common places without considering the size of the roof. Also there is no owner to look after and maintain the tanks at the common places. But, if the appropriate sizes of the tanks are given to the people to their individual households to match with the area of the roof, it would be sustainable. Now people are buying plastic tanks on lease from a private company" (he didn't remember the name of the company).

If the tanks are provided on long-term loan basis through the Fisheries Cooperative Union or through any other societies, will the people accept it and pay back the loans to the society?

"Yes. The people will".

The sump dug by Mr. Nagalingam to collect the rain water (The water in the sump is groundwater which is not suitable to drink). The sump will be concreted and the system will be completed soon.

Impact of the Projects Implemented by NWS&DB and Delft Navy:

Positive Impacts:

The improvement of the water supply network and the existing delivery system of drinking water implemented by NWS&DB and Delft Navy ensure the availability of drinking water to the Delft population. But, it does not ensure the availability of Saline-free purified healthy water for the people.

Provision of filtered water through the Reverse Osmosis Plant by the Delft Navy has a very positive impact. Water from the RO Plant is highly accepted by the people and scientifically and biologically it is healthy to drink since the saline, other sea water minerals and microbial are removed through this system. The proposed project on installing two large scale (50 cubic meters) RO plants by the NWS&DB is a good solution to rectify the drinking water problem in Delft Island.

Criticism:

The mode of implementation of the construction of rain water harvesting tanks undertaken by the NWS&DB is not appropriate since the tanks are been offered in common places. The previous cases such as the rain water harvesting tank built at the Fisheries Cooperative Union of Delft by UNHCR have not been studied or taken into account. From economic and technical points of view, the tanks are made out of cement which is more costly and not appropriate to the area like Delft where the wind contains more salt, which will penetrate the cement and corrode the iron-based reinforcement and leads to crack in few years. An 8 cubic meter cement tank costs about Rs.280,000 but a 10.5 cubic meter high quality PVC tank costs about Rs.166,000.

Negative Impacts:

The Reverse Osmosis Plant requires high energy (electricity) which is obtained from diesel-powered power generators which are the electricity source to Delft Island. The water delivery system is run by diesel-powered tankers. This leads to the emissions of CO_2, Co and leaves a significant carbon footprint in the environment.

Cost of the Project:
An amount of Rs.263,970,000 is allocated to the Delft Water Project by the NWS&DB. The proposed RO plants cost approximately Rs.120,000,000 (60 million each) and the rest of the funds are allocated for the improvement of the water supply network and the rain water harvesting tanks.

Funds Needed for Replication/Improvements:

Based on the observations in the field and on the interviews with development practitioners in the area, ICES identifies that the following projects are required as replications/improvements:

Drinking water projects: However, there is no need of funds for the drinking water projects/establishments since the projects are being implemented and RO plants to rectify the drinking water are planned by the NWS&DB, funded by Asian Development Bank.

Water conservation and revitalizing agriculture: Highly required. Funding for recharging the groundwater from the available rain water and collecting rain water and managing through drip irrigation to restart the farming practices are highly recommend.

Estimated Budget for Rain Water Recharging System for 50 Farmers in Delft

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Plastic tanks	116,000.00	No. of items	50.00	5,800,000
Pipes and fittings	850.00	No. of items	50.00	42,500
Gutters and fittings	6,000.00	Set	400.00	2,400,000
Subtotal				8,242,500
Labor and contracting charges (30%)				2,472,750
TOTAL BUDGET				**18,957,750 (EUR 108,955)**

Introducing Drip Irrigation System from collected rain water for 10 acres in Delft. 10 Acres could benefit approximately 5 farmers

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Drip irrigation sets	420,000.00	1 acre	10.00	4,200,000
Pumps	25.00	No. of items	35,000.00	875,000
Installation charges (15%)				761,250
TOTAL				**5,836,250 (EUR 33,541)**

3.2.2. Saltwater Exclusion Bund Project done by International Organization for Migration (IOM), Jaffna and Department of Agrarian Services in Chavakachcheri Divisional Secretaries Area at Thankalappu and similar projects done by the Department of Irrigation in Delft Island

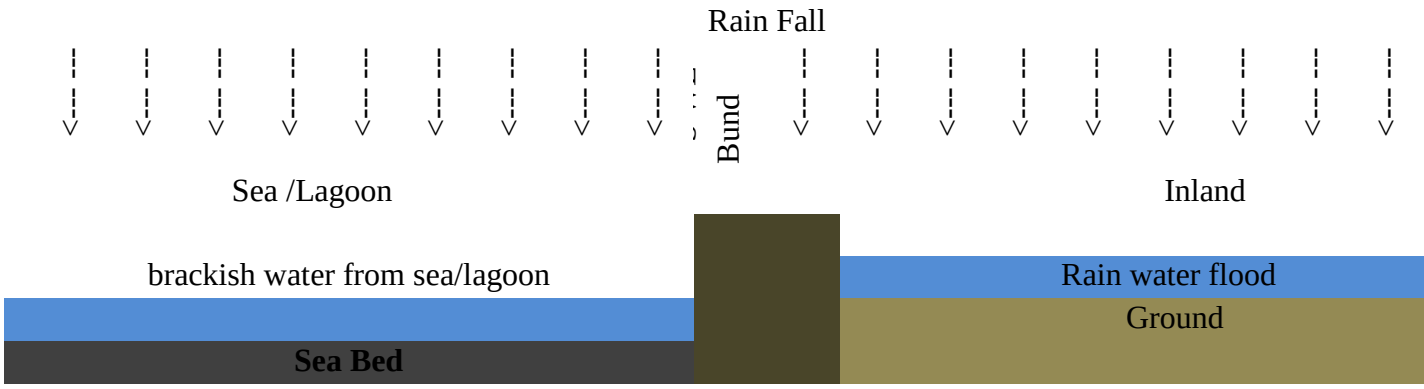
Invasion of salt/brackish water by the sea and the lagoons is a major problem in the Jaffna peninsula. It causes salinification of agricultural lands and groundwater; affects the settlements of the coastal communities causing displacement, losing of livelihood and damages to the property.

Farmers, fishing communities and the general population are the most vulnerable to the sea water invasion. Farmers lose their farmlands and grazing lands for cattle, fishermen of fresh water sources lose their fishing shores and settlements and the increased salinity of fresh water wells affect the general public in terms of drinking water.

The only and long lasting system to overcome this crisis is the construction of Sea Water Exclusion Bunds (SWE Bunds) / barrages / Walls in the affected coastal, areas.

The technical function / purpose of the SWE Bunds are to:

1. Prevent the intrusion of the sea/lagoon water inland
2. Retain the rain water flood inland by functioning as a dam.



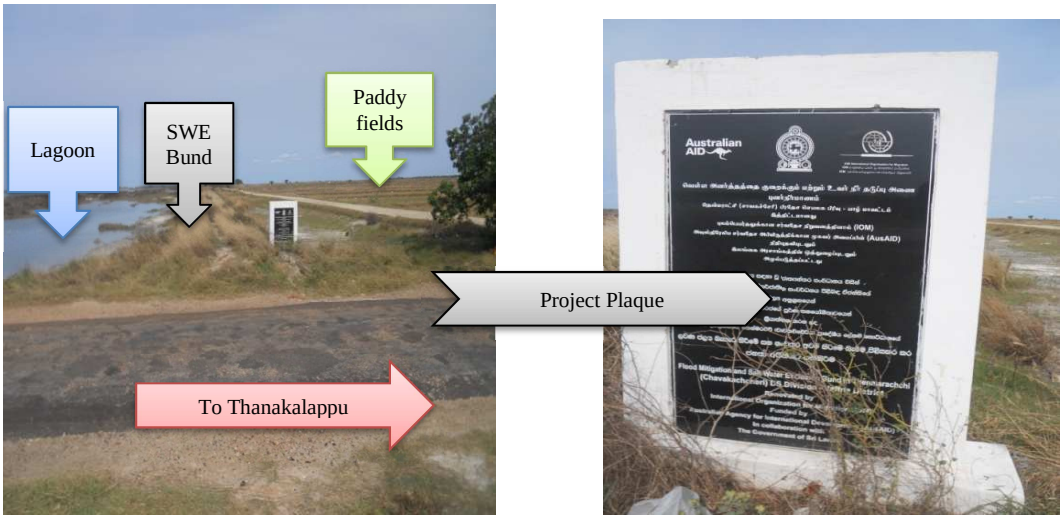
Section of a Sea Water Extrusion Bund (SWE Bund)

The Department of Irrigation is the implementer of the SWE bunds in the coastal areas and the Department of Agrarian Services implements the construction projects of SWE bunds in the areas where the paddy lands/ agricultural lands adjoin lagoons/ the sea. One of the recently built SWE bunds in the west coast of Delft Island was visited as per the directions given by the Divisional Secretary of Delft. The Project Officer Mr. Udayakumar of the International Organization for Migration (IOM) was contacted over the telephone and he directed the Chavakachcheri-Thanakilappu SWE Bund renovation project implemented by IOM under AusAID's funds. The engineer of the Department of Irrigation-Jaffna Mr. Karunanity and the

Senior Technical Officer of the Department of Agrarian Services –Jaffna Mr. Sivananthan have been interviewed directly as the project implementing partners.

According to the Divisional Secretary of Delft, Mr. Alvappiali Siri, in the Delft Island, 21 sites for the construction of SWE bunds have been identified and three are already constructed. The allocated project budget is Rs. 30.89 million and the project period is 2013 to 2014. The purpose of these bunds in Delft is to prevent the salinification of the only inland water source in the west coast – Sarapity wells - and to prevent the coastal population from sea level rise during the tidal periods and to retain the rain water floods during the rainy season. This project was supposed to help more than 1,500 people living in the coastal areas who have been affected in terms of drinking water as well as agricultural water.

The recently constructed SWE Bund at Sarapity, the west coast of the Delft Island. It is just located about 300 meters from the drinking water wells and the purpose of this structure is to prevent the salination of the well water by blocking the sea to penetrate the inland and to retain the floods in the inland during rain.



The renovated SWE bund at Chavakachcheri,Thannakalapu, Jaffna, funded by AusAID through IOM Sri Lanka.

Project Implementer's Perceptions:

According to Mr. Karunanity, Engineer, Department of Irrigation Jaffna

"Penetration of sea water in the agricultural and grazing lands of livestock is becoming a major problem in Jaffna district. It also affects the groundwater aquifer to become saline. Moreover, the major climate change issue is the drought, where water is becoming more and more limited for drinking and agricultural purposes. The Jaffna population is dependent on groundwater and the SWE bunds have been built in 1970s under the Mahavali Project to prevent the penetration of sea water into the inland and to block the rain floods from running off to the sea as a measure of recharging the groundwater table. But, during the war period the SWE bunds have not been maintained and all of them were damaged and the sea water started to penetrate inland. Many grazing lands were destroyed and agricultural lands turned un suitable for cultivation because of the solidification. Many fresh water wells in the most vulnerable areas have turned into salt water".

"Therefore, the floods, which is a valuable resource, have to be managed in an efficient way rather than seeing this resource just as "FLOOD". But there are some interruptions because of poor coordination among the development projects. For example, housing schemes are established in the identified sites and the sites where the SWE bunds are built to retain the water. Ideally, these locations are not suitable for housing schemes and also the houses are not designed for the flooding area. The people are cutting / breaking the bunds during the flooding seasons to divert the fresh water to the sea and it leads to mixing of sea and fresh water after the stabilization of the water levels on either side of the bunds. Also in some seasons the sea water level increases due to the tidal effects and it penetrates inland. Therefore, apart from the rehabilitation process of the SWE bunds, proper understanding and coordination among the project implementers from different sectors is very important".

He also mentioned that the proposed fresh water delivery scheme to Jaffna from Iranamadu tank, Kilinochchi is not actually required because, the groundwater sources in Jaffna are sufficient to cater the requirements of the population. If the Iranamadu water comes to Jaffna, the people will completely forget about conserving the rain water floods and it will lead to a disaster in the near future". The Iranamadu Irrigation Development Project (IIDP) is an integral part of the holistic arrangement for the transfer of water to Jaffna on the one hand and the rehabilitation of the downstream canal system as demanded by the target group population on the other. It is complementary to the ADB/ADF-financed Jaffna and Kilinochchi Water Supply and Sanitation Project, which aims at improving the Iranamadu reservoir bund and head works to increase the reservoir's water holding capacity, part of which would be used for Jaffna drinking water supply[20]).

The Senior Technical Officer of the Department of Agrarian Services, Jaffna, Mr.Sivananthan says,

"The SWE bund of Chavakachcheri-Thankakilappu was existing almost for the last 60 years, but not as a continuous bund. This project was funded by AusAID IOM through the IOM Jaffna

[20] http://www.ifad.org/operations/projects/design/104/srilanka.pdf

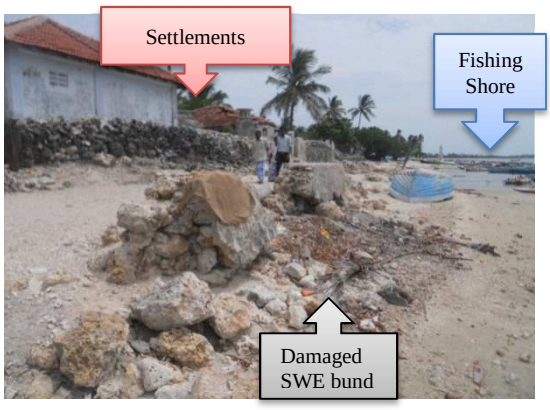
to rehabilitate the bund. The project commenced in July 2012 and was completed in December 2012 at a budget of Rs. 18,000,000 (EUR 103,479). The bund had been damaged for constructing secure bunkers during the war period and adjoining paddy fields became more vulnerable with saline water. The total length of the bund is 7 km and 2 km have been newly constructed. We have observed that the soil structure is changing in the vulnerable paddy fields and it is becoming suitable for cultivation. Also, the grass in the grazing lands has started to grow after the renovation. The Department of Agrarian Services is also engaged in the rehabilitation of inland ponds, cannel systems and agro wells in Jaffna district, under funding from ADB through the Ministry of Economic Development.

Perception of People from Delft Island

Mr. Rajan, the president of the Fisheries Cooperative Union and Mr. Thavarasa another villager in Delft were interviewed about the SWE bunds at Thaliaturai, the northern coast of Delft. They showed a damaged SWE bund at the Thaliaturai Fishing Shore extended to 3 km, which was completely damaged due to the Tsunami in 2004. The structure is concrete and it was preventing the entry of sea water to the settlements during the tidal seasons from November to February.

"Now the sea water enters the settlements and many people have moved away from their homes during the high tidal season. The fishermen lost almost Rs. 15 million worth of fishing gear and boats due to the high tides in 2013. Fishermen can't go for fishing in the tidal season and are losing their livelihood. We have put the request many times to the Government Authorities but it is not done and not in the development plan".

M.Rajan (left) and Mr.Thavarasa.



The broken SWE bund at Thalaithurai, Delft.

Perception of People from Chavakacheri-Thanaknkalappu at the SWE Project:

Mr. N.Senturan, owning a shop at the Thankalappu junction located about 2 kms from the renovated SWE bund and his father K. Nantha Kumar and a villager Mr. K. Mahendran were interviewed at the Thankalappu junction. Their main livelihood is paddy farming, owning about 2 acres of paddy land. The questions and answers are as follows:

Do you know about the SWE Project?
"Yes we know about the project. It was implemented by IOM."

Do you know the cost of this project?"
"No".

What was the contribution of the community to the Project?
"Community did not take part in this project. The Project Implementers also did not approach the community".

Are you experiencing any changes after the Project?
"Yes, the salt water wells have turned into drinkable water suddenly. Also we use the bund as a pathway to our paddy fields and to other villages after the renovation."

How about the soil moisture?
"Soil is always with moisture and we do home gardening for our food purposes. We do not face any serious problems for water. Earlier we had to go to a common fresh water well located about 1 km away from our village".

Left to right: Mr. N.Senturan is father Mr.K.Nandakumar and Mr. K.Mahendran who have been interviewed to know the impact of the renovation of the SWE bund at Chavakachcheri-Thankilappu, Jaffna implemented by IOM and Department of Agrarian Services, Jaffna.

Funds Needed for Replications and Identified New Projects:

According to Mr. Karunanithi, the engineer of the Department of Irrigation Jaffna, the SWE bund projects undertaken by the Department of Irrigation are only the rehabilitation of identified 34 existing SWE bunds. Twenty two sites have been completed now and the other sites have to be completed by 2014. The Project is funded by the Asian Development Bank and

World Bank through the Conflict Affected Regional Emergency Projects (CARE) under the Ministry of Economic Development. The implementation partner is the Department of Irrigation, Northern Province. However, the project doesn't focus on improving the existing bunds because of the limitation of funding. Improvements are needed for the paving of the bunds and fixing rubber linings to the gates to seal the penetration of water. The approximate estimated cost for this activity is Rs.50,000,000 (EUR 287,443). There is a shortage of Rs.30,000,000 (EUR 172466) for the ongoing rehabilitation work as well. If all the individual projects are implemented it will help to uplift the lives of more than 50,000 people directly and many more indirectly.

The Delft Thalaiturai SWE bund is not under the development plan because of the shortage of funds. However, it is necessary to build such a structure to prevent about 900 fishermen getting their lives, property and livelihoods damaged.

The Project Officer of IOM, Mr.Uthayakumar has mentioned that Kumulamunai at Poonarin is a lagoon area in the southern part of the Jaffna peninsula falling under Kilinochchi district, which is highly affected by the sea water rise due to the tidal effects. More than 2,000 people in this area have been moving away because of the penetration of sea water into their settlements. Large area of farm lands, paddy fields and grazing lands are becoming saline because of this disaster. There is a need to build a new SWE bund there but, due to the lack of funds, the project is not implemented. However, UNDP and IOM are interested in funding a part of it. There are no estimations done yet for this project. However, an amount of Rs.55,000,000 (EUR 316,187) is forecasted to be funded by a third donor (still not identified) to contribute to the initial estimations.

Shortages of Funds for the Rehabilitation and Improvements of the Existing SWE Bunds in Jaffna

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Improvements of the existing bunds	Lump sum			30,000,000
Rehabilitation costs	Lump sum			50,000,000
TOTAL				**80,000,000 (EUR 459,770)**

NOTE: The above estimations are in lump sum as per the information provided by the engineer of Department of Irrigation, Jaffna.

Estimation for 500 meters of Concrete Protection wall at Thalaiturai, Delft (No. of beneficiaries would be 900-1,200 people)

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Excavation	2,500	Cubic Meter	1,000	2,500,000
Random rubble masonry work	36,500	Cubic Meter	2,000	73,000,000
Rubble packing to support the foundation	7,500	Cubic Meter	2,000	15,000,000
Engineering consultation 15%				13,575,000
TOTAL				**104,075,000 EUR 598,132**

Estimation for the Sea Water Extrusion Bund in Poonarin (No. of beneficiaries would be 2,000-3,000 people)

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Building 5 kms of SWE bund at Kumulamunai, Poonarin	Lump sum			55,000,000
TOTAL				**55,000,000 EUR 316,091**

3.3. Infrastructure

This section is dedicated to get a glimpse of different types of infrastructure development adaptation measures. Infrastructure development is a cross cutting sector which provides basis for any type of adaptation measures. However, this section brings up two infrastructure development projects implemented in the Kandy district on the issue of landslides which is a direct consequence of climate change in terms of unpredictable rainfall patterns and their high intensities. Landslides can create massive damage to properties, livelihood as well as lives of the people. Displacement caused by this can even have socio-psychological impacts. Recent studies have identified that due to the unpredictable changes and intensities of rain patterns and rainfall, no accurate mapping of vulnerable areas can be traced as the experts did in the past. Climate change induced extreme rainfall have been causing abrupt landslides. Therefore, it is important to see how different infrastructure development projects have been able to function as adaptation measures.

Kandy District

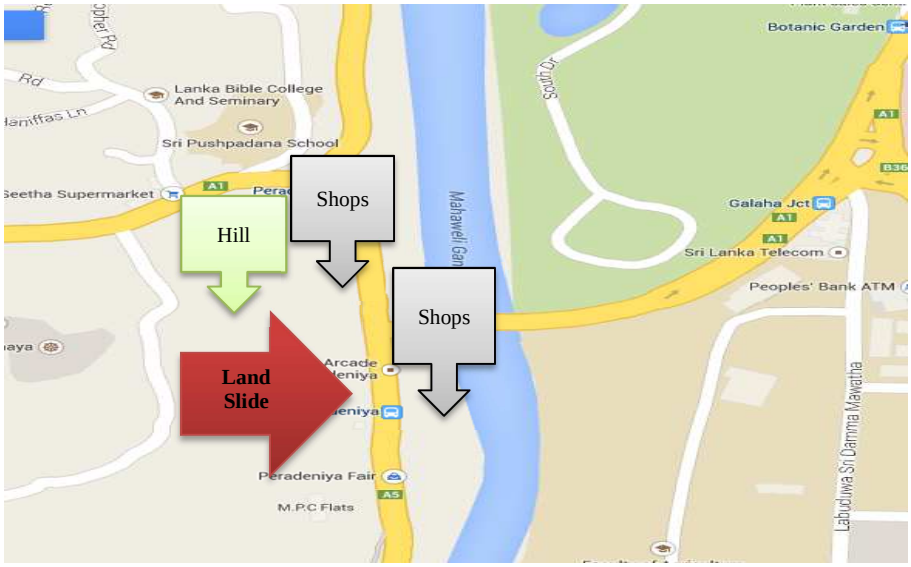
Kandy is located in the central hills, the most famous city for cultural heritage and natural beauty. Kandy district is situated in the middle of the country surrounded by Kegalle, Nuwara Eliya, Badulla and Kurunegala districts. It falls under the country's wet zone and mid country intermediate zones. In terms of the Sri Lankan highway system and food and commercial crops sectors, Kandy district operates as a connecting hub of the country. Kandy district also makes a significant contribution to the country's tea production. The climate records have shown increase in rainfall in the wet zones of Sri Lanka while rainfall is decreasing in the dry and intermediate zones. According to Tea Research Centre of Sri Lanka[21], rainfall during the rainy seasons have gradually increased in Kandy district in the past 10 years although in general the frequency and durations of the rainy seasons have reduced with records of overall temperature of the district going up over the time. This implies occurrence of short-term heavy rain falls which can cause heavy damage to the soil of the mountains. Therefore, the most serious issue in Kandy is the occurrence of landslides with the heavy rainfall. The impact of climate change and the hazards of landslides in Kandy are explained in the following case study as per the information given by the senior research scientist of the National Building Research Organization of Sri Lanka.

[21] www.tri.lk/userfiles/file/228%20E.../228%20E&E%20Proceedings.pdf

3.3.1. Peradeniya Landslide Rehabilitation Project

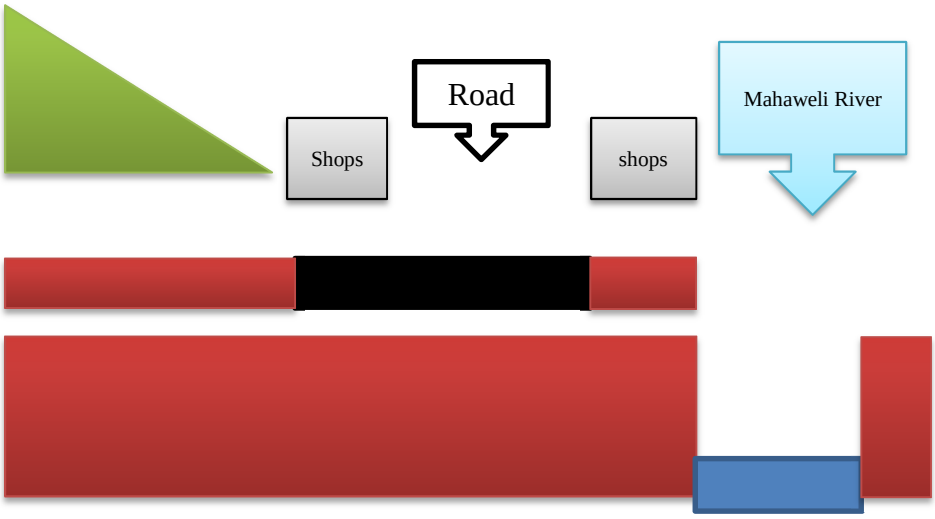
Peradeniya is located in the southern part of the Kandy district along the Kandy-Colombo road, where the famous University of Peradeniya and the Royal Botanical gardens are located. Peradeniya town is located at the Junction of the Nuwara Eliya-Peradeniya road and Peradeniya-Colombo road between the left bank of the Mahawali River[22] and the Peradeniya-Nuwara Eliya road and Kandy-Colombo Road. It is a mini-commercial town with approximately 150 shops and 50 homes.

The landslide occurred at the right turn of the junction from Peradeniya to Colombo in November 2006, where the hill on the left side had broken down to the road. Almost 1 acre of land and 7 shops on at the left side of the road were destroyed. No deaths or serious injuries were reported.



Map: site of the landslide happened in 2006 at Peradeniya Junction (Google Map)

[22] The longest river in Sri Lanka originating in Horton Planes National Park, passing through Peradeniya and Kandy and falling to sea in Trincomalee: http://en.wikipedia.org/wiki/Mahaweli_River



Cross section of the site of the land slide occurred at the Peradeniya town, Kandy

Left: Reconstructed Site of Peradeniya landslide (the site is more hazardous as it could be seen clearly from the vehicles and people are on the road side in front of the site of the landslide).
Right: The identified area which is more susceptible for landslide in the near future.

Project Implementers' Review:

The National Building Research Organization of Sri Lanka (NBRO) has undertaken the reconstruction project of the Peradeniya landslide. NBRO falls under the Ministry of Disaster Management Sri Lanka.[23] The project commenced in 2007 and was completed in the year 2010.

[23] www.disastermin.gov.lk

The Senior Research Scientist of the NBOR, Kandy, Mr, Nishantha Peries was interviewed to obtain information of the project and the relationship between climate change and the occurrences of landslides in Kandy and the other parts of Sri Lanka.

What are the main causes of landslides in Sri Lanka?

"There are many causal factors for the occurrences of landslides in Sri Lanka. The major factors are:

i- The causal factors: the geological structure
ii- Triggering factors: rainfall
iii- Man-made factors: mining rocks, disforestation, construction of buildings not falling within the geological structure and in the most vulnerable areas for landslide, poor management / failure to manage the rain floods and drains etc."

What are the basic functions of the National Building Research Organization (NBRO) with respect to landslides?

- *Landslide hazard zonation mapping*
- *Landslide hazard identification and assessment of landslide risk*
- *Application for landslide investigations*
- *Guidelines for construction and land Use planning in hilly areas*
- *Landslide mitigation*
- *Awareness and training programmers*
- *Landslide early warning*
- *Landslide database*

NBRO does geological testing and provides certification for construction which is a requirement to construct buildings in Sri Lanka in the identified areas for landslides".

What is the relationship between climate change and landslides in Sri Lanka?

"Due to the climate change in Sri Lanka, it is very difficult to predict rainfall. Sometimes there are sudden rains and continuous rainfall which do not fall in line with the forecast done by the Department of Meteorology, Sri Lanka. The landslide happens with the rain, in the rainy season, when the soil of the slope/ steep parts of the hills gets moist and slides. Therefore, it is very difficult to predict the occurrences of landslides which are directly correlated to rain fall".

What is the trend of the occurrences of landslides in Sri Lanka and Kandy?

"The occurrences are increasing. Now there are many cases all over the island with the unpredictable rainfall, and man-made factors. Even though the government has provided lands for settlements and basic aid has been provided to shift their homes and business places, people tend to build buildings, homes and continue to live in the most vulnerable areas even

after warning. This is because, they do not like to move away from their native homes and business places".

What are the identified locations? Do you have any maps of the identified locations?"

"Yes. We have mapped the most vulnerable areas using GIS technology. The Maps are available on the website of NBRO".

Are there any automated warning systems for landslides?

"Yes. We have fixed sensors with warning sirens. The sensors will sense the earth movements and then provide signals to the sirens. The people who are living around will get the sound from the siren if there is a risk. Such systems are fixed at Garandigala, Pussalawa (located in the hill country on the way to Nuwara Eliya).

There are automated rain gauges (the equipment which is used to measure the rainfall) fixed all over the island. They are connected to the main computer at NBRO-Colombo to monitor and record rainfall. In the central part, 50 rain gauges are fixed. If the rainfall is exceeding 75 mm a day, then the NBRO will announce the risk of landslides through the Government Agencies and Media".

What are the adaptation methods for landslides you implement?

"*We maintain the proper slope of the affected areas or the most vulnerable areas which are highly hazardous. The locations closer to settlements, with the settlements, roads, highways, railway tracks and towns are the most hazardous areas. If a disaster happened like Peradeniya, we do the appropriate engineering to mitigate the disaster.*

- *In Peradeniya the main engineering methodology we use is to maintain the proper slope of the hill in Sri Lanka: the angle is 39°. It is cut to three terrains as steps and proper drainage systems have been constructed.*
- *Concrete retention walls and turfing with grass are the techniques we have adopted to avoid the landslide.*
- *In some areas due to the rain, the groundwater table goes up and it loosens the bottom soil and triggers landslides. Here, we have dug deep wells and installed automated pumps to pump out the water when the water level rises.*
- *We advise the people to maintain proper surface water drainage systems to avoid seepage and water logging in the vulnerable area. Draining out the water will prevent the soil from getting wet and the probability to slide is very low.*

Have you fixed the sensors with sirens in all the areas?

"No. In the most vulnerable and hazardous areas only we have fixed. Due to the cost, we do not fix in all areas. A sensor will cost about Rs.250,000 (EUR 1,436). We get the sensors designed and made from the Industrial Technological Institute of Sri Lanka".[24]

What is the cost for the Peradeniya Project?"

"Approximately Rs.102,000,000".

What are the gaps in implementing the adaptation methods for landslides in Sri Lanka?

"There are not enough experts in the sector. Also the cost and the funds are limited. According to the government procedure, it is very complex to recruit new professionals for the landslide-related services. If any NGO can train the professionals and make them available to offer appropriate services, then it would be a good solution. Also, certain level of technologies such as sensors and upgrading the maps".

Perception of People about the Peradeniya Landslides:

Mr.Y.M.A.Bandara (age 34) the owner of Udaya Traders Peradeniya, who is one of the victims of landslide was interviewed. He is also the secretary of the Peradeniya Traders' Association. He is the only victim out of another seven continuing commercial operations. His main business is selling home appliances.

According to Mr. Bandara, the landslide occurred on the 13th of November 2006 and he lost about Rs. 4.5 million worth of assets and properties including his shop and the commercial materials. The vendors at Peradeniya town didn't know about any signs of the landslide till it happened in November 2006. Another seven shops were also destroyed completely. Fortunately, there wasn't any damage to the lives of the people who were at the shops and the passengers on the road. He is renting out an office space and continuing his business. The other vendors who lost their shops have given up their business after the disaster.

They had insured their buildings, but the insurance agent refused to give compensation. They filed a court case at the Kandy District Court, but finally the insurance agent won and they only got Rs.500,000 as compensation. The National Building Research Organization has informed them that the area is of about 100 meters in radius from the present site of the landslide. The government authorities have requested them to move to the new proposed site which is about 1.5 km away on the Colombo road. But the merchants in Peradeniya do not want to move because the present location is the most suitable place for their business because the Peradeniya traders are highly dependent on the community of the University of Peradeniya: the students and the staff are the main customers of their business.

[24] http://iti.lk/

When the questions were asked about the causes for this disaster, he mentioned that, there were about 10 families on top of the hill who were diverting their sewage and water to the hill. Similarly, the weight of those houses contributed a lot to the landslide. The houses got assistance from a NGO (he doesn't remember the name of the NGO) and they have got new houses in a new place and resettled there.

About the impact of the reconstruction project, he stated that up to now it is very efficient. Even during the continuous showers between 2010 December and 2011 January not even a single stone fell down. NBRO had been monitoring the earth's movements until 2013, but now they are not continuing it.

He is well aware of the project cost: Rs.120,000,000 (EUR 689,655) and he also said that another Rs. 794 million is estimated to shift the Peradeniya Town to the new proposed site. The vendors who lost their shops have given three alternatives to the Government:

1. If their previous lands are acquired by the government, then to provide the value of their lands in cash
2. Or allow them to rebuild their shops at the same site on a long term lease
3. Or government to construct the buildings and then sell the buildings to them

However, their requests have not been taken into account seriously by government officials and parliamentarians.

Then the question was asked as to what support they need from an NGO
The answers were:

1. *Influence the government officials to listen and provide a solution to their requests*
2. *Provide engineering consultations on designing the shops at the particular location, where they can continue their business without any risks in the future*

In what ways can you contribute if any agencies are helping you?

"We can provide and work together through the Peradeniya Traders Association."

Evaluation of the Project in Terms of Result:

1. Peradeniya landslide rehabilitation project was successful and there are no occurances of landslides after the project.
2. The landslide caused loss of business to seven vendors
3. There is no proper initiative by the government to evacuate the vendors and the settlements in the surroundings which are identified as vulnerable for landslide and hazardous for human lives.

Left: Mr. Bandara at his shop at the present rented shop space.
Right: The site of Mr. Bandara's shop existed before the landslide (red arrow). It is his 0.25 acres of own land.

Identified New Projects and Funding Needed:

1. Installation of landslide sensors to strengthen the warning system
2. Assisting the victims in designing their building and infrastructure by providing engineering consultations

Installation of landslide warning systems

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Landslide sensors with sirens	250,000	No. of items	100	25,000,000
Installation costs	50,000	No. of items	100	5,000,000
Transport	100,000	Trip	1	100,000
Total				**30,100,000 (EUR 172,988)**

Engineering Consultations to the Victims of Landslide in Designing Their Homes and Buildings

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Engineering consultancies to the Peradeniya vendors in reconstruct their buildings	5,000,000	Lump sum		5,000,000
Total				**5,000,000 EUR (28,735)**

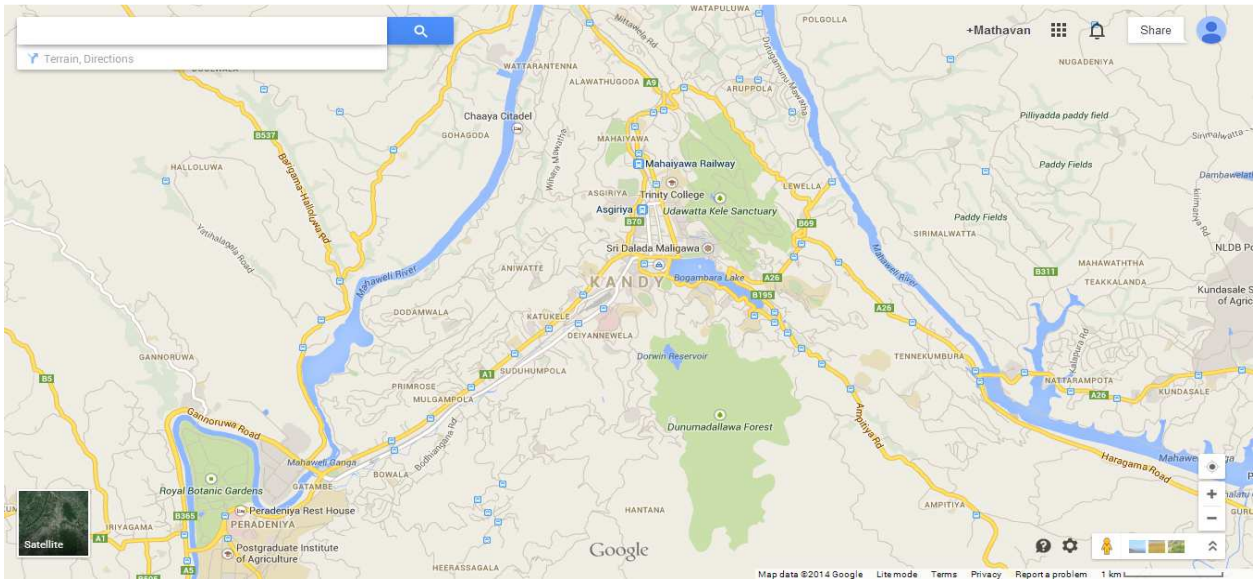
3.3.2. Landslide of Suduhumpola, Kandy in 2010 and the Hanthana-Kitulmulla Housing Scheme Project for the Victims of Landslide in Kandy District

Suduhumpola is an urban settlement of Kandy city, which is located between the New Road and the Hanthana mountain range. It is almost like an urban slum where the main livelihood is based on urban labor – casual/permanent, small business such as street vendors, but the population is much less dense than a typical slum. The houses are located on the adjoining hill of the Hanthana mount and also on the flat landscape sloping down towards the New Road (William Gopallawa Mawatha), Kandy.

The landslide occurred on 10th January 2011, during the continuous rain which lasted for about three months from December 2010 to January 2011.

A visit was made to the site of the landslide at Suduhumpola and to the site of the resettlement project at Hanthana-Kitullmulla, which is a part of the Hanthana Group Tea Estate.

The victims who lost their houses and who are vulnerable to face the most hazardous disasters have been interviewed at the site of the landslide and the people who settled in the new housing scheme have also been interviewed about the incident and to get their views and suggestions.



Map:Site of the landslides occurred at Suduhumpola, Tennekumbura and the area of resettlement project

Suduhumpola Site –Kandy: Mr. Nilantha Jayasooriya owner of a hairdressing saloon, Mrs.U.G.Ukkuamma, her daughter (did not mention the name), the neighbor Mr. Annisappu and his wife were interviewed.

According to them, they didn't know that the site was hazardous and most vulnerable to landslides till the disaster happened at around 10 a.m. on 11 January 2011. Fortunately no incidents of damage to lives were reported because the victims were away from home and their

children were at schools at the time of the disaster. Five houses were badly damaged and two were completely destroyed and another 10 houses were partially damaged.

When the question was asked as to what compensation was provided by the government, it was learned that about 100 families in that area have been requested to move to the proposed area of resettlement, which is located in the Hanthana Group Estate in the Kitulmulla area, which is about 15 km from the Kandy town. Thirty perches (759 sq meters) of land plots are given to the families who have lost their properties. An amount of Rs.100,000 was given in three installments as a grant and another amount of Rs.200,000 was given as a housing loan (with the repayment period of 10 years), to build their new houses at the proposed site.

Are you all happy with the new location?

"No. Our earning is based on our daily labor we get from Kandy city. Almost every day we will have jobs. Also our children go to schools which are close by. There are no expenses for transport because we are located almost in the Kandy city. The new site is too far from Kandy city and we have to spend almost Rs. 110 a day for the bus fare. There is no electricity, the road is of very poor condition and it takes two hours to reach there. Also there are no schools, shops and hospitals nearby as government informed us before. There is no such development coming up as was told earlier."

Do you have any warning systems such as sensors fixed here?
No.

Do you need such a system here in order to get the warning signals when there is a possibility of disaster?

"Yes. Of course. That would be a great thing. At least we can save our lives if there is such a system".

Mrs..U.G. Ukkuamma;

Mr.Annisappu

Most vulnerable regions for landslide and hazardous areas to humans. The houses are built on the steep landscape of the hills.

Subsequently, a visit was made to the site of the resettlement project at Kitulmulla, Hanthana Group Estate. It took 1 hour and 45 minutes to reach the location situated 15 km from the Kandy city by a 150cc motorbike. The resettlement housing scheme is located on a plateau. Land plots in this have been given not only to the victims of the Suduhumpola landslide victims but to the victims of few other landslide disasters as well. Newly-built incomplete houses could be seen scattered with an average distance of 50 meters from each. No people were living in the houses: grass and vegetation have grown inside the new houses and in the premises. There are three clusters of houses, each area having about 13 houses. Most of the houses are incomplete and the few which were completed were locked.

There was an elderly woman (about 65 years) living in a house in the second cluster. Her name was Anulawathi. She was originally from Tennekumbura (a village adjoining the Mahawali river), which is about 6 km from Kandy city. She lost her house in a landslide in the first week of January 2011 during the same period of the Suduhumpola disaster. According to her, there are about 40 houses built and only four families are living in the housing scheme. She directed us to her daughter's family and to their neighbor's which were located about 300 meters from her house. Her husband goes for daily labor to the neighboring villages and to Kandy city for earning. She stated the following:

"We lost our houses completely. My family and daughter's family moved to this site since we did not have any shelter. We stayed in the Tennekumbura community hall as refugees for a year and in 2012 we moved to this place. Altogether seven families lost their homes and became refugees. Initially we got assistance from the Catholic Priests from Ampitiya Catholic Seminary for about a month. Then the males started going for work. We also got Rs.100,000 as a grant and Rs.200,000 as a 10-year loan. A standard plan was given by the National Housing

Authority to build the house and we built the house according to the plan. We also worked together with the mason".

Why have others not completed the houses and settled here?

"Because of the difficulties in reaching Kandy for jobs and the poor facilities here".

In that case, why have the people accepted this site and built the houses even though they are not living here?

"Yes. Because they got this land they have accepted. People like us do not have any other land, so we accepted. And people built their houses since they got the grant and loan for housing. Since the loan and the grant was released upon the progress of the construction of the houses the people have constructed the houses".

From where are you getting water?

"We have dug a well. Here there is enough water throughout the year".

Do you have proper sanitation and latrine facilities?

"No. The latrines are not given in the plans. It is costly to construct permanent latrines. So we are having temporary toilets."

After the interview with Mrs. Anulawathi, a visit to her daughter's house and to their neighbor's was made. Mrs. Lalitha Premarathne (daughter of Mrs. Anulawathi) and Mrs. M. Rajalakshmi Selvanayagem (their neighbor) were interviewed.

They also stated the same problems and the same reasons as to why they are living in the newly given settlement which is very remote.

In addition, the following points have been indicated by them:

1. Mrs. Lalitha Premarathne's children (daughter 13 years, son 10 years) do not have proper access to school. They have to go to Galaha, which is located about 15 km away, to attend the Sinhalese medium school. The bus fare is Rs.110 a day per child. Their father is the only earning member of the family and he has to go to Kandy to find a causal job. If the father doesn't have enough money, the children do not attend the school since they cannot afford the bus fare. (Their third son is 3 years old and he has not reached the age of schooling).

2. At present there is no toilet. They use a temporary toilet.

3. The site is very windy all the time and there are no trees to resist the wind. The roofs of the houses tend to fly with the strong wind.

When the question was asked about what their real requirements are, the answers from all the interviewees in this case study were:

1. The basic facilities of transportation, electricity, sanitation, hospital and schools have to be provided.
2. A good and sustainable livelihood has to be given to the settlers who are the victims.

Left: Mrs.Anulawathi and her new house.
Right: Anulawathi's daughter Mrs. Lalitha Premarathne with her children

Left: A part of the clusters of newly-built houses in Kitulmulla.
Right: A newly-built completed house which is closed up at the scheme. The picture clearly indicates that there is no electricity line provided to the house. The well grown grass clearly shows the fertility and the availability of water in the soil.

Evaluation and the Findings of the Hanthana-Kitulmulla Housing Scheme Project for the Victims of Landslide in Kandy District

1. The housing scheme is not a successful project unless the basic facilities and proper pathway for livelihood development is provided to the settlers who are the victims of the landslides.

2. The Government does not have a clear plan for any developments because there is no proper data available for this scheme from the District Secretaries of Kandy.

3. There is no reduction of the landslide hazard for the community: Except for a very few (only four families out of 100 families) who have moved to live in the resettlement housing schemes, the others are continuing to live in the hazardous regions of landslides. The major reason for this is to obtain a sustainable livelihood and basic facilities.

Positive Points and Potentials:

1. Fertile site with good soil, water and grass. Thus ideal to promote dairy development as a source of livelihood.

2. There is enough sunlight and wind (with an average speed of more than 20 km per hour). Solar energy and wind energy could be provided to illuminate the houses in the night.

3. The location is surrounded by beautiful nature and the Hanthana hills. Also very close to the Hanthana nature reserve and Hanthana Group Tea Estate. Thus, tourism could be promoted as a means of income generation to the people.

Identified New Projects:

As severe landslides are a result of increasingly changing climate (unpredictable rains) of Kandy, the priority adaptation measure identified in this is the implementation of well-planned resettlement projects of people along with alternative livelihood opportunities in less vulnerable areas. This is due to the gaps in forecasting, risk management and financial scarcities to reconstruct landslide prone areas. Compared to the immense cost of the infrastructure development in the vulnerable sites, this is identified as more cost-effective and less time consuming. However, as a long-term sustainable measure, developing accurate warning systems and infrastructure development projects in vulnerable areas are needed. Following are the possible projects to address the gaps in the resettled villages. They are applicable to any future resettlement projects as well.

1. Livelihood Development: Providing assistance to initiate dairy development to the victims

   A social/community based enterprise development project could be launched focusing on dairy processing facilities and tourism in order to pave a path for a closed and cooperative structure to build up a 'Dairy Village' as a model for economic and social sustainability. The average farm gate price of a liter of raw milk in Sri Lanka is Rs. 50. If the victims are trained to do cattle farming and provided with two milking cows to ensure 10 to 15 liters of milk a day, the minimum income would be about Rs.500. By providing a central milk processing plant, value added products such as yogurt and cheese-making will add up another 80% of the income. Thus, a family could get about Rs.900 from milk. In addition cow dung is a fertilizer and it could be composted and used for home gardening, where they can grow their vegetables for their daily food. In such a way they can save money and time for shopping of vegetables. Poultry also could be considered since chickens could scavenge for the worms and insects in the home garden. Facilitation to market the milk and milk products also have to be done at the initial stages. Ideally it is advisable to hand over the operations to a private company/nonprofit organization to ensure the sustainability of production and marketing.

   Besides everything, the milk, purely grown vegetables and poultry eggs will feed the family and strengthen food security.

   However, the challenge would be influencing the social change of this urban labor population to get into farming. This has to be done by proper result-oriented training modules, exposure visits and selection of positive beneficiaries as the pioneers of the project.

2. Provision of basic facilities:
   i. Assistance to complete the incomplete homes in the colony
   ii. Renovation of the road
   iii. Provision of solar panels to the houses to produce electricity
   iv. Providing shops/sales outlets to an identified businessman to start selling basic foods and consumables for the households
   v. Provision of a bus for transportation
   vi. Provision of a school service vehicle (small van) for transportation
   vii. Provision of an advanced first aid unit cum dispensary to provide primary treatment to the patients (health professionals have to be identified from the victims' community or at least five young men and women have to be trained in providing first aid in case of accidents/ emergencies)
   viii. Provision of sanitation facilities

Funds Required:

Budget for Dairy development as an option for livelihood

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Livelihood support for 100 families (dairy farming/any other suitable livelihood	350,000	No. of units	100	35,000,000
Providing a vehicle to transport milk	1,500,000	No. of units	1	1,500,000
Providing a mini dairy processing plant and accessories	12,000,000	No. of units	1	12,000,000
Initial running cost for the business	4,000,000	Lumps um	1	4,000,000
Initial cost for marketing facilitation	3,500,000	Trip	1	3,500,000
Total				**56,000,000 EUR 321,839**

Provision of Basic Facilities to the Victims' Houses in the Colony:

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Assisting to complete the incomplete homes in the colony	200,000	No. of units	100	20,000,000
Renovation of the road	15,000,000	kms	4	60,000,000
Provision of solar panels to the houses to produce electricity	12,000,000	No. of units	1	12,000,000
Providing shop/ sales outlet to an identified businessman to start selling basic foods and consumables for the households	5,000,000	Lump sum	1	5,000,000
Provision of a bus for transportation	300,000	No. of units	1	300,000
Provision of a school service vehicle (small van) for transportation	9,000,000	No. of units	1	9,000,000
Provision of an advanced first aid unit cum dispensary to provide primary treatment to the patients.	10,000,000	No. of units	1	10,000,000
Provision of sanitation facilities	75,000	No. of units	100	7,500,000
Training 5 youngsters in providing first aid	100,000	No. of units	5	500,000
Total				**124,300,000 EUR 714,367**

3.4. Summary Budget for Replication Projects and New Projects Immediately Required in Jaffna, Mannar, Puttlam, Hambantota and Kandy Districts

Estimated Budget for the Implementation of Effective Adaptations and Mitigation Methods for the Climate Variations in Jaffna Kandy and Puttalam Districts of Sri Lanka	
Activities /Projects in Jaffna and Mannar Districts in Northern Province	**Cost (EUR)**
Required Budget to provide sprinkler irrigation systems to another 675 Farmers in Koopai and Nallur DS Divisions (covering approx. 200 acres)	517,500
Estimated Budget for Ridge and Furrow System with Coconut Husk for 100,000 cubic meters in Jaffna District benefitting about 1000 farmers	1,379,280
Estimated Budget for Rain Water Recharging System for 50 Farmers in Jaffna district	47,237
Estimated budget for introducing drip irrigation system from collected rain water for 10 acres in Delft	33,541
Shortages of Funds for the Rehabilitation and Improvements of the Existing SWE Bunds in Jaffna district	459,770
Estimation for 500 meters of concrete protection wall at Thalaithurai, Delft	598,132
Estimation for the sea water exclusion bund at Poonarin	316,091
Estimated budget for replicating the rice chain project in Musali and Manthai	237,931
Activities in Hambantota District	
Estimated budget for providing irrigation facilities, sprinkler water systems, rain water harvesting systems and awareness raising programs on climate change and technology to 200 farmer families in Sooriya Wewa and Thissamaharama	131,609
Estimated budget for replicating the rice chain project in Weerawila and Thissamaharama	237,931
Activities in Puttalam District	
Estimated budget for replicating the rice chain project to benefit 100 families in Kalpitiya,	118,965
Activities /Projects in Kandy District	
Installation of landslide waning systems	172,988
Engineering consultations to the victims of landslide in designing their houses and buildings	28,735
Budget for Dairy development as an option for livelihood to the Kitulmulla Resettlements	321,839
Provision of Basic Facilities to the Kitulmulla Resettlements	714,367
Budget for other adaptation methods	
Awareness creation to convert the flood paddy farming system to a non-flood based paddy farming system for 100 farmers(applicable to all the dry and intermediate zones of the country)	4,310
Estimated budget for the bio fertilizer project that can cater a 2-3 divisional secretariats in Sri Lanka	193,103
Training of Professionals and volunteers in Climate change and adaptation methods	34,482
Budget to Develop a Precision Farming system	218,390
TOTAL	**5,766,201 (LKR 1,003,318,974**

The above adaptation measures and funding needs are based on the case studies covered in this report and on the literature reviewed. Therefore, this by no means implies that they are the only projects urgently required to be implemented. No adequate research has been conducted to identify the overall adaptation needs of the country and their funding needs. No national level surveys have been conducted to capture the impact of climate change in Sri Lanka for estimating the number of victims, vulnerable populations or economic losses. Therefore, a broader study on these areas is needed to develop a more effective and holistic intervention system in the future

4. CLIMATE CHANGE FUNDING IN SRI LANKA

This section is a brief discussion on few national level climate change adaptation measures related projects implemented by international organizations. The objective of including this section is to provide an overview of main focuses of the climate change funding in Sri Lanka so far.

1. United Nations Development Program (UNDP)

Following is a quote from the UNDP Sri Lanka website[25] regarding a project to improve paddy production through adaptation technology,

"Given the urgent need to find a solution to improve the productivity of salt-affected paddy lands, the United Nations Development Program (UNDP) and Disaster Management Centre (DMC) of the Ministry of Disaster Management joined hands with the Rice Research & Development Institute (RRDI) and the National Federation for Conservation of Traditional Seeds and Agricultural Resources (NFCTSAR - a local NGO) to implement a Climate Change adaptation pilot project.

The area selected, "Angithgakulam Yaya", in Puttalam District, a dry zone, is home to hundreds of agricultural families, resettled as a result of an expansion of an irrigation development project named "Deduruoya Project." Due to the inability to cultivate the paddy lands given to the resettled community and the resulting economic hardships, the settlers were determined to move back to their previous lands.

This pilot project, carried out between 2008-2010, was successful and the findings were used to establish best practices of paddy cultivation in salt-affected lands in Sri Lanka. During the pilot project a selection of proven traditional and improved rice varieties recommended by RRDI and Department of Agriculture was used to test the performance of different varieties under salinity-affected paddy fields. "We have had to change the way we farm as the soil here is salinated when compared to where we lived earlier," said Mr. W. D. Premachandra, a farmer, adding "We do not have any experience in farming this type of soil and we had to learn to do things differently"."

The new practices introduced include delaying of the time for transplanting seeds, draining water from paddy fields on a more frequent basis to reduce salinity levels, application of more organic materials to the soil in land preparation, and establishing a nursery for transplant paddy instead of seeding, as seed germination is sensitive to salts. According to Premachandra, each successive season helped them to better understand improvements and adjustments needed. Most farmers were uncertain at the start, however, having witnessed the success of a few champions during the first season the participation increased in subsequent seasons.

[25]http://www.lk.undp.org/content/srilanka/en/home/ourwork/environmentandenergy/successstories/improving-paddy-production-through-adaptation-technology--/

The results of this pilot project were encouraging and revealing. Both traditional and research-developed varieties of rice performed better than the national average, partly due to the increased attention and training of farmers. The average yield of improved rice varieties cultivated using 'business-as-usual' practices in this area was about 520 kg per acre. However, as a result of the pilot project, the yield increased to about 2,800 kg per acre with enhanced soil, residue and water management in the same area. National average for the same varieties is around 1,700 kg per acre. This phenomenal success led the RRDI and Department of Agriculture to report the pilot project as the "Best Research of 2009."

In Addition to this, The Economic Development Ministry signed an agreement with the United Nations Development Programme (UNDP) on 25th June 2014 to support the Divi Neguma Livelihood Development Programme to withstand climate related shocks. This four year project is worth Rs. 410 million.

2. Global Environment Facility (GEF)[26]

Sri Lanka is one of the first countries which accessed GEF financing. GEF-SGP Sri Lanka was launched as a pilot initiative in 1995. Since then it has developed into a fully operational program and is now in its fifth operational phase. The following information was quoted from National Portfolio Formulation Exercise GEF Cycle 5 report published by Ministry of Environment, Sri Lanka[27].

To date Sri Lanka has received approximately US$ 59.30 million for implementing 21 projects of national importance from 1991 to 2011.Sri Lanka is involved in three regional projects of US$ 19.89 and six global projects worth of US$ 139.77.The GEF funds have also generated co-financing amounting to US$ 341,90 million (National), US$ 26.68 million (Regional) and US$ 126.30 million (Global) from other donor agencies and the Sri Lanka government."

During the past 15 years (1995 - 2010), the country program has implemented 340 projects, amounting to US$ 6,579,760 of funding, which also includes financial allocations received for implementing the Community Water Initiative (CWI) and Mekong Asia Pacific/Community Based Adaptation (MAP/CBA) initiative that provides assistance for implementing climate change adaptation activities at community level. In addition, an amount of US$550,000 (not included in the above total) was mobilized for rehabilitation and reconstruction of destroyed habitats and infrastructure in the aftermath of the December 2004 tsunami.

The GEF funded projects have also helped to develop in-country capacity to identify and address national environmental problems that will help conserve the global environment by

[26] http://www.thegef.org/gef/whatisgef
[27] http://www.thegef.org/gef/sites/thegef.org/files/documents/document/Sri%20Lanka%20NPFD.pdf

strengthening governmental and non-governmental organizations, the corporate sector and communities to contribute towards environmental conservation. In doing so, the GEF has communicated with not just key actors in government but with the public at large right down to the grassroots.

3. Climate Resilient Action Plan for Coastal urban Areas of Sri Lanka

Quoted source- http://www.climateresilience.lk/

"Climate resilient action Plans for Coastal urban areas of Sri Lanka (CCSL) which intends to enhance multi-stakeholder resilience to climate change in coastal Sri Lankan Cities is carried out in Sri Lanka primarily in Batticaloa Municipal Council (BMC) & Negombo Municipal Council (NMC) areas of Sri Lanka. This project is funded by the Nordic Climate Facility. (NCF) is financed by the Nordic Development Fund (NDF) and implemented jointly with the Nordic Environment Finance Corporation (NEFCO).The project is jointly implemented by the Norwegian Institute of Water Research (NIVA) , University of Moratuwa -Sri Lanka, United Nations Human Settlement (UNHABITAT), Batticaloa Municipal Council (BMC) & Negombo Municipal Council (NMC).

This project will support key stakeholders in BMC and NMC to develop and implement the 4 CRASA projects in a participatory manner:

- Water resource management, and especially drainage and sanitation impacts from more intense rainfall events, supported by a Pre-Feasibility Study (PFS) for funding support from the SIDA supported City Development Initiative for Asia (CDIA);

- Multi-purpose green belt (12km in length of BMC coast) established to protect the lagoon and coastal areas, restore mangrove eco-systems & coastal bio-diversity;

- GIS-based Rapid Response System (RRS)& Knowledge Management centre for climate exacerbated disasters established at BMC & NMC with training (1 month for selected 50 participants) and equipment (building, Software, 20 computers, 10 GPS, printers, scanners, broadband facilities);

- Disaster resilient; energy efficient; low-cost shelter adaptation training, supported by local resource based- livelihood diversifications options for 100 participants live in vulnerable areas."

5. CLIMATE CHANGE ADAPTATION GAPS AND RECOMMENDATIONS FOR A BETTER FUTURE

5.1. Gaps in Climate Change Adaptations

Following is a list of gaps existing in Sri Lanka's climate change adaptation efforts which were identified through literature review and interviews with several organizations.

01. "Adaptation efforts have so far been fragmented, lacking a strong link between national climate change strategies, plans, and existing disaster risk reduction, agricultural, and other relevant policies. This is due to lack of conceptual understanding as to what constitutes adaptation" (Oxfam 2011[28]). Although various national and international organizations have developed CCA programs in the country, most of them operate as stand-alone projects.

02. Importantly, the following research gaps have been identified by the same Oxfam Report 2011[29].

- Research on climate-induced migration is urgently required;
- Research on economic diversification at household level and how this reduces the impacts of climate change;
- Research to test the links between access to basic services, such as energy, water, transport, finance, health, and education; and how these affect a community's ability to adapt;
- Research to identify opportunities for encouraging the spread of low-carbon technologies to support diversification and mobility in areas undergoing rapid economic development;
- Micro-finance research to better understand how micro-finance can be linked to larger social support systems that strengthen livelihoods and increase disaster risk resilience rather than increase the risk and debt burden for the poor;
- Financial incentives research to identify how risk sharing and risk transfers can be promoted through existing institutional mechanisms in terms of CCA.
- Importantly, there hadn't been any research on the impact of the war and resettlements on environment damage and climate change in North and East.

[28] Review of Climate Change Adaptation Practices in South Asiahttp://www.oxfam.org/sites/www.oxfam.org/files/rr-climate-change-adaptation-south-asia-161111-en.pdf
[29] ibid

3. Inadequate tools, knowledge, and financial resources in forecasting and communicating adverse climate weather changes to vulnerable communities.

4. Lack of climate change adaptation infrastructure.

5. Lack of understanding of what climate change means and its impacts among the people.

6. Insufficient long-term perspective aggravated by short-term funding cycles. Most of the funding projects have been short-term and are not sustainable.

7. Lack of integration among adaptation strategies in food security and development strategies.

8. Insufficient integration between institutions, including intergovernmental co-operations, civil society and the funders. Majority of the funds have been distributed through the government without proper consultation of affected people or civil society. The development practitioners believe that this can cause waste of funding resources.

5.2. Recommendations

1. Reducing carbon footprint in order to reduce the instability of the atmospheric temperature.

2. Promoting reforestation projects, forest gardens, planting trees**:**
   The natural vegetation is the main source of converting the atmospheric carbon dioxide (CO_2) into Oxygen. In addition, the trees cover the ground/soil and prevent the loss of water from the earth and cool the environment.

3. Shifting to non-flooding method of paddy cultivation:
   Presently the paddy cultivation method in Sri Lanka is based on flooding the paddy fields. This is a system that causes high level of water wastage. It leads to the emission of methane (CH_4) due to the decomposition of the soil's organic matter which is a potent greenhouse gas for retaining the atmospheric temperature. More awareness creation and pilot level farmer-based participatory experimental works have to be done for the non-flooding method paddy farming system.

Budget for an awareness creation to convert the flood paddy farming system to a non-flood based paddy farming system- for 100 farmers

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Training and awareness creation	750,000	Lump sum	1	750,000
Total				**750,000 (EUR 4,310)**

4. Introducing precision agriculture to the Sri Lankan farmers

Precision farming is a way of applying the inputs up to the accurate levels depending on the quality of soil, availability of water and climatic conditions. In short, it is the site-specific crop management system to optimize the usage of agro chemicals based on inter- and intra-field variability of crops.[30] This method is highly technology intensive in observing and measuring the levels of nutrition, climatic conditions pest and diseases and water in the field by the infra-red imaging technology with GPS and GIS. This system leads to:

i. Optimizing the farming methods much accurate to the need of the crop,
ii. Protection of the environment by limiting the amount of the usage of Nitrogen fertilizer,
iii. Economic way of farming by reducing the over usage of fertilizers and chemicals,
iv. Functions as a good information source of previous records, decision- making, traceability marketing of farm products, and improve the inner quality of the products (protein content etc.).

Precision agriculture is an efficient and appropriate adaptation and mitigation method to climate change issues by reducing the levels of application of Nitrogen fertilizer to the farms, thus the emission of greenhouse gases are controlled by reducing the carbon footprint.[31].

A research done by the Department of Electronic and Telecommunication Engineering indicates that an in-situ precision agriculture network based on Reflectance Spectroscopy could be adopted to develop a precision farming system in Sri Lanka.[32]

[30] Precision Agriculture: http://en.wikipedia.org/wiki/Precision_agriculture

[31] FAO: http://www.fao.org/docrep/014/i2096e/i2096e03.pdf

[32] An In-Situ Precision Agriculture Framework for Sri Lanka based on Reflectance Spectroscopy, A.S. Maxworth, J.A.K.S Jayasinghe, Department of Electronic and Telecommunication Engineering, University of Moratuwa. International Journal of Scientific and Research Publications, Volume 2, Issue 12, December 2012 1: http://www.ijsrp.org/research-paper-1212/ijsrp-p1237.pdf

Therefore, developing a precision farming system at a pilot scale to the selected 500 farmers from all the high intensive agricultural districts: Amapara, Anuradhapura, Polonnaruwa, Vavuniya, Kilinochchi, Jaffna, Mullaithivu would be a good initiative in Sri Lanka.

Budget to Develop a Precision Farming System

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
Mobile soil analyzer	20,000,000	unit	1	20,000,000
Reagents and accessories	3,000,000	unit	2	6,000,000
Cost for field activities , remote sensing and GIS mapping	12,000,000	unit	1	12,000,000
TOTAL				**38,000,000.00 (EUR 218,390)**

5. Training the professionals in climate change and adaptation methods

i- Providing professional training programs in identification of disasters at the most hazardous areas and rescue. Village level youth volunteers have to be selected and trained in disaster identification and rescue.

ii- Postgraduate training to the selected professions from government organizations and NGOs in integrated water resource management, disaster management, environmental engineering, management of technology and project management relevant to climate change, mitigations and relief.

Training of Professionals/volunteers in Climate Change, Disasters and Adaptation Methods

Activity /Description	Unit cost in LKR	Unit	Total units	Total cost in LKR
General awareness and workshops on climate change disasters and adaptation measures for development practitioners and volunteers	500,000	personnel	100	1,000,000
Training 100 youths in identification of signs for landslides and rescue	50,000	personnel	100	5,000,000
Total				**6,000,000 (EUR 34,482)**

6. Establishing a climate change research center dedicated to provide data and information to funders, development practitioners and people on a regular basis. Data and information would include gaps in adaptation measures, impacts, funding needs, risks and forecasts.

7. Developing an accurate mapping system for the wet and intermediate zones in order to identify landslide and floods prone areas. These information have to be updated with the daily meteorological data as well.

5.3. Prospective Implementing Partners

Partner	Activity
Department of Agrarian Services	For the construction of inland Salt Water Exclusion Bunds
Department of Irrigation	Construction of the Coastal Salt Water Exclusion Bunds
Sevalanka Foundation	For overall local coordination and implementation of the Drip Irrigation projects and Rain Water Harvesting Projects
National Building Research Organization	Installation of Landslide sensors in Kandy
Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya	Technical Advice for the Development of Precision Farming System
Ecowave (Gte) Ltd	Implementing the Precision Agriculture Project (Island wide) and the Bio Fertilizer Project, Dairy Development and Solar Projects in Kandy and for the overall technical consultancies for the agricultural components (with the experience of implementing such projects since 2004 directly through the Italian findings).
Department of Soil Science, Faculty of Agriculture, University of Peradeniya	Research and Development Part of the Bio Fertizer Project
National Engineering Constancy Bureau	For the consultation of architectural design for the rebuilding the affected buildings by landslide in Peradeniya.
International Centre for Ethnic Studies	Researching on adaptation gaps, monitoring and evaluation of the projects and providing advocacy to the stakeholders