NeelaHaritha

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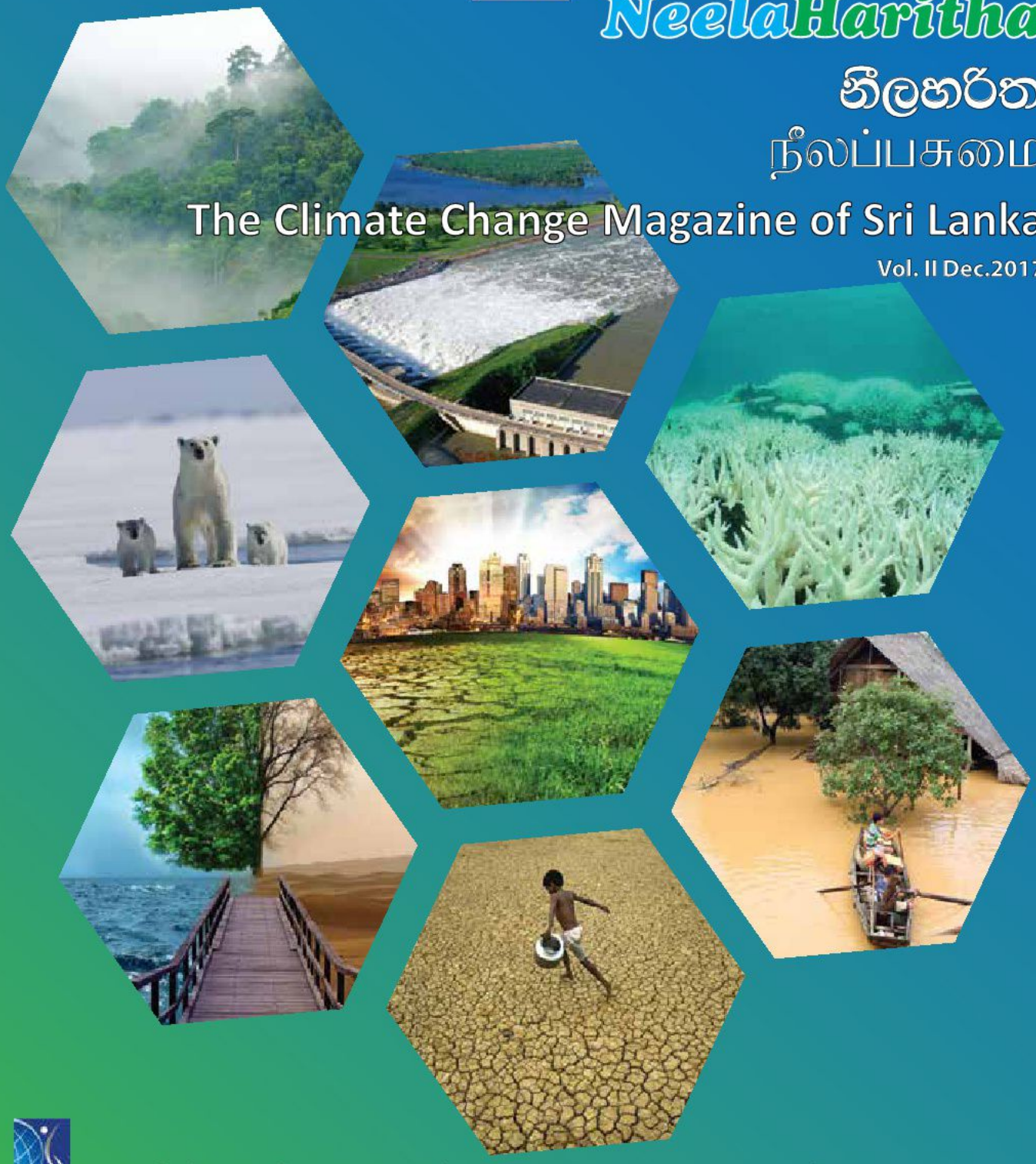
The Climate Change Magazine of Sri Lanka

Vol. II Dec.2017



Ministry of Mahaweli Development and Environment
Climate Change Secretariat

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Editorial

It is a well-established fact that global warming due to enhanced Greenhouse Gas (GHG) emission is creating climate change and associated natural disasters. This deep climate crisis will impact the whole world in the 21st century and beyond.

As a tropical island nation, Sri Lanka is faced with adverse disasters in many sectors including agriculture and food security, energy generation, water, health, *etc*. Rainfall pattern has changed and aggravated drought situation in the dry zone has persisted for consecutive years and heavy rainfall with flash floods and landslides are a frequent occurrence. According to the latest report of the Intergovernmental Panel on Climate Change (IPCC, 2014), the rainfall of tropical Asia will vary with an increase during June, July and August (JJA) and a decrease in December, January and February (DJF). Research at local level indicates less rainfall in the dry zone and more rainfall in the wet zone during the coming years. Department of Meteorology in their latest prediction shows nearly 60% reduction in the dry zone rain and doubling of rainfall in the hill country by 2050.

As a country, we may not be able to avert completely the impending climate change impacts but it is a necessity that the country prepares for adaptation in the most effective way. We strongly believe that it will be easy to do it if the citizens are aware of climate change and related issues. Recent studies indicate that most of the general public and especially, farmers and rural community are not educated on this subject.

United Nations Framework Convention on Climate Change (UNFCCC 1992) and the Paris Agreement (UN 2015) state that the development and implementation of education and training programmes are necessary particularly in developing countries and parties should take necessary measures to enhance awareness creation.

The main aim of this publication is to educate and create awareness on this critical and important subject. Some articles in this volume contain various aspects of climate change. Some of them are research based, while others are based on field experience. The views and ideas expressed and data and facts presented in these articles belong solely to the authors.

We hope this magazine will provide the opportunity for those who are interested in this field to share their views and experience.

Editors

Prof. W.L.Sumathipala
Dr. R.D.S.Jayathunga
Dr. Athula Senaratne
Mr. Shamen Vidanage
Dr. Erandathie Lokupitiya
Dr. Terney Pradeep

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Character and Behavior of Nature-A View Point

W.L. Sumathipala

Ministry of Mahaweli Development & Environment
wlsumathipala@hotmail.com

Natural disasters are due to nature trying to balance things by transporting from high to low. Higher the gradient higher will be the strength of the disaster and damage. With enhanced global warming the tropics will become warmer and the temperature gradients in horizontal and vertical directions will increase and that in turn will produce severe and frequent natural disasters. It must be understood that this is due to nature trying to maintain equilibrium. Sri Lanka is faced with increased natural disasters in recent times leading to loss of life and property amounting to massive economic burden and severe hardships.

Introduction

Natural disasters have become a common occurrence in recent times and they occur in different scales and magnitudes. Some of these are interlinked and are a result of climate change. Climate change is fundamental to our future that poses a significant threat to living beings on the planet. As such it is very important to use all available tools and scientific methods to find a solution to this serious problem. Finding or suggesting solutions are based on understanding the underline causes for these disasters.

Nature is a complex system with many aspects and variables that one can describe or study. For example, nature supports and help living beings to survive in this world by providing all essentials for healthy living, provide biodiversity and ecosystem services, etc. But, there are many other aspects of nature that control its activities.

Animals including human beings learn by observing nature and natural happenings in the world. All adjust their behavior and adapt to changes taking place in their surroundings. It is also a well known fact that observation is very important in scientific discoveries. Scientists improved their observing ability and capacity by developing tools that has contributed to many discoveries. Scientists have proved that observations are very important and science starts with observing what is happening around us in nature and in trying to understand and explain natural phenomena. The field of Astronomy and Sir Isaac Newton's observation and theory of gravity are good examples how observation of nature led to understanding of nature and scientific development. Developing transport systems like bullet train, airplanes are some examples of how observation of nature had led to development. Even today green building concept was in some ways helped by observing

termites building their Mounds. Termites build their Mounds with proper natural ventilation. Japanese have produced a gadget to extract tiny amount of blood without causing any pain by observing how mosquitoes bite and suck blood.

Nature

It is not difficult to understand that nature likes equilibrium. In order to achieve equilibrium, nature always tries to transport any physical property of nature from a place where it is high to a point where it is low. With this concept it is possible to look at natural disasters and how they occur. There are imbalances occurring in nature. The essential energy for our survival and to do things on planet earth is mostly supplied by the Sun. Sun's energy drives the atmospheric systems such as wind patterns, ocean currents, hydrological cycle etc.

Atmospheric Temperature Gradients in Horizontal and Vertical Directions

Due to uneven distribution of solar energy at the earth's surface a higher amount of solar energy is received in the tropical region of the earth mainly because the Sun is overhead throughout the year and the duration of the sun shine is also high. Higher latitudes receive less energy and are subjected to seasonal changes. On the average, tropics are several degrees warmer than high latitudes. As shown in Figure 1, while the average temperature in the tropics is around 29 or 30^{0}C, value is about 5 ^{0}C at around 45 deg. latitudes. As such there is a horizontal temperature gradient between tropics and the higher latitudes. Therefore, the horizontal gradient will continue to stay and play a role in weather and climate of the planet earth.

Annual Average Temperature Map

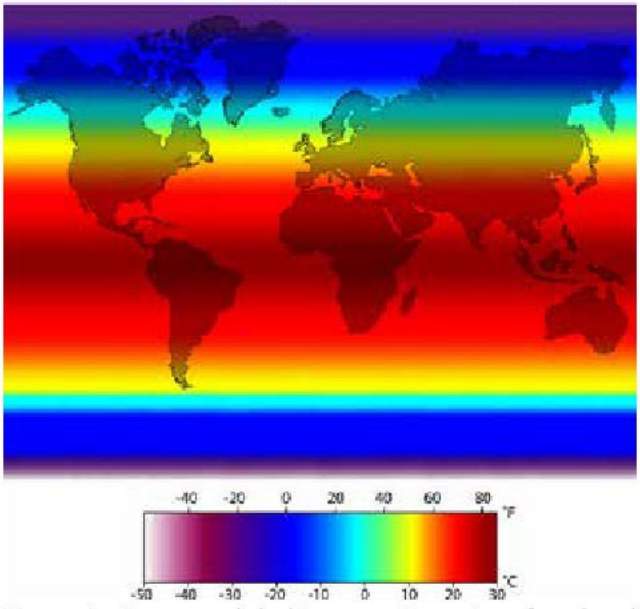


Figure 1: Average global temperature at surface level

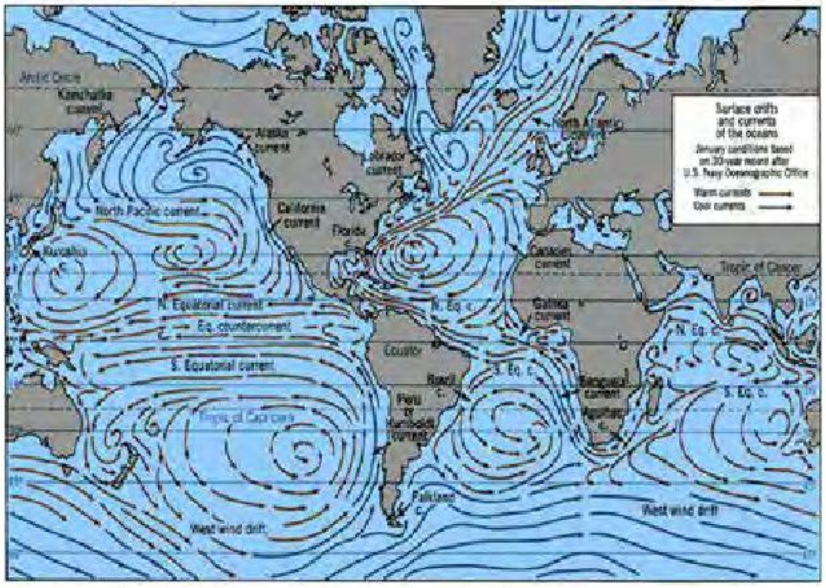
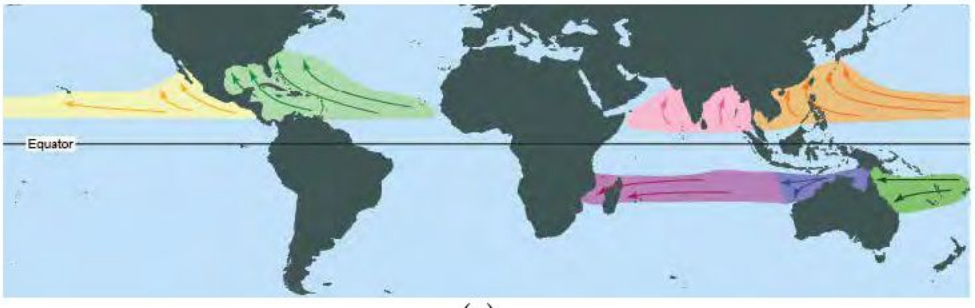
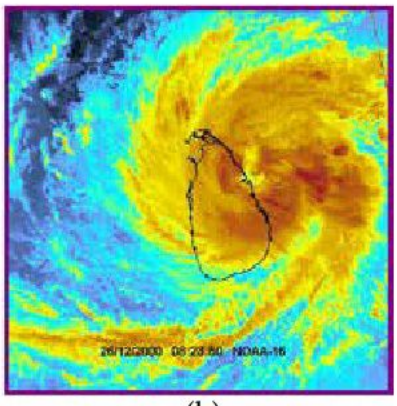


Figure 2: Oceanic Gyres that circulate ocean waters
(Courtesy of the Ocean Cleanup Project, Boyan Slat, Delft, Netherlands.htm)

Nature does not like to keep this temperature difference or the horizontal temperature gradiant and will try to reduce it. This can be done by transporting energy from tropics to higher latitudes. Further, tropics are covered by large oceans (Pacific, Atlantic and Indian) with resulting massive amounts of water. Solar energy received by these tropical oceans is stored and amounts to massive oceanic heat source. This heat has to be transported horizontally to higher latitudes and nature has found ways and means for it. Oceanic gyres in all tropical oceans take warm water from tropical regions to higher latitudes and bring back cold water from high latitudes to the tropics by means of ocean currents (Fig. 2). This natural phenomenon is considered as a normal process. There are other processes like cyclones. Cyclones are considered as massive "heat engines" and these systems extract a huge amount of energy from the warm pools of the tropics and transport to high latitudes (Fig.3 a,b).



(a)



(b)

Figure 3: (a) Cyclone generating warm pools (Courtesy of the NWS Jet Stream Online School)
(b) Cyclone that went across Sri Lanka in 2000 (NOAA Satellite picture)

The temperature variation in the vertical direction is complicated and the world average condition is shown in Figure 4. The temperature decreases from the surface level to about 10 Km and increases from there to about 50 Km. Again it decreases and increases with height.

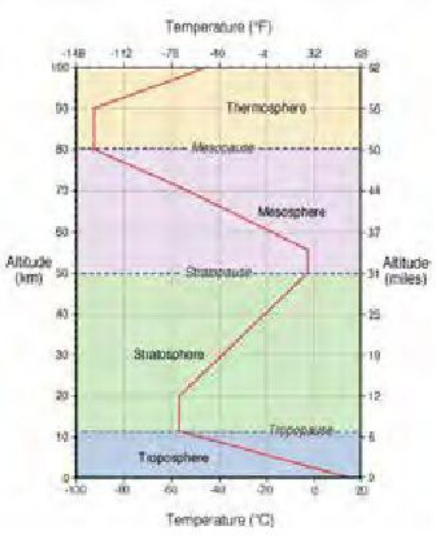


Figure 4: Average vertical temperature profile of the atmosphere
(Adopted from WWW.Physicageography.net)

When vertical direction is considered there is a decrease of temperature with height in the lower level of atmosphere (troposphere) close to the surface of the earth. This reduction is referred to as Lapse rate and is normally around 5-6 ^{0}C per km.

Nature has found methods to transport heat energy vertically to reduce this gradient. The primary method is water vapour carrying latent heat of evaporation with air vertically and releasing at higher levels by forming clouds which at times produce rain and snow by releasing energy at high altitudes

(latent heat of condensation). When the vertical gradient become strong, in order to transport more energy in a short time (like within an hour) nature selects the method of a thunderstorm or severe thunderstorms. According to estimates, on the average there are bout two thousand active thunderstorms at any given time around the world. In Sri Lanka thunderstorms are more frequent during the inter monsoon periods where surface heating is high and vertical temperature gradient become strong.

Natural Disasters

Natural disasters can be categorized into different scales as well as length of time or duration. For example a cyclone can be of 200 to 300 km in diameter and may last for a week or more. Tornados on the other hand with a diameter of 100 km will last for only a few minutes. The damage due to both these systems is huge. As shown in Fig. 5 events such as earth quakes, volcanic eruptions, tsunami, cyclones, tornadoes, severe thunderstorms, floods, landslides, droughts are considered as natural disasters. When looking at the root cause of these disasters one thing comes to light. Most of these events occur due to nature trying to reduce gradients in order to keep the equilibrium. In order to do this nature is looking for means of spreading excess energy by taking from a place where there is excess and transferring it to areas where there is less. Nature always tries to make a balance by reducing gradients. Most of the events that we see in nature are there to keep the balance/ equilibrium. Good examples for this are monsoons, normal thunder activity, rainfall, average number of cyclones. If the gradients are greater than normal the average events will not be able to handle the situation and abnormal events have to take over. In such occasions either more events (eg. more cyclones) or large events (eg. huge typhoons) have to take place.

Recently a Category 5 typhoon with a 600 km diameter and wind speeds over 310 km/hr killed over 1,200 people in the Philippines and affected 4.5 million in its path. It also affected Vietnam and China and created enormous damages. The economic loss itself is estimated to be over US$ 1.7 Billion. There were several severe typhoons in the area affecting China and the neighboring countries in the recent past. Hurricane Katarina which devastated some parts of United States is another example of an abnormal natural disaster. All these cases are examples of nature trying to reduce the gradient; both horizontal and vertical by transporting excess heat from the enormous heat reservoir of tropical oceans by using the huge natural heat engine.

Due to global warming, gradients have increased and thereby abnormal disasters occur. The reason for the gradient to become greater than normal is the exponential increase of global temperature due to anthropogenic activities. It is therefore justifiable to consider that these are manmade disasters.

These disasters can be considered as remedial measures taken by nature to avoid a tragic situation where the world will move into a level where it will never come back to the level that could produce livable conditions.

Figure 5: Natural disasters with varying temporal and spatial scales

Landslides

If we take landslides in the country, it can be considered as nature trying to balance because it favors equilibrium. In hilly areas there is an equilibrium of forces in the vertical direction. While gravity is pulling the landmass downward, forces like friction acts upwards and keep the landmass in equilibrium. There are tree and root systems binding the soil and the rocks and boulders together. When rainfall occurs, water is drained gradually downwards. However, when the trees are cut and land is cleared soil mass is open to rain. As in Fig.6, the rainwater is absorbed by soil and become heavier and the downward force increases. At the same time there are no trees and root systems to bind and hold the landmass. With water the frictional effect becomes less and as such the gravity pull will overcome the weak upward directed frictional force and landslides occur.

Figure 6: Landslides in Sri Lanka (Courtesy of National Building Research Organization)

Downward directed atmospheric electric field is another variable that is observed in nature. With the constant movement of electrons vertically the potential gradient will increase. This increase is counteracted and maintained at an appropriate (reasonable) level by thunder activity.

These are few examples to show that the natural disasters are due to nature trying to balance things by transporting from high to low. Higher the gradient higher will be the strength of the disaster and damage. With enhanced global warming the tropics will become warmer and the temperature gradients in horizontal and vertical directions will increase and that in turn will produce severe and frequent natural disasters.

Therefore, it is necessary to help nature to keep all systems in balance and equilibrium by minimizing human interference with natural systems as much as possible. This idea that "nature trying to balance things to keep the equilibrium of the system" is applicable not only in Science or Physics where physical parameters are considered, but it is applicable even in social sciences. If the economy of a country is not kept at a manageable level and if the economic gradient increase (gradient between rich and poor) it also can lead to a disaster situation like a revolution.

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The NWS Jet Stream Online School

WWW.Physicageography.net

The Socio-Economic Impacts of Flood Disasters in Sri Lanka

K. Kumudika Erangi Perera

Computer Teaching Unit, University of Colombo, Sri Lanka
kumudikaerangi@gmail.com

The world is becoming increasingly susceptible to unexpected events due to climate change. Therefore, the frequency and intensity of natural disasters have been increasing over the years. Esspecially, seasonal flooding is more frequent and a common occurrence in Sri Lanka than the other natural disasters (Jegarasasingam, 2017). In this respect, it is important to understand the trends, patterns and impacts of the flood disaster in Sri Lanka. Therefore, this paper has focused on discussing the socio-economic impacts of the flood disasters in Sri Lanka.

Rainfall Patterns in Sri Lanka

According to the Department of Meteorology, the annual rainfall in Sri Lanka varies from 900 mm in the driest parts to over 5000 mm in the wettest parts (Survey Department, 2007). There are four major rainfall seasons in Sri Lanka namely; First Inter-monsoon (March to April), South-west monsoon (May to September), Second Inter-monsoon (October to November) and North-east monsoon (December to February).

The South-west monsoon period of the island receives 100 mm to over 3000 mm of rain. The variation towards the South-western coastal area is less rapid, with the South-eastern coastal belt experiencing between 1000 mm to 1600 mm of rain during this five-month long period. The North-east monsoon period contributes about 500 mm to 2500 mm of rain. According to the Survey Department (2007), the maximum North-east monsoonal rainfall is experienced at Kobonella estate (1281mm) and the minimum is in the Western coastal area around Puttalam (Chilaw -177mm).

The distribution of rainfall during the First Inter-monsoon period shows that the entire South-western sector and the hill country receives over 250 mm of rainfall, with a localized area on the South-western slopes experiencing rainfall in excess of 700 mm. Over most other parts of the island, the amount of rainfall varies between 100 and 250 mm, the notable exception being the northern Jaffna peninsula. Almost the entire island receives in excess of 400 mm of rain during the Second Inter-monsoon period, with the South-western slopes receiving higher rainfall in the range 750mm to 1200 mm, with Weweltalawa estate in Yatiyantota receiving 1219 mm (Survey Department, 2007). However, according to Punyawardena (2012), variability of both annual and seasonal rainfall has increased during recent decades due to climate change. Especially, the North-east monsoon has shown an increased variability. Further to this, the frequency of heavy rainfall events has also increased (Perera, 2016).

With this brief background, it can be mentioned that flood disasters are associated with rainfall seasons in Sri Lanka. Therefore, floods occur almost annually and it is most important to understand the rainfall patterns in Sri Lanka. Out of the four main rainfall seasons, according to the Disaster Management Center (2016), major floods in Sri Lanka are associated with the two monsoons. Typically, during the South-west monsoon season, the Western, Southern and Sabaragamuwa provinces are vulnerable to floods because the country receives the most precipitation while during the North-east monsoons, the Eastern, Northern and North-central provinces are prone to flooding by cyclones or cyclonic storms. Although, such storms rarely occur, when they do, even offshore as in May 2003 and August 1947; they have a severe impact on precipitation on the Western and South-western slopes of the island.

Especially, the districts of Kegalle, Ratnapura, Kalutara, Colombo, Gampaha and Galle are vulnerable to floods during the South-west monsoon season while the districts of Ampara, Trincomalee, Badulla, Polonnaruwa, Batticaloa, Matale and Monaragala are vulnerable to flood during the North-east monsoons. Thus, the two regions in the country show distinct seasonal floods. Further to this, floods in Sri Lanka are mainly due to excessive rainfall received as a result of development of low-pressure systems in the Bay of Bengal. As already mentioned, floods are directly related to the amount of rainfall and therefore a proper understanding about the distribution of rainfall becomes important.

Moreover, according to the study on National Climate Change Adaptation Strategy for Sri Lanka - 2011 to 2016 undertaken by the Environmental Ministry of Sri Lanka, it has been reported that, increased intensity of rainfall in the wet-zone due to climate change is expected to increase the propensity for flooding of flood prone rivers and to increase the intensity and frequency of landslides associated with prolonged and heavy rains in this region.

River System in Sri Lanka

Sri Lanka's radial network of rivers begins in the central highlands. According to the water resources map of the country, it can be identified that 103 river basins cover 90 percent of the island. Ten of the rivers are considered as major rivers. Out of the major rivers in Sri Lanka Kelani, Kalu, Gin, Nilwala and Mahaweli are identified as vulnerable to floods (Ranagalage and Manawadu, 2010). Further, among these vulnerable rivers, four rivers namely; Kelani, Kalu, Gin and Nilwala are located in the Wet Zone. Moreover, according to the Irrigation Department in Sri Lanka, 25 river basins are identified as being more vulnerable to floods.

Flood Disaster in Sri Lanka

When considering the global situation of flood disaster, Figure 1 illustrates that Sri Lanka belongs to a group with a moderate number of reported flood events. However, as has been mentioned before, floods are the most common and destructive hazard in Sri Lanka. According to the spatial

distribution map of flood events reported from different districts of Sri Lanka from 1990 to 2011 created by the Disaster Management Center (2012), it has been illustrated that the highest number of events being reported are from high rainfall areas; Ratnapura and Kalutara. Mannar, Mulativu and Vavuniya report the lowest number. Surprisingly Kandy, despite its higher rainfall, has a smaller number of floods than Kurunegala.

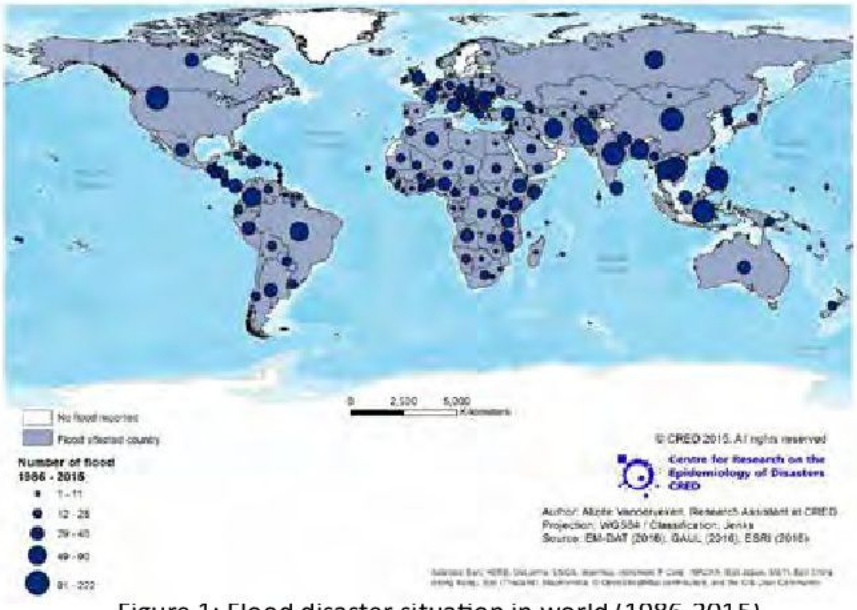

Figure 1: Flood disaster situation in world (1986-2015)
Source: EM-DAT, 2017

Drawing attention to the causes of floods in Sri Lanka, it can be identified that the heavy rainfall in the Eastern and South-western slopes is a principal cause of the flood risk. Especially, with global warming due to the greenhouse effect, tropical countries are expected to get less annual rainfall, but increased rainfall intensities (Jegarasasingam, 2017). Runoff from the large volume of water from the catchment areas of rivers is also one of the main causes of the flood risk. In addition, the topography of certain districts, deforestation, absence of scientific soil conservation practices and land use patterns are also significant factors.

However, according to the current situation of flood occurrences, the flood risk is gradually increased due to climate change and intense monsoon rainfall. Moreover, rapid urbanization with the insufficient infrastructure facilities such as drainage systems triggers the urban flash floods together with global phenomena like climate change, with increased rainfall intensities (Peiris, 2006). Therefore, several flash floods occurred recently, without giving much time for evacuation and diminished within two to three days. According to Gunasekara (2008), there were three flood events in Sri Lanka on 29th April, 30th May and on 19th July 2008 for Kelani, Kalu and Gin basins respectively.

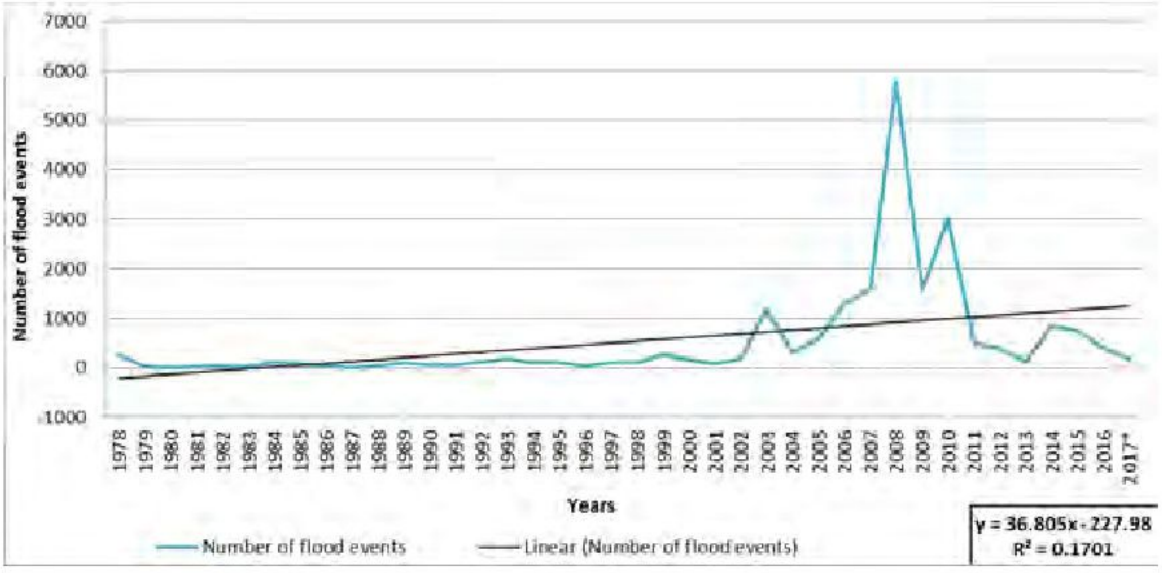

Figure 2: Trend in number of flood events in Sri Lanka (1978 - 2017)
Source: DesInventar database of DMC, 2017

Figure 2 demonstrates the overall trend of number of flood event records/ data cards during the period of 1978 to 2017. It shows a rapid increase in the number of flood events during the past 15 years. The highest number of flood events was reported in 2008. According to EM-DAT (2017), the frequency of reported flood occurrences in Sri Lanka during the period of 1978 to 2017 has shown a clear increasing trend (Figure 3).The figure also indicates that there is an increase of occurrence of flooding after 2006 and it has taken on quite a fluctuate pattern.

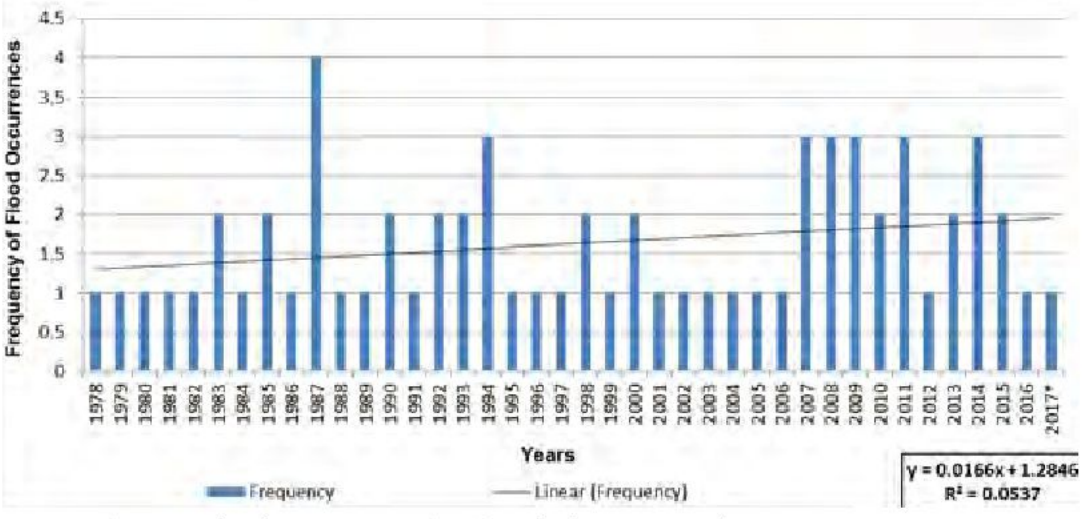

Figure 3: Flood occurrences in Sri Lanka (1978 - 2017); Source: EM-DAT, 2017

Socio-Economic Impacts of Flood Disaster

Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation (Corbane *et al;* 2015). A rise in extreme events and natural disasters as a result of climate change is expected to pose considerable threat to Sri Lanka's economy and human health (GFDRR, 2011). Especially since floods are the most destructive form of natural hazards in both local and global contexts. This is in terms of both loss of life and property damage (DMC, 2012).

Floods directly affect the lives of humans. With the increasing frequency and intensity of floods as well as high intensity of rainfall and other man-made factors, a large number of people are affected by flood disasters annually. The increase in population and subsequent need for land have forced more and more people to live and work in these vulnerable areas, thereby intensifying the risk to life and property in the event of major floods (Peiris, 2006).

According to the historical data, it can be identified that there is an increase in the number of affected people after the year 2002 due to the flood disaster. Figure 4 illustrates that the highest number of people were affected by floods in 2010. Further, there is an increase in loss of lives during the recent decade due to the flood disaster (Figure 5). The maximum numbers are recorded in the years of 1989, 2003, 2016 and 2017.

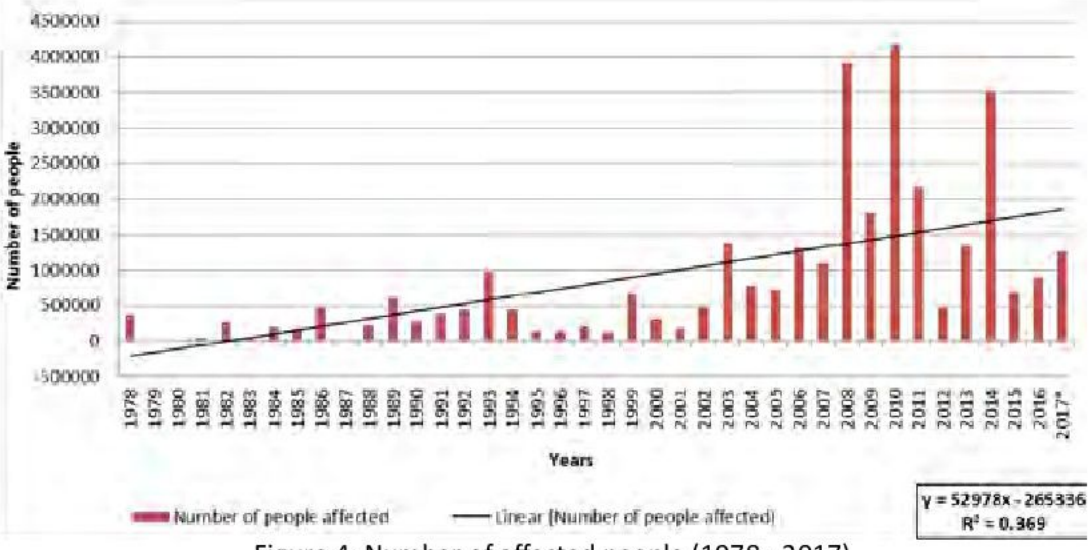

Figure 4: Number of affected people (1978 - 2017)
Source: DesInventar database of DMC, 2017

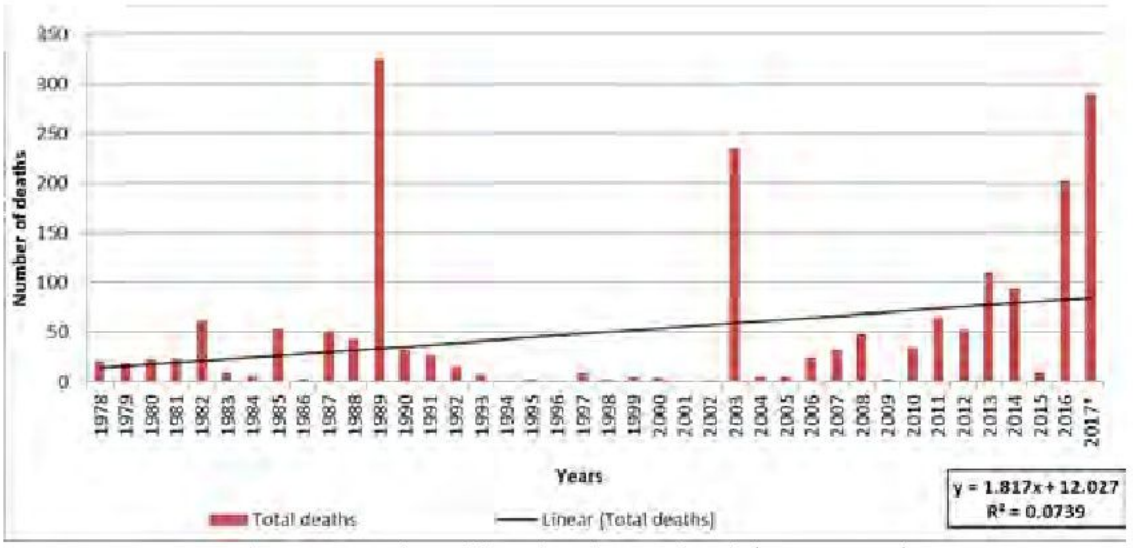

Figure 5: Number of lives lost due to floods (1978 - 2017);
Source: DesInventar database of DMC, 2017

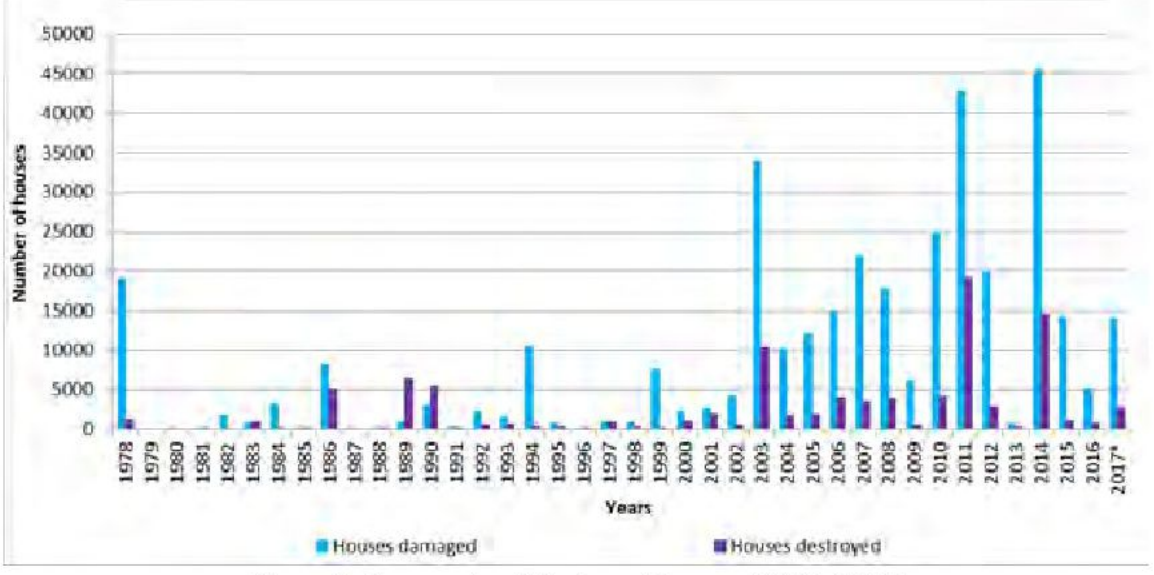

Figure 6: Damaged and destroyed houses (1978 - 2017)
Source: DesInventar database of DMC, 2017

When attention is given to the damages of Flood disaster, it can be identified that there is an increasing pattern in damaged and destroyed houses after the year 2002 (Figure 6). This may have high impacts on reconstruction costs in the vulnerable areas. Maximum damages are reported in the years of 2003, 2011 and 2014. The maximum number of houses destroyed are also reported in the same years.

Therefore, the relief distribution recorded is very high. Moreover, according to the study on Integrated Post Flood Assessment, carried out after the flood in the Western and Southern provinces in May 2010 by DMC with the World Bank and UNDP assistance,it indicated that the total flood damages and losses amounted to over Rs. 5,000 million. A similar study carried out by the National Planning Department recorded losses and damages due to 2011 floods, primarily in the Eastern part of Sri Lanka, and the reported damages and losses exceeded Rs. 77,000 million (DMC, 2014). However, according to the Ministry of Disaster Management (2016), the five flood disasters that caused the highest damage so far are listed in Table 1.

Table1: Worst Flood Disasters in Sri Lanka in Terms of Damages

Year	Damages (US$)
2016	300,000,000
1992	250,000,000
2011	200,000,000
2010	105,000,000
1989	35,000,000

Source: Ministry of Disaster Management, 2016

When considering the recent flood events, from 14th May in 2016 onwards a low-pressure zone above Sri Lanka caused torrential rainfall all over the country, and in some places it was the heaviest recorded rainfall in more than 18 years. Several rivers including Kelani River, Kalu Ganga, Mahaweli River, Deduru Oya, Yan Oya, Maha Oya and Attanagalu Oya, observed rising water levels, which caused widespread flooding in 24 districts. Heavy rainfall was recorded in Deraniyagala (355.5 mm), Colombo (256 mm), Katunayake (262 mm), Ratmalana (190 mm), Mannar (185.5 mm) and Trincomalee (182.4 mm). Further, districts such as Kurunegala, Kegalle, Nuwara Eliya, Ratnapura, Kalutara, Kandy, Puttalam, Batticaloa and Anuradhapura also received more than 100 mm of rainfall. The resulting floods were the worst in 25 years. As another result of the rainfall, severe landslides occurred in several divisions in the Kegalle district. The floods and landslides resulted in the loss of at least 93 lives and affected almost half a million people. The disaster damaged over 58,000 houses and caused a loss in income for over a million people dependent on agriculture, trade and industries (Ministry of Disaster Management, 2016).

The economic impact of the floods and landslides, as measured by damage to physical assets and losses in production flows, is estimated at LKR 105 billion, equal to 0.94 percent of 2015 GDP. Total losses are estimated at LKR 18 billion or 0.16 percent of GDP and damages LKR 87 billion or 0.78 percent of GDP. Specially, the floods and landslides have resulted in the loss of about 1.5 million work days and LKR 4,912 million of personal income during the Financial Year 2016. The manufacturing and trade sectors damages and losses in all districts have been assessed to be LKR 19,700 million of which the pay-out by insurance was LKR 15,710 million. The major damages and losses were

sustained by two sectors only (food and beverages and tea) were estimated at LKR 13,925 million accounting for approximately 88 percent of insurance pay-outs. The damages and losses to informal sector in Colombo and Gampaha districts was estimated at LKR 3,990 million which was equal to 20 percent of the total flood and landslide impact.

Further to this, according to the Disaster Management Center (2017), South-west monsoon was activated over Sri Lanka from 24th of May, 2017 and a very low upper air wind convergence was formulated over the Eastern sea of Sri Lanka which was absorbing westerly winds. As a result of this, heavy rains were received on 25th of May to the South-western watersheds in the country. Large amount of rains were received within 12 hours in South-western regions including Namunuthanna (619 mm), Bulathsinghela (419 mm), Morawaka (406 mm) and Walasmulla (437 mm) leading riverine floods of the Kalu, Nilwala and Gin rivers. Around 717,622 people were affected in 15 districts. 70,000 people have been classified as severely affected. The impact analysis model has estimated approximately 495,000 people as moderately affected population. In addition, around 290,000 women and 138,000 children were directly affected. 212 deaths reported as per the situation report issued by DMC on 04-06-2017 1800hrs. Further, over 2,313 houses were fully destroyed and around 12,529 houses were partially damage.

Conclusion

Floods are the most frequent type of disaster worldwide. Floods mainly occur in Sri Lanka due to the South-west and North-east monsoon rains. According to the historical data, it has shown a clear increasing trend in flood events as well as impacts of flood disaster in the most recent years in Sri Lanka. A combination of many factors such as intense monsoon rainfall, population growth in exposed areas, increase in extreme weather events, rapid growth of flood occurrences and man-made causes have exacerbated this situation. Therefore, it has become necessary for the identification of spatial and temporal behavior of flood events as well as the possibility of predicting and controlling such events totally.

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කාන්තාව සහ දේශගුණ විපර්යාස

Chandima Mohottige

Environmental Planning & Economics Division
Ministry of Mahaweli Development and Environment
chaani2000@yahoo.com

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ගෝලීය හෝ කලාපීය දේශගුණ රටාවේ ඇතිවන වෙනස් වීම් යනුවෙන් දේශගුණ විපර්යාස සරලව නිර්වචනය කල හැකි වුව ද එහි බලපෑම එතරම් සරල නොවේ. දේශගුණ වෙනස්වීම් කාලයත් සමග ඇති වන ස්වභාවික සංසිද්ධියක් වන නමුත්, වර්තමානයේ දේශගුණයෙහි වෙනස්වීම් සිදුවන වේගය මානව ක්‍රියාකාරකම් නිසා සීග්‍ර සහ අති ප්‍රබල වී විශාල සමාජයීය සහ ආර්ථික බලපෑම් ඇති කරනු ලබයි මෙම දේශගුණ විපර්යාසවල කෙටි කාලීන සහ දිගුකාලීන බලපෑම් වලට අප සියල්ලන් නතු වුවද විවිධ ජන සහ සමාජයීය කණ්ඩායම් ඒ ඒ බලපෑම් සඳහා මුහුණ දෙන ආකාරය විවිධාකාර වේ දේශගුණ විපර්යාස පිළිබඳව සිදු කර ඇති සමාජයීය විශ්ලේෂණවලට අනුව පිරිමින්ට සාපේක්ෂව කාන්තාවන් හට දේශගුණ විපර්යාස මගින් බලපෑම් එල්ල වීමේ හැකියාව ඉහළ වන අතර විශේෂයෙන්ම දරිද්‍ර රටවල කාන්තාවන්ට දේශගුණ විපර්යාස මගින් විදින්නට සිදු වී ඇති ගැහැට වඩාත් බලවත් වේ.

කාන්තාව යනු පවුල සහ සමාජය වෙනුවෙන් අතිමහත් සේවයක් ඉටුකරනු ලබන්නියකි පවුල කෙරෙහි බැඳුනු මනසක් ඇති ඇය විවිධ සීමා බන්ධනවලින් පිරිමින්ට වඩා පටු නිදහසක් භුක්ති විඳියි. ඇය පවුල සහ සමාජය වෙනුවෙන් වැඩි වගකීමක් සහ වෙහෙසක් දරන අතර පවුල සහ සමාජය වෙතින් ලැබෙන නිසි රැකවරණය ඇයගේ පැවැත්මට අත්‍යවශ්‍ය සාධකයක් වේ. වර්තමාන ආර්ථික සහ භෞතික සංවර්ධනයත් සමග පවුල පිලිබඳව අතීතයේ පැවති ඇයගේ වගකීම් අද සමස්ත ලෝකයෙහි සමාජයීය සහ ආර්ථික වගකීම් දැරීම දක්වා ක්‍රමයෙන් පුළුල් වී ඇත. එමෙන්ම දේශගුණ විපර්යාස මගින් කාන්තාවන් සතු පවුල සහ සමාජය සම්බන්ධ මෙම වගකීම්, එමගින් ඇතිකරනු ලබන පීඩනය සහ අනාරක්ෂිත බවද තව දුරටත් ඉහළ නංවා ඇති අප දන්නා පරිදි ගෘහස්ත සම්පත් කළමනාකාරිත්වය තවමත් රඳා පවතින්නේ ගෘහණිය මතයි දේශගුණ විපර්යාස මගින් මෙම සම්පත් වල සුලභතාවය සහ ප්‍රවේශය සීමා කරනු ලබන විට එම විචල්‍යතා සහ සීමාවන් සඳහා වැඩි වශයෙන් මුහුණ දීමට සිදුවන්නේ කාන්තාවන්හට බව මින් වඩාත් පැහැදිලි වේ. එබැවින් දේශගුණික බලපෑම් වල අහිතකර සහ අප්‍රතිවර්ත්‍ය බලපෑම් වලට

ලක් වන කෘෂිකර්මය සහ ආහාර සුරක්ෂිතතාවය, ජෛවවිවිධත්වය, ජල සම්පත, සෞඛ්‍යය, ජනාවාස සහ සංක්‍රමණ රටා, බලශක්තිය, මානව අයිතිවාසිකම් වැනි අංශ හා බැඳී පවතින කාන්තා ජීවන රටාව කෙරෙහි දේශගුණ විපර්යාස ඇති කරනු ලබන බලපෑම පිළිබඳව අපගේ අවධානය යොමු කිරීම කාලෝචිත යයි හැඟේ.

ජීවනෝපාය බිඳ වැටීම

සංවර්ධනය වෙමින් පවතින රටවල ග්‍රාමීය ජන කොටස් ස්වභාවික සම්පත් මත පදනම් වූ ජීවනෝපායන් මත යැපෙන අතර ඔවුන්ගේ ප්‍රධානතම ඉපැයුම් මාර්ගය වන්නේ කෘෂිකර්මයයි. වර්ෂාව වෙනස් වීම, නියඟ සහ ගංවතුර වැනි කාලගුණික ව්‍යසන මගින් වඩාත් තර්ජනයට ලක්වන මෙම රටවල් බොහෝමයක් සර්ම කලාපයෙහි පිහිටා ඇති අනෙකුත් කලාප වලට සාපේක්ෂව අප්‍රිකා සහ ආසියානු ග්‍රාමීය ප්‍රදේශ වල ජනයා තම ජීවනෝපාය සඳහා කෘෂිකාර්මික භෝග මත යැපේ. සාමාන්‍යයෙන් සංවර්ධනය වෙමින් පවතින රටවල කලාපය අනුව 45% ත් 80% ත් අතර ප්‍රමාණයක ආහාර නිෂ්පාදනයක් සඳහා ගෙවිලියන් දායක වෙයි එසේම කෘෂිකර්මය ආශ්‍රිත රැකියා වල නිරත වන කාන්තා කම්කරුවන්ගේ ප්‍රතිශතය සංවර්ධනය වෙමින් පවතින රටවල 2/3ක් සහ අප්‍රිකානු රටවල 90%ක් පමණ වේ. දේශගුණ විපර්යාස නිසා වගා පාළුවීමත් කෘෂිකාර්මික භෝග වල තත්වය හා ප්‍රමාණය අඩු වීමත් නියඟ සහ ගංවතුර වැනි ව්‍යසන නිසා සත්ව පාලනය අසීරු වීමත් නිසා මොවුන්ගේ ආර්ථික තත්වය පහළ වැටීම, ආහාර හිඟතාවය ඇති වීම සහ අහාර වල මිල ඉහළ යාම සිදුවේ. උදාහරණ ලෙස නේපාලයේ මුගු දිස්ත්‍රික්කයෙහි ග්‍රීෂ්ම ඍතුවෙහි පවතින අධික උෂ්ණත්වයත් ශීත ඍතුවෙහි ඇතිවන අධික හිම පතනයත් නිසා ඔවුන්ගේ වාර්ෂික භෝග නිෂ්පාදනය පහළ ගොස් ඇති අතර කාන්තාවන් මේ නිසා ආර්ථික අර්බුදයකට සහ ආහාර හිඟතාවයකට මුහුණ පාන බව සඳහන් වේ.

එසේම දේශගුණ විපර්යාස ඇතිවීම ජෛවවිවිධත්ව පරිහානියට ප්‍රධාන සාධකයක් ලෙස සහශ්‍ර වර්ෂ පරිසර පද්ධති ඇගයුමෙහිදී හඳුනා ගෙන ඇත. දේශීය කාන්තාවන් ගෘහස්ථ සහ ආර්ථික අවශ්‍යතා සපුරා ගැනීම සඳහා මෙම ජෛව සම්පත් මත යැපෙන අතර ජෛව විවිධත්වය හානි වීම නිසා ස්වභාවික වූ දේශීය සහ සාම්ප්‍රදායික අහාර ප්‍රභව දුර්ලභ වීම, ආහාර වල වන දර්ශ දුර්ලභ වීම, දඩයම් කිරීම, ආහාර එකතු කිරීම, ඵල හට ගැනීම සහ නෙලා ගැනීමේ නිවැරදි කාලය වැනි කරුණු පුරෝකථනය කිරීමේ හැකියාව ද අවම වේ. මේ නිසා මෙම දේශීය ආහාර මත යැපෙන්නන්ගේ අදායම් ඇනහිටීම සිදුවේ.

සෞඛ්‍ය ගැටළු

අහාර හිඟතාවය නිසා මන්දපෝෂණය සහ සෞඛ්‍ය ගැටළු ඇතිවන අතර විශේෂයෙන්ම අහාර හිඟතාවය හමුවේ කාන්තාවන් සහ ගැහැණු දරුවන්ගේ සෞඛ්‍ය තත්වය පිරිමින්ට සාපේක්ෂව වඩාත් පිරිහීමට ලක්වන බව හඳුනාගෙන ඇත. සාමාන්‍යයෙන් ගර්භනී සහ කිරි දෙන මව්වරුන් මන්දපෝෂණයට ලක්වීමේ වැඩි ප්‍රවනතාවයක් පවතී. වර්තමානයේ කාන්තාවන් මන්දපෝෂණයෙන් පෙළීමේ ප්‍රතිශතය පිරිමින්ට සාපේක්ෂව දෙගුණයක් වන අතර පිරිමි දරුවන්ට සාපේක්ෂව ගැහැණු දරුවන් දෙගුණයක ප්‍රමාණයක් මන්දපෝෂණය නිසා මිය යයි. දේශගුණ විපර්යාස වල බලපෑම් නිසා කාන්තාවන් හට ඇති මෙම අවදානම ඉහළ යා හැක. තවද ව්‍යසනකාරී පාරිසරික වෙනස්කම් නිසා ගොවිබිම් වල සේවය කිරීම වැනි ක්‍රියාවන්හි දිගු වෙලාවක් ගත කිරීමට ගෙවිලියන්ට සිදු වන අතර එහිදී ඇතිවන අධික වෙහෙස සහ විඡේකය මද වීම නිසා ඔවුනට විවිධ සෞඛ්‍ය ගැටළු ඇතිවන බව ද අධ්‍යයන වාර්තා වල සඳහන් වේ.

බොහෝ රටවල ග්‍රාමීය කාන්තාවන් සහ ළමුන් ගෘහස්ත ජල අවශ්‍යතාවයෙන් වැඩි ප්‍රමාණයක් සපුරන්නන් වේ. මෙහිදී සංවර්ධනය වෙමින් පවතින රටවල කාන්තාවන් සහ දරුවන් හට විවිධ ගැටළුවලට මුහුණ පෑමට සිදු වේ උදාහරණ ලෙස ජල භිඟතාවයෙන් පෙළෙන නැගෙනහිර අප්‍රිකාව වැනි රටවල කාන්තාවන් තම කැලරි ශක්තියෙන් 27% ක් පමණ ජලය සපයා ගැනීම සඳහා වැය කරනු ලබන අතර ඌන සංවර්ධිත ආසියා-පැසිපික් රටවල කාන්තාවන් දිනකට පැය 6ක් පමණ කාලයක් කී.මී. 6 කට වඩා වැඩි දුරක් මේ සඳහා ගමන් කරයි. වියලි කාල වලදී අප්‍රිකාවෙහි කාන්තාවන් සහ ගැහැණු දරුවන් ජලය සොයා කි.මී. 2-25 පමණ දුර ගමන් කරන බවත් ඒ නිසා කපාල අවපිඩනය, අධික හිසරදය, කොඳු ඇටපෙල ඇදවීම, දරු උපත් වලදී සංකූලතා සහ ගැටළු ඇති වීම සහ ඉහල මාතෘ සහ ළදරු මරණ අනුපාතිකයක් ඇති වන බවත් වාර්තා වේ. දේශගුණික බලපෑම් ඇති වීමත් සමග ජල භිඟතාවය තව දුරටත් වර්ධනය වන නිසා ජලය සොයා යාමට ගතවන කාලයත් දුරත් වැඩි වේ. මෙසේ ලබාගන්නා ජලය ද සිය අවශ්‍යතා සඳහා ප්‍රමාණවත් නොවීමත් දූෂිත වීමත් නිසා මෙම ගැටළුව තවදුරටත් තීව්‍ර වේ. නියඟ කාල වලදී ජලය සිදී යාම නිසා ජලයෙහි දූෂ්‍ය කාරක සාන්ද්‍රණය ඉහළ යන අතර මෙම දූෂිත ජලය සඳහා කාන්තාවන් දිගින් දිගටම නිරාවරණය වී රෝග වලට ගොදුරු වීම සිදු වේ. උදාහරණක් වශයෙන් වර්ෂාපතනය අඩු වීමෙන් පොළොව තුලට ජලය කාන්දු වීම ප්‍රමාණවත් නොවන නිසා භූගත ජලයේ ආසනික් සාන්ද්‍රණය ඉහල යාමත් දූෂණය වූ මෙම ජලයට නිතර නිරාවරණය වීම නිසා තුවාල ඇතිවීම, සම ඝනකම් වීම, අත් පා මත අඳුරු ලප ඇතිවීම සහ බාහු ඉදිමීම වැනි ගැටළු ඇතිවේ. එවැනි කාන්තාවන් ඇතැම් විට සමාජය විසින් පිළිකුල් කිරීම සහ අපකීර්තියට ලක් කිරීම සිදු වන අතර බාහිර පෙනුම නිසා විවාහ දිවියට ඇතුළු වීමට පවා නොහැකි බැවින් තවදුරටත් දරිද්‍රතාවයට, මානසික පීඩනයට ලක්වීම සහ සමාජයෙන් බැහැර වී අනාරක්ෂිත තත්වයට පත්වීම සිදු වේ.

අඩු පෝෂණ තත්වයක් යටතේ වැඩිපුර වෙහෙස වීම නිසා කාන්තාවන් හට සෞඛ්‍ය ගැටළු වලට අමතරව මරණයට මුහුණ දීමට පවා සිදු වන බව ද වාර්තා වේ. ජලය සහ ආහාර මෙන්ම කාන්තාවන් සහ දරුවන් සඳහා ඉහළ සනීපාරක්ෂාවක් සහ පොදු සේවාවන් අවශ්‍ය වුවද සංවර්ධනය වන සහ දරිද්‍රතාවය පවතින රටවල කාන්තාවන් සහ දරුවන් ප්‍රමාණවත් නොවන සෞඛ්‍යාරක්ෂාවක් සහ ගුණාත්මකභාවයෙන් අඩු පොදු සේවාවක් යටතේ ජීවත් වේ එසේම ඉපයීම් අඩු නිසා එම අවම පහසුකම් සඳහා වැය වන මුදල පවා ඔවුන්ට දරා ගැනීම අපහසුය.

එසේම ලෝක සෞඛ්‍ය සංවිධානයට අනුව වසර 2000 දී; ලෝක පාචන තත්වයෙන් 2.4% කට පමණ ද මධ්‍යම අදායමක් ඇති රටවල මැලේරියා තත්වයෙන් 6% කට පමණ ද දේශගුණ විපර්යාස වගකිව යුතුයි මෙම රෝග, සංවර්ධනය වෙමින් පවතින රටවල දරුවන් වෙත විෂමකාරී ලෙස බලපෑම් එල්ල කරයි. පවුලේ සාමාජිකයන්ට සහ ප්‍රජාව තුල මෙම රෝග පැතිරීම නිසා ඔවුන් රැක බලා ගැනීම ආදී තත්ත්ව වලට දිගින් දිගටම මුහුණ දීම නිසා ද කාන්තාවන්හට ඇතිවන්නේ ගැටලුකාරී සහ පීඩාකාරී මානසිකත්වයන් ය.

ස්වභාවික සම්පත් කළමනාකරණය

ජෛවවිවිධත්වය හා දේශීය ප්‍රජාවගේ පාරිසරික සහ පාරම්පරික දැනුම අතර ඇත්තේ ද ඉතා සමීප සම්බන්ධතාවයකි. ආහාර ප්‍රභව වල පුර්වජයන්, ඖෂධීය ශාක, සත්ව පාලනය, පරිසර පද්ධති තුල ඇති සහජීවී සම්බන්ධතා, පරිසර පද්ධති ව්‍යුහය සහ ආවේනික ජීවී විශේෂ වල ක්‍රියාකාරිත්වය සහ එම ජීවීන්ගේ භූගෝලීය ව්‍යාප්තිය පිලිබඳ දැනුම මෙම දේශීය දැනුමට ඇතුලත් වේ. එසේම දේශීය කාන්තාවන් ගෘහස්ත සහ ආර්ථික අවශ්‍යතා සපුරා ගැනීම සඳහා ස්වභාවික සම්පත් මත යැපෙන අතර එහි ප්‍රතිපලයක් ලෙස මෙම ස්වභාවික සම්පත්වල කළමනාකරුවන් බවට පත්වේ. එසේම එම දේශීය සම්පත් පිලිබඳ සැලකිය යුතු පාරම්පරික දැනුමක් ද මෙම කාන්තාවන් සතු වේ. දේශගුණ විපර්යාස නිසා ජෛව විවිධත්වය හානි

වීමත් සමග ද්‍රව්‍යමය සුභසාධනය සහ ජීවනෝපයට අමතරව කාන්තාවන්ගේ ආරක්ෂාව, ප්‍රත්‍යස්ථිරීය, සමාජ සම්බන්ධතා, සෞඛ්‍යය, විකල්ප සම්පත් තෝරාගැනීමේ නිදහස සහ නිර්මාණශීලි ක්‍රියාකාරකම් වල යෙදීම යන අංශ ද දුර්වල වේ. එසේම වර්ෂාපතනය වෙනස් වීම නිසා ජල සැපයුමෙහි ප්‍රමාණය සහ ගුණාත්මකභාවය පහළ යයි. ජලය හිඟ වීම නිසා කාන්තාවන් වඩාත් පීඩාවට ලක් වන්නේ ගෘහස්ත ජල කළමනාකරණය බොහෝ දුරට ඔවුන් අතින් සිදු වන නිසාය.

දේශගුණ විපර්යාස සහ කාන්තාවගේ සුරක්ෂිතතාවය

කාලගුණය සම්බන්ධ කුණාටු සහ ගංවතුර වැනි ආපදා නිසා නිවාස, දේපල සහ පවුල් අහිමි වීම; සංක්‍රමණය සහ කඳවුරු ගත වීම වැනි අවස්ථා වලදී කාන්තාවන්ගේ ආරක්ෂාව අවම වේ එවැනි අවස්ථා වලදී ඔවුනට වැඩි ආරක්ෂාවක් අවශ්‍ය වුවද එම ආරක්ෂාව පිලිබඳ අඩු විශ්වාසය, හිංසා පීඩාවන්ට ලක් වීමේ වැඩි නැඹුරුතාවය සහ පෞද්ගලිකත්වය රැකගැනීමට ඇති අඩු ඉඩකඩ නිසා බොහෝ කාන්තාවෝ ආරක්ෂිත ස්ථාන කරා යාම ප්‍රතික්ෂේප කරති. ප්‍රමාණවත් දේපොළ, ඉඩකඩම් සහ ඉතුරුම් නොමැති විට පසු ආපදා තත්ත්ව යටතේ කඳවුරු කරා ගමන් කළ යුතු වුවත් අනාරක්ෂිත. තදබද සහිත ස්ථාන වල ජීවත් වීමට ඇති අකමැත්ත සහ අවදානම නිසා එසේ ඉවත් නොවීමෙන් කාන්තාවන්ට අනතුරු සිදු වන බව පැවසේ පවුල් සහ දේපල වැනි දේ රැකගැනීම සඳහා ද මෙවැනි ස්ථාන කරා ගමන් කිරීමට ඔවුන් අඩු කැමැත්තක් දක්වයි. සාමාන්‍යයෙන් ආපදා තත්ව ඇති විට ප්‍රමාණවත් ආරක්ෂාවක් ලබා ගැනීමේ හැකියාවත් සමාජයීය තත්වයත් අතර සෘජු සහසම්බන්ධතාවයක් පවතී දුප්පත් සහ ස්ත්‍රී පුරුෂ සමානාත්මතාවය අවම රටවල කාන්තාවන්ගේ සමාජ තත්වය පිරිමින්ට සාපේක්ෂව පහළ නිසා නිසි උපකාර ලබා ගත නොහැකි වීමේ, ආරක්ෂාව අවම වීමේ සහ අනතුරු වලට ලක්වීමේ හැකියාව ඉහළ වේ. ආපදා අවදානම සහිත ස්ථාන වලින් ඉවත් විය යුතු අවස්ථා වල දී පවා ඔවුන් වටා පවතින සංස්කෘතික සහ සමාජයීය බාධාවන් ද ඇතැම් විට ආගමික විශ්වාසයන් ද එම සංක්‍රමණ සඳහා ඇති නිදහස සීමා කරයි. මේ නිසා නිවැරදි අවස්ථා වලදී ඉවත් නොවීම, සෙවණ සහ සෞඛ්‍යාරක්ෂාව ලබා ගැනීමේ අවස්ථා අවම වීම යන තත්ත්ව වලට මුහුණ දීමට ඇයට සිදු වේ. එමෙන්ම දුප්පත්කම නිසා නිවැරදි ආරක්ෂක උපායමාර්ග සලසා ගැනීමට ඇති ද්‍රව්‍යමය සහ මූල්‍යමය හැකියාව අවම වන අතර මෙවැනි තත්ත්වයේ සිටින කාන්තාවන් අනතුරු වලට ලක්වීමේ අවදානම ද ඉහළ වේ. එසේම ඇතැම් කාන්තාවන් සහ ගැහැණු දරුවන් ජලය සහ දර රැගෙන යන අතරමගදී ලිංගික අපයෝජනයන්ට නතු වන බව අසන්නට ලැබීම ඉතා කණගාටුදායකය.

බලශක්තිය සහ කාන්තාවගේ දායකත්වය

දේශගුණ විපර්යාස පිටුදැකීමේ තාක්ෂණය සඳහා පුනර්ජනනීය බලශක්තිය ඉතා වැදගත් අංශයක් වුවද බොහෝ විට බලශක්ති පිලිබඳ ගැටළු වලදී කාන්තාවන්ගේ කාර්යභාරය පිළිබඳව ඇත්තේ අඩු තක්සේරුවකි. බලශක්තිය ලෙස බොහෝවිට හඳුනා ගනු ලබන්නේ විදුලිය, ගෑසොලින්, ඩීසල් සහ ස්වභාවික වායු නිපදවීමට අවශ්‍ය ඉන්ධනය. කාන්තාවන් බලශක්ති උත්පාදනයේ සහ ඉන්ධන බෙදා හැරීමේ කටයුතු වල නිරත වීම අවම නිසා මෙම සම්පත් සමග කටයුතු කිරීම පිරිමින්ගේ කාර්යභාරයක් ලෙස හඳුනාගනු ලබයි.

කෙන්යාව වැනි රටවල කාන්තාවන් සහ ගැහැණු ළමුන් දර සපයා ගැනීම සඳහා සතියකට පැය 2 සිට 20 පමණ දක්වා කාලයක් වැය කරනු ලබන අතර ඔවුන් හට අනෙකුත් ගෘහස්ත වගකීම් දැරීම, රැකියාවන්හි නිරතවීමට පොදු ක්‍රියාකාරකම් වල නිරත වීම, දැනුම සහ හැකියා වර්ධනය හෝ අවම වශයෙන් විවේක ගැනීමට හෝ කාලය ඉතිරි නොවේ දරට අඟුරු සහ කෘෂිකාර්මික අපද්‍රව්‍යය වැනි සම්පත් එකතු කිරීම සහ කළමනාකරණය කාන්තාවන් විසින් සිදු කළ ද බලශක්තිය පිලිබඳ තීරණ ගැනීමේ, සැලසුම් සහ

ප්‍රතිපත්ති සකස් කිරීමේ ක්‍රියාවලියන්හි සතුටුදායක කාන්තා සහභාගීත්වයක් සිදු නොවන බව අධ්‍යයන මගින් හඳුනාගෙන ඇත.

සංක්‍රමණය සහ කාන්තා දිවිය

දේශගුණ විපර්යාස මගින් ඇතිවන පරිසර හායනය නිසා මිනිසා ජීවත්වන ප්‍රදේශ සහ ජනාවාස වලට සංකීර්ණ ගැටළු ඇති කරයි. ඉදිරි දශකය තුල දේශ සීමා හරහා සහ රටවල් තුල සිදුවන සංක්‍රමණ ප්‍රමාණය ඉහළ දැමීමට දේශගුණ විපර්යාස හේතු වන බව හඳුනාගෙන ඇත. තීව්‍ර කාලගුණික සිදුවීම්, වෙරළ බාදනය, මුහුදු ගොඩගැලීම, නියඟ සහ කෘෂිකාර්මික කටයුතු බිඳ වැටීම නිසා මිනිසුන් විශාල වශයෙන් සංක්‍රමණය වන අතර එයට උදාහරණ ලෙස 2008 දී මියන්මාරයේ ඉරවඩි ඩෙල්ටා ප්‍රදේශයේ සිදු වූ නර්ගීස් නම් කුණාටුව නිසා මිලියන 2.4 ක් පමණ ජනතාව පීඩාවට ලක් වී ඇති බවත් ලක්ෂ 8 පමණ ජනතාව අවතැන් වී ඇති බවත් දැක්විය හැක. එසේම කාන්තාරීකරණය නිසා මෙක්සිකෝවේ වියළි ප්‍රදේශ වල සිටින ලක්ෂ 6-7 පමණ ජනතාව වාර්ෂිකව මෙම ප්‍රදේශ වලින් වෙනත් ප්‍රදේශ කරා සංක්‍රමණය වන බව ද සඳහන් වේ. එහෙත් සංවර්ධනය වෙමින් පවතින සමාජය තුල කාන්තාවට ඇති සමාජ, සංස්කෘතික, දේශපාලන සහ ආර්ථික සීමා මගින් ඇතිකරනු ලබන සීමිත සංචලන හැකියාව; සංක්‍රමණ වලදී මෙම කාන්තාවන් හට ඇතිවන බලපෑම් වල විෂමතාවයක් ඇති කිරීමට හේතු වේ. මෙමගින් ඔවුන් හට අවශ්‍ය සම්පත් සහ ආරක්ෂාව ලබා ගැනීමේ හැකියාව ද සීමා වේ එසේම අනතුරු මැඩ පැවැත්වීමේ හැකියාව, ස්වාධීනව ක්‍රියාකිරීමේ හැකියාව, සංක්‍රමණ වලදී සහ අහිතකර බලපෑම් වලදී නිසි පියවර ගැනීමේ හැකියාව ආපදා තත්ත්ව වලදී කාන්තාවන් හට අත්‍යවශ්‍ය වුව ද එම හැකියාවන් සමාජ, සංස්කෘතික, දේශපාලන සහ ආර්ථික බාධක මගින් සීමා කරයි. එබැවින් පිරිමින්ට සාපේක්ෂව වැඩි කාන්තාවන් සංඛ්‍යාවක් ආපදා තත්ත්ව වලදී මිය යන බව අධ්‍යයන වාර්තා පෙන්වා දෙයි. මෙහිදී නිවැරදි තොරතුරු වෙත ප්‍රවේශ වීම ද අත්‍යවශ්‍ය වුවත් සංවර්ධනය වෙමින් පවතින රටවල කාන්තාවන් හට නිවැරදි තොරතුරු වෙත ප්‍රවේශ වීමට ඇත්තේ අඩු ඉඩකඩකි.

දේශගුණ විපර්යාස බලපෑම් මගින් ආර්ථිකය බිඳවැටීම වැනි අසීරුතා හමුවේ කාන්තාවන් වෙනත් රැකියාවන් සොයා නගර වෙත යාම සහ විදේශගත වීම සිදුවන අතර මේ නිසා ඔවුන් වඩාත් අනාරක්ෂිත තත්ත්වයකට පත්වේ. මව්වරුන් සිය පවුලෙන් ඈත්වීම නිසා දරුවන් ද අනාරක්ෂිත තත්ත්වයට පත්වන අතර විශේෂයෙන් ගැහැණු දරුවන් සඳහා අවශ්‍ය රැකවරණය නොලැබී යාම, ඔවුන්ගේ සෞඛ්‍ය මට්ටම පිරිහීම, නිසි අධ්‍යාපනය සඳහා යොමු නොවීම, මානසික පීඩනයට ලක්වීම වැනි ගැටළු වලට මුහුණ පෑමට සිදු වේ. එසේම ඇතැම් ගැහැණු දරුවන් අවස්ථාවෝදී වැඩිහිටියන්ගේ ගොදුරු බවට පත් වන බව ද වාර්තා වී ඇත.

කාන්තාව සහ මානව අයිතිවාසිකම්

ගෝලීය උණුසුම සහ උග්‍ර කාලගුණික තත්ත්ව යටතේ මානව අයිතිවාසිකම් වලට බලපෑම් එල්ල විය හැකි බව ද වාර්තා මගින් පෙන්වා දෙයි. උදාහරණ ලෙස ගෝලීය උණුසුම මගින් ලෝකය තුල කුසගින්න. මන්දපෝෂණය. රෝග ව්‍යාප්තිය. ජලය හිඟතාවය වැනි ගැටළු ඇති කරන අතර එහිදී සිදු වෙන සංක්‍රමණ නිසා ප්‍රමාණවත් වාසස්ථාන සහ නව ජීවනෝපාය ලබා ගැනීම සඳහා ද බාධක ඇති කරයි. සාමාන්‍යයෙන් සංවර්ධිත රටවලට සාපේක්ෂව සංවර්ධනය වෙමින් පවතින රටවල මානව අයිතිවාසිකම් සුරැකීම පවතින්නේ දුර්වල තත්වයකය. සාමාන්‍ය තත්ත්ව එසේ වන විට දේශගුණ විපර්යාස නිසා සංවර්ධනය වන රටවල කාන්තා අයිතිවාසිකම් උල්ලංඝනය වන ආකාරය පිළිබඳව වටහා ගැනීමට වෙනත් සාක්ෂි අනවශ්‍ය තරම්යි ආර්ථිකය පිළිබඳ ලන්ඩන් පාසැල මගින් සිදු කර ඇති පර්යේෂණයකට අනුව ඉතා මූලික අවධියේදී ස්වභාවික විපත්

නිසා සිදුවන කාන්තාවන්ගේ මරණ ප්‍රමාණය සහ පිරිමි මරණ ප්‍රමාණය අතර වෙනස් කම් පැවතී ඇත. එහෙත් 2006 දී එවැනි විපත් 141 ක් අලලා සිදුකල අධ්‍යනයක් අනුව පෙන්වා දී ඇත්තේ මෙම කොට්ඨාශ දෙකම සමාන ආර්ථික සහ සමාජ අයිතිවාසිකම් සපුරා ඇති විට සිදුවන මරණ සංඛ්‍යාව නොවෙනස් බවය. එහෙත් එම කාලසීමාවේදී කාන්තාවන් පිරිමින් තරම් අයිතිවාසිකම් සපුරා නොමැති විට සිදුවන කාන්තා මරණ සංඛ්‍යාව පිරිමි මරණ සංඛ්‍යාවට වඩා ඉහළ බව ඔවුන් හඳුනාගෙන ඇත. මෙම ස්ත්‍රී පුරුෂ විෂමතාවය ආසියානු කලාපයේ ඇති වූ සුනාමි ව්‍යසනය, මිච් කුණාටුව, කට්රිනා කුණාටුව, සහ අමෙරිකානු කලාපයේ ඇතිවූ කුණාටු, යුරෝපිය උණුසුම් තරංග සහ දකුණු ආසියානු සුළි කුණාටු ආදී තත්ව වලදී ඉතා පැහැදිලිව දක්නට ලැබුණු බව ඔවුන් සඳහන් කරයි. තවද පරිසර භායනය මානව ආරක්ෂාව සඳහා ප්‍රධානතම තර්ජනයක් වන අතර කාන්තාව පරිසර භායනය සහ අනාරක්ෂිත බව යන ගැටළු ද්විත්වයෙන්ම පීඩාවට ලක්වන පිරිසකි. එබැවින් ආරක්ෂාව සහ දේශගුණ විපර්යාස මගින් ඇති කරනු ලබන පාරිසරික සහ මානවවාදී අර්බුද සඳහා ස්ත්‍රී පුරුෂ විෂමතාවය සඳහා සංවේදී උපායමාර්ග හඳුනා ගැනීම වැදගත් වේ.

මෙවැනි කරුණු මත ඇතිවන ආර්ථිකය බිඳවැටීම සහ අසීරුතා හමුවේ කාන්තාවන් වෙනත් රැකියාවන් සොයා නගර වෙත යාම සහ විදේශගත වීම සිදුවන අතර සිය පවුලෙන්, සුපුරුදු සමාජයෙන් සහ පරිසරයෙන් ඈත්වීම වැළැක්විය නොහැකිය. මේ නිසා ඔවුන් වඩාත් අනාරක්ෂිත තත්වයකට පත්වේ. මව්වරුන් සිය පවුලෙන් ඈත්වීම නිසා දරුවන් ද අනාරක්ෂිත තත්වයට පත් වන අතර විශේෂයෙන් ගැහැණු දරුවන් සඳහා අවශ්‍ය රැකවරණය නොලැබී යාම, ඔවුන්ගේ සෞඛ්‍ය මට්ටම පිරිහීම, නිසි අධ්‍යාපනය සඳහා යොමු නොවීම, මානසික පීඩනයට ලක්වීම වැනි ගැටළු වලට මුහුණ පෑමට සිදු වේ. එසේම ඇතැම් ගැහැණු දරුවන් අවස්ථාවාදී වැඩිහිටියන්ගේ ගොදුරු බවට පත් වන බව ද වාර්තා වී ඇත. උදාහරණයක් ලෙස ණය ලබාගැනීම සහ නිවසට අවශ්‍ය ද්‍රව්‍ය ලබාගැනීමට යාමේදී වෙළඳසල් හිමියන්ගේ අතවරයන්ට ලක්ව අනවශ්‍ය ගැබ් ගැනීම් වැනි සිද්ධි සහ ලිංගික සම්ප්‍රේෂණ රෝග සඳහා ගොදුරු වූ ගැහැණු දරුවන් පිළිබඳ වාර්තා එම තත්වය වඩාත් පැහැදිලිව විටහා දෙයි. ජලය පමණක් නොව දර සෙවීම සඳහා දුර බැහැර යාමේදී ද කාන්තාවන් සහ ගැහැණු දරුවන් මෙවැනි අතවර වලට ලක් වේ.

ඒ සඳහා අප කලයුත්තේ කුමක්ද?

ලෝක ආර්ථිකය හමුවේ දේශගුණ විපර්යාස අවම කිරීම සහ අනුහුරු වීම සඳහා අවශ්‍ය මූල්‍ය උපාංග තම රටට ගැලපෙන පරිදි එක් එක් රටවලින් ගොඩ නැගීම සිදු කල යුතුය. සමාජ සහ භෞතික භාණ්ඩ සඳහා ප්‍රවේශය, අධ්‍යාපනය ලැබීම, ආදායම් ඉපයීම වැනි කාර්යයන් වල නිරත වීම සඳහා කාලය වැය කිරීමේ හැකියාව සහ විවේකය යන කරුණු පිළිබඳව ද කාන්තාවන් සහ පිරිමින් අතර අසමානතාවයක් පවතී. ගෘහස්තව, සමාජයියව මෙන්ම කම්කරු වෙළඳ පොළ පිළිබඳ කාර්යභාරය සහ ඔවුන්ගේ වගකීම් වල ද ඇත්තේ අසමානකමකි. එබැවින් කාන්තාවන් කරා ඵලදායි ලෙස මූල්‍ය සම්පත් ගලා යාම සිදු නොවේ. යම් ජන කොටසක් කෙතරම් දුරට ආර්ථික සම්පත් පාලනය කරන්නේද සහ ආර්ථික සහ මූල්‍ය සම්පත් සඳහා ප්‍රවේශ වීමේ හැකියාව කෙතරම්ද යන්න මත දේශගුණ විපර්යාස කෙරෙහි අනුහුරු වීමේ හැකියාව රඳා පවතී. සාමාන්‍යයෙන් අනතුරු කළමනාකරණය කිරීම සහ ආපදා වලට පෙර සුදානම් වීම සඳහා අවශ්‍ය සම්පත් ප්‍රමාණය දෛනික අවශ්‍යතා සඳහා අවශ්‍ය සම්පත් ප්‍රමාණයට වඩා ඉහළ වේ. දුප්පත්කම තුරන් කිරීම සඳහා ඌන සංවර්ධිත රටවල කාන්තාවන් දිරිගැන්වීම සහ ඔවුන් සඳහා ආයෝජනය කිරීම ද ඉතා අත්‍යවශ්‍ය වන අතර මේ සඳහා ඉහල සම්පත් ප්‍රමාණයක් අවශ්‍ය වේ. මෙම තත්ත්ව වලට මුහුණ දෙමින් දේශගුණය වෙනස්වීම් සඳහා අනුහුරු වීමට සහ කාලගුණ විපත් නිසා ඇතිවන අලාභ ආවරණය කරගැනීමට ප්‍රමාණවත් මූල්‍ය අවශ්‍යතාවයන් සපුරා ගැනීමට මෙම රටවල කාන්තාවන්හට පහසු නොවේ. විශේෂයෙන්ම දේශගුණ විපර්යාස සඳහා අනුහුරු වීමට අවශ්‍ය තාක්ෂණය ලබා ගැනීමට අවශ්‍ය මූල්‍ය පහසුකම් මෙම රටවල අවම

වන අතර කාන්තාවන් හට ලැබෙන්න ඉන් ඉතා සුළු ප්‍රතිශතයකි. තවද දේශගුණ විපර්යාසයන්ට මුහුණ දීම සඳහා කාන්තාවන්ගේ ඇති හැකියාව ඔවුන්ගේ සමාජ ජාලයේ පුළුල් බව, සුභසාධනය සහ සෞඛ්‍යමය ශක්තිමත්භාවය මත රඳවා පවතින නමුදු සංවර්ධනය වෙමින් පවතින රටවල කාන්තාවන්ගේ සමාජ ජාලත් ඔවුන් සුභසාධනය සහ සෞඛ්‍යමය ශක්තිමත්භාවයත් එතරම් ප්‍රබල නොවේ.

ජෛවවිවිධත්වය සංරක්ෂණය සහ ජෛවවිවිධත්වය හායනය සීමා කිරීම මගින් ගෝලීය වශයෙන් දේශගුණ විපර්යාස කෙරෙහි ක්‍රියාකාරී වීමට දේශීය ජනතාවගේ සහභාගිත්වය ඉතා ප්‍රමුඛ වැදගත්කමක් දරයි. එසේම දේශගුණික බලපෑම් සඳහා අනුහුරු වීම සහ අවම කිරීමේ ක්‍රියාදාමයන් ක්‍රමානුකූලව සහ ඵලදායී ලෙස හඳුන්වා දීම සඳහා දේශගුණ විපර්යාස මගින් කාන්තාවන් සහ පුරුෂයන් වෙත ඇතිවන බලපෑම් වල විෂමතා මට්ටම් හඳුනා ගැනීම අත්‍යවශ්‍ය වේ. එසේම දේශගුණ විපර්යාස සඳහා අනුහුරු වීම සඳහා අවශ්‍ය දැනුම, තොරතුරු සහ තාක්ෂණය සඳහා කාන්තාවන්ට සම්පූර්ණ ප්‍රවේශය ලබාදීම වැදගත් වේ. එහෙත් ගැටළුව වන්නේ දේශගුණ විපර්යාස මගින් කාන්තාවන් සහ පුරුෂයන් වෙත ඇතිවන බලපෑම් වල විෂමතා මට්ටම් අඩු සැලකීමකට ලක් කිරීමයි. කාන්තාවන් ප්‍රධාන පරිසර ක්‍රියාකරුවන් ලෙස ස්වභාවික ආපදා කලමනාකරණය පිළිබඳ තීරණ ගැනීමේ ක්‍රියාවලියෙහි සහ දේශගුණ විපර්යාස අවම කිරීම සහ අනුහුරු වීම යන උපායමාර්ග හඳුනාගැනීම සඳහා සහභාගී කරවා ගැනීම වැදගත් වන අතර ඔවුන්ගේ හැකියාවන්, උපායකෞෂල්‍යයන් සහ නායකත්වය යන ලක්ෂණ කෙරෙහි අවධානය යොමු කිරීමද ඉතා වැදගත් වේ.

දේශගුණ විපර්යාස නිසා පීඩාවට ලක්වීමත් ස්වභාවික සම්පත් පරිහරණයෙහි දැනුම සහ විශේෂඥතා පැවතීමත් නිසා දේශගුණ විපර්යාස සඳහා අනුහුරු වීම සහ බලපෑම් අවම කිරීම යන කර්තව්‍යයන් සඳහා කාන්තාවන්ගේ දායකත්වය ඉතා වැදගත් බව අන්තර්ජාතිකව හඳුනා ගෙන ඇත. ස්වභාවික සහ ගෘහස්ත සම්පත් පිළිබඳ කාන්තාවන් සතු වගකීම් සහ දැනුම වෙනස් වන පරිසරික තත්ත්ව අනුව ජීවනෝපාය උපායමාර්ගයන් අනුහුරු කර ගැනීමේ සහ දේශගුණ විපර්යාස අවම කිරීමේ කර්තව්‍යය කරා දායක කර ගැනීමට මහඟු පිටිවහලක් වන බව සඳහන් වේ. ඔවුන් මේ සඳහා නියෝජිතයන් සහ ක්‍රියාකරුවන් ලෙස යොදාගැනීමේ හැකියාව මෙහිදී උපුටා දක්වයි. උදාහරණ ලෙස ගෘහස්ත අවශ්‍යතා සහ වගාබිම් වාරිකරණය සහ පශු සම්පත් පාලනයට ජලය යොදා ගන්නා නිසා ජලය පවතින ස්ථාන, විශ්වාසනීයත්වය සහ ගුණාත්මකභාවය, ජල සැපයුම් අවහිරතා සහ ගබඩා කිරීමේ ක්‍රම ආදිය පිළිබඳව ඔවුන් තුල පවතින දැනුම, ජලය පිරිමසා ගැනීම සඳහා යොදාගනු ලබන සරල ප්‍රතිචක්‍රීකරණ සහ ප්‍රතිභාවිත ක්‍රම ආදිය ජල සුරක්ෂිතතාවය තහවුරු කිරීම සඳහා යොදා ගත හැකි බව පෙන්වා දිය හැකිය. ජල සුරක්ෂිතතාවය සහ ඉන්ධන කාර්යක්ෂමතාවය වැනි සම්පත් කළමනාකරණ උපායමාර්ග ක්‍රියාත්මක කිරීම සඳහා කාන්තාවගේ මෙම දැනුම සහ සහභාගිත්වය ලබාගතයුතු බව අන්තර්ජාතිකව නිර්දේශ වන්නේ එබැවිනි. කාන්තාවන් සහභාගී කරවීම තුලින් දේශගුණ විපර්යාස හමුවේ බලශක්ති සැපයුම වඩා ඵලදායී ලෙස කළමනාකරණය කිරීමට ත් ජෛව ඉන්ධන මත යැපීම අඩු කර දරිද්‍රතාවයෙන් මුදවා ගැනීමට ත් හරිතාගාර වායු සහ අංශුමය විමෝචන අවම කිරීමටත් අවස්ථාව ලැබේ. එසේම ආහාර සුරක්ෂිතතාවය, සම්පත් කෙරෙහි සම ප්‍රවේශය සහ තීරණ ගැනීමේ ක්‍රියාවලියේදී ග්‍රාමීය කාන්තාවන්ගේ දායකත්වය තහවුරු කිරීම ද ඉතා වැදගත් වේ.

සාමාන්‍යයෙන් සංවර්ධනය වෙමින් පවතින රටවල සම්පත් භාවිතය පිලිබඳ ක්‍රමවේද ක්‍රියාත්මක කිරීමේදී සහ තීරණ ගැනීම් වලදී කාන්තාවන්ගේ දැනුම සහ විශේෂඥතාවය යොදා ගැනීම එතරම් සතුටු දායක නොවේ. විශේෂයෙන්ම සම්පත් සඳහා ප්‍රවේශ වීමේ සහ සම්පත් පිළිබඳව තීරණ ගැනීම සඳහා සංවර්ධනය වෙමින් පවතින රටවල වෙසෙන සහ ග්‍රාමීය කාන්තාවන්ට පවතින්නේ ඉතා සීමිත වූ ඉඩ හසරකි. පරිසර පාලනය පිළිබඳ තීරණ ගැනීමේ ක්‍රියාවලිය සඳහා ද කාන්තා නියෝජනය සම්පූර්ණ වුවක් නොවේ. උදාහරණයක් ලෙස කෘෂිකර්මාන්තය සහ සත්වපාලනය වැනි කටයුතු වල යෙදුන ද ඒ හා සම්බන්ධ ඉඩම් භාවිතය

පිලිබඳ තීරණ ගැනීමේදී කාන්තාවන්ගේ දායකත්වය අවමය. එසේම ජලය වැනි අත්‍යවශ්‍ය ස්වභාවික සම්පත් කළමනාකරණයේ සහ හදිසි මුදවාගැනීම්, ඉවත් කිරීම් සහ පසු ආපදා ප්‍රතිසංස්කරණ කටයුතු ආදී ස්වභාවික ආපදා සඳහා ප්‍රතිචාර දැක්වීමේ දෘශ්‍ය වෙනසක් ජාතික, දේශීය සහ ප්‍රජා මට්ටමේ කාන්තා නායකත්වය හරහා සිදු කර ඇත.

තවද තාක්ෂණය යනුවෙන් සාමාන්‍යයෙන් උපකරණ හෝ යන්ත්‍ර මුල් කොටගෙන පැවති සරල හැඳින්වීම තුල වර්තමානයේ දැනුම, ක්‍රියාවලීන්, ක්‍රියාකාරකම් සහ සමාජ සංස්කෘතික අංගයන් ද ඇතුලත් වේ. දේශගුණ විපර්යාස සඳහා අනුහුරු වීම සඳහා ද තාක්ෂණය ඉතා අවශ්‍ය වන අතර එය තුල රක්ෂණ යෝජනා ක්‍රම, හෝග මාරු රටාවන් සහ සාම්ප්‍රදායික දැනුම වැනි මෘදු තාක්ෂණය මෙන්ම නියඟ ප්‍රතිරෝධී හෝග වර්ග, වාරි මාර්ග පද්ධති වැනි දෘඩ තාක්ෂණයන් ද ඇතුලත්ය. බොහොමයක් සංවර්ධනය වෙමින් පවතින රටවල තොරතුරු සහ සන්නිවේදන තාක්ෂණය සඳහා කාන්තාවන් සහ ගැහැණු දරුවන්ගේ ප්‍රවේශය; සමාජ සහ සංස්කෘතික අපක්ෂපාතිත්වය, ග්‍රාමීය ප්‍රදේශ වල ප්‍රමාණවත් නොවන තාක්ෂණික යටිතල පහසුකම්, කාන්තාවන්ගේ විශේෂයෙන් විද්‍යාව සහ තාක්ෂණය විෂයන් පිලිබඳ අඩු අධ්‍යාපනික තත්ත්වය, තාක්ෂණ විෂයන් සඳහා ඇති අකමැත්ත සහ බිය සහ තාක්ෂණික සේවා ලබාගැනීමට සුදුසු ආර්ථික පහසුකම් නොමැති වීම මත සීමා වේ. නව තාක්ෂණය විකසනය සඳහා කාන්තාවන්ගේ දායකත්වය ලබා ගැනීම මගින් එම තාක්ෂණ භාවිතය සඳහා සුදුසු සමාජයකට හෝ රටකට දැරිය හැකි, ඵලදායි සහ තිරසර බව සහතික වන පරිදි නිර්මාණය කල හැකිය. දේශගුණ විපර්යාස සම්බන්ධ තාක්ෂණික සංවර්ධනයේ දී කාන්තාවන්ගේ විශේෂිත ප්‍රමුඛතා, අවශ්‍යතා සහ කාර්යභාරයන්, ඔවුන්ගේ දේශීය සහ සම්ප්‍රදායික දැනුම ඇතුළු විශේෂඥතා සහ දැනුම සම්පූර්ණ ලෙස යොදාගැනීම පිළිබඳව අවධානය යොමු කිරීම සහ ඔවුනට ගැලපෙන පරිදි තාක්ෂණය නිර්මාණය කිරීම වැදගත් වේ. එසේම මෙහිදී කාන්තාවන්ගේ ප්‍රමුඛතා සහ අවශ්‍යතා සඳහා ගැලපෙන සුනම්‍ය මූල්‍ය යාන්ත්‍රණයක් ද හඳුන්වා දිය යුතුය.

දේශගුණ විපර්යාස සඳහා කාන්තාවන්ගේ සම්පූර්ණ සහභාගිත්වය තහවුරු කිරීමට ඔවුන් පුනුණු කිරීම, අගයකිරීම, හැකියා වර්ධන වැඩසටහන් ආදිය සඳහා සමාන ප්‍රවේශයක් තිබීම ද මෙහිදී වැදගත් වේ. කාන්තා පුරුෂ විෂමතාවය සඳහා සංවේදී මිනුම් ලකුණු සහ දර්ශක ඇතිකිරීම, කාන්තා පුරුෂ විෂමතාවය පිලිබඳ තොරතුරු රැස්කිරීම සහ භාවිතය, ක්‍රමවත් විශ්ලේෂණ සිදු කිරීම මගින් කාන්තා පුරුෂ යථාදර්ශනය ජාතික ප්‍රතිපත්ති, ක්‍රියාකාරී සැලසුම් සහ අනෙකුත් තිරසර සංවර්ධන සහ දේශගුණ විපර්යාස ක්‍රියාමාර්ග සඳහා ඇතුලත් කිරීමට අවශ්‍ය බව අන්තර්ජාතිකව හඳුනාගෙන ඇති කරුණකි. මෙහිදී කාන්තා කණ්ඩායම් සහ සමාජ ජාල වල කාර්යභාරයන් ශක්තිමත් කළ යුතු අතර දේශගුණ විපර්යාස ක්‍රියාමාර්ග සඳහා කාන්තා උපදේශනය සහ සහභාගිත්වය තහවුරු කළ යුතුය. ස්වභාවික සම්පත් කළමනාකරණය සම්බන්ධ ගැටළු පිලිබඳ කාන්තාවන් සතු දැනුම සහ අත්දැකීම් මගින් කාන්තාවන් හට සැලකිය යුතු දායකත්වයක් ලබා දිය හැකි බැවින් ඔවුන්ගේ අනන්‍ය සහ වටිනා යථා දර්ශනයන් සහ දේශගුණ විපර්යාස පිලිබඳ විශේෂඥතාවය දායක කල හැකි අයුරින් තීරණ ගැනීමේ ක්‍රියාවලි සඳහා ඔවුන්ගේ සම නියෝජනය තහවුරු විය යුතු බවත් මෙම හඳුනාගත් කරුණු අතර වේ.

Climate Change and Psychology

U.L.Gayashani Uswatte

SWITCH-Asia SCP NPSC SL, Ministry of Mahaweli Development & Environment
gkkmadu@gmail.com

Simple behavioral changes may lead to a big difference in the process of finding solutions for issues relating to Climate Change. In the end, however, to mitigate the problems on Climate Change there must be a transformation of feelings, thinking and behavior within the individual.

'There are no environmental problems where humans are not centrally connected. Thus, psychology and education ought to play important roles in solving these various problems.'

-American Psychological Association-

Why are Humans Central to All Environmental Problems?

This is because mainly, we have been the dominant species on this planet for many years. The history of evolution for all biological species has been the same. The organism slowly changes via random genetic mutations coupled with selective retention to become better adapted to the environmental roles the world offers it.

Humans quickly alter the environment and then adapt to the future. They, thereby, are changing the course of evolution. However, we can now greatly change the environment which shapes our evolutionary path.

However, Climate change is not just a political, social and economic issue. It is also a deeply psychological one and now, behavioral scientists are using psychology to better understand the complex relationship between people and nature.

How Does Psychology Relate to Climate Change?

An increasing number of researches and psychological interventions are showing that in order to tackle the growing threat to our environment, we need to understand people's emotional and cognitive responses to this new reality which could be from denial to indifference, to violence, to anger or even to grief. However, scientists in the expanding field of environmental psychology are working hard to bring psychological insights into discussions about climate change.

Psychological Research Outcomes Vs Climate Change

Climate change as an occurring sensation

According to the research done by Dr.Susann Clayton, a conversation psychologist at the College of Wooster in Ohio, most people who acknowledge that climate change is occurring feel that the public response has been inadequate. Therefore, the psychologists have been looking at how people process this information about risk and come to their understandings. This is useful to know, before providing solutions with regard to issues on climate change, in terms of thinking about how you can create messages that are more effective for people in order to getting them on board (Gregoire, 2016).

Research in environmental psychology can focus on a number of different areas of inquiry relevant to climate change, including the use of psychology to inform communication about climate change, psychological and mental health impacts of ecological crises and disconnection from nature, advocacy and policy and the psychological roots of climate change denial, boredom and inaction.

While psychology has largely been left out of the climate change conversation, the field is now slowly growing. For example, in 2009, the American Psychological Association created a task force to examine the role of psychology in understanding and addressing global climate change. Also, politically, Barack Obama during his presidential period, called for the use of behavioral sciences to inform policy, communication and engagement around pressing issues, including climate change (APA 2017).

Why We, as a Community, Fail to Act on Climate Change?

As Dr. Renee Lertzman, a San Francisco-based psychosocial researcher whose work focuses on promoting climate change action in organizational settings said " Psychology is very innovative and it is very emerging, but they have to get to the point where they really can be open to new and different ways of looking at things" (Gregoire, 2016).

However, research done by Dr.Lertzman, seek to explain why we, as a community, fail to act on climate change, even when we are aware of the magnitude of the threat that lies before us. As she explained, it is not just because people do not care, rather, the emotional response to the issue, which for many people is a deep but developed untreated sense of anxiety and loss, leads to feeling powerless and paralyzed. As Dr. Lertzman further explained this state of untreated grief over the damage to the natural world, which she refers to as "environmental melancholia," prevents people from taking correct or the better action.

She defines it further in her own words, "There's this feeling of loss but it hasn't been named, partly because we're not used to talking about it in our culture ... It's a kind of loss that people

are experiencing on both a personal and a social level. It's a loss that comes with either seeing or experiencing changes in our environment, or hearing about those changes." (Gregoire, 2016)

Is There any Reason for Hope?

From many studies, it was found that people would spend many hours speaking to a counsellor about how distressed and sad they are about the way things are changing, and also their sense of powerlessness. At the same time, people move quickly to show that they deny that they care for environmental issues at all.

Further, most of these studies have found that people do show a lack of concern for the environment. However, according to Dr.Lertzman's point of view, people do already care and are already motivated, but are tied up in dilemmas and conflicts about how to actually respond. (Gregoire, 2016)

These studies explain further that more experts and advocates need to think about how to communicate with people in a way that supports and enables them to tackle environmental issues. By understanding emotional barriers to action, they may be able to devise better guidelines for communication, advocacy and policy.

Can Psychology be a Useful Way to Help People Feel More Connected to Nature?

This is well explained by Clayton, a pioneer in the field of conservation psychology. She describes the field as aimed at understanding how people relate to the natural world, and how to improve that relationship. She further states that they also teach people how to be strong in the face of climate change. (Gregoire, 2016)

In my opinion, it is reasonable to say that the space and structure of our modern urban lives are increasingly indoor, onscreen and detached from nature. However, research shows that our relationship with the natural world is still doubtful and psychologists do not yet have enough data to say what the exact effects might be.

Further, Clayton's research has pointed out a therapy. Exposing people to nature in an accessible way at their local zoos and aquariums can help to mitigate feelings of disconnection from nature.

In her research, Clayton surveyed more than 7,000 zoo and aquarium visitors to

see how they interacted with animals and whether these interactions promoted concern over climate change. She found that feelings of connection to animals at zoos or aquariums were associated with increased concern over climate change. The research also suggested that offering information about climate change at zoos helped to overcome ideological barriers (Gregoire, 2016).

Does Policy Formulation Along with Psychology Help to Mitigate Effects from Climate Change?

Most of the researchers emphasized the need for a greater understanding of people's deep and layered psychological responses to climate change. In other words, to tackle the problem, we cannot just focus on providing people the information about the issue.

As Clayton explained, information is not enough, largely because people are capable of huge levels of denial. Thinking about effective means of communicating information is something that psychologists have a lot of experience with.

Her research has shown some leaders in the world fail to empower people and prevent them from being able to locate themselves and their own actions with regard to climate change. Acknowledging people's emotional responses to the crisis is a start, and offering a middle ground between facts and solutions can begin to suppress anxiety and help side action to address the problem (Gregoire,2016).

However, to my mind, we must recognize that all of us are facing extraordinary challenges that require us to access new capacities, including how we relate to change and risk of climate. In the long term, of course, we do not just need to create small behavioral changes. Instead, we want people to rethink and prioritize their relationship with nature in order to face the changes and the risks relating to Climate Change by changing their own thinking, feelings and behaviors.

Glossary

Selective retention: In relating to the mind, is the process whereby people more accurately remember messages that are closer to their interests, beliefs, and values

Climate change denial: Rejecting to accept the impacts on nature or the society from human action.

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Socio Economic Approaches to Strengthen the Fisheries Sector Against the Impact of Climate Change

Kapila Chinthaka Premarathne

Institute of Policy Studies of Sri Lanka
nmkapila@yahoo.com

Climate change is considered as a global threat. Moreover, the mitigation actions are becoming a challenge due to many global geopolitical reasons. On this backdrop, climate change impacts are expected to increase in the coming years, alarming some industries like fisheries, causing socio economic issues. This global threat is not a nightmare. Therefore, Sri Lankan policies should be enforced to ensure the wellbeing of fishermen.

Fisheries Sector and Sri Lankan Economy

The fisheries sector is of importance to the Sri Lankan economy. According to Fisheries Statistics of 2016 Sri Lanka has 190,960 marine fishing households and 48,900 land fishing households. Fisheries sector has contributed to 1.4 % of GDP in 2015. Marine fisheries have the largest share of 1.3% and Inland fisheries 0.1% (Fisheries Statistics,2016).In addition to these monetary aspects, nutritional aspects like providing proteins and nourishing the nation prove the importance of the industry. Fisheries industry has been identified as a vulnerable sector to climate change in the National Adaptation Plan for Climate Change Impacts in Sri Lanka 2016-2025 (NAPCC, 2016). Similarly, agriculture and farmers are also subjected to the same climate change impacts. However, some protection mechanisms like crop insurance, crop loss compensations, and irrigation etc., have already been introduced to the agriculture sector. Hence, it is important that the fisheries sector too is sufficiently supported. This article has attempted to point out possible impacts on fisheries sector due to climate change and some research findings in the other sectors in order to show the importance of linking scientific methods and social science methods as a practice in Sri Lankan context.

Evidences of Climate Change Impacts on Coastal Areas and Fisheries

Food and Agriculture Organization of the United Nations (FAO) has shown that marine fisheries production peaked in the 1980's and is expected to decline due to climate change impacts (FAO, 2007a). To support this statement, as an example The Mean Sea Level (MSL) has increased by 0.19 meters (globally) during the last century and it is expected to rise rapidly in this century (IPCC, 2014).

The greenhouse effect has increased the temperature in the ocean. Studies have shown the impacts on the global fisheries due to conditions like rising temperature and changing biogeochemistry. This

could affect the reduction of fish harvest and income losses to the big companies as well households. (Brander, 2007; Cheun *et al.*, 2010).Growth and reproduction of fish can be affected by changes occurring in the ocean (Pörtner, 2007). As an example fishes in warmer waters are expected to have a smaller maximum body size and smaller size at first maturity (Pauly,2007). Similarly, many marine species have moved towards the poles and into deeper waters under ocean warming places like in the Northeast Atlantic (Perry *et al.*, 2005). These factors are directly important to the productivity of fisheries and may cause high costs in the industry and income losses *etc.* in the future.

Sea Level Rise Issue in Sri Lanka and Existing National Scientific Actions

Sri Lanka is vulnerable to the impacts of sea level rise because the Asian region usually experiences marginally higher sea level rise than global level. However, the exact sea level rise has not yet been specifically studied in the Sri Lankan context (NAPCC, 2016).Fisheries industry is susceptible to such impacts and it could affect the country's economy (Senarathne *et al.*, 2009). This has an impact on livelihoods and food security in the country as well.

Existing NAPCC 2016-2025 has included the coastal and marine sector action plan, highlighting adaptation needs. One such adaptation need is coastal zone management to face the impacts of sea level rise. This requires basic studies on the impacts inorder to establish a monitoring system that strengthens the coastal protection and management in the vulnerable areas. Another identified adaptation need is enhancing the resilience of coastal systems against extreme events.

Introduction of scientific support on intensive fishing methods, technology, sustainable use of fishing sites and proper fishing gear has been done in order to strengthen the fishermen to increase fishing productivity.

Importance of Socio Economic Approaches Against Experiencing Climate Change and Expected Sea Level Rise Impacts

There is a close link between the biophysical components of marine ecosystems and the socio-economics of fisheries. Global ocean–atmosphere changes could affect on multiple levels of organization of marine ecosystems and human society. It may cause many impacts on the economics of fisheries, creating larger global issues like global food security, energy supply and food prices. (Sumail *et al.*, 2011)

As shown in one of the research articles, actions solely based on science, especially which are practiced in less developed parts of the world would not solve the problems in marine ecosystems and coastal management (Rice *et al.*, 2011). Thus, adaptation of similar practices to Sri Lankan context will not address or may be totally incompatible with required actions for future food security needs. This highlights the importance of incorporating the socioeconomic aspects in addition to the natural science approaches, especially to build the resilience or awareness and adaptation against

the risks in national level plans. It helps to meet the food security goals and the socio economic wellbeing of fishermen.

Socio Economic Approaches: How It Works

Reducing the vulnerability to climate change via planned adaptation is such an approach. To assist in this, understanding of current response mechanisms to climate variability, recognition of the opportunities that climate change could bring to the sector and risks like loss of livelihood are important. Therefore, multi sectorial adaptive strategies which include adaptation and recognition of fisheries potential are important. (Badjeck *et al.*,2010).

Approaches to Identify the different sensitivity levels of fishermen, most vulnerable groups, within the fisheries sector, demographic characters of people who are more vulnerable etc. (Cinner,2012) are important. These kinds of approaches have revealed that the vulnerability of fisheries and fishing communities depend on their exposure and sensitivity to change, and on the ability of individuals or systems to anticipate and adapt. This adaptive capacity depends on the culture or marginalization and on reactive or anticipatory actions by individuals or public institutions. Similarly, the level of vulnerability varies between demographic groups within society. Generally, the poorer and less empowered individuals are more vulnerable to climate impacts, and the vulnerability of fisheries is likely to be higher where they already suffer from overexploitation or overcapacity. (Cochrane *et al.*, 2009)

Options to increase resilience and adaptability through improved fisheries and aquaculture management include the adoption of standard practices of adaptive and precautionary management. Aquaculture insurance is one of the options for frequent severe weather events. Strategies for reducing vulnerabilities of fishing and fish farming communities have to address measures including investment and capacity building on improved forecasting; early warning systems; safer harbours and landings; and safety at sea. More generally, adaptation strategies should promote disaster risk management, including disaster preparedness, and integrated coastal area management. (Daw *et al.*, 2009)

The socio economic index approaches have been introduced to lead sustainable farming and livestock systems. These indicators can be modified and used to monitor the fisheries sector performance as well to scale up the adaptation activities of Sri Lankan fishermen. Researchers have identified social stability, economic stability and environmental stability as the essential components of such indicators. The input management, natural resources management, wellbeing of farm community and overall sustainability are measured by these indicators. These could also be adapted to the fisheries sector.

Further, some studies have shown that although the communities have adapted to climate change throughout history, projected climate change includes multiple additional risks to fishery dependent

communities that might limit the effectiveness of past adaptive strategies. Therefore, some adaptation strategies will require to be context and location specific and to consider impacts both short-term (e.g. increased frequency of severe events) and long-term (e.g. reduced productivity of aquatic ecosystems). Adaptation of communities will clearly require and benefit from stronger capacity building, through creation of awareness on climate change impacts on fisheries and aquaculture, promotion of general education and targeted initiatives in and outside the sector. (Daw *et al.*,2009)

How The Link Should Perform

A practice is required consisting of multi sectorial methods. In this regard, the socio economic knowledge should be coupled with scientific actions. The link needs to be built in many prominent areas. One such area is scientific weather forecasting and dissemination.There is a dire necessity to fill this communicating gap in scientific climate information systems. People should be given accurate details via proper channels which have easy access and reliability *etc*. This increases the adaptation capacity of the fishermen.

The concept of sustainable fishery should be practiced with available farm assets with technology. In the same time, the socio economic wellbeing should be improved with introduction of livelihood improvement activities like differentiation of incomes, entrepreneurship development etc. In this regard, micro credit facilities, investment opportunities, gender based economic activities like processing maldive fish and infrastructure development are essential. Some of these things have already started in Sri Lanka. However, building awareness and resilience via suitable adaptation is needed to improve. In this regard, location specific characters should be identified in both scientific and socio economic parameters. The culture and historical background are important in such mobilizations.

Education and extension are major components of the socio economic approach. The fishermen need to be aware about the scientific methods and advance management practices to withstand the losses and damages. This link could help them to be more updated.

Fishermen need to introduce good management practices to prevent the possible quality and quantity losses. At the same time, knowledge in financial management and business is important. The youth need to be provided training and more opportunities to get the technology and available practices to catch export markets. In this regard, as a socio economic approach, the fishing community based organizations need to be provided training sessions on packaging, quality assurance, value addition *etc*.

Community mapping can be done based on the vulnerability levels by considering both geological and socio economic characteristics. The proposed socio economic indicators are important in this

regard. This could help to identify the needy people and establish small villages with different production levels.

Conclusion

The socio economic approach and scientific approach should link to avoid the potential climate change impacts on fisheries sector and people. This will help them to withstand the possible income losses due to production loss, high cost and loss of original livelihoods.

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Climate Change as a Contemporary Security Challenge to Sri Lanka

G.G.M.G De Silva

desilva.madhu@gmail.com

As an island nation, Sri Lanka is deeply conscious of the impacts of climate change and it is already experiencing its adverse impacts. Climate change is a security concern because it brings groups with existing tensions into contact, changes the scale of problems and reduces resilience/adaptive capacity. It can put stress on top of other stresses, interrupt straight-line projections such as those for water and energy, and start chain reactions in multiple systems.

Introduction

The climate of a region or a city is its typical or average weather. For example, the climate of Puttalam in Sri Lanka is sunny and warm, but, the climate of Antarctica is freezing cold. Earth's climate is the average of all the regional climates of the world. Climate change, therefore, is a change in the typical or average weather of a region or a city. This could be a change in a region's average annual rainfall or it could be a change in a city's average temperature for a given month or season .Climate change is also a change in Earth's overall climate. This could be a change in Earth's average temperature or it could be a change in Earth's typical precipitation patterns [1].

Climate change is increasingly recognized as having national security implications, which has prompted dialogue between the climate change and national security communities, with resultant advantages and differences. Climate change research has proven useful to the national security community sponsors in several ways. It has opened security discussions to consider climate as well as political factors in studies of the future.

It has encouraged factoring in the stresses placed on societies by climate changes to help assess the potential for state stability, and it has shown that changes, such as increased heat, more intense storms, longer periods without rain, and earlier spring onset, call for building climate resilience as part of building stability. For the climate change research community, studies from a national security point of view have revealed research lacunae, such as the lack of usable migration studies. This has also pushed the research community to consider second- and third-order impacts of climate change, such as migration and state stability, which broadens discussion of future impacts beyond temperature increases, severe storms, and sea level rise and affirms the importance of governance in responding to these changes. The increasing emphasis in climate change science toward research in vulnerability, resilience, and adaptation also frames what the intelligence and defense communities need to know, including where there are dependencies and weaknesses that may allow climate change impacts to result in security threats and where social and economic

interventions can prevent climate change impacts and other stressors from resulting in social and political instability or collapse. At the same time a coalition of 25 military and national security experts, including former defense advisers, has warned that climate change poses a "significant risk to US national security and international security[2]."

The Secretary General of NATO Jens Stoltenberg in an interview with POLITICO magazine, stated that "climate change is in fact a security risk, and an issue to consider in the context of conflict prevention, peace and stability[3]"

Climate Change and National Security

National security is the ability to preserve the nation's physical integrity and territory[4].It is the requirement to maintain the survival of the state through the use of military, political, economic power and diplomacy. After the cold war, with new global structure and rising tide of globalization, environmental degradation has opened new facets of security. Focused away from the military power (or traditional security), as the core determinant of international order and security, modern security (non-traditional security) came up with new main elements[5] such as:

- Energy security
- Food security
- Health security
- Human security
- Water security
- Climate change

However, according to Mely Caballero-Anthony, Non-traditional security threats may be defined as "challenges to the survival and well-being of peoples and states that arise primarily out of nonmilitary sources, such as climate change, cross-border environmental degradation and resource depletion, infectious diseases, natural disasters, irregular migration, food shortages, people smuggling, drug trafficking, and other forms of transnational crime."

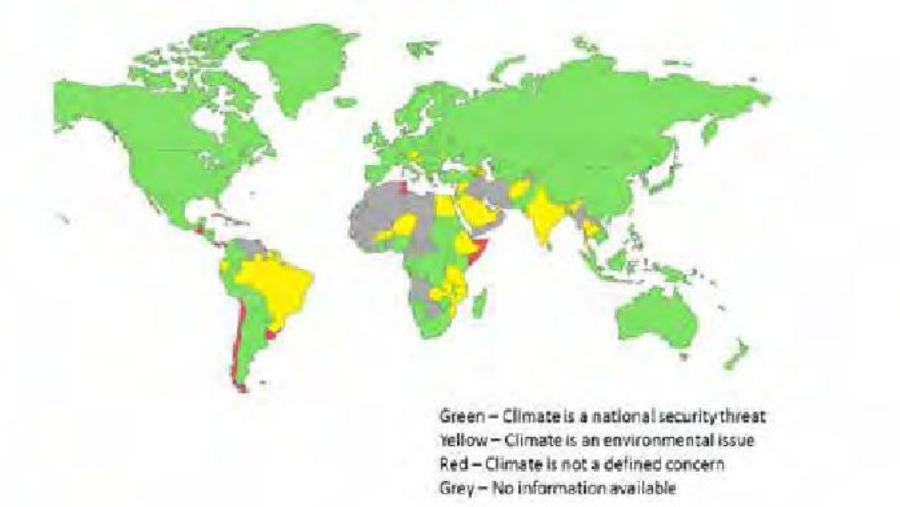
Relativity Between Climate Change and National Security

Climate change is a risk to global security because it increases vulnerability in infrastructure, agriculture, energy and other factors[6]. The security consequences of climate change will be determined by how it affects and interacts with local political, social, and economic conditions as much as by the magnitudes of the climatic shift itself.

Academic researchers have been debating the links between climate change and conflict for decades. A changing climate will increase vulnerability by exacerbating tensions related to water scarcity and food shortages, natural resource competition, underdevelopment and overpopulation.

It acts as an accelerant of instability, which may lead to violence. These disruptions will burden civilian and military institutions around the world.

The Global Security Defense Index on climate change evaluates the extents of governments in considering climate change to be a national security issue. The Index analyzes how governments around the world and their militaries plan for and anticipate the strategic threats of climate change. According to the authors, the results show that over 70% of the nations in the world view climate change as a serious national security issue. To arrive at such a number the American Security Project (ASP) divided the countries into four groups: 1.Countries which definitively state that climate change is a national security threat. 2. Countries that label climate change as an environmental issue. 3. Countries that have not defined it as a concern. 4. Countries for which there is no information available (Fig. 1).



- Climate Change is a National Security Threat - 110 out of 155* - 71% of countries
- Climate Change as an Environmental Concern - 32/155* - 21% of countries
- Climate Change is Not a Defined Concern - 13/155* - 8% of countries
- No Information Available - 41/196* - 21% of countries

Figure 1 : Level of concern about how climate change threatens security
Source: Global Security Defense Index on Climate Change

Climate Change and Sri Lanka

Sri Lanka is an equatorial island with a total area of 65,610 km^2, a land area of 62705Km^2, Inland water of 2905 Km^2 and a coastal area of 1660 Km^2, which hosts many diverse endemic species, and is considered to be a biodiversity hotspot[7,8].

Vulnerable areas to climate change in Sri Lanka are identified as Agriculture, Water Resource, Human Health, Coastal Zone, Tourism, Forestry, Wildlife, Biodiversity and Ecosystem[10]. Based on information available on the people, assets and infrastructure affected by natural disasters during the period 2012-2017, the figures below clearly identify floods, drought, storm, landslide events as the most common natural disasters in Sri Lanka. (Table 1)

Table 1 : Informations reported on the natural disaster hazards in sri lanka from 2012 .01.01 to 2017.03.01

Event	Deaths	Injured	Missing	Houses De-stroyed	Houses Damaged	Affected	No. Families Affected	No. of people in the camps
Coastal Erosion	0	0	0	15	10	153	22	103
Coastline	0	0	0	4	42	734	179	0
Cutting Failure	21	22	0	69	690	15365	3931	5265
Cyclone	0	0	0	1	33	141	32	0
Drought	0	0	0	0	0	4588650	1316176	0
Drowning	78	8	13	0	0	53	21	0
Earth Slip	6	9	7	44	87	2445	936	0
Flash Flood	4	2	0	69	618	5881	1592	2
Flood	103	83	4	6707	29775	2498381	663239	352613
Ground Vibration	0	0	0	0	1	2	1	0
Land Subsidence	3	1	0	0	1	0	0	0
Landslide	106	21	148	344	2282	48906	12912	13184
Lightning	140	71	0	8	80	469	120	0
Rains	3	154	0	90	1181	13088	3789	100
Rock Fall	2	4	0	8	33	443	141	43
Storm	0	0	0	2	32	0	0	0
Strong Wind	84	114	30	2918	18970	262776	69878	1858
Subsidence	0	0	0	0	33	220	56	178
Surge	0	0	0	3	0	15	3	0
Tidal Wave	2	1	3	0	0	19	3	0
Tornado	0	0	0	25	100	374	106	0
TOTAL	**642**	**628**	**208**	**10753**	**54285**	**7471596**	**2082934**	**373642**

Source – DMC, Disenventar - 2012 .01.01 to 2017.03.01

As per the information available, 642 people died during the last five years and 212 deaths were reported by a DMC situation report dated 9th June 2017. Other than that, Sri Lanka was one of the countries struck by the Tsunami with a reported 30,196 confirmed deaths[11].

Considering the situation in the country, tri-forces commanders of the Sri Lankan armed forces had taken the challenge during the floods that resulted from a heavy southwest monsoon, beginning around 18th to 19th May 2017. The Sri Lankan armed forces initially deployed nearly 10,000 personnel and equipment for relief, help and rescue operations. This is the biggest deployment of troops during peace time in Sri Lanka (Figure 2).

The Sri Lanka Army deployed more than 1700 Army personnel of 17 Battalions, including Commando, Special Forces, Mechanized Infantry and Army medical personnel. BTRs, WMZs troop carriers and 30 Army boats and other machinery were deployed by the Army for the rescue operations. The Army also deployed sandbags for flood defenses. The Sri Lanka Navy deployed over 110 search-and-rescue teams comprising 776 naval personnel along with 116 relief boats. The Navy began rescue work along the Kelani River by 19th May 2017. The Sri Lanka Air Force deployed Mil Mi-17s, Bell 212s, and Bell 412 helicopters to rescue the affected in all areas. Flights involving B200 Beach craft were deployed for continuous reconnaissance /observations over affected areas[12]. At least, 77,000 people were evacuated from the floods and relocated to safe locations. Sixteen hospitals in the flood-affected areas were also evacuated. Not only the Sri Lanka, but also other militaries around the world have taken the matter seriously.

Fig 2: Rescue operations by the armed forces

Climate change is predicted to strain economies and societies around the world, placing an additional burden on already vulnerable areas of a nation and putting pressure on development. Sri Lanka has shown progress during the past years in Fragile State Index, and rising towards sustainability, but climate change can badly affect its pathway to achieve the sustainable development goals by 2030. Climate change will change the nature and doctrine of military missions in future. Considering climate change security threats that Sri Lankan military and militaries around the world are taking seriously, subjects such as disaster management, casualty evacuation and rescue missions will be inserted into military academic discipline. Assessing of climate change impacts on economic security, food security, health security, human security, water security, political stability and social security characterizes the contemporary challenge to the national security.

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US Exit From the Paris Agreement: Global Politics of Climate Change

Athula Senaratne

Institute of Policy Studies
athulahsenaratne@yahoo.com

The controversial decision by the United States Government to withdraw from the Paris Climate Agreement attracted strong responses. The decision was not endorsed even by the traditional allies of the US such as EU and Britain. Moreover, it provoked a defying stand by some sections of US citizens, politicians and business community. This article examines the key implications of the US decision on global efforts to mitigate climate change.

Politics of Climate Change

In a world where all kinds of human affairs are influenced by politics, common challenges faced by humanity also are viewed, interpreted, and promoted (or suppressed) along the lines of personal or group interests. Individuals/groups with conflicting interests contest for power, with the objective of enforcing solutions for common problems that fit their agendas. Climate change is not an exception.

Climate change used to be a politically sensitive subject, despite its strong scientific discourse, aimed at understanding complex dimensions of the phenomenon. Even though climate change is yet to become a priority in national politics of developing countries like Sri Lanka, it has emerged as a divisive issue in some developed countries. The latest, and perhaps the most compelling, episode in politics of climate change is now unfolding in the USA.

Broadly, the debate over climate change extends over a wide range of opinions. The spectrum of opinions ranges from the strong advocates at one end—who identify climate change as a major challenge faced by humanity—through various layers of proactive groups, to those who suspect or deny climate change at the other end. Even among those who believe that climate change may actually be happening, some do not accept that human actions are the major cause for it. There are disagreements over what actions should be taken and who should take the main responsibility for those actions even among the advocates of climate action.

Climate Negotiations and Global Politics

From the beginning, politics played a strong role in global negotiations on climate change. Differences in opinion and disagreements over climate action remained the major stumbling block in negotiations on Kyoto Protocol, sponsored by the United Nations Framework Convention on Climate Change (UNFCCC). Under the Kyoto protocol, negotiations were aimed at assigning

greater responsibility in emission reductions to developed countries classified as Annex 1 countries, based on their high per capita emission levels and historical responsibility for the buildup of the greenhouse gasses in the atmosphere. However, this strategy failed due to the resistance from certain Annex 1 countries. During the process of Kyoto Protocol negotiations, the US—the second largest emitter in terms of total emissions (next to China) and the largest historical contributor to the buildup of GHG during the period of 1850-2011—remained uncommitted (World Resource Institute 2017). The dissenting parties argued that without the commitment from other large emitters such as China and India, GHG reduction efforts would fail to achieve desired results. This argument has been countered by developing countries on the grounds of responsibility of Annex 1 countries to the historical buildup of GHG emissions, and comparatively low per capita emissions originating from developing economies. While the arguments from both sides had some elements of truth, resulting disagreements caused the negotiations to drag on without a significant result. Even among developing countries, there was no consensus about the issue, since countries were impacted by the issue in different ways. For instance, oil producing countries ignored calls for climate actions, since the reduction of GHG emissions implied phasing out fossil fuel as a source of energy, replacing it with renewable sources of energy. This meant loss of income for oil producing nations which led to strong resistance of the Kyoto Protocol from these countries

Paris Climate Agreement (PCA) in 2015 has become an important milestone in this process, where the negotiating parties made a breakthrough with the contribution of USA. The parties agreed to accept the global responsibility of GHG emissions and to identify the necessity of controlling global average temperature at least below 2 degrees Celsius than the average of the pre-industrial era. To reach this goal, all parties are expected to commit through Nationally Determined Contributions (NDCs). In this process, major emitters like US under the leadership of President Barrack Obama committed to this agreement. In this backdrop, the recent decision of President Donald Trump to withdraw USA from the PCA sparked a major controversy. It has fundamentally disturbed the political equilibrium achieved in Paris in 2015.

US Withdrawal from Paris Agreement

Like many of the decisions taken by the Trump Administration, the decision to exit from PCA was also mired in controversy and attracted strong responses. Among the declared reasons for the withdrawal was the argument that PCA has imposed burdens on US workers and taxpayers, while creating benefits to other countries. However, this argument has not been backed by strong evidence. Threat of job losses in fossil fuel industries such as coal, due to increased push towards renewable energy, appeared to be a major underlying justification. Also, the USA has become a major oil producer during the last decade, using the technological innovation called 'fracking' that helps to extract oil from hitherto untapped sources. Moreover, the President complained about the burden on tax payers due to US$ 3 billion commitment to Green Climate Fund, of which US$ 1 billion has already been paid by the previous Obama Administration. President Trump has called for renegotiation of terms of agreement, if the USA is to continue with it.

It is a known fact that conservative Republican administrations in the USA are usually averse to climate action, unlike liberally oriented, Democratic administrations. The Trump administration, a Republican administration, appears to be taking an extreme position even for conservatives. Going beyond the withdrawal from PCA, the administration has taken a controversial stance by challenging the credibility the of growing body of scientific evidence from climate change studies, embracing the views of climate change sceptics. A number of important government positions, such as the Head of Environmental Protection Agency (EPA), were filled with climate change sceptics. It seems that resistance to climate action originates from a general aversion towards global and multilateral commitments, including trade agreements considering them as a kind of zero-sum game. President Trump entertained strong views against multilateral agreements from campaign days, claiming that these were responsible for job losses to US workers, creating monetary burdens to US tax payers.

Predictably, the decision to withdraw from PCA attracted strong resistance and criticism. They mainly arose not from purported 'beneficiaries' (as claimed by Trump allies) such as China, but from parties within the US and its traditional allies such as the European Union (EU). Strong resistance and counter arguments have emerged from within the USA itself against the decision, and it is said that even sections within the Trump Administration are divided over the issue. A major faction within the corporate sector, publishing a full page public request in major newspapers, urged President Trump not to abandon the PCA. The companies involved included such giants as Apple, Microsoft, Intel, Facebook, Google, Adobe, Morgan Stanley, Levi Strauss, HP and Unilever. Well-known businessman and philanthropist Michael Bloomberg publicly declared the intention to contribute US commitments to PCA through collecting funds from the corporate sector and civil society sources, within hours of the President's statement about the withdrawal. The media was flooded with articles criticizing the move and many members of the scientific community came forward to express their dissatisfaction.

In spite of the federal government's decision to withdraw from the PCA and to reverse many national initiatives on climate change, a number of state governors and city mayors have pledged their commitment to continue with Paris Agreement targets. Governors of California, New York, and Washington announced the establishment of United States Climate Alliance (USCA) to work towards a low carbon economy without the federal support. Since then it has grown into a bi-partisan coalition, partnered by 13 states and self-governing territories, comprising of both Democratic and Republican States. These States jointly represent more than one third of US population, US$ 7.16 trillion of US GDP and 1.3 million clean energy jobs. The three principles upon which the USCA was formed were: States are continuing to lead on climate change; State-level climate action is benefitting economies and strengthening communities; and, States are showing the nation and the world that ambitious climate action is achievable. Joining the dissenting Governors, a group of over 200 mayors identified themselves as 'Mayors' National Climate Action Agenda' came forward to denounce the federal government's decision, indicating their desire to intensify efforts to meet city level climate goals and push for new actions to meet the 1.5 degrees Celsius target.

President Trump's demand for renegotiation has largely been ignored even by traditional allies such as EU leaders. This was reflected in cold-shouldered response he received in his first G7 meeting, where other major leaders reaffirmed their commitment to PCA, isolating the USA. Leaders of France, Germany, and Italy publicly responded to the decision on withdrawal expressing 'regret' while rejecting the demand for renegotiation. Some experts pointed out that during the course of negotiations the agreement has been designed to meet US demands so that USA need not resist.

Possible Consequences of US Exit from PCA

The most important question is how the US withdrawal would affect the global agenda for combatting the climate change. On one hand, the USA is the second largest emitter of GHGs, with the second highest per capita emission level. It has been a main contributor to global buildup of GHG emissions since the industrial revolution. On the other hand, the USA is the incumbent global super power with the highest economic, military and scientific capabilities to confront any global challenge. As a global leader, it has the capacity to influence decisions taken by other nations too. Both these facts, count heavily when considering the impacts caused by the US' withdrawal.

Under the Obama Administration, the USA committed to reduce GHG emissions by 26-28% from 2005 level in 2025. To achieve this target, they planned different strategies of emission cuts that required significant innovations in low carbon technologies. Besides the direct benefit from low emissions in the atmosphere, efforts to achieve these targets expected to bring in significant advances in low carbon technologies that would benefit other nations as well. Hence, the absence of the leadership US could have provided in the technology frontier would be a definite setback. Besides abandoning emission reduction efforts, Trump Administration is apparently planning to expand fossil energy production through various means that can further increase current emission levels. It is also unlikely that US will fulfill its pledge to provide the remaining US$ 2 billion to GCF. This would adversely affect adaptation efforts by vulnerable communities in many developing countries for whose benefit the fund was established. Hence, the reversal of US stance on PCA could have direct and indirect effects on global efforts on climate change. Even though some sections of US corporate sector and state governors expressed their commitment to PCA, their efforts cannot be expected to neutralize all the negative effects of Federal Government actions.

However, despite the clout of USA in the international politics, the Trump administration has apparently failed to influence the global community to rally around it. This has undermined the US' position as a global power, a negative result in the international political arena. Observers in international politics commented that this could harm US position in the world political order, a kind of 'abdication' of leadership at a critical time of global transition.

However, there are other uncertainties too. The US will remain a part of the United Nations Framework Convention on Climate Change despite its withdrawal from implementation of the non-binding commitments to Paris accord. Any party to the agreement has to remain for at least

three years before starting the withdrawal process. This date comes on Nov. 5, 2019 and the official process of withdrawal takes about one year, making Nov. 5, 2020 the earliest date of US official withdrawal. There are more than 3 years before this date, a sufficient time to many changes in global scenario under huge uncertainties associated with global politics as well as climate change.

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Coastal Effects of Climate Change

A.M. Gammanpila*, P.B. Terney Pradeep Kumara

Marine Environment Protection Authority
*shanigam@yahoo.com

Climate change is significantly affecting the coastal and marine areas as well as their sensitive ecosystems. Rising sea level, increases in sea water temperature, ocean acidification are some of the major challenges due to the climate change.

Climate change, is defined by the Intergovernmental Panel on Climate Change (IPCC) as "any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2000). Climate change is causing significant challenges to vulnerable coastal and marine areas as well as to the function and structure of their ecosystems. It is believed that climate change and its effects on the world were very significant in the past decade and will be further increased over the next 100 years.

In coastal regions, the biggest danger is that climate change is causing sea levels to rise rapidly. Global sea level rise is largely attributable to the thermal expansion of the oceans and the melting of glaciers and polar ice sheets resulting from a warming atmosphere. IPCC reported that, global average sea level rose 1.7 mm/year during the 20th century, 1.8 mm/year between 1961 and 2003, and 3.1 mm/year between 1993 and 2003 (IPCC, 2007). If sea level rise occurs with greater and more frequent storms, coastal flooding and erosion problems will occur in vulnerable coastal areas. Further, rising sea levels will inundate coastal wetlands, barrier islands, and other low-lying lands. Inundation, erosion, and flooding will threaten human health, coastal property, and disrupt various types of infrastructure as well as coastal ecosystems. Any damage to these ecosystems will, in turn, affect the biological, ecological, and physical services they provide. The amount of light reaching offshore plants and algae dependent on photosynthesis could be reduced as a result of increased sea water level. Human and ecosystem populations will also suffer from a loss in quantity and quality of freshwater as saltwater intrudes in to estuaries, marshes, rivers, and aquifers. The growth of mangrove ecosystems, which require stable sea levels for long-term survival will also face threats. In the United States of America, approximately 86% of the United States east coast barrier beaches have experienced erosion during the past 100 years. Widespread erosion is also well documented in California and the Gulf of Mexico.

Increasing air temperature will in turn lead to warmer conditions in both marine and fresh water systems. In addition to their role in sea level rise, increases in water temperature will impact the quality of coastal and marine waters and living resources. These changes will ultimately affect the species distribution, metabolism, life cycle, and behavior of marine species. For many species, temperature serves as a cue for reproduction and any changes in sea water temperature could affect their successful breeding and threaten population survival. Warming seas will increase the incidence of coral bleaching, hypoxia, pathogens and disease, harmful algal blooms, and invasive

species. Ecosystems, habitats, and species will be weakened or lost. It is reported that, since the 1970s, coastal water temperatures have risen by about 0.6°C in several regions (IPCC, 2007). The coastal communities who make their livelihoods based on these vulnerable resources, such as fisheries or tourism will face severe social and economic problems.

As the ocean is the greatest absorber of carbon dioxide in the atmosphere, the increased greenhouse gases will make changes in the chemistry of the ocean. Ocean acidification is the result of increased absorption of carbon dioxide by ocean water and the corresponding decrease in pH. According to IPCC, globally, the pH of seawater has decreased significantly (0.1 units) since 1750, making it more acidic (IPCC, 2007). As seawater becomes more acidic, fish, squid, and other gilled marine animals may find it harder to "breathe". And increased levels of carbon dioxide in the sea water makes availability of calcium carbonate decreased for corals, shellfish, and other sea life to build their shells and skeletons. Threats to these ecosystems and species will be wide-ranging across the marine food web and associated coastal communities.

The challenge of climate change effects on coastal resources needs to be addressed through integrated and ecosystem-based approaches and instruments, such as Integrated Coastal Zone Management (ICZM). ICZM mainly focuses on three operational objectives:

- Strengthening sectoral management through training, legislation, and staffing
- Preserving and protecting the productivity and biological diversity of coastal ecosystems, mainly through prevention of habitat destruction, pollution, and overexploitation
- Promoting rational development and sustainable utilization of coastal resources (ESD,1996).

More importantly, public awareness of coastal resources and the adverse impacts of climate change should be increased. The changes on coastal and marine environment should be continuously monitored and adaptation plans developed in order to guarantee the stability and security of the coast. The government should prepare an exploitation and utilization plan, make polices for scientific management, and especially strengthen law enforcement for coastal protection. New zoning can be introduced to protect high risk land uses and environments and prevent development activities in environmentally sensitive or risky areas.

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Impact of Ocean Acidification on Calcifiers

Terney Pradeep Kumara*, Madhusha Mihirani Subasinghe

Marine Environment Protection Authority
*terneypradeep@yahoo.co.uk

Climate related changes, such as warmer temperatures and changes in the chemistry of the oceans threaten entire marine ecosystem including shellfish. The ocean is known as a "Carbon sink", or an area where excess carbon can be removed from the atmosphere, absorbing about 30% of carbon dioxide emissions. Ocean acidification results from carbon dioxide in the atmosphere dissolving in the seawater and reduction in the pH of sea water for an extended period of time due primarily to the uptake of carbon dioxide from the atmosphere by the ocean. About one-quarter of human-generated carbon dioxide emissions have been absorbed by the ocean. As a result, the average acidity of the surface ocean has increased about 30 percent since 1750. Today's ocean acidification is important not only for the amount of the change that has occurred thus far but also for how quickly it is happening. The rapid pace changes gives marine organisms, marine ecosystems and humans less time to adapt, evolve or otherwise adjust to the changing circumstances (EPA, 2015, https://www.epa.gov/cira/climate-action-benefits-shellfish, Access date:2017/08/18).

Many life processes, including photosynthesis, growth, respiration, recruitment, reproduction and behavior are sensitive to carbon dioxide and pH. As a result, ocean acidification has the potential to affect a wide range of organisms in different ways (Gzeau *et al*;2007). Most of the marine shellfish are vulnerable to ocean acidification by virtue of their dependency on the mineral calcium carbonate to make shells, skeletons and other hard body parts. Shellfish such as oysters, clams, scallops, mussels, abalone, crab, geoducks, barnacles, sea urchins, sand dollars, and sea stars have calcareous shells. Even some sea weeds that produce calcium carbonate structures are affected by ocean acidification. Organisms that use carbonate and calcium ions dissolved in seawater to construct their shells and skeletons are known as calcifiers. As a result of increase of carbon dioxide concentrations in the sea water, the availability of carbonate ions decreases making it more difficult for calcifiers to form, build, and maintain calcium shells and other calcium based body parts. Decrease of the carbonate ions in the sea water in low level results in seawater being chemically corrosive to calcium carbonate (Figure 1). Some calcifiers will therefore experience greater difficulty in making or maintaining their shells, slower growth rates and higher mortality. Shellfish juveniles and larvae are especially vulnerable to ocean acidification. (https://www.epa.gov/cira/climate-action-benefits-shellfish, Access date:2017/08/18)

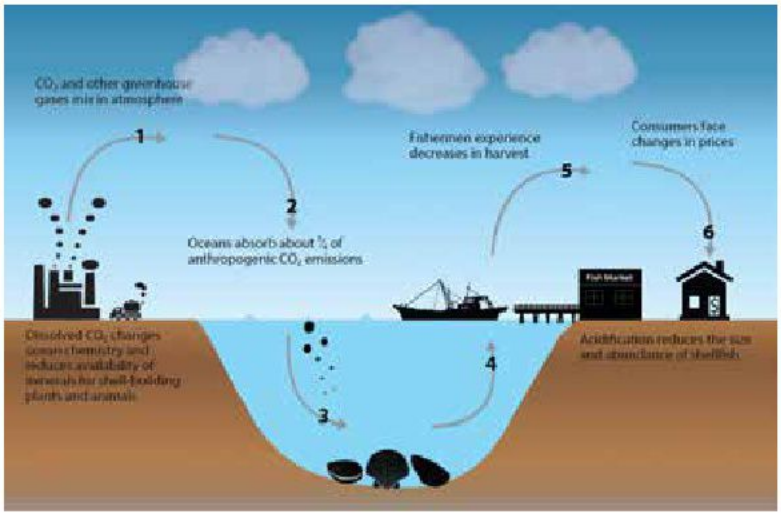

Figure 1: Ocean Acidification Impact Pathway for Shellfish
(Source: United States Environmental Protection Agency, https://www.epa.gov/cira/climateaction-benefits-shellfish)

As an example for the impact of ocean acidification, in the USA between 2005 and 2009 a disastrous production failure of oysters in North Western oyster hatcheries can be shown. During the period between 2005 and 2009, several major commercial Pacific Northwest oyster hatcheries experienced disastrous production failures when billions of oyster larvae, mysteriously died. It was signaled as a shift in ocean chemistry that has profound implications for Washington's marine water. Researchers revealed the cause; the arrival of low pH sea water along the West Coast, which created conditions corrosive to shell forming organisms like young oysters due to ocean acidification (Figure 2,3). Also wild oysters in Willapa Bay, Washington, have failed to reproduce successfully because corrosive waters have prevented oyster larvae from forming shells. Other wild oyster beds in the Pacific Northwest have sustained losses in recent years at the same time that scientists have been measuring alarmingly corrosive water along the Pacific coast. Ultimately supply for the shellfish will decrease by the end of the century influencing economic impacts in this sector (Ocean Acidification: From Knowledge to Action, 2012).

Figure 2: Impact of ocean acidification on oyster larvae and oyster reefs
(Source: Ocean Acidification: From Knowledge to Action, 2012)

Figure 3 : Some examples of Puget Sound calcifiers (clockwise from upper left): blue mussels; juvenile king crab and pink calcifying algae;Dungeness crab. (Source: Ocean Acidification: From Knowledge to Action, 2012)

Impact of ocean acidification on calcifiers also affect other marine organisms and marine environment in different ways. Many calcifiers provide habitat, shelter and food for a variety of plants and animals. While scientists have primarily studied the direct effects of ocean acidification on laboratory algae, plants, and animals, indirect effects mediated by food webs or changes in species interactions can also be important. For example, young salmon consume pteriods, and people consume salmon which consequently declines in the abundance of pteriods that could indirectly affect people by changing the number of salmon available for humans. Some animals, known as keystone species, are of particular interest because their fates can determine the fates of whole communities.

Ocean acidification presents a significant challenge to marine environment and economy of many countries in the world depending on the fisheries and tourism industry, but it can be met by reducing carbon dioxide emissions, the most significant driver of ocean acidification. The reduction of local land-based contributions to ocean acidification, reducing inputs of nutrients and organic carbon from local sources can decrease the acidity in marine waters to minimize the impact of ocean acidification on marine organisms. The report on Climate Change in the United States: Benefits of Global Action published by EPA (EPA, 2015) described a selection of the estimated benefits of global GHG mitigation in 2100 for major U.S. sectors. According to this report, in 2100 it avoided a loss of approximately 34% of the U.S. oyster supply, 37% of scallops, and 29% of clams and avoided loss of

approximately 35% of current Hawaiian coral in 2100, with a recreational value of $1.1 billion.

Due to a lack of information on marine research on ocean acidification on calcifiers and other marine living resources in Sri Lanka, there is a lack of information on the scenario of ocean acidification of the marine environment. Therefore, it highlights the need for scientific research on the marine environment to study ocean acidification and it's impact on shellfish and other marine organisms.

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Environmentally Sustainable Transportation (EST) in Sri Lankan Context

S.M.D.J.T. Jayatilake

Vehicle Emission Testing Programme, Department of Motor Traffic
jananijayatilake@ymail.com

Mobility is an essential human need and transport plays a major part in economic and social development. Environmentally Sustainable Transportation (EST) is a concept that could help safeguard our environment while fulfilling transport needs. In present day, there is a tendency for vehicle users to adapt environmentally sustainable practices. This needs to be reflected in policy making by considering consumer choices with proper policies and legislations to improve the driver behavior techniques to reduce fuel consumption while improving the road safety.

Introduction

Human survival and societal interaction depend on the ability to move people and goods. Efficient mobility systems are essential facilitators of economic development. Cities could not exist and global trade could not occur without systems to transport people and goods cheaply and efficiently (WBCSD, 2002).

Thus, transportation plays a key role in economic and social development. Nevertheless, it has many spill-over effects such as congestion, safety, pollution and non-renewable resource depletion. More importantly, this contributes to global warming, accounting for a large and growing share of greenhouse gas (GHG) emissions worldwide (Harrington & McConnell, 2003). Rising fuel prices and growing environmental concerns among consumers are encouraging vehicle manufacturers to expand their portfolios of small vehicles and shift production to cleaner and efficient technologies such as hybrid electric automobiles, which has been a promising trend for future industry growth through EST concepts.

Currently, the transport sector consumes about one half of the world's oil production, the bulk of which is motor fuel. Transport predominantly relies on a single fossil resource, petroleum, which supplies 95% of the total energy used by world transport. In 2004, transport was responsible for 23% of world energy-related GHG emissions with about three quarters coming from road vehicles. Over the past decade, transport GHG emissions have increased at a faster rate than any other energy using sector (Ribeiro *et al.*, 2007). This has increased contribution of vehicle emissions to climate change. In this order of significance, the principal GHGs associated with road transport are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Road transport also remains the main source of many local emissions including carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter (PM). Within urban areas, the percentage of contribution due to road transport is particularly high.

Given the likely growth of the world vehicle fleet, the problems of global warming and urban air pollution will almost certainly need to be addressed by making a long-term shift away from oil as the universal energy source for transportation. However, designing a new generation of resource-efficient, environmentally sustainable vehicles is one of the most challenging technological problems faced by the industrialized world. Most of the major automakers around the world are responding to this challenge and are actively developing more efficient conventionally fueled vehicles as well as so-called alternatively fueled vehicles. The latter are variously powered by fuels or electric batteries or hydrogen. In all cases, the vehicles have electric drives, meaning they are ultimately driven by electric motors, cutting down the emissions.

Motor Vehicle Trend in Sri Lanka

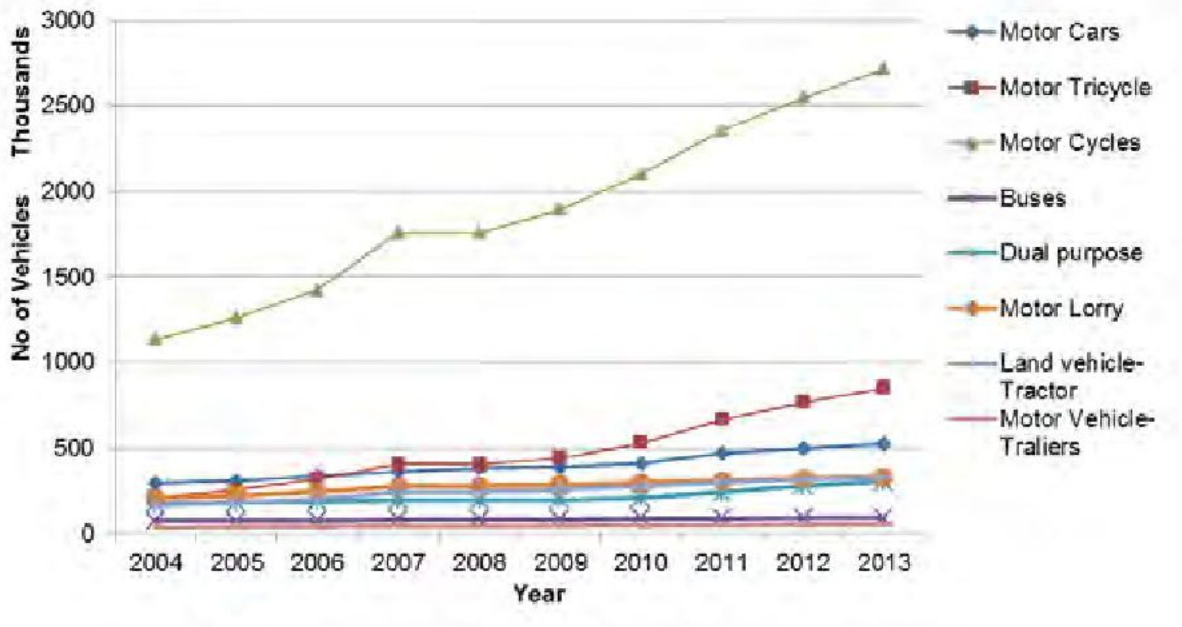

Figure 1: Motor vehicle trend in Sri Lanka in 2004-2013 (DMT)

According to the Central Bank Report (2013) it is predicted that a sustainable transportation system will provide a high quality urban environment and a better quality of life for people in the country. This will also provide forward and backward linkages to the development processes such as major highway projects and roads and bridge development projects by facilitating the movement of people, goods, and economic growth. Before the introduction of unleaded petrol to the Sri Lankan market, it was observed that the levels of Total Suspended Particulate (TSP), SOx, O_3 and Pb were significantly higher than air quality standards recommended by the World Health Organization (WHO) and the Central Environmental Authority (CEA) in Sri Lanka.

The role in petrol and diesel fuel reformulation has a direct impact on vehicle emissions, in the context of the vehicle population of Sri Lanka. Further improving fuel quality can also make possible

the adoptions of more advanced vehicle emission control technologies such as:

1. Use of catalysts, on light duty petrol engine vehicles, in conjunction with unleaded petrol
2. Adoption of EURO technologies, on diesel engine vehicles, in conjunction with low sulphur diesel fuel (with sulphur below 500 ppm).

The adoption of EURO, with a diesel fuel quality, together with unleaded petrol, would reverse the observed emission increase trend due to the significant growth of vehicle population in Sri Lanka.

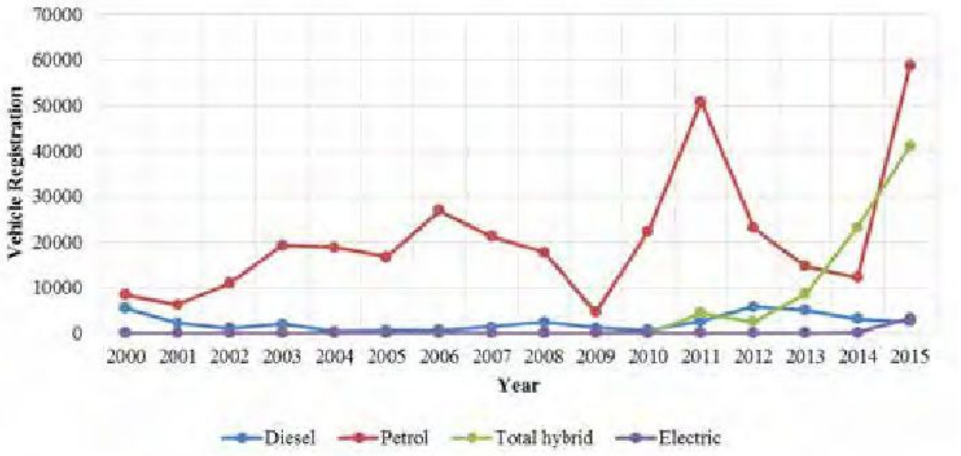

Figure 2 : Vehicle registration trend according to fuel wise in 2000-2015, (DMT)

According to the Department of Motor Traffic (DMT) records, it is seen that there is a significant increase in the new registrations of hybrid vehicle market during 2011 to 2015, and 79,949 hybrid motor cars have been added during this period (see Figure 2). Further it is seen that electric vehicles have been introduced to the Sri Lankan market, and according to new registration statistics of DMT, 3361 electric motor cars have been added to the current vehicle fleet as new registrations during 2006 to 2015. This is mainly due to the vehicle taxes and rules for the imports which encouraged the promotion of green vehicles.

Figure 3 : Large number of vehicle imports

Vehicle Taxes and Rules for Vehicle Imports in Sri Lanka

The proper taxation of road fuels must balance a number of conflicting objectives. In addition to the revenue-raising reasons, road users are taxed to cover the cost of road use and environmental damage caused by vehicles. Fuel excise duties are the simplest way to charge for road use, as they are distance-related charges. They are similarly the simplest way to charge for pollution. Sri Lankan vehicle taxes are concentrated at the point in time when vehicles are imported. Vehicle import taxes are substantial and can even double the cost of vehicles. Excise duties on imported diesel cars and diesel-powered dual-purpose vehicles vary other than for petrol versions of the same vehicles.

In addition, there are strict rules on the age of second-hand vehicles which can be imported into Sri Lanka. Earlier, motor cars could be up to three years old when imported and dual purpose vehicles up to five years old. These rules affect the choice of vehicles because the price of vehicles falls with their age and therefore, imported vans could be considerably cheaper than cars (It is assumed that total mileage driven is related to the age of vehicles). Recently, the regulations changed and these only allowed cars to be imported which were one year old. However, after considering the views of the used vehicle importers and the public, the Government of Sri Lanka (GOSL) has increased this to two years, while commercial vehicles age limit has been increased from three and a half years to four. As for hybrid and electric vehicles, before 2015 Government has cautiously kept duty rates comparatively low even after the recent revision.

In order to encourage low income families to purchase a motor car to improve their living standards, it is proposed to reduce the taxes applicable on the motor cars, with engine capacity less than 1,000cc, by around 15%. The present tax structure on motor vehicles has created an unhealthy disparity between hybrid and normal motor cars. Several budget proposals have introduced in order to rectify this anomaly. As an example in 2015, Finance Minister proposed to revise the excise taxes applicable on hybrid vehicles as the Interim budget 2015, but this has led to decrease in the vehicle sales of Hybrid vehicles after the introduction of the new tax in January 2015.

To meet increasing fuel economy and emissions legislation, the automotive industry will need to undergo drastic changes in vehicle and engine designs. Unlike conventional vehicles on the road today, hybrid electric vehicles (HEV) are designed with a smaller engine and an on-board energy storage system. The smaller engine allows the vehicle to achieve better fuel economy and fewer emissions. The integration of petrol-engine technology into a hybrid electric vehicle configuration is one of the most promising ways to comply with fuel-economy and emissions legislation.

Concerns in Electric Mobility in Sri Lankan Context

The GOSL seems to take a strong stand as the future of the power and energy sector remains positive with the Sri Lankan economy, which is expected to continue on a high growth path in the country's accelerated post-conflict development landscape. A glance around the city traffic in

Colombo during peak hours will reveal a certain scattering of electric vehicles among petrol, diesel and hybrid vehicles that move in the streets of Colombo.

With the taxes on hybrid vehicles being increased and those on electric vehicles being reduced from 25% to 5% through the new Government's Interim Budget, the Power and Energy Minister's attention has been drawn towards establishing recharging centers island-wide with the involvement of the private sector participators at fuel servicing stations, supermarkets and even homes. As the Government's economic policy is strengthening the disposable income of its population, many cost mindful consumers are making long-term investments in keeping with future cost savings.

Having an efficient road network and robust road infrastructure is a factor that contributes to the longevity of any vehicle, be it electric or not. However, given that levels of efficiency and performance contribute to speed of the vehicle, road development levels remain a factor to be reckoned with. Sri Lanka has prioritized the development of road infrastructure to facilitate the growth momentum of the economy. Construction of highways and express ways as articulated in the Public Investment Strategy 2014-2016, developed by the Department of National Planning, was dynamically followed by the Government. This is estimated to contribute to the improvement of the urban-rural linkage, the expansion of economic opportunities and regionally balanced growth that will lead to reduction in poverty.

Conclusion

Rising fuel prices are causing mainstream awareness and interest in alternative transportation technology. Many automobile companies are working hard to develop more environmentally sustainable vehicles in order to combat fuel costs and the harmful environmental effects of petroleum as a fuel source.

In order to cater to the increasing number of vehicles, infrastructure facilities must be developed and also it is needed to address the issues of rising fuel prices and fuel security among the poor. Human powered or non-motorized transport includes walking, bicycles, row boats, and other environmentally friendly ways of getting around. In addition to the health benefits of the exercise provided, they are far more environmentally sustainable than most other options.

When looking at the Sri Lankan context, consumer choices in selecting EST methods need to be considered based on the current market structure which is the cost of the vehicles and also the fuel economy concepts. In order to develop suitable policies, more studies on data collection and analysis need to be done continuously. Consumer choices on in-use vehicles due to the rapid increase in the vehicle fleet could be based for these studies.

Proper policies and legislations need to be tightened and monitored to improve the driver behavior and techniques to reduce fuel consumption which also improves the road safety. This can be

addressed in various age groups, and fine or penalty systems can be applied to improve the driver behavior. Infrastructure measures need to be improved time to time with the improved technologies for a proper traffic flow in order to minimize wasteful congestion. Uniflow roads, dedicated lanes for buses and taxies, pedestrian and cycling areas and proper parking mechanisms also can be considered.

Therefore, current legislation needs to be focused on improving the air quality to lessen the emissions, by following an integrated approach of having various EST concepts to influence consumer choice to produce proper driving behavior and purchase choices. This information would not only help a better consumer choice, but also assist the Government to make more rational policy decisions in the transport sector to mitigate climate change impacts.

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Reducing Fossil Fuel Burning and Co_2 Emissions in Textile Industry Through Low Carbon Technologies and Strategies of Sri Lanka

Shyamika Shiwanthi[1*], Erandathie Lokupitiya[2], Sena Pieris[3]

[1,2] University of Colombo, [3] University of SriJayawardenapura
Shyamika22@gmail.com

Textile industry plays a major role in Sri Lankan economy, but it is an energy intensive industry which releases a large amount of CO2 to the atmosphere. Therefore, it is important to take sustainable measures to reduce energy consumption and greenhouse gas emissions in textile manufacturing while making efforts to increase the production. Some textile factories from Biyagama Export Processing Zone have successfully managed the situation by using low carbon technologies and strategies.

Textile Industry of Sri Lanka

Textile industry is a major consumer of energy and water and it is the 5th largest contributor to CO_2 emission of the world (Athalye, 2014). It plays a critical role in Sri Lankan economy due to its contribution to industrial production, employment and exports. Textile industry accounts for 16% of Gross Domestic Product of the country and it is the highest foreign exchange earner in the industrial sector amounting to 40% of the total exports and 52% of industrial exports. It is the largest employer in the industrial sector, providing more than 300,000 employments to the people (Embuldeniya, 2015).

Electricity, Diesel, HFO (Heavy Fuel Oil), LPG (Liquid Petroleum Gas), and Biomass (sawdust and wood) are the main sources of energy used in the textile industry (Table 1) which are used to generate electrical, thermal and kinetic energy for boilers, processers, motors, compressor, lighting and air conditioning. Specific energy requirement for natural fiber processing has been recorded as 10-20 MJkg-1 and that for chemical fiber processing is 5-50 MJkg-1 (Chavan, 2001).

High energy consumption of the process directly reduces the profit of a factory due to its cost and it also indirectly contributes to climate change through releasing CO_2 to the atmosphere. Therefore, if a factory can reduce its energy consumption or move towards more environmentally friendly and efficient fuel alternatives it becomes a win-win situation which will provide benefit to both the environment and the economy. Therefore, some textile factories of the Biyagama Export Processing Zone have adopted cleaner production strategies and best practices to reduce the energy requirement and increase the production per unit of energy use.

This study was conducted considering three textile manufacturing factories in Biyagama Export Processing Zone which produce knitted fabric, and based on the data availability, the energy consumption data for those factories were collected and analyzed for the period 2011-2015.The factories have been identified as A, B and C, considering certain ethical concerns. Average annual energy consumption of the factory A, B and C are 158 TJ, 86 TJ and 717 TJ, respectively. Further, energy requirements of factories have increased by 37%, 23% and 54% within the study period. Factories fulfilled this energy requirement using different energy sources as shown in Table 1.

Table 1 : Energy use of companies from different sources as a percentage

Energy source	Use of energy	Factory A (%)	Factory B (%)	Factory C (%)
Grid electricity	Lighting, chilling system, etc.	32	30	13
HFO	Boilers	17	18	53
Diesel	Fork lifts, Generators, etc.	3	1	1
Wood	Boilers	45*	41	24**
Sawdust	Boilers	14*	4***	31**
LPG	Canteen, Some machines	1	1	0.1
* Introduced in 2012 ** Introduced in 2013 *** Used only in 2015				

Energy Consumption

As indicated in Table 1, all three factories are using renewable energy sources to meet part of their energy requirement. Renewable energy sources included biomass and hydroelectricity (i.e. fraction of hydroelectricity in the grid electricity in a given year) and non-renewable energy sources included HFO, diesel, LPG and thermal-electricity (i.e. thermal energy fraction in the grid electricity in a given year). Even though factories have increased their energy consumption year by year along with the production, they could cover the higher portion of energy requirement through renewable energy as illustrated in Figure 1.

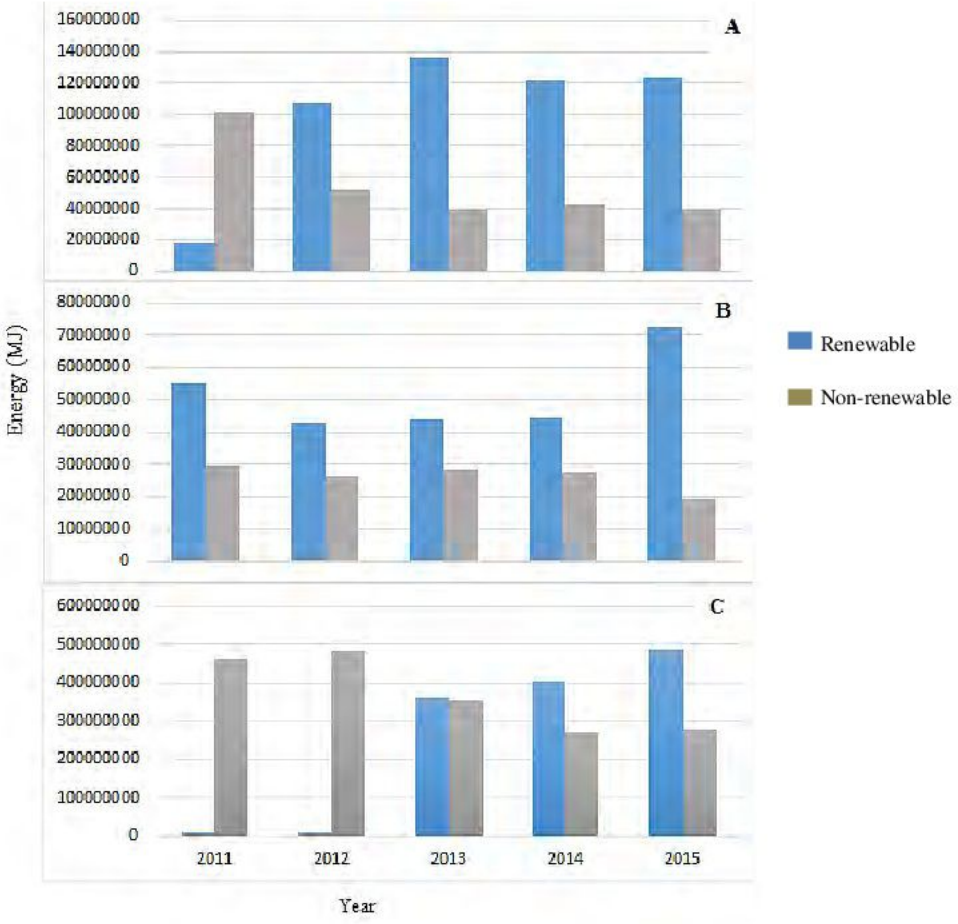

Figure 1: Renewable and non-renewable energy consumption by factory A (top), factory B (middle), and factory C (bottom). Renewable and non-renewable energy also comprised the respective fractions in the grid electricity which were obtained from the annual reports of the Ceylon Electricity Board (CEB) of Sri Lanka.

Even with the increased demand for energy consumption, the factories were still able to increase their eco-efficiency (i.e. mass of product sold per energy consumption) as illustrated in Figure 2, through different strategies. This trend of eco-efficiency is related to the measures factories have taken to use energy in a more sustainable way. Such measures include sustainable lighting systems (skylights, conversion of T8 bulbs to T5, etc.), motors, heating, chilling systems and steps that have been taken to improve fuel use by selecting more environmentally friendly fuel (Biomass and solar energy) and replace furnace oil fired boilers with environmentally friendly boilers (biomass boilers). Further improvements have been done on steam use by reducing the leakages, installing steam accumulators, etc. Most of the above measures taken by factories come under operations, maintenance and engineering, and the factories still need more efficient management strategies. Factories could have increased their energy efficiency further by adopting the energy management

standard ISO 50001, which provides a strong organizational framework for energy management while gaining the highest possible advantage over sustainability measures.

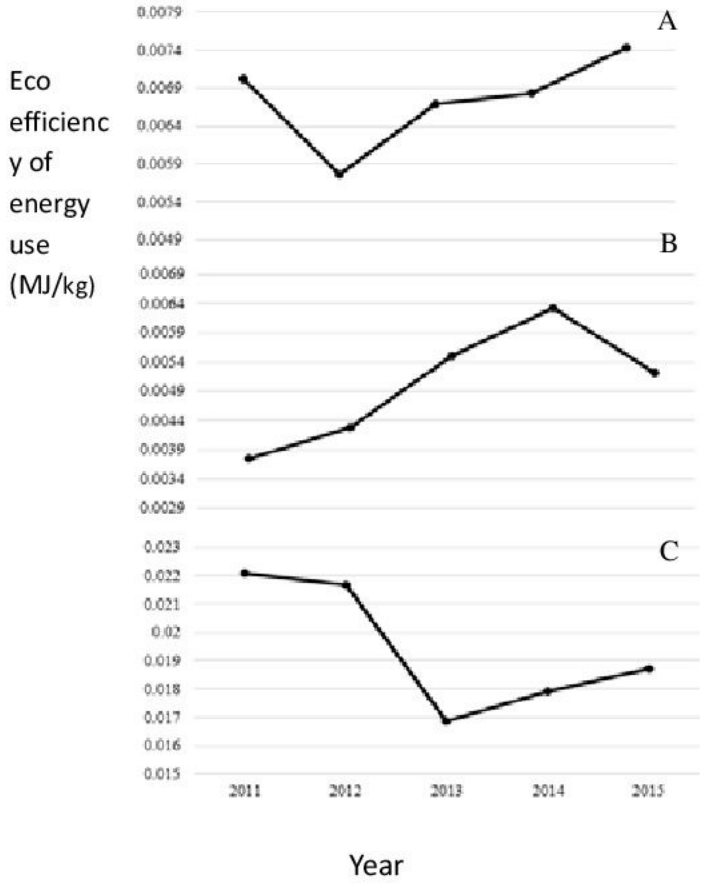

Figure 2 : Eco-efficiency of energy use - factory A (top), factory B (middle), and factory C (bottom)

Carbon Dioxide Emission

Within the study period, year by year eco-efficiency of CO_2 emission (i.e. mass of the product sold per CO_2 emission) has increased with fluctuations in between. Moreover, all three factories indicated a similar pattern in eco-efficiency change of CO_2 emission over time. These variations are mostly due to the thermal and hydroelectricity fraction changes of the grid electricity and changes of fuel type used within the factories. Eco-efficiency of CO_2 emission within the study period is illustrated in Figure 3.

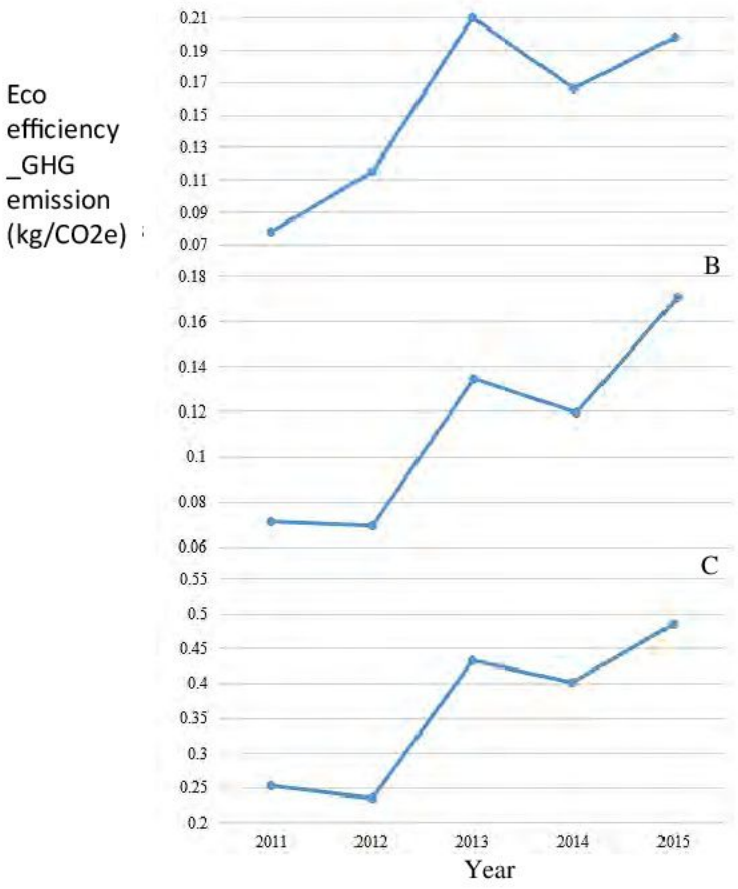

Figure 3 : Eco-efficiency of greenhouse gas emission (CO_2) – factory A (top), factory B (middle), and factory C (bottom)

In 2015 factory A has increased its production by 45% compared to 2011 and its energy consumption has increased by 27%. However, it was able to reduce its CO_2 emission by 74% mainly through the reduction of HFO consumption by 88%. Its energy requirement was mostly fulfilled through biomass and grid electricity.

Factory B has increased its production by 71% by end of the period only through increasing total energy consumption by 23%. It was also able to reduce its CO_2 emission by 40% as it has reduced its HFO consumption by 118% within the study period (2011-2015).

Total production of factory C has increased by 31% in 2015 compared to 2011. It has achieved this target through increasing its energy consumption by 54% but it was able to reduce its CO_2 emission by 46% as it has reduced its HFO consumption by 70%.

The above percentages were calculated as follows:

$$\frac{(\text{Total carbon emission}_{2015} - \text{Total carbon emission}_{2011})}{\text{Total carbon emission}_{2011}} * 100$$

Further, Hydroelectricity fraction of the grid electricity varied between 28 - 58% within the study period (2011-2015) and thermal fraction varied between 40-71% (Ceylon Electricity Board, 2011, 2012, 2013, 2014, 2015).These changes also affected our results. Moreover, reduction of diesel consumption and grid electricity consumption through sustainable measures, such as using more efficient and modern machines, training staff, automation, using full load of the machines, etc., also have positively contributed to the above results.

Sustainable Energy Consumption

Replacing furnace oil with biomass in the factories has caused a reduction of cost of fuel and greenhouse gas emission, but it might have led to other environmental problems such as deforestation. Firewood supply by the villagers around the factories has become a way of income, but sometimes uncontrolled logging may cause severe environmental problems. Therefore, alternatives such as sawdust, wood chips, agricultural residues like: rice husks, straw, bagasse, sugarcane tops, cotton stalk, coconut residues, etc., can be used (Netherlands Organization for Applied Scientific Research, 2010). According to Karunasena and Kannangara (2012), even dewatered sludge can be used as a fuel for the boilers with advanced technology.

After identifying the uncontrolled logging as a significant environmental issue, all three factories have reduced the consumption of wood logs compared to the initial year of biomass consumption and increased the consumption of sawdust for biomass energy generation instead. This trend is more environmentally sound and economically beneficial, especially as the cost of sawdust is much less than that of wood logs. Even with the use of wood logs, the sustainability of the biomass supply chain can be managed by buying only sustainably harvested wood. Factory C has initiated this by buying only rubber logs from known sources.

Industries are major contributors to climate change as they require a large amount of energy which is obtained mostly through fossil fuel burning. Even though developing countries like Sri Lanka do not emit considerable amounts of greenhouse gases compared to developed countries, it is important to reach development through a green (sustainable) pathway. Therefore, it is important to find which and how industries can achieve this in an environmentally friendly and economically beneficial way. Our study provides some evidence that, with the existing trend and need for energy conservation, certain textile manufacturing companies have developed certain sustainable energy consumption measures and low carbon measures, although there is still more potential for improving energy consumption and management while reducing the greenhouse gas emissions.

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Data in Computers, Climate Change and Green Computing

Prabath Chaminda Abeysiriwardana

Ministry of Science Technology and Research
abeysiriwardana@yahoo.com

In simplest terms, climate change is caused by Green House Gases (GHG) and a major source of GHG is non-renewable fossil fuel energy. It is evident, that climate change, accompanied with rising global temperatures, has posed imminent danger to the human beings by changing the favorable conditions in our environment. Many places have seen unprecedented changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The oceans are warming and becoming more acidic, while ice caps of glaciers are melting, causing sea levels to rise.

Fossil fuel use in transport and industrial sectors are the prominent sources of GHG emissions. However,there are some other sources which are less prominent but may cause significant impact on climate change. One such culprit is data in computers.

Data in Computers

Data is text, numbers or any other symbol. When it is stored in a computer, it becomes computer data. This data would be destined as information when it is processed and stored by a computer. This information may be in the form of text documents, images, audio clips, software programs, or other types of information.

Computer data/ information processed by the computer's Central Processing Unit is usually stored in files and folders on the data storage device like computer's hard disk. Storing can be done using virtually any form of energy, spanning from manual muscle power in handwriting, to acoustic vibrations in phonographic recording, to electromagnetic energy in tape and optical discs. Electromagnetic data may be stored in either an analog data formal or digital data format on a variety of media.

Data storage in computer requires electrical power to store and retrieve that data. Most electronically processed data stored in magnetic or optical storage will remain stored even when power is removed from the device. In contrast, most electronically stored information within most types of electronic circuits or chips is volatile memory, as it vanishes when power is removed.

Data Storage in Internet

Humans will be quickly outnumbered by Internet-connected devices. The term used to describe this phenomenon is the Internet of Things (IoT). More formally, IoT is a system of interrelated devices, machines, objects or any other things that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Crump, 2017). These things perform a range of tasks, relatively simple functions like capturing images and uploading them to social sharing sites to capturing and transmitting more complicated sensor data and sending real-time information on an organization's various assets.

The obvious thing in this system is that there is more data to store. One type of data is large-file data, such as images and videos captured from smart phones and other devices. This data type is typically accessed sequentially. The second data type is very small, for example, log-file data captured from sensors. These sensors, while small in size, can create billions of files that must be accessed randomly.

Data in Data Centers

Data center (Stroud, 2017) is a large group of networked computer servers typically used by organizations for the remote storage, processing, or distribution of large amounts of data. In other words, this kind of facility is used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and various security devices.

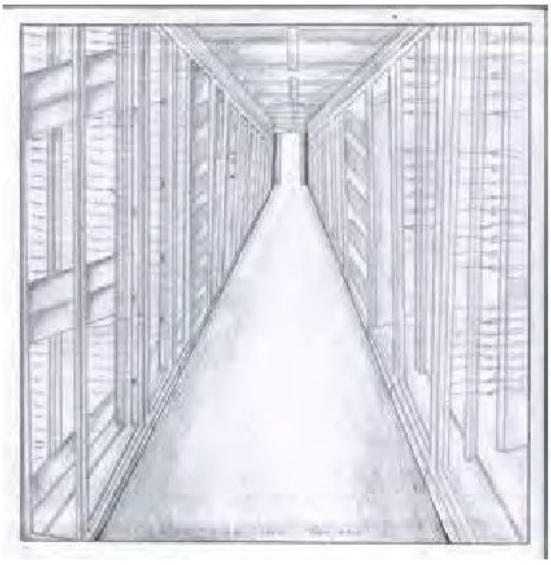

Fig 1: The Facebook server hall in the city of Lulea, Sweden.

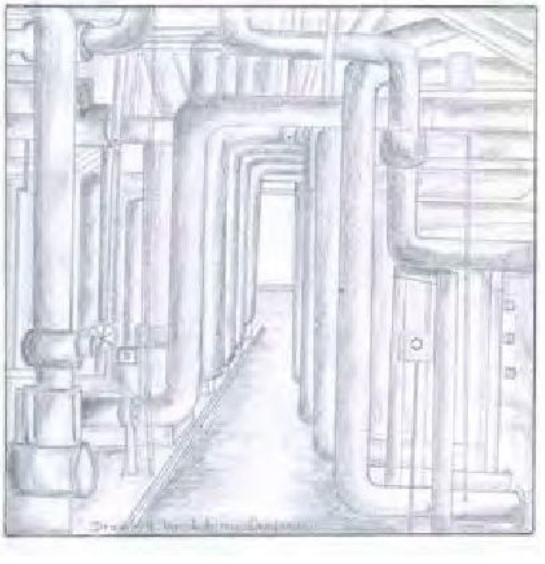

Fig 2 : The facilities of the Google data centre in Taiwan. (AFP/ Getty)

How Data Contribute to Climate Change

The power consumption of a computer varies depending on whether it is a desktop or a laptop. A desktop uses an average of 200 W/hour when it is being used (loudspeakers and printer included) compared to a laptop which uses only between 50 and 100 W/hour. So, a computer that is on for eight hours a day throughout the whole year uses about 600 kWh (this is equivalent to driving 900 km in an average car) and emits 175 kg of CO_2 per year while a laptop for the same time period uses between 150 and 300 kWh and emits between 44 and 88 kg of CO_2 per year.

In stand-by mode, the power consumption of both a desktop and a laptop falls to about a third. Although, the internet is a virtual space, using it still requires power and results in CO_2 emissions. For example, the internet modem requires 10 W for its operation.

Large data centers in industrial scale usually use as much electricity as a small town. In 2016, 416.2 terawatt hours of electricity was used by world's data centers and it was far higher than UK's total consumption of 300 terawatt hours (Bawden, 2016).

Already, data centers have mushroomed from virtually nothing 10 years ago to consuming about 3 per cent of the global electricity supply and accounting for about 2 per cent of total greenhouse gas emissions.

When you "like" something on Facebook, search a latest movie in Google or post an instagram from the pub, it needs huge amounts of data to be stored somewhere. It is expected that the amount of energy consumed by the world's data centers will treble in the next decade, putting an enormous strain on energy supplies and dealing a hefty blow to efforts to contain global warming.

Green Computing: A Solution to Curb the Issues of Climate Change

Green computing is the environmentally responsible and eco-friendly use of computers and their resources. In broader terms, it is also defined as the study of designing, manufacturing/engineering, using and disposing of computing devices in a way that reduces their environmental impact. Green computing is also known as green information technology (green IT). Green computing practices came into prominence in 1992, when the Environmental Protection Agency (EPA) launched the Energy Star program.

To promote green computing concepts at all possible levels, the following four complementary approaches are employed:

- **Green use:** Minimizing the electricity consumption of computers and their peripheral devices and using them in an eco-friendly manner
- **Green disposal:** Repurposing an existing computer or appropriately disposing of, or recycling, unwanted electronic equipment

- **Green design:** Designing energy-efficient computers, servers, printers, projectors and other digital devices
- **Green manufacturing:** Minimizing waste during the manufacturing of computers and other subsystems to reduce the environmental impact of these activities

Green use:

One way to curb the carbon footprint caused by use of data in computers is to increase the amount of renewable energy such as solar and wind used for computers. Even if the industry were able to shift to 100 per cent renewable electricity, the volume of energy IoT would need would put intolerable pressure on the world's power systems.

Green disposal:

E-waste includes cell phones, computers, stereos, televisions, etc. One of the largest problems in E-waste is perhaps computers. So, E-waste should be carefully recycled. One such method would be overwriting the storage media/ magnetic media as much as possible and reuse the storage media for a longer period.

Green design:

Unless there is some kind of game-changing breakthrough on data storage – such as the development of a far-superior alternative to silicon – the world's internet use is eventually going to have to be significantly rationed. "Deoxyribonucleic acid (DNA), is a biological molecule which acts as the hereditary material in humans as well as in almost all other organisms and has already been successfully used as an alternative component to electronic chip." DNA computers and use of Graphene in storage system could potentially revolutionize data storage. DNA computer is a nanocomputer that uses DNA and its associated components to store information and perform complex calculations. DNA provides the added benefits of being cheap, able to withstand extreme environmental conditions and energy-efficient computing.

Some internet companies such as Facebook, Google and Apple, are leading efforts to be more environmentally responsible. The measures being taken include housing data centers in cold climates – which dramatically reduce the energy needed to cool the facilities – with a ready supply of renewable energy.

Green manufacturing:

It may not be possible to completely green-manufacture computers and related items, but we must take certain measures. Some companies have also developed a prototype printer which uses corn-starch plastic so it would decay like a rotten vegetable when disposed. Therefore, some companies have tried the biodegradable computer; it has certainly come one step closer and has given us hope. Also, DNA computers will be a good solution in this regard as well.

Green Computing and Efficient Ways of Using Computers in Day To Day Life

The following good practices in green computing include some simple procedures to be followed to reduce emissions:

1. Switch off the loudspeakers, printer when they are not needed.
2. Switch off the screen if you are not working on the PC just now.
3. Switch off your computer or put it in stand-by mode if you are not going to work on your PC for more than 30 minutes. Use a laptop in preference to a desktop.
4. Switch off the modem at night.
5. Activate the power management features for controlling energy consumption
6. Make proper arrangements for safe electronic waste disposal
7. Refill printer cartridges, rather than buying new ones
8. Instead of purchasing a new computer, try refurbishing an existing device
9. The most import thing is how we use the data and for what purpose it should be used. Data centers are usually driven by social media and mobile phones. It is all about films, pornography, gambling, dating, shopping and anything that involves images and videos. So, responsible use of internet only for necessary things will contribute to reduce emissions.

Many IT manufacturers and vendors are continuously investing in designing energy efficient computing devices, reducing the use of dangerous materials and encouraging the recyclability of digital devices and paper. However, even with other revolutions in data storage and energy production, the only long-term solution to this data and energy problem will rely on involving significant cuts to our internet use and following good practices of computer use in the future.

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Climate Change Mitigation Using Ocean Iron Fertilization

Thamarasi Aththanayaka*, Darshana Thilakarathne

Marine Environment Protection Authority
* thamarasiaththanayaka@yahoo.com

Ocean Iron Fertilization in High Nutrient Low Chlorophyll (HNLC) areas is a geo- engineering method which stimulates the phytoplankton growth to capture and export carbon to the deep ocean bottom for reducing the atmospheric CO2 concentration. However, it is debatable whether iron fertilization can sequester sufficient amount of carbon for an extended period of time due to the ocean currents. More over long term impacts of the method should be studied.

Climate Change and CO_2 Deposition

Annual carbon emission of today's world from fossil fuel burning is 8.6 PgC yr^{-1}. And land and oceans absorb 60% from this carbon (Lal, 2007). Since ocean's heat capacity is 1000 times higher than that of the atmosphere, the ocean plays a major role in mitigating climate change. Due to that from 1961- 2003 global ocean temperature has risen from 0.1^0C. At the same time from 1750- 1994 total inorganic carbon concentration in the ocean has increased from 118±19GtC. Apart from that due to global warming, salinity decrease, water mass changes, sea level rise has occurred (Bindoff *et al*. 2007). Moreover absorption of CO_2 by the ocean has changed the carbonate chemistry of the sea water. According to the model predictions, oceanic pH value will decrease by 0.4 units compared to the preindustrial era in 2100. Ultimately, this will decrease the calcification rate and increase the $CaCO_3$ dissolution rates in the marine ecosystems. This will threaten the calcium bearing fauna and habitats such as coral reefs. (Kleypas *et al*., 2005).

Therefore, cost effective mitigation strategies are essential for lowering the greenhouse gasses specially the CO_2 (Baker *et al*., 2007). Carbon sequestration is a process that transfer and deposit the atmospheric CO_2 either using abiotic or biotic techniques. Examples for abiotic techniques are injecting CO_2 in to geological strata, deep ocean, coal mines and saline aquifers (Lal 2007; Yang *et al*. 2008). In biotic methods CO_2 is stored in biota as organic carbon through photosynthesis (Lal 2007). Marine phytoplankton, base of oceanic food webs can produce 45Gt of organic carbon per year. From this 16 Gt will be flux to ocean bed (Falkowski *et al*. 1995). Although abiotic methods allows the deposition of large CO_2 amounts immediately, it is expensive and should be done carefully since leakages can happen (Lal, 2007).

Iron Hypothesis

There are high nutrient low chlorophyll (HNLC) areas in the world which shows less primary productivity (Fig 2) such as Southern ocean and Northeast and equatorial Pacific. But these water masses are rich in nutrient such as nitrogen (Fig 1) and phosphorus. (Chisholm *et al.,* 2001). There are several suggestions for the existence of HNLC areas in the world. One argument is that intense grazing by zooplankton along with the NH4 limitation has reduced the phytoplankton growth. In sub Antarctic region light limitation affects the phytoplankton growth (Frost, 1991). Moreover limitation of macronutrients such as Fe and Si also leads to reduce the primary productivity in these regions (Martin and Fitzwater 1988; Frost, 1991).

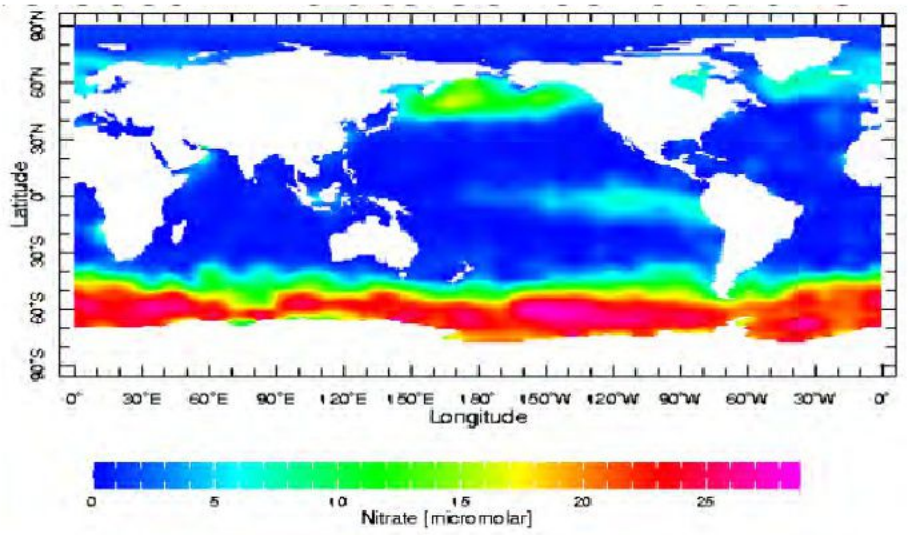

Fig 1: Nitrate concentration in the world ocean.
(Source: http://www.soest.hawaii.edu/oceanography/courses/OCN626/2008_OCN%20626/ HNLC%20regions%20lecture_2008.pdf)

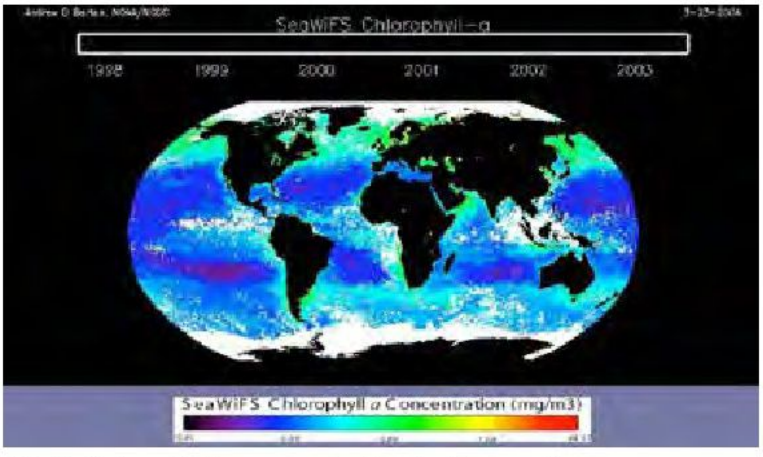

Fig 2: Chlorophyll a concentration in the world ocean.
(Source: http://www.soest.hawaii.edu/oceanography/courses/OCN621/Spring2009/Selph_2_18_09%5B1%5D.pdf)

Atmospheric dust which contains Iron can induce the phytoplankton growth in these areas. During the last glacial maximum where the Fe containing dust concentration was high the atmospheric CO_2 level reduced due to the increased phytoplankton productivity than the interglacial period showing an inverse relationship between the atmospheric CO_2 concentration and Fe containing dust concentration (Martin 1990; Coale *et al.* 2004). This iron hypothesis has been proved by iron fertilization experiments in the Southern ocean (Coale *et al.* 2004; Smetacek *et al.* 2012; Salter *et al.* 2015) and Galapagos Island (Martin *et al.* 1994). Therefore, several laboratory and field experiments have been done to assess the probability of iron fertilization of nutrient rich areas to remove the CO_2 from the atmosphere.

Ocean Iron Fertilization Technique

Ocean iron fertilization is a geo-engineering technique (Baker *et al.*, 2007) that stimulates phytoplankton growth by adding iron to the ocean (Buesseler *et al*. 2008; Yang et al. 2008; Robinson 2014). Ocean iron fertilization experiments have been done in open ocean in Southern ocean and equatorial Pacific regions. In this technique iron is mixed with SF6 labeled seawater with acidic pH values and then injected to open ocean using vessels. SF6 is used to track the phytoplankton patch (Coale *et al.*, 1996; Martin *et al.* 1994; Martin *et al.,* 2013). Approximately 4nM of iron is sufficient to fertilize a 64km^2 area within 5-7 days according to laboratory experiments (Martin *et al.,* 1994). But single iron enrichment cannot utilize the excess nutrient completely and did not increase the chlorophyll concentration as predicted from the laboratory experiment. Therefore, it is recommended to multiply iron addition within several days (Coale *et al.,* 1996; Martin *et al.,* 1994). Iron fertilization can increase growth of phytoplankton belong to all size classes and increase the primary productivity by 3-4 times (Martin *et al.,* 1994). Patch formation and sinking of the particles after the fertilization can be detected by measuring the primary productivity, chlorophyll concentration, particulate organic carbon, dissolved organic carbon and pigment concentration in each water layer (Coale *et al.,* 1996; Martin *et al.*, 1994; Martin *et al.,* 2013). Apart from that the depletion of nutrient concentration such as nitrate, phosphate, silicate and ammonia in the surface mixed layers are also good indicators for the phytoplankton growth (Martin *et al.,* 1994).

Part of the carbon that is fixed by the phytoplankton which is retained in the upper water layers are released to the atmosphere within several months or years due to the heterotrophic activities while part of this particulate organic carbon sink to deeper layers before remineralization (Chisholm *et al.*, 2001; Cullen and Boyd 2008; Yang *et al.*, 2008; Smetacek *et al.*, 2012; Salter *et al.*, 2015). These sinking particles are important for the atmospheric CO_2 reduction.

Effectiveness of Ocean Iron Fertilization for Climate Change Mitigation

Iron fertilization experiment in Southern Ocean has shown a considerable carbon export from surface mixed layer (Buesseler *et al.*, 2004; Smetacek *et al*., 2012).Diatom blooms generated due to the ocean Iron fertilization can sink to depths greater than 1000m after their mortality (Figure 3).

This has been proven by the European Iron Fertilization experiment carried out during February 2004 in Southern ocean (Smetacek *et al.*, 2012). This organic carbon that is deposited in the deep layers or in the ocean bed can be retained for more than 100 or 1000 years (Chisholm *et al.*, 2001; Cullen and Boyd 2008; Yang *et al.*, 2008; Smetacek *et al.*, 2012; Salter *et al.*, 2015). Carbon sequestration become effective if carbon particles were separated from the atmosphere for more than 100years (Chisholm *et al.*, 2001).

However, studies conducted using Nucleus for European Modelling of the Ocean (NEMO) model has shown that from the particles that were injected to 1000m depth, 66% has been released to the atmosphere within 37.8 years making the Ocean Iron Fertilization ineffective. Moreover, in Southern Ocean which is a widely used area for ocean iron fertilization studies, the rate of upward flux of the deposited particles is higher due to the effect of Antarctic Circumpolar current. Further, this study has shown that from the particles that has been injected to 2000m depth 71% of the particles have retained in the deep ocean layer (Figure 4) for 100 years (Robinson 2014). Fertilization experiment carried out in a closed eddy core in Sub Antarctic Atlantic waters has concluded that iron addition to silicon limited water increase the chlorophyll concentration and primary productivity. But it does not increase the downward flux of particulate organic matter (Martin *et al.*, 2013). Under low silica concentration nano-pico phytoplankton dominate over diatoms. These nano- pico phytoplankton can easily be grazed by the micro zooplankton (Frost 1991).

During fertilization experiments although primary productivity increased rapidly initially, it can be ceased later due to the limitation of other macronutrients. At the same time high phytoplankton biomass stimulate the growth of zooplankton in the area leading to rapid grazing pressure on phytoplankton patches. So that the rate of primary productivity will become a constant. More over iron can be decreased from the system due to particle aggregation and sinking, making the system iron limited (Coale *et al.*, 1996; Martin *et al.*, 1994).

Beside this downward flux of particulate organic carbon, it is necessary to consider the flux of particulate inorganic carbon by means of calcareous species owing to the fact that this Calcium Carbonate deposit in the seabed for a longer time period would support to sequester carbon for more than 100 years. This has not been well estimated during these iron fertilization experiments (Salter *et al.*, 2015).

These examples prove that ocean Iron fertilization can remove some amount of CO_2 from the atmosphere. But it can sequester only several hundred million tons of carbon per year which is not a considerable amount (Buesseler *et al.*, 2008). Furthermore, these carbon deposits are exposed to the atmosphere rapidly due to the disturbance from ocean currents (Chisholm *et al.*, 2001).

On the other hand, long term impacts of iron fertilization on the ocean ecosystem has not been well studied yet (Chisholm *et al.*, 2001; Buesseler et al. 2008; Cullen and Boyd 2008). Similar to the issues that have arisen due to the nutrient enrichment in freshwater and coastal areas, iron fertilization

may affect the food webs and other natural biogeochemical cycles (Chisholm *et al.*, 2001; Chisholm *et al.*, 2001; Yang *et al.*, 2008). Models predict that it could cause hypoxic or anoxic conditions due to the increase of microbial decomposition (Fuhrman and Capone 1991; Cullen and Boyd 2008). This low oxygen condition can lead to the production of other greenhouse gasses such as methane and nitrous oxide (Fuhrman and Capone 1991; Cullen and Boyd 2008; Yang *et al.*, 2008). Moreover due to the high primary productivity in Iron fertilized zones, macronutrient concentration will be depleted in the water columns below this zone (Cullen and Boyd 2008).

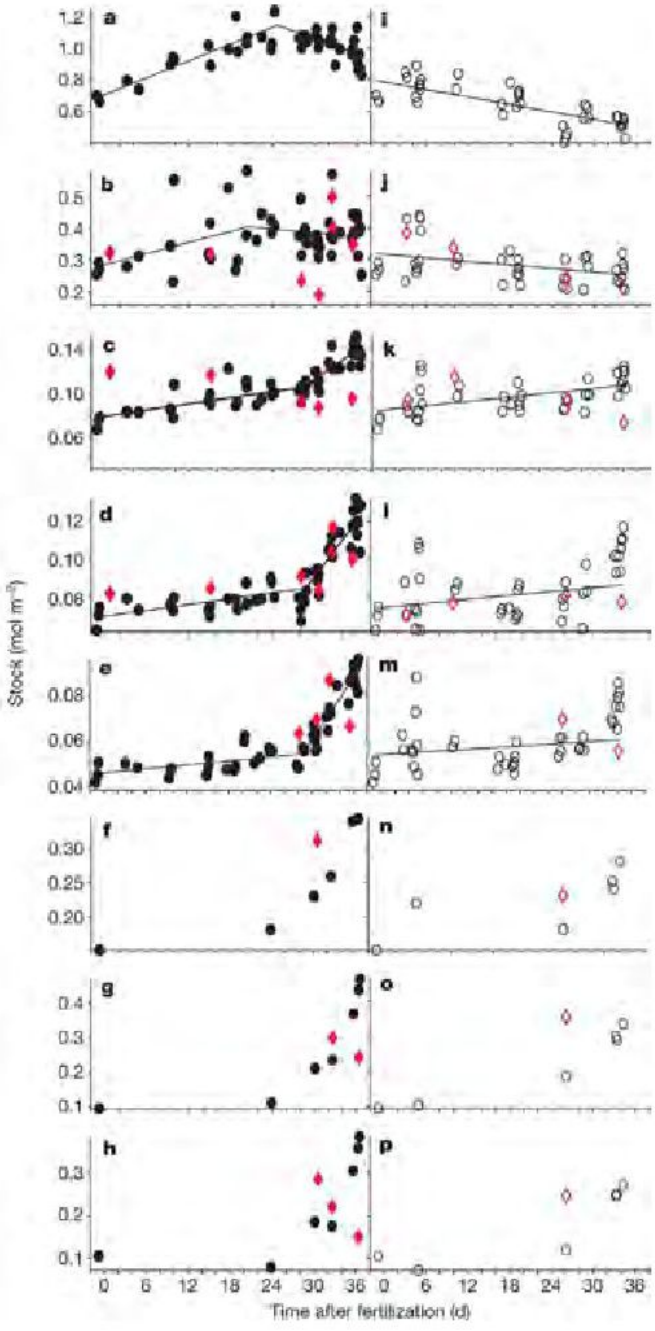

Figure 3: Temporal evolution of particle organic carbon stocks in successive depth layers.

Filled symbols for inside the patch and open symbols for outside the patch

(a,i) 0-100m, (b,j) 100-200m, (c,k) 200-300m, (d,l) 300-400m (e,m) 400-500m, (f,n) 500m-1000m, (g,o) 1000m-2000m, (h,p) 2000m-3000m

(Smetacek *et al.*, 2012)

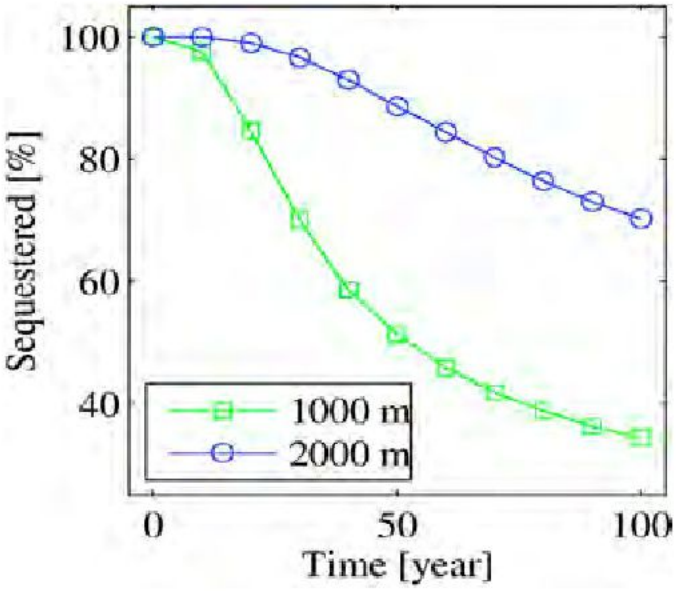

Figure 4: Decadal time series showing the number of particles that remain successfully sequestered below the upper mixed layer for both the 1000 m (green line) and 2000 m (blue line) experiments. (Robinson *et al.*, 2014)

Conclusion

Due to anthropogenic activities, CO_2 concentration in the atmosphere has increased dramatically and it brings adverse impacts to the terrestrial and marine ecosystems. Hence, there is a timely need to decrease the atmospheric CO_2 concentration. Therefore, scientists are exploring several methods. Sequestration of CO_2 by adding Fe to HNLC areas to stimulate the phytoplankton blooms is one such geo-engineering technique. It can export carbon to deep ocean layers as particulate organic carbon. Due to the oxic and slightly basic nature of seawater iron does not dissolve easily in seawater. Therefore, iron limited areas can also exist near coastal waters as well (Street and Paytan 2005). Although this iron fertilization technique has been tested in open ocean HNLC areas in large scale this can be practiced in coastal upwelling zones where the iron concentration is low. But it is needed to assess the cost effectiveness of the method before conducting at commercial scale.

However, this artificial fertilization can affect the food web structure and the natural biogeochemical cycles. Today, we are experiencing detrimental results of anthropogenic involvement to change the natural ecosystems. So it is necessary to analyze long term impacts of artificial fertilization. If not, we have to face more serious issues than this in the future.

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Climate Change, Waste Management and Biogas Technology: The Scope for Sri Lanka

***Eng. Namiz Musafer[1], P. G. Ratnasiri[2], M. R. Ajith Kumara[3]**

[1] Lanka Biogas Association and IDEA, [2] Department of Chemical and Process Engineering, University of Moratuwa, [3]Department of Animal Production and Health
*namizm@gmail.com

Organic solid waste and livestock litter can naturally generate methane, a strong GHG contributing to climate change, under certain conditions in the presence of anaerobic bacteria. Biogas technology is a green technology which gives multiple benefits from the areas of environment (waste management), agriculture and energy. Biogas can be used as a substitute for LP gas and natural gas, and thus an alternative energy solution. The electricity equivalent potential from biogas in Sri Lanka is very marginal. Although, purely from an energy economics perspective, biogas may not give sound returns, it is an integrated solution may lead to benefits far outweighing the costs.

Introduction

Methane is a greenhouse gas which contributes to global warming and climate change. Waste and livestock are major anthropogenic sources of methane emissions in the world. When waste is released to the dump sites or landfills, the organic components in them decompose and produce landfill gas, which is a mixture of methane and carbon dioxide with 40-60% of methane. Similarly, methane is also emitted by the livestock sector. The ruminant animals such as cattle, buffaloes and goats produce methane as part of their normal digestive process as a by-product and release methane as one of the gases, through eructation. The anaerobic decomposition of their dung by anaerobic and facultative bacteria produce methane as well. Although, we cannot do much about methane generated during the digestive process of the ruminant animals, we can manage organic waste and animal dung in such a way that we capture the methane effectively and use it for different productive purposes. Since Methane has a Global Warming Potential of over 20 times compared to Carbon Dioxide, it is vital to manage it effectively.

Biogas Technology

Biogas is a technology that converts organic waste into methane and a few other products, under oxygen free (anaerobic) and controlled environment. Therefore, it is a technology that could be used in organic waste management. As both organic solids and liquids containing organic matter could be subjected to biogas generation process, technologies that generate biogas are used in both solid waste management and waste water treatment. What happens in a biogas system is, organic

matter going through a process where some bacteria would break long molecules of the organic matter fed into the biogas system, and during their metabolism, produce gaseous elements such as methane, carbon dioxide, water vapour, hydrogen sulfide, ammonia, and few other traces, and a slurry of the fermented organic matter, which is rich in nutrients. The content of methane in biogas can range from 50 to 65% in most cases.

Methane

Methane is a colourless, odorless combustible gas. In fact, the principal component of natural gas is also methane as around 75% of it is constituted of methane. The other gases in natural gas include around 15% of Ethane and 5% of Propane and Butane gases. Sri Lankan populace is more familiar with Liquified Petroleum (LP) gas, which predominantly contains Propane and Butane. All these are combustible gasses, which can produce heat when combusted. Heat generated thus is what is being used as a source of energy for different applications. Commonly, these gases, including biogas, can be used for different purposes including power generation, cooking, running vehicles, pumping water, and lighting (illumination). As one Methane molecule produces one Carbon Dioxide molecule when combusted, the overall Global Warming Potential reduces by over 20 times to the amount of methane so combusted.

Benefits of Biogas Systems

Apart from using biogas systems to generate methane as a source of energy, they bring numerous other benefits. As the biogas slurry produced in biogas systems is rich in nutrient it can be used as an input in agriculture and horticulture. This slurry is applied as a rich fertilizer in place of compost. Some farmers have revealed that they have used this as a pest repellent and as a soil conditioner to retain humus and moisture. As spreading the slurry on land prevents the growing of weeds it is used as a substitute for weedicides. Some agriculture experts opine that this slurry should be mixed with some amounts of chemical fertilizer to make it more balanced, as required by the plants. The processed slurry could be sold directly. Further, fruits and vegetables etc. that use biogas slurry as an organic input could also be sold as organic produce (organic food). Therefore, biogas systems help provide livelihood options to the people, apart from providing direct and indirect employment opportunities to those who are engaged in design, construction, maintenance of biogas systems and supplying of appliances and equipment etc.

Biogas systems provide alternatives to conventional sources of energy. The slurry is a substitute for agrochemical inputs to agriculture sector easing the economic pressure of the country which is dependent on imports of petroleum based oils and chemical fertilizer. Consuming organic produce is also healthier than consuming food produced using chemical inputs. At the same time, as this technology can use organic waste as inputs, it gives a solution to the waste management problems too, giving environmental benefits. In other words, biogas gas gives three prominent benefits from a single technology.

History of Biogas Use

The origin of recorded history of biogas dates back to the 19th century, to Mumbai, India. However, biogas, as a technology, was first propagated by the Chinese as a developing country from 1930s. Since 1970, China has included biogas programmes in their 5 year plans. It is estimated that nearly 100 million Chinese people are benefited by nearly 42 million biogas systems installed in China, of which nearly 40 million households are located in rural areas. Nearly 23% of rural China is said to be benefiting from biogas systems. Biogas has been integrated with agriculture and livestock, while subsidies have been offered for the people to takeup this technology. India, Nepal, and some countries of South-East Asia, and now some African countries, have taken national level initiatives to promote biogas and use the technology for different purposes for the benefit of the respective countries, with similar interventions. Developed nations however, have taken a fairly different route in which advanced technologies have been developed and used to manage organic waste efficiently, where biogas is produced as a by-product and gas is used for different purposes including city heating, generating electricity, feeding to the electricity grids, injecting to the gas grids and running vehicles.

Biogas in Sri Lanka

In Sri Lanka, the recorded history of biogas dates back to 1973-74 era. Some experiments on biogas had been carried out at the Engineering Faculty of the University of Peradeniya. Technology had been transferred from China and India. Government institutions and some NGOs had taken this technology further, with some initial momentum. With some technology and other issues, the uptake had retarded around late 1980s to late 1990s. With some rejuvenation, as a result of findings, recommendations and implementing the recommendations of a national survey of existing biogas systems around 1996, this technology has re-awakened to propagate in the country, slowly and steadily, especially with the involvement of the NGOS, and thereafter, programmes being mainstreamed by the government institutions, especially, the Department of Animal Production and Health and Provincial Councils. By today, it is estimated that, about 10,000 biogas systems have been installed in Sri Lanka. We also have seen Sri Lanka Standards being released by the Sri Lanka Standards Institution for biogas systems while a professional group has formed a volunteer association dedicated to promoting biogas systems in the country, and a number of biogas programmes implemented by the government and private sector with the assistance of the donor and NGO community, and the investments of the private sector. Further, universities such as Moratuwa, Peradeniya and Ruhuna, and National Engineering Research & Development Centre continue the research on various aspects on biogas related disciplines.

The evolution of using biogas technology in Sri Lanka clearly demonstrates that it is the 'energy' component of the biogas systems that was seen as important until recently, despite the specialists emphasizing the other benefits too. Today, it is seen more from a perspective of an environmental solution for waste management, be it liquid or solid, containing a fair portion of organic matter. As

a matter of fact, there are many biogas systems which are connected to the toilets, so that biogas systems also bring some solutions to sanitation. From the early days to the present, health and sanitation benefits of biogas systems are reaped by the users.

Potential of Biogas in Sri Lanka

If we assume that, of the Sri Lankan and expatriate population, about 20 million people live inside the country at a time, and the average daily household waste generation is around 0.6 kg per capita, the total waste generation works-out to be around 12 million kg per day. Nearly 60% of the household waste generated in Sri Lanka is organic. Therefore, the estimated amount of daily organic waste generation is 7.2 million kg. Considering that moderate (fairly efficient) medium sized biogas systems could generate 100 liters of biogas from 1 kg of organic waste, about 720,000 cubic meters of biogas could be generated in the country per day, if all the generated waste could be processing via biogas systems. If this biogas is used to generate power, at the rate of 1.25 kWh from a cubic meter of biogas, the amount of power that could be generated is around 900,000 kWh, which is around 38 MW installed capacity of power plants. Similarly, if we process sewerage waste, at 400g of daily excreta per capita, the installed capacity of biogas power plants would be 41 MW. If we consider livestock (cattle, buffaloes, goats, poultry, swine etc.,) it can be equated to about 109 MW of power plants. If we ignore the organic waste generated from agriculture, forestry, and industries, etc to be processed using biogas technology, the total capacity of biogas based power generation from household waste and human and livestock excreta in Sri Lanka would be about 190 MW.

Is the Energy Potential from Biogas Significant?

The installed capacity of Victoria (hydro) and Norochcholai (coal) power plants are 210 MW and 900 MW respectively, which are about 6 and 24 times bigger than 38 MW, the potential capacity of power plants based on biogas technology processing household waste. If we process all human and animal excreta and household organic waste generated from the whole country of Sri Lanka, still the installed capacity of Victoria and Norochcholai power plants are nearly 1.1 times and 5 times bigger. Accordingly, even if we process all the organic waste generated at homes and livestock sector using biogas technology, the amount of electricity it could generate is negligible compared to the total demand and installed capacity of the country. Biogas would give better economic returns if used for thermal (heat) energy applications. However, this does not mean that biogas is not a worthwhile technology in organic waste management.

Conclusions

The famous waste management mantra is the 3R concept, Reduce, Reuse and Recycle, although more Rs are being added. The government of Sri Lanka also has taken steps to promote better waste management and reduce the use of waste generation. Under the current circumstances, biogas technology would suit well at the small to medium scale as an organic waste management

technology while providing by-products. The biogas as a source of energy and bio slurry, as an agricultural input. The government has approved some waste management projects associated with waste management sites that use biogas based technologies (e.g. At Karadiyana, a biogas systems with capacity of 100 tons of source separated waste per day). The economics of biogas as source of energy, particularly as a source to generate electricity, alone may not work-out well, as there are better economically viable energy solutions. The electrical equivalent of biogas is not a good measure compared to the benefits of biogas. If we consider biogas systems as a 'triple benefit technology', the benefits may well outweigh the costs, and possibly be rated as one of the best solutions ever for multiple problems, while giving multifaceted benefits and solutions.

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දේශගුණ විපර්යාස ගෝලීය කතිකාවතෙහි හරිතාගාර වායු විමෝචනය අඩුකිරීම සඳහා වූ යාන්ත්‍රණ

Chamika Iddagoda

Climate Change Secretariat, Ministry of Mahaweli Deveopment and Environment
ciddagoda@gmail.com

කාර්මීකරණයත් සමග වායුගෝලයේ කාබන්ඩයොක්සයිඩ් සාන්ද්‍රණය පෙර නොවූ විරූ ලෙස ඉහළ යාමේ ප්‍රතිඵලයක් ලෙස ගෝලීය උෂ්ණත්වය ඉහල යාම නිසා එයට පිලියමක් ලෙස 1992 දී එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතිය (UNFCCC) ඇති කර ගන්නා ලදී. එහෙත් සම්මුතියක් තුළින් නීතිමය බැඳීමක් ඇති නොවන නිසා සම්මුතියේ අභිප්‍රායන් සපුරා ගැනීම සඳහා නීතිමය බැඳීමක් සහිත කියෝතෝ සන්ධානය 1997 දී ජපානයේ කියෝතෝ හිදී ඇති කර ගන්නා ලදී.

මෙම සන්ධානය මගින් සංවර්ධිත රටවල් සඳහා විමෝචන අඩු කිරීමේ ඉලක්ක ලබා දෙන ලදී. එසේම එම ඉලක්ක සපුරා ගැනීම සඳහා විමෝචන අඩු කිරීම සඳහා යාන්ත්‍රණ 3 ක් ද හඳුන්වා දෙන ලදී.

1. එක්ව ව්‍යාපෘති ක්‍රියාත්මක කිරීම (Joint Implementation)
2. විමෝචන හුවමාරුව (Emission Trading)
3. පවිත්‍ර සංවර්ධන යාන්ත්‍රණය (Clean Development Mechanism)

එක්ව ව්‍යාපෘති ක්‍රියාත්මක කිරීම, මෙම යාන්ත්‍රණය භරහා ව්‍යාපෘති ක්‍රියාත්මක කොට ඒ මගින් සංවර්ධිත රටවල් වල විමෝචන අඩුකිරීමේ ඉලක්ක කරා ලඟා වීම සඳහා වන ක්‍රියාවලියකි.

විමෝචන හුවමාරුව ද සංවර්ධිත රටවල් අතරට සීමා වූ කියොතෝ සන්ධානයෙහි ඉලක්ක කරා ලඟා වීම සඳහා වූ යාන්ත්‍රණයකි.

ඉහත යාන්ත්‍රණ 3 අතුරින් එක්ව ව්‍යාපෘති ක්‍රියාත්මක කිරීම හා විමෝචන හුවමාරුව සංවර්ධිත රටවල් අතර පමණක් ක්‍රියාත්මක කිරීම සඳහාද පවිත්‍ර සංවර්ධන යාන්ත්‍රණය සංවර්ධිත හා සංවර්ධන වෙමින් රටවල් අතර ක්‍රියාත්මක කිරීම සඳහා ද හඳුන්වා දෙන ලදී.

පවිත්‍ර සංවර්ධන යාන්ත්‍රණය ක්‍රියාවට නැංවීම සඳහා එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතියේ ලේකම් කාර්යාලයෙහි පවිත්‍ර සංවර්ධන යාන්ත්‍රණ විධායක කමිටුවක් (CDM Executive Board) පිහිටුවන ලදී. මෙම විධායක කමිටුව විසින් පවිත්‍ර සංවර්ධන යාන්ත්‍රණය පිළිබඳ රෙගුලාසි සම්පාදනය, ව්‍යාපෘති ලියාපදිංචි කිරීම, මාර්ගෝපදේශ සැකසීම ආදී කටයුතු සිදු කරන ලදී. එසේම මෙම යාන්ත්‍රණය සාර්ථකව ක්‍රියාත්මක කිරීම සඳහා සංවර්ධනය වෙමින් පවතින රටවල් වල පවිත්‍ර සංවර්ධන යාන්ත්‍රණ ජාතික අධිකාරින් ද (Designated National Authorities) පිහිටුවන ලදී. ජාතික අධිකාරිය මගින් ව්‍යාපෘති අනුමත කිරීම, අදාළ පාර්ශවකරුවන් දැනුවත් කිරීම ආදී කාර්යභාරයන් ඉටු කරයි. ශ්‍රී ලංකාව ද සිය ජාතික අධිකාරිය පරිසර අමාත්‍යාංශය තුල පිහිටුවන ලදී.

පවිත්‍ර සංවර්ධන යාන්ත්‍රණ මූලධර්මයට අනුව සංවර්ධනය වෙමින් පවතින රටවල් වල හරිතාගාර වායු අඩු කිරීමේ ව්‍යාපෘති (ජල විදුලිය, සුළං බලය, ජීව වායු, කසල කළමනාකරණය ආදී) ක්‍රියාත්මක කරන අතර එම ව්‍යාපෘති මගින් අඩුකරන හරිතාගාර වායු සංවර්ධිත රටවල් මගින් සිය කියෝතෝ ඉලක්ක සපුරා ගැනීම සඳහා මිලදී ගැනීම සිදු කරයි. මෙය කාබන් වෙළඳාම (Carbon Trading) නමින් ද හඳුන්වයි.

ඒ අනුව පවිත්‍ර සංවර්ධන යාන්ත්‍රණය ලොව පුරා කියෝතෝ සන්ධානයෙහි පාර්ශවකරුවන් අතර සීඝ්‍රයෙන් ව්‍යාප්ත වියි තවද මෙම යාන්ත්‍රණයට අදාලව ගෝලීය කාබන් වෙළඳපලක් ද (Global Carbon Market) නිර්මාණය විය. මෙම කාබන් වෙළඳපලෙහි ජපානය, ලෝක බැංකුව, යුරෝපා සංගමය ආදීන් ප්‍රමුඛ ගැනුම්කරුවන් වුහ.

කියෝතෝ සන්ධානයෙහි පළමු වගකිවයුතු කාලය (First Commitment Period) 2012 අවසන් වියිදෙවන පරිච්ඡේදය (Second Commitment Period) සඳහාද එනම් 2012-2020 කාලය සඳහා ද පවිත්‍ර සංවර්ධන යාන්ත්‍රණය වලංගු වුවත් පළමු වගකිවයුතු කාලයේදී මෙන් දෙවන පරිච්ඡේදයේ දී සාර්ථකව ක්‍රියාත්මක නොවේ.

මේ වන විට ව්‍යාපෘති 7783 ක් පවිත්‍ර සංවර්ධන යාන්ත්‍රණ විධායක කමිටුවේ ලියාපදිංචි වී ඇති අතර එම ව්‍යාපෘති මගින් 1,853,959,835 (tCO_2) පමණ විමෝචන අඩුකර ඇති ශ්‍රී ලංකාව ද ව්‍යාපෘති 24 ක් පවිත්‍ර සංවර්ධන යාන්ත්‍රණ විධායක කමිටුවේ ලියාපදිංචි කර ඇත.

ගෝලීය හරිතාගාර වායු විමෝචන අවම කිරීම සඳහා 2007 දී ඉන්දුනීසියාවේ බාලි නුවර පැවැත්වූ දී එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතිය (UNFCCC) යෙහි පාර්ශවකරුවන්ගේ 13 වන සමුළුවේ දී නව යාන්ත්‍රණයක් හඳුන්වා දෙන ලදී. මෙය ජාතික වශයෙන් යෝග්‍ය හරිතාගාර වායු අවම කිරීමේ ක්‍රියාකාරකම් (Nationally Appropriate Mitigation Actions-NAMAs) ලෙස හඳුන්වන ලදී. එහිදී සංවර්ධනය වෙමින් පවතින රටවල් වලටද NAMA ක්‍රියාත්මක කරන ලෙසට දන්වන ලදී. සංවර්ධනය වෙමින් පවතින රටවල් NAMA ක්‍රියාත්මක කිරීම සඳහා සිය එකගතාවය පල කරන ලද්දේ එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතිය (UNFCCC) යෙහි පාර්ශවකරුවන්ගේ 16 වන සමුළුවේදියි එහිදී සංවර්ධිත රටවල් විසින් සංවර්ධනය වෙමින් පවතින රටවල NAMA ව්‍යාපෘති ක්‍රියාත්මක කිරීම සඳහා තාක්ෂණය, මූල්‍ය පහසුකම් ආදිය ලබා දීමට එකග වූ අතර සංවර්ධනය වෙමින් පවතින රටවල් NAMA ව්‍යාපෘති ඇගයීමේ, වාර්තාකිරීමේ සහ තහවුරුකිරීමේ (MRV) ක්‍රමවේදයට අනුකූලව සිදු කල යුතු බවට ද තීරණය විය. NAMA ව්‍යාපෘති සඳහා පහසුකම් සැපයීම සඳහා ජාත්‍යන්තර ලියාපදිංචි ලේඛනයක් (International NAMA Registry) එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතියේ ලේකම් කාර්යාලයෙහි පිහිටුවා ඇත.

මෙම ගෝලීය එකගතාවයට අනුව ශ්‍රී ලංකාව ද බල ශක්ති ජනනය හා පරිභෝජනය යන ක්ෂේත්‍ර සඳහා මෙය ජාතික වශයෙන් යෝග්‍ය හරිතාගාර වායු අවම කිරීමේ ක්‍රියාකාරකම් ව්‍යාපෘතියක් ක්‍රියාත්මක කරමින් පවතී. ගෝලීය පරිසර පහසුකම (Global Environment Facility) සහ එක්සත් ජාතීන්ගේ සංවර්ධන වැඩසටහන (United Nations Development Programme) මගින් මෙම ව්‍යාපෘතිය සඳහා මූල්‍යාධාර සපයයි. බල ශක්ති ජනනය හා පරිභෝජනය යන ක්ෂේත්‍ර සඳහා ජාතික වශයෙන් යෝග්‍ය හරිතාගාර වායු අවම කිරීමේ ක්‍රියාකාරකම් හඳුනාගෙන ඒවායින් තෝරාගත් කිහිපයක් ක්‍රියාත්මක කරයි. එසේම NAMA ව්‍යාපෘති සඳහා ආයතනික රාමුවක් ද ඇගයීමේ, වාර්තා කිරීමේ සහ තහවුරු කිරීමේ (MRV) ක්‍රමවේදයක් ද ජාතික NAMA ලියාපදිංචි ලේඛනයක් ද (National Registry) සකසනු ලබයි.

ශ්‍රී ලංකාව විසින් ප්‍රවාහන සහ කසළ කළමනාකරණය යන ක්ෂේත්‍ර සඳහාද NAMA ව්‍යාපෘති ක්‍රියාත්මක කරමින් සිටී.

තවද, හරිතාගාර වායු විමෝචනය අවම කිරීම සඳහා ජපානය විසින් Bilateral Offset Credit Mechanism (BOCM) නමින් යාන්ත්‍රණයක් හඳුන්වා දුන් අතර එය ඇතැම් රටවල ක්‍රියාත්මක වේ.

2015 දී ප්‍රංශයේ පැරිස් නුවර පැවති දී එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතිය (UNFCCC) යෙහි පාර්ශවකරුවන්ගේ 21 වන සමුළුවේ දී ඇතිකර ගත් පැරිස් ගිවිසුම (Paris Agreement) දේශගුණ විපර්යාස පිළිබඳ ගෝලීය කතිකාවතෙහි සන්ධිස්ථානයක් මෙන්ම නව මුහුණුවරක් එක් කිරීමටද සමත් විය. පැරිස් ගිවිසුමට අනුව සංවර්ධිත රටවල් වලට මෙන්ම සංවර්ධනය වෙමින් පවතින රටවල් සඳහා ද හරිතාගාර වායු විමෝචන අවම කිරීමේ ඉලක්කයන් සහිත ජාතික වශයෙන් නිර්ණය කරන ලද දායකත්ව (Nationally Determined Contributions-NDCs) ක්‍රියාත්මක කල යුතු වන්නේය.

පැරිස් ගිවිසුමේ හරිතාගාර වායු අවම කිරීමේ ඉලක්ක සපුරා ගැනීම සඳහා දැනට පවතින හරිතාගාර වායු විමෝචන අවම කිරීමේ යාන්ත්‍රණම ක්‍රියාත්මකවේද" නැතහොත් දේශගුණ විපර්යාස ගෝලීය කතිකාවතෙන් නව යාන්ත්‍රණය ඉදිරිපත්වේද යන්න ඉදිරියේ පවත්වන දී එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතිය (UNFCCC) යෙහි පාර්ශවකරුවන් ගේ සමුළු වලදී තීරණය කරනු ඇත.

Earnest Effort Needed to Mitigate the Effects of Climate Change and Instil Public Awareness Regarding the Multiple Threats Faced by Ratnapura Municipal Area

G.P.T.S .Hemakumara

Department of Geography, University of Ruhuna
shemakumara@hotmail.com

Introduction

Ratnapura City area is considered as a multi-hazard zone due to the high risk situations such as floods, landslides, lightning strikes and seasonal droughts that occur with unusual frequency and severity. The most regular disasters in the city are flooding, landslides and strong winds, which have the effect of disrupting the citizens' daily lives. Due to the global climate change effect, the frequency and impact of the above hazards appear to have increased lately. Therefore, there is now the imperative need to apply appropriate measures to cope with climate change and adapt to it, while raising public awareness of this issue in the Ratnapura MC area. According to a survey conducted in 2016, it was found that certain matters were highlighted by practically all the Grama Niladharis in the Ratnapura MC area. The survey was conducted by the GN Officer of each GN Division regarding the harm the division had suffered in the last five years.

Questionnaire Survey and Interview

The questionnaires were filled by 18 Grama Niladhari Officers in the Ratnapura Municipal area. Questionnaires called for basic data about those GN Divisions that were considered the most multi-hazard risk prone areas. Such areas were selected through field observations after noting their susceptibility to landslides, floods and high winds. The surveys were then done covering the most risk prone areas. The structured questionnaire was also used to gather information about the Socio Economic impact of disasters on those areas.

Table 1 Summary of Survey Data about Multi Hazarded Condition in Ratnapura MC Area

GN Division Name	GND Number	Area (Ha)	Type of Natural Disaster	Number of Families affected by Disaster	Number of Deaths Caused by Disaster	Number of Persons Injured in Disaster	Number of Fully Damaged Houses	Number of Partially Damaged Houses	Overall Risk of Floods	Overall Risk of Landslides	Overall Risk of High Winds
Mahawala	152C	78.32	Land-slide	1	2	0	0	2	No Risk	Moder-ate Risk	No Risk
Mihindugama	152D	54.61	No	0	0	0	0	0	No risk	No Risk	No Risk
Kospalavinna	153D	385.88	Flood	8	0	0	0	5	No risk	No Risk	No Risk
Muwagama	182	154.57	Flood/ Land-slide	280	0	0	0	20	Mod-erate Risk	Moder-ate Risk	No Risk
Dewalaya Gawa	151	118.71	Flood/ Land-slide	137	0	0	0	6	High Risk	Low Risk	No Risk
Samagipura	182C	60.26	Land-slide	52	0	0	0	6	No Risk	Moder-ate Risk	No Risk
Thiriwanaketiya	181B	182.11	No	0	0	0	0	0	No Risk	No Risk	No Risk
Mudduwa	182A	55.54	Flood	3	0	0	0	0	Low Risk	No Risk	Low Risk
Angammana	181C	106.46	Flood	100	0	2	0	0	No Risk	No Risk	Low Risk
Ratnapura Town North	152E	87.24	Flood/ Land-slide	25	0	0	0	3	Low Risk	Low Risk	No Risk
Kolandagala	181A	916.47	Land-slide	16	0	2	1	1	High Risk	Moder-ate Risk	No Risk
Weralupa	152B	217.47	Flood/ Land-slide	20	0	0	1	5	Mod-erate Risk	No Risk	No Risk
New Town	153A	603.89	Strong wind	12	0	0	1	11	High Risk	No Risk	High Risk
Batugedara	181	93.43	Flood/ Strong wind	275	0	0	3	2	High Risk	No Risk	High Risk

Mudduwa East	182D	120.87	Flood/ Land-slide	400	0	0	5	2	Mod-erate Risk	Low Risk	No Risk
Ratnapura Town	152A	28.63	Flood/ Strong wind	125	0	10	15	2	High Risk	No Risk	Mod-erate Risk
Godigamuwa	152	128.96	Flood/ Land-slide/ Strong wind	193	30	40	22	22	High Risk	Very High Risk	High Risk
Ratnapura Town West	152F	52.1	Flood/ Land-slide	102	0	0	50	20	High Risk	No Risk	No Risk

Sources: Field Survey and Interview with GN officers in study area, 2016

According to the data collected through extensive field observation, the landslide, flood, and high wind sites were identified. Data and information gathered were tabulated using Microsoft Office Excel Tabulation and GIS.

In this part of the analysis, the results of the study are presented. Figure 1 indicates the number of families affected by the disasters in each GN Division.

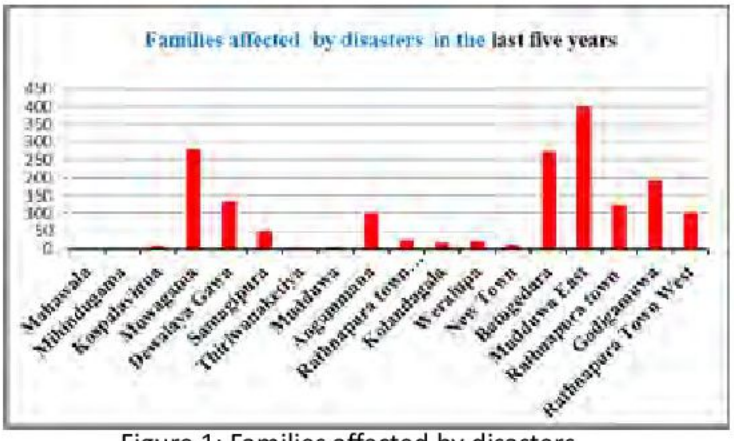

Figure 1: Families affected by disasters
Source: Field survey

According to the above chart, a large number, of affected families, was recorded in Mudduwa East GN Division. It had about 400 families. Muwagama GN Division had 280 affected families, followed by Batugedara and Godigamuwa GN Divisions.

Figure 2 shows the number of affected people by two categories. One indicates the number of people who died in the disasters and the other the number of people injured in the disasters.

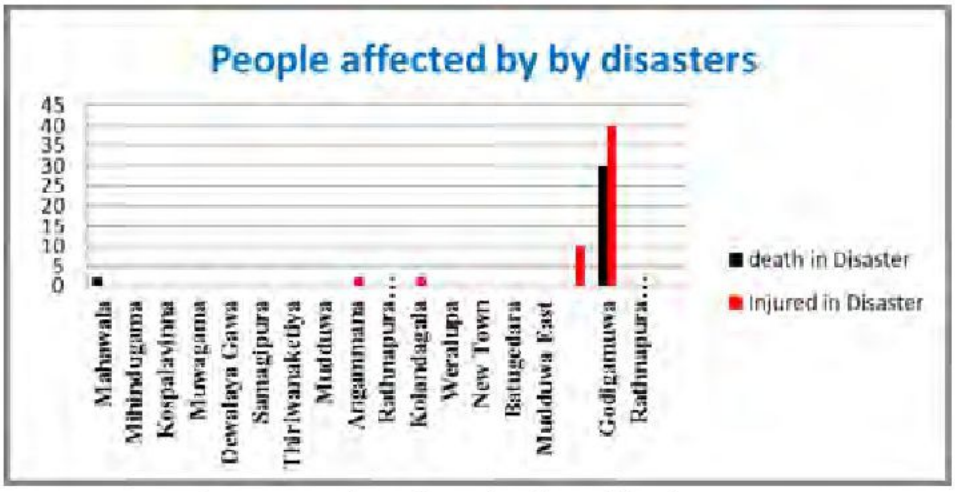

Figure 2: Number of people affected by disasters
Source: Field survey

Disasters had the greatest impact on the Godigamuwa GN Division according to the records. Godigamuwa GN Division recorded forty deaths and thirty injuries.

Figure 3 shows the number of houses affected by the disasters. This figure also displays two categories, viz. the number of fully damaged houses and the number of partially damaged houses.

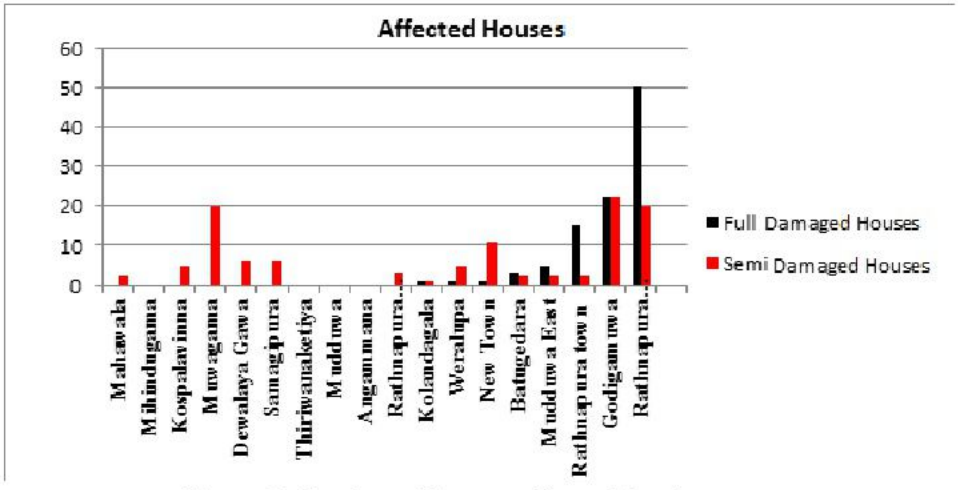

Figure 3: Number of houses affected by disasters
Source: Field Survey, 2016

According to the above chart, the highest number of damaged houses was recorded in Ratnapura Town West GN Division as 50 houses were fully damaged and 20 houses semi damaged. Godigamuwa GN Division had 22 fully damaged houses and 22 partially damaged houses.

This map shows the GN Divisions and the nature of the damage suffered in each of the divisions.

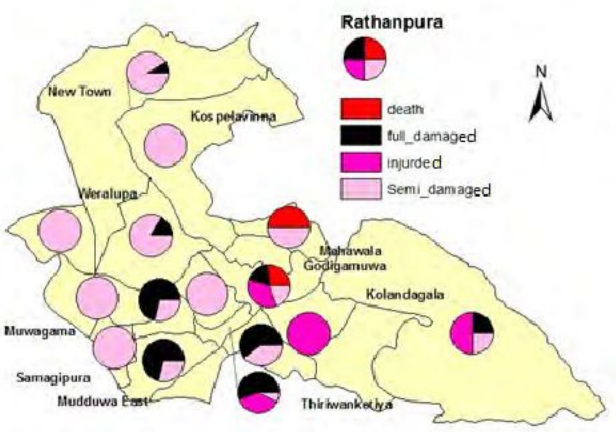

Figure 4: Overall condition of houses affected by disasters in study area
Source: Field Survey, 2016

The questionnaire was designed to collect information about the overall risk of flooding in the Ratnapura Municipal area. This question had to be marked in terms of the level of flood risk, varying from very high risk, high risk, moderate risk, low risk to no risk.

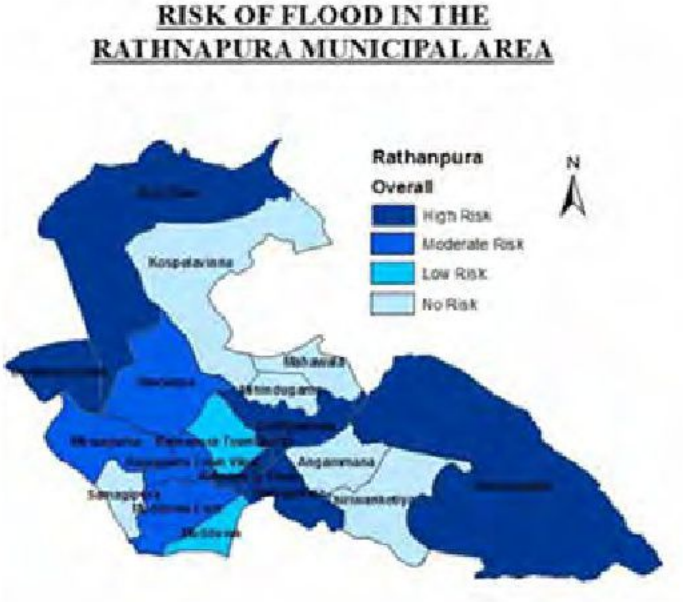

Figure 5: Risk of flood in Ratnapura Municipal area as noted in last five years
Source: Field survey of 2016

According to the above map, a very high flood risk was reported in Ratnapura Municipal area in the following GN Divisions: Dewalaya Gawa, New Town, Ratnapura Town, Batugedara, Kolandagala and Godigamuwa GN Divisions.

Landslides are also a major hazard in Ratnapura Municipal area. They mainly occur in the hilly areas of Godigamuwa, Samagipura, Muwagama Mountain, Helauda, Mihindugama, Dewalaya Gawa, Mahawala, Mudduwa East, Thiriwanaketiya, Ratnapura Town North, Batugedara and Meehitiya. The map in Figure 6 shows Risk of Landslides in the Ratnapura Municipal area.

Figure 6: Risk of landslides in the Ratnapura Municipal area
Source: Field survey, 2016

Strong winds have also been reported in Godigamuwa, Mudduwa, New Town, Muwagama, Mahawala, Angammana and Batugedara areas in Ratnapura Municipal area. Figure 7 shows risk of strong winds in Ratnapura Municipal area.

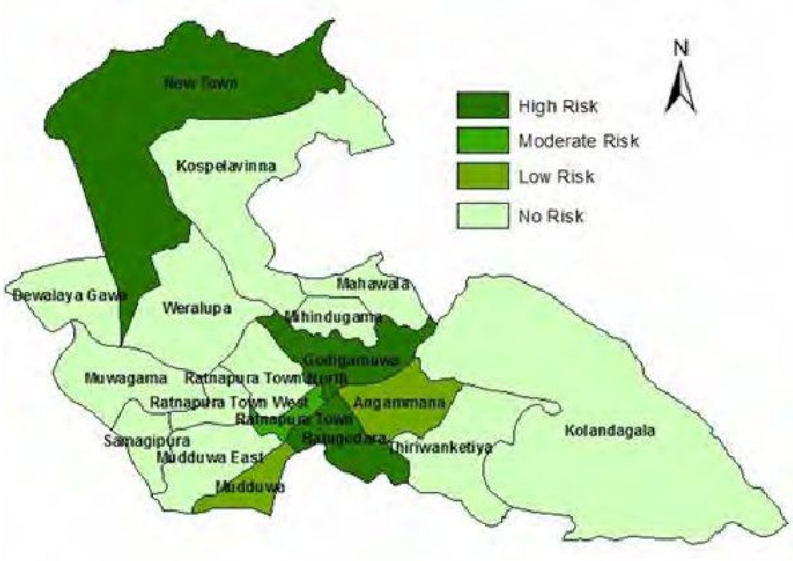

Figure 7: Risk of strong winds in the Ratnapura Municipal area
Source: Field survey

Conclusion and Recommendations

The most troublesome natural hazards faced by the Ratnapura MC area are identified as floods, landslides and high winds and they have had a very hazardous impact on human life and the other assets of the city, such as homes, buildings, roads and services. The analysis of the primary data in figure 1 indicates that Mudduwa East GN Division has a large number of families affected (about 400 families). Figure 2 indicates the dead and injured in Rathapurea MC. 40 deaths and 30 injured had been reported in Godigamuwa GN Division in the last five years due to disasters. In figure 3, Ratnapura Town West GN Division has 40 fully damaged houses and 20 semi damaged houses, while Godigamuwa GN has 42 semi-damaged houses. Accordingly table 1, Godigamuwa GN Division is the area most at risk from multiple hazards in the three forms of floods, landslides and wind. Detailed study and consideration suggest that people empowerment is very essential, especially in the Godigamuwa area, to enable them to cope with and overcome these natural disasters that occur there periodically.

Based on the findings of this study, it appears necessary to constantly monitor the situation in Ratnapura MC area, as it is a Multi-Hazard hotspot vulnerable to natural hazards. There will be more danger in the future because of global warming and climate change increase. Climate change is influencing the rate and intensity of disasters and further exacerbating their impacts. Hence, it is very important to ensure that people are aware of the effects of climate change in the study area and also entire Sri Lanka to help in reducing the danger from natural disasters and the damage caused by them. To accomplish this they must be taught how to mitigate and adapt to the effects of natural hazards such as floods, landslides and high winds in vulnerable areas. Empowering the families in disaster prone areas to cope effectively with these hazards can only be done by advising them of the dangers and disseminating information on how to adapt them to survive in such situations.

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දේශගුණික විපර්යාසවල අහිතකර බලපෑම්වලට අනුහුරුවීම සඳහා පාරම්පරික දැනුම නැවත සමාජගත කිරීම

T.M. Anuruddha Tennakoon

Environment Planning and Economic Division, Ministry of Mahaweli Development and Environment
anuruddha_mails@yahoo.com

යම්කිසි භූගෝලීය ප්‍රදේශයක ජීවත්වන ජනතාව සතු දැනුම අදාළ ප්‍රදේශයේ ජනතාව සතු පාරම්පරික දැනුම ලෙස හඳුන්වයි. මෙය සෑම ක්ෂේත්‍රයකම පැතිරී ඇති අතර දේශගුණික විපර්යාසවල අහිතකර බලපෑම් අවම කිරීම හා ඒ සඳහා අනුවර්තනයවීමේදී ඒ සඳහා සුදුසු ක්ෂේත්‍රවල පාරම්පරික දැනුම් යොදාගැනීමට හැකියාව ඇත. ආන්තික පාරිසරික තත්ත්ව යටතේ පහසුවෙන් වගාකල හැකි බෝග වර්ග, සත්ත්ව විශේෂ ප්‍රචලිත කිරීමෙ, පාරම්පරික ආහාර තාක්ෂණය නැවත සමාජගත කිරීම ආදිය සිදුකළ හැක. පාරම්පරික දැනුම පිළිබඳ පර්යේෂණ සඳහා පහසුකම් සැලසීමත්, දිරිගැන්වීමත් සහ දැනුම නැවත සමාජගත කිරීමත් රාජ්‍ය මට්ටමින් සිදුකල යුතුව ඇත.

මූලික වචන - පාරම්පරික දැනුම/ දේශගුණික විපර්යාස/ අනාවැකි පලකිරීම

යම්කිසි භූගෝලීය ප්‍රදේශයක ජීවත්වන ජනතාව සතු දැනුම අදාළ ප්‍රදේශයේ ජනතාව සතු පාරම්පරික දැනුම ලෙස හඳුන්වයි. පාරම්පරික දැනුම සතු ප්‍රධාන ලක්ෂණයන් ලෙස මුඛ පරම්පරාවෙන් (කට වහරින්) පරම්පරා අතර ගමන්කිරීමත්, ස්ථානීය සුවිශේෂීතාවක් සහිතවීම හා සංස්කෘතිකමය වශයෙන් සුවිශේෂීවීමත් දැක්විය හැකි ශ්‍රී ලංකාවේ ජෛව විවිධත්වයේ ඇති එක් සුවිශේෂිතාවයක් වන්නේ ජෛව විවිධත්වය හා ඇසුරුකොටගත් පාරම්පරික දැනුමක් පැවතීමයි. පාරම්පරික දැනුම, දේශීය දැනුම, දේශීය ඥානය - Traditional Knowledge (TK)/ Traditional Wisdom/ Local Knowledge ලෙස හැඳින්වෙන අතර පාරම්පරික දැනුම අස්පර්ශීය සංස්කෘතික උරුමයක් - Intangible Cultural Heritage (ICH) ලෙස සළකනු ලබයි. පාරම්පරික දැනුම ගොඩනැගීම පරිසරය අනුසාරයෙන් සිදුවන අතර පරිසරයෙන් ලැබෙන අත්දැකීම් මගින් වඩාත් පෝෂණය ලබයි. දැන පුරුද්ද, (දැන ගැනීම) දැක පුරුද්ද, (සිදුවන ආකාරය දැක සිටීම) කළ පුරුද්ද (අත්හදා බැලීම) හා පලපුරුද්ද (ප්‍රවීණත්වයක් ලබා සිටීම) යන අවස්ථා පාරම්පරික දැනුම පරම්පරා හරහා ගමන්කිරීමට ඉතා වැදගත්වන ලක්ෂණයකි. එමගින් යම් කාර්යක් ඉටුකරගැනීමට ඇති හැකියාව (Know-how) දැනුම දරන්නන්ට උරුම වේ.

පාරම්පරික දැනුම සෑම ක්ෂේත්‍රයකම පැතිරී ඇති අතර දේශීය කෘෂිකර්මාන්තය, දේශීය වාරිකර්මාන්තය, පාරම්පරික ආහාර තාක්ෂණය, ඉදිකිරීම් ක්ෂේත්‍රය, අනාවැකි පලකිරීම වැනි ක්ෂේත්‍ර සතු පාරම්පරික දැනුම සුවිශේෂිය වේ. මෙම දැනුම් ඍජුවම මිනිසාගේ සහ සමස්ථ පරිසරයේ පැවැත්ම සඳහා ඉතා වැදගත් වේ. දේශගුණික විපර්යාසවල අහිතකර බලපෑම් අවම කිරීම හා ඒ සඳහා අනුවර්තනය වීමේදී ඒ සඳහා සුදුසු ක්ෂේත්‍රවල පාරම්පරික දැනුම් යොදාගැනීමට හැකියාව ඇති මෙහිදී ඉතා සරළ ක්‍රම යොදාගතහැකිවීමත්, ඒවා පරිසරය සමග ඍජුවම බද්ධව පවතින ක්‍රම වීමත්, විවිධ ස්ථානයන්හි යොදගතහැකි වීමත් නිසා ඉතා සුවිශේෂිය වේ. එසේම දේශීය අනන්‍යතාවක් පැවතීමත් ප්‍රදේශයේ ජනතාව විසින්ම පවත්වාගෙන එනු ලබන ක්‍රම වීමත් නිසා එහි ඇති සංස්කෘතිකමය වටිනාකමත් ඉතා ඉහළ වේ.

පාරම්පරික දැනුමෙන් පෝෂිත දේශීය කෘෂිකර්මාන්තය

දේශගුණික විපර්යාස හේතුවෙන් ඇතිවන ආන්තික තත්වයන් හමුවේ කෘෂිකර්මාන්තය තර්ජනයට ලක්වන අතර අඩාලවන ආහාර නිෂ්පාදනය සමාජ, ආර්ථික හා දේශපාලනික ගැටළු නිර්මාණය කරනු ලබයි. මෙම තත්ත්වයන් අවම කිරීම සඳහා පාරම්පරික දැනුම යොදාගත හැක. පාරම්පරික කෘෂිකර්මාන්තය තුළ අඩු ජල ප්‍රමාණයක් අවශ්‍යවන වී සහ වෙනත් බෝග වර්ගයන් මෙන්ම, වැඩි ජල ප්‍රමාණයක් හෝ තෙතමනයක් සහිත ස්ථානවල පහසුවෙන් වගාකළ හැකි බෝග වර්ග ඇත. එසේම අඩු ජල ප්‍රමාණයක වගාකල හැකි "කැකුලම" වැනි වගා ක්‍රම ද වේ. පාරම්පරික ආහාර බෝගයන්ගේ සුවිශේෂිය තාවයන් ද වටහා දීම ඉතා වැදගත්ය.

ආන්තික පාරිසරික තත්ත්ව යටතේ පහසුවෙන් වගාකළ හැකි හා ක්ෂේත්‍රයේ පවත්වා ගත හැකි බෝග ප්‍රචලිත කිරීම පහසුවෙන් සිදුකළ හැකි කාර්යකි. "නියං වැටකොදු" මේ සඳහා හොඳ උදාහරණයකි. වියළි පරිසර තත්ත්වයන්හිදී වඩාත් හොඳින් එලදරමින් මෙම බෝගය වර්ධනය වේ. එසේම ශාකයේ එළය දැඩි ලෙස වියලි අවස්ථාවේදී ස්වාභාවිකවම පරිනතවූ බීජ පරිසරයට මුදාහරී. එම බීජ සතුව ද වියලි පරිසරයට ඔරොත්තුදීමේ හැකියාව ඇත. එසේම බොහොමයක් දේශීය වී වර්ගයන්ගේ ගොයම් ගස ශක්තිමත්ය. ගොයම් ගස උසින් වැඩි හා අඩු හා මධ්‍යම ප්‍රාණයේ ලෙස ද විවිධ ලක්ෂණ පෙන්වයි. මෙම ලක්ෂණයන් සහිත වී වර්ග කලාපයේ ඇති දේශගුණික ලක්ෂණ අනුව වගාව සඳහා යොදාගත හැක.

පවතින කෘෂිකර්ම භූමි සැලසුම් සිතියම් හා පෙර ලද අද්දැකීම් අනුව ගංවතුර, නියගයන්ට, දැඩි සුළඟට ගොදුරුවන ප්‍රදේශ ඇතුලත් සිතියම් එකිනෙක සම්බන්ධකර වඩාත් පහසුවෙන් අවදානම් සහිත වගා භූමි හඳුනාගෙන ඒ සඳහා සුදුසු පාරම්පරික වගා ක්‍රම හා බෝගයන් හඳුන්වාදීමට හැකියාව ඇත.

පාරම්පරික ආහාර තාක්ෂණය යොදාගැනීම

පාරම්පරික ආහාර තාක්ෂණය නැවත සමාජගත කිරීම ද දේශගුණික විපර්යාසයන්ගේ අහිතකර බලපෑම් සඳහා අනුවර්තනයක් ලෙස යොදාගැනීමට හැකියාව ඇත. පාරම්පරික ආහාර තාක්ෂණය තුළ ආහාර සඳහා යොදාගත හැකි ශාක විශේෂ අති විශාල සංඛ්‍යාවක් හඳුනාගත හැක. කොළ එළවලු (පලා) හා එළවලු ලෙස යොදාගත හැකි ශාක විශේෂ රැසක් ඒ අතර වේ. මෙම ශාක විශේෂ අතරින් සමහර විශේෂ විවිධ ආන්තික පාරිසරික තත්ත්ව යටත් පරිසරයේ සුලභ වේ. ඒ අනුව ආහාර සුරක්ෂිතතාවය ඇතිවේ. දැඩි නියං කාලවල හෝ අධික වර්ෂා සමයේ වැවෙන ශාක විශේෂ ආහාරයට සුදුසු පරිදි සකසාගත හැකි පාරම්පරික ආහාර තාක්ෂණ දැනුම සංරක්ෂණය කිරීම හා නැවත සමාජගත කිරීම තුළින් පුළුල් ආහාර පරිභෝජන රටාවක් පවත්වා ගැනීමේ හැකියාව ඇති අතර පෝෂණ ඌණතා මගහරවා ආහාර සුරක්ෂිතතාවය ඇතිකළ හැක.

මෙම සුවිශේෂිය බෝග වර්ග ආහාර ලෙස පිළියෙල කිරීමේදී ද එක් එක් බෝගයට අනන්‍ය වූ පාරම්පරික ආහාර සැකසුම් ක්‍රම ඇති උදාහරණ - ආහාරයට සැකසීමට පෙර ජලයෙන් තම්බා එම ජලය ඉවත්කර වෙනත් පිසීමේ ක්‍රමයකට භාජනය කිරීම, දින කීපයක් ස්වභාවිකව මැලවීමට ලක්කර පිසීම (උදා- වෙල් අල කොල දළු). මේ හේතුව නිසා ආහාර සැකසීමට අදාළ පාරම්පරික දැනුම සමාජගත නොකර පාරම්පරික ආහාර බෝග ප්‍රචලිත කිරීම සුදුසු නොවේ.

ආහාර තාක්ෂණය හා සම්බන්ධව තවත් වැදගත් අංශයක් වන්නේ පාරම්පරික ක්‍රම භාවිතයෙන් ආහාර කල් තබාගැනීමේ දැනුමයි. අච්චේ වියළීම, දුම් මැස්සේ වියළීම, වැලි යට තැබීම වැනි සර ක්‍රමවල සිට "අනුග" සකස්කිරීම වැනි සංකීර්ණ ක්‍රම භාවිතයෙන් යම් යම් ආහාර ද්‍රව්‍ය සුලභ කාලවලදී ඒවා කල් තබාගත හැකි

ආකාරයට සකස්කළ හැක. මෙමගින් ආහාර ද්‍රව්‍ය අපතේයාම වලක්වාගත හැකි අතර දේශගුණික විපර්යාස මගින් අතිවන ආහාර සුරක්ෂිතතාවය හා සම්බන්ධ ගැටළු සඳහා පිළියමක් ලෙස ද භාවිතා කළ හැක.

දේශීය පශු සම්පත් භාවිතයේ වැදගත්කම

පශු සම්පත සැලකීමේදී ද දේශීය ගව විශේෂ, කුකුළු විශේෂ, එළු විශේෂයන්ගේ විවිධත්වය හා පැවැත්ම තහවුරු කිරීම ඉතා වැදගත්ය. මෙම දේශීය විශේෂ අතර රළු පාරිසරික තත්ත්ව යටතේ හොඳින් ජීවත්විය හැකි ජීවී විශේෂ වේ. විශේෂයෙන් මෙහිදී වියලි හා නියං තත්ත්ව යටතේ පහසුවෙන් ගතකළහැකි සත්ත්ව විශේෂ සංරක්ෂණය කිරීම හා නොනැසී පවත්වා ගැනීම ඉතා වැදගත්ය. වැඩිදියුණු කරන ලද සත්ත්ව විශේෂ හඳුන්වාදීමේදී පාරම්පරික සත්ත්ව විශේෂ අභාවයට යාම වලක්වාගැනීම සිදුකිරීම මගින් දේශගුණික විපර්යාසයන්ගේ බලපෑම අවම කිරීමටත් ආහාර සුරක්ෂිතතාවය ඇතිකිරීමටත් ප්‍රවේණික විවිධත්වය පවත්වාගැනීමටත් හැකියාව ලැබේ. කෘෂිකර්මාන්තය, පසු අස්වනු තාක්ෂණය හා ආහාර තාක්ෂණයට අදාළ පාරම්පරික දැනුම දුෂ්කර ප්‍රදේශයන්හි ප්‍රචලිත කිරීම මගින්
දේශගුණික විපර්යාසයන්ට පහසුවෙන් ගොදුරුවන ග්‍රාමීය හා දුෂ්කර ප්‍රදේශවල ජනතාවට විකල්පයක් හඳුන්වාදිය හැක.

වැව් පද්ධතිය හා සම්බන්ධ ජල සංරක්ෂණ ක්‍රම භාවිතය

එල්ලංගා පද්ධතිය මෙරට ජල සම්පත උපරිම ආකාරයක භාවිතයට යොදාගැනීම අරමුණුකර පාරම්පරික වාරි තාක්ෂණය ඇසුරෙන් ස්ථාපිත කරන ලද පද්ධතියකි. ජල පෝෂක ප්‍රදේශයක් ආශ්‍රිතව පවතින අභ්‍යන්තර ජලාශයන් එකිනෙක සම්බන්ධකරමින් වැවකින් වැවකට ජලය ගමන්කරන ආකාරයට සකස්ව ඇති මෙම පද්ධතිය තුළ ජලජ ජීවය නොනැසී පවත්වාගැනීමට අවස්ථාව සැලසේ. එසේම පද්ධතියේ ඉහළින්ම ඇති වැව් වන ජීවීන්ගේ පැවැත්ම සඳහා සෘජුවම දායක වේ. දේශගුණික විපර්යාස හේතුවෙන් ඇතිවන ආන්තික පරිසර තත්ත්ව වලදී වැඩි ජල ප්‍රමාණයක් වැව් තුළ රඳවා ගැනීමටත්, නියං සමයේ ජලය නිග නොවී අවම මට්ටමෙන් හෝ පවත්වාගැනීමටත් මෙම පද්ධතිය ඉතා වැදගත් වේ. වැව වී වගාව සඳහාම පමණක් නොව කෘෂි ජෛව විවිධත්ව පද්ධතිය හා සෘජුවම සම්බන්ධ වේ. පාරම්පරික වැව එල්ලංගා පද්ධතිය ලෙසම ප්‍රතිස්ථාපනය කිරීම හා එහි ක්‍රියාකාරිත්වය තහවුරු කිරීම මගින් කෘෂි ජෛව විවිධත්වය භාවිතයට හා පරිසර සංරක්ෂණයට අවස්ථාව සැලසේ. එසේම එමගින් වනසත්ත්ව මිනිස් ගැටුම අවම කිරීමට ද අවස්ථාව උදාවේ.

වැවක් ආශ්‍රිතව නිර්මාණයවන පාරම්පරික හූ සැලැස්ම සැලකුවිට වැවට ඉහළින් ඇති පෙරහන, ගස් ගොම්මන හා ඉස්වැටිය මගින් වැවට එකතුවන ජලය පෙරීමකට ලක්කරයි. ආන්තික තත්ත්ව යටතේ අධික වර්ෂාවකින් වැවට එක්වන ජලය ඉහත සෑම අංගයක් හරහාම පෙරීමට ලක්කර වැවට රොන්මඩ එක්වීම පාලනය කරයි. එසේම තද සුළං සහිත අවස්ථාවල සුළඟ මගින් වැව් ජලය වාෂ්පීකරණය වීම ගස් ගොම්මන මගින් පාලනය කරයි.

වැවකට වැවක් එල්ලංගා පද්ධතිය මගින් සම්බන්ධවන බැවින් මත්ස්‍යන්ට ජලාශ අතර පිහිනීමට අවස්ථාව ලැබේ. එබැවින් වැව් පද්ධතියේ ජීවය නොනැසී පවත්වාගත හැක. ආන්තික දේශගුණික තත්ත්වයන් යටතේ ජෛව විවිධත්වය ආරක්ෂාකර ගැනීමට මෙය ඉතා වැදගත් අතර ආහාර සුරක්ෂිතතාවයේදීද වැදගත් මෙහෙයක් ඉටුකරයි.

අරපිරිමැසුම්දායි වන සම්පත් භාවිතය

දේශගුණික විපර්යාසයන් ඇතිවීමට බලපාන ප්‍රධාන හේතුවන් ලෙස වන ගහනයේ අඩුවීම හඳුන්වයි. වැඩිවන ජනගහනයත් සමග දැව සම්පත සඳහා ඇති ඉල්ලුම ඉහළ යන අතර ම නව සංවර්ධන ක්‍රියාකාරකම් සඳහා වන ආවරණයෙන් සමන්විතව පවතින ප්‍රදේශ එළි පෙහෙළි කිරීමට සිදුවේ. මේ හේතුව නිසා වන ආවරණය සීඝ්‍රව අඩුවීම සිදුවේ. පවතින වනාන්තර ආරක්ෂා කිරීම, නැවත වන වගා කිරීම මෙම ගැටළුවට පිළියම් වන අතර භාවිතකරන දැව පරික්ෂණ ක්‍රම මගින් කාලයක් පවතින ලෙසට පත්කර ගැනීම මගින් දැව නිපයුම්වල ආයු කාලය ඉහළ නැංවිය හැක.

නවින තාක්ෂණය යොදාගනිමින් සිදුකරන දැව පරිරක්ෂණ සේවාවන් වෙළඳපොළේ පවතී. දැව කල්පවතින තත්ත්වයට පත්කිරීමේ පාරම්පරික දැනුමක් පවතින අතර එහිදී මඩයට දමා පදම් කිරීම, විවිධ වලිත්ති (දොරණ තෙල් වැනි) ආලේප කිරීම මෙන්ම, කරුවලට (සඳෙහි අවපසට) දැව දඩු කපාගැනීමත් සිදුකරනු ලබයි. වේවැල්, උණ බට, කුඩා දැව කණු වැනි වැඩිපුර හා නිතර නිතර අවශ්‍යවන සරළ ඉදිකිරීම් හා නිපයුම් සඳහා මෙම ක්‍රමය පහසුවෙන් භාවිතා කල හැක. අතීතයේ කුඹුරේ හෝ හේනේ පැල සැකසීමේදී, මෙම පාරම්පරික දැනුම යොදාගෙන ඇත. දේශගුණික විපර්යාස හේතුවෙන් ඇතිවන අහිතකර බලපෑම් අවම කිරීම සඳහා පිළියමක් ලෙස පවත්වාගන්නා වන ආවරණය දිගු කලක් ස්ථාවරව පවත්වාගැනීමටත්, නැවත නැවත දැව දඩු සඳහා වනය විනාශ නොකිරීමටත් මෙවැනි සරළ ක්‍රම හඳුන්වා දිය හැක.

පාරම්පරික දැනුම මගින් කාලගුණ අනාවැකි පලකිරීම

දේශීය කෘෂි කර්මාන්තය තුළ හමුවන තවත් එක් සුවිශේෂිය අංගයක් වන්නේ කාලගුණික තත්ත්ව හා දේශගුණික තත්ත්ව පිළිබඳව අනාවැකි පළකිරීම හා එම අනාවැකියන්ට අදාළව ඉදිරි සැලසුම් සකස් කිරීමයි. දෛනික කාර්යන් සඳහා සුදානම්වීමේදී කාලගුණික අනාවැකි භාවිතාවී ඇති අතර දේශගුණික තත්ත්ව පිළිබඳව සිදුකරන ලද අනාවැකි අනුව කෘෂිකාර්මික කටයුතු සැලසුම් කිරීම සිදුවිය. කෘෂිකර්මාන්තයේදී ජලය තීරණාත්මක සාධකය වන බැවින් වැවට හෝ වගා බිමට ඉදිරියේදි වර්ෂාව මගින් ලැබිය හැකි ජල ප්‍රමාණය පිළිබඳව කල් ඇතිව තීරණයකට එළඹීම අනුව වගා කරන බෝග වර්ගය තීරණය කරනු ලැබීය.

මෙම අනාවැකි පලකිරීම සඳහා ජෛවිය හා ජෛවීය නොවන සාධක යොදාගෙන ඇති වලාකුළුවල හැඩය, වලාකුළු අහසේ විසිරී ඇති ආකාරය, වලාකුළුවල පැහැය, වැහි වලාකුළු මෝදුවන දිශාව හා කාලය, උදැසන පවතින මිදුම, සීතල අච්චේ ස්වභාවය ආදී ලක්ෂණත් ජ්‍යොතීෂ්‍යය අනුව කලාව, තිථිය, රිටිටා ආදිය ජෛවීය නොවන සාධක ලෙස යොදාගෙන ඇත. අනාවැකි පලකිරීම සඳහා යොදාගත් ජෛවීය සාධක රැසක් ද ඇත.

වැව් තාවුල්ලක ඇති ගස්වල වඩු කුරුල්ලන් කූඩු බදින්නේ ඉතා පහලින්ම එළබෙන කන්නයේ ඉතා අඩු වර්ෂාවක් ලැබෙන බවත් වඩුකුරුල්ලන් ඉතා ඉහලින් කූඩු බදින්නේ නම් ඉදිරි කන්නයේ වැඩි වර්ෂාවක් ලැබෙන බවත් මේ අතර ඇති එක් අනාවැකියකි. හදිසියේ වැඩි වර්ෂාවක් ලැබුනහොත් පහලින් බැඳි කුරුළු කූඩු ජලයට යටවී වි විනාශවී යාමේ අවදානමක් ඇති බැවින් වඩුකුරුල්ලන් ඒ බව යම් ආකාරයකින් දැනගෙන ඔවුන්ගේ කැදලි වඩා ඉහළ අතුවල තනන බව කියැවේ. එසේම ඉදිරි කන්නයේ ජලය අඩුවෙන් ලැබේනම් තම කැදලි වලට ජලයෙන් හානි නොවන නිසා කැදලි ගස්වල පහළ අතුවල බඳින බව කියැවේ.

මේ ආකාරයටම කාක් කූඩුවල ඇති බිත්තර ගණන, ඔකුළුවන් ගුල් හාරා ඇති ආකාරය, වනජ පලතුරුවල (ගඩා ගෙඩි) ඵලදැරීම අඩු වැඩි බව, ගවයන්ගේ හැසිරීම් රටා, පක්ෂීන්ගේ නාදකිරීම් හා පියාසැරි රටාවන්,

මෙරු පිටවීම ආදී ලක්ෂණ කාලගුණික හා දේශගුණික අනාවැකි සඳහා යොදාගෙන ඇත. මේ සියල්ලක් දෙස විමසිලිමත්වීමේදී ඒතුළ තාර්කික බවක් විද්‍යාමාන වේ.

දේශගුණික විපර්යාසයන්ගේ අහිතකර බලපෑම් මගහැරීමට හා ඒ සඳහා අනුවර්තනය වීමේදී එයට අදාළ පාරම්පරික දැනුම සැලකිල්ලට ගැනීම ඉතා වැදගත්ය. දේශගුණික විපර්යාසයන්ගේ බලපෑමට ලක්වන දුෂ්කර ග්‍රාමීය ප්‍රදේශයන් සතුව තවමත් පාරම්පරික දැනුම පවතින අතර එම දැනුම් රැස්කර ලේඛනගත කිරීමත් දේශගුණ විපර්යාසයන්වල අහිතකර බලපෑම් පාලනය කිරීමට හා වැලැක්වීමට යොදාගත හැකි පාරම්පරික දැනුම් රාජ්‍ය මට්ටමින් සමාජ ගත කිරීමටත් පියවර ගත යුතුය. ඒසේම පාරම්පරික දැනුමට අදාළ පර්යේෂණ සඳහා පර්යේෂකයන් යොමුකිරීමත්, ඒ සඳහා දිරිගැන්වීමත් සිදුකල යුතුය.

මූලාශ්‍රයන්

පරිසර හා ස්වභාවික සම්පත් අමාත්‍යාංශය, 2008, ශ්‍රී ලංකාවේ කෘෂි ජෛව විවිධත්වය, ජෛව විවිධත්ව ලේකම් කාර්යාලය

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Climate Change Impact Assessment on Medium Irrigation Scheme in Dry Zone

Himasha Abeysiriwardana

Water Management Secretariat, Mahaweli Authority of Sri Lanka
hdabeysiriwardana@gmail.com

A case study was conducted on Ethimale irrigation scheme to investigate the impacts of climate change on water resources in the dry zone and the possible adaptation measures. The response of the scheme to four anticipated climatic scenarios was observed and found that cropping intensity and yield decreased by 40% and 11.4% respectively under the worst-case scenario, demonstrating adverse climate change impacts. As an adaptation measure, crop diversification would increase the cropping intensity by 26%.

Introduction

Being a developing and tropical island, Sri Lanka is highly vulnerable to climate change impacts which is proven by the recent records of extreme weather events such as high intensity rainfall followed by floods and landslides, longer dry periods, and changes in average temperature *etc*. (The National Climate Change Policy of Sri Lanka, 2014). These water related impacts of climate change can have adverse impacts on many water related sectors of the country such as agriculture and food production, water supply, energy generation etc.

Sri Lanka is divided in to three main climatic zones namely "Wet zone", "Intermediate zone" and "Dry zone" based on the annual rainfall. Based on the monsoon pattern - Northeast Monsoon ([NEM] from December to March), Inter monsoon and Southwest Monsoon ([SWM] from June to October) - Sri Lanka has two main cultivation seasons called "Yala season" (from April to September) and "Maha Season" (from October to March). Most of the agricultural lands are in the dry zone of the country where water availability is naturally low and more than two-thirds of the annual rainfall is received during the Maha season (Amarasinghe, Mutuwatta, & Sakthivadivel, 1999). With the changing climate, the water scarcity in the dry zone is likely to become more critical. Hence, the study focuses on assessing the availability of water resources in the dry zone as a preparedness for the consequences of climate change in the future.

Climate Information

Precipitation and temperature are major climatic variables that influence the agriculture and crop production (IPCC, 1997; Kurukulasuriya and Ajwad 2007). According to the Intergovernmental Panel on Climate Change (IPPC), many water resources are being affected particularly by temperature

increases. According to Chandrapala 1996; Fernando and Chandrapala 1992 (as cited in Eriyagama & Smakhtin, 2010), annual mean temperature anomalies from 1871-1990 show a significant warming trend throughout Sri Lanka. Chandrapala (1996) shows (as cited in Eriyagama & Smakhtin, 2010) the rate of increase in temperature is 0.016 °C per year during the time period 1961 to 1990. As De Silva (2006) predicted, the average annual temperature is to be increased by 1.6°C - 1.2°C by the year 2050. With the increase of temperature, evaporation and evapotranspiration tend to be increased. The study carried on large reservoirs in Australia (Helfer, Lemckert & Zang, 2012) indicates the evaporation will be increased by 5.6% by 2050 due to 1oC temperature rise. According to De Silva (2007), crop evapotranspiration will be increased by 2% with 1.6°C increment of temperature by 2050.

Several authors have studied the rainfall pattern changes of Sri Lanka as a whole but a significant trend in country's Mean Annual Rainfall (MAR) has not been identified (Eriyagama & Smakhtin, 2010). However, MAR has decreased by 144 mm (7%) during 1961-1990 (Eriyagama & Smakhtin, 2010). Changes in the number of wet and dry days are another indication of climate change. A day can be identified as a "Dry Day", when certain levels of precipitation, which are stabilized based upon the planned activity, are not exceeded and a "Wet Day" when those levels are reached. Ratnayake & Herath (2005) and Premalal (2009) have published that the number of consecutive dry days has increased and the number of consecutive wet days reduced in the last decade indicating climate changes in Sri Lanka. Even though several efforts have been taken to predict the future precipitation pattern in Sri Lanka, there are contradictions in those projections. According to Basnayake and Vithanage (2004) (as cited in Eriyagama & Smakhtin, 2010), both South West Monsoon (SWM) and North East Monsoon (NEM) rainfall will be increased. De Silva (2006) suggests increase in SWM and decrease in NEM. On the other hand as cited in Eriyagama & Smakhtin, 2010, Basnayake, Rathnasiri and Vithanage in 2004 , elaborate decreases in both SWM and NEM.

Assessment of Climate Change Impacts

A case study was conducted on Ethimale Irrigation scheme in Monaragala district to assess the impacts of climate changes on a medium irrigation scheme in the dry zone. Ethimale Tank is a medium irrigation tank with a gross capacity of 5500 sq.mile, a catchment area of 24.6 km^2 and a total command area of 450.5 ha.

To study the future behavior of the reservoir, several climate change scenarios were developed because of the uncertainty associated with the future and the contradictions in the future rainfall predictions. For example, several studies predict an increase in Mean Annual Rainfall (MAR), while several studies reveal that MAR will be decreased. Two climatic variables; rainfall and temperature, were used to develop the scenarios considered under this study. Temporal and spatial variability of rainfall has a huge impact on country's agriculture. Therefore, seasonal changes of rainfall are considered under the study instead of MAR. Several future predictions (for year 2050 or beyond) on temperature and rainfall of Sri Lanka were collected through a literature survey. Increase in both

NEM and SWM, increase in SWM while NEM decrease and decrease in both NEM and SWM are the most concerned seasonal changes in the literature. Hence, these three possibilities are considered in the scenarios below. In addition to that, one month delay in occurrence of both monsoon periods was considered in the study. Changes of those variables in year 2050 were estimated, considering 2016 as base year and assuming linearity of the selected climate change predictions. The following four scenarios were developed using the estimated percentages.

Scenario 1 – Evaporation will increase by 9 % due to 1.6 °C increment of temperature. NEM will increase by 32% and SWM will increase by 40%.

Scenario 2 – Evaporation will increase by 9 % due to 1.6 °C increment of temperature. NEM will decrease by 34% and SWM will increase by 38%.

Scenario 3 – Evaporation will increase by 9 % due to 1.6 °C increment of temperature. NEM will decrease by 30% and SWM will decrease by 30%.

Scenario 4 – Evaporation will increase by 9 % due to 1.6 °C increment of temperature. Monsoon will be delayed by a month.

The irrigation water demand calculations and reservoir water balance studies for the current situation and selected scenarios were carried out according to the Irrigation Design Guideline ([IDG] 1984). Reservoir water balance studies were carried out considering an annual cycle, The changes in SWM were also considered in the study, even though the tank is located in the Dry Zone, to identify the influences of changes of SWM on the water resources in Dry Zone. The irrigation demand was calculated considering 135 days paddy for Maha and 105 days paddy for Yala. Reservoir water balance equation can be written as;

$$I_t-(E_t+Se_t+Sp_t+ID_t)=S_t-S_{t-1}$$

where *t* is considered as time steps in month; *I* is the inflow which is only from rainfall runoff; *E* is the evaporation from the water surface; *Se* is the seepage from the tank bottom; *Sp* is the monthly spill; *ID* is the irrigation demand; *S* is the storage of the tank.

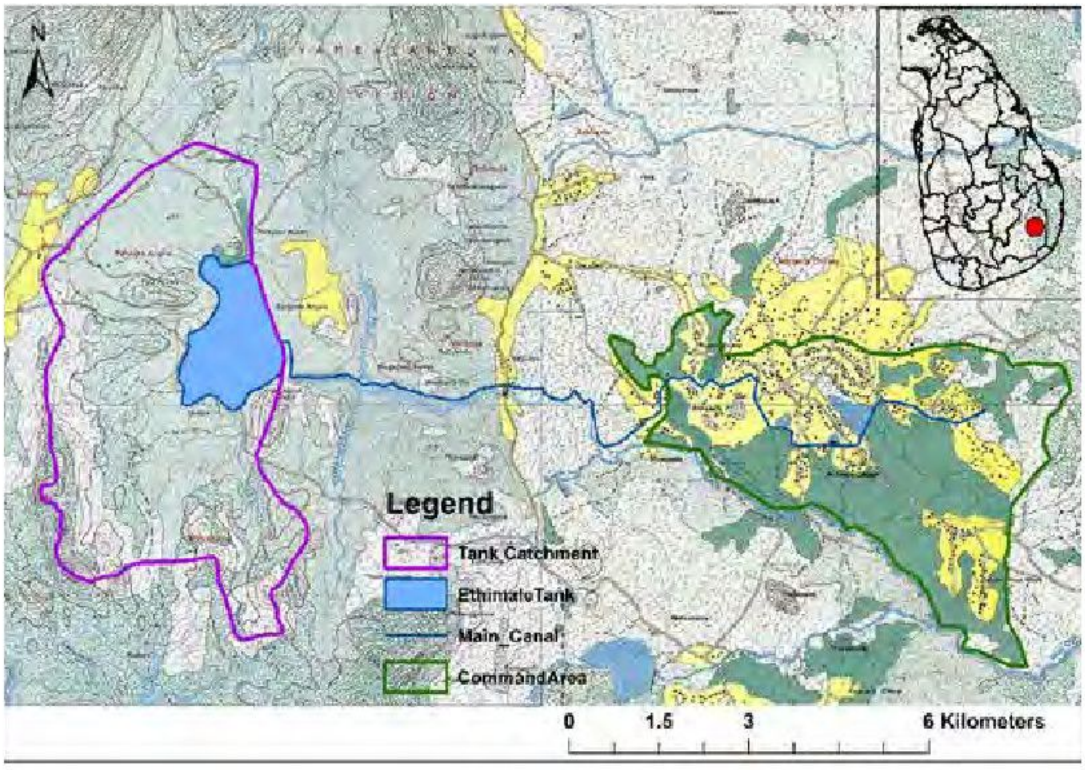

Figure 1 : Study Area

It was observed that Maha irrigation demand increases by 17%, 14% and 4% for scenario 2, 3 and 4 respectively, while the Maha irrigation demand for scenario 1 decreases by 13%. Scenario 3 shows the highest increment in Yala irrigation demand by 4%. The results show that 100% of the command area can be cultivated under each and every scenario. The highest cropping intensity would be expected under scenario 1 and the lowest would be expected under scenario 2. According to the results, it would be possible to expand the Yala cultivation extent by 10% under scenario 1, whereas the same extent possibly will be decreased by 40% and 32.5% respectively for scenario 2 and 3. It was observed that the scenario 2 gives the highest reduction of 11.4 % in crop yield, while crop yield decreases by 9.3% and 7.1% respectively under scenario 3 and 4. Under the scenario 1 the crop yield would be increased by 2.9%.

The tank does not have any spillage under scenario 2, 3 and 4. The tank spills only under scenario 1 with a total spill height of 1.09m, which will not result in a flood situation as per the infrastructure performance assessment. The total monthly volume that can be released through the single sluice gate of the tank is 600 Ha.m which is greater than the maximum monthly water demand under each scenario.

The critical scenario was identified considering the demand requirement, Cropping intensity and yield. Therefore, the scenario 2 can be identified as the most critical scenario while the scenario 3 is in the second and scenario 4 is in the third. The critical scenario clearly indicates that the changes in NEM are more critical than the changes in SWM, for the water resources management in dry zone.

However, the scenario 1 does not identify as critical at all because it gives higher cropping intensity, yield and lowest irrigation water requirement and also does not cause floods in the area.

Assessing Adaptation Measures

The results clearly indicate that the climate change has impacts on water resources of Ethimale scheme, hence, the agriculture and the food production of the system will be vulnerable to climate change. This situation would result in several socio economic concerns such as poverty, food scarcity, water scarcity etc. The livelihood of the population in the system mainly depends on the agriculture, but it will be very difficult at least to maintain the existing cultivation extent under climate change and, again, with the increased population the demand will be high for food, water and employment. Hence, to fulfill future demand without making unnecessary stress within the irrigation system, it is necessary to plan and implement adaptation measures at present. The study reveals the water demand decreases by 2% and cropping intensity increases by 26% under scenario 2, if the Minimum Operating Level (MOL) is reduced by 0.1m. However, the MOL reduction can be considered as a low regret adaptation measure, since there is no requirement of such action at present. Crop diversification on the other hand, is considered as a "no regret" measure, since it will be good practice even under the current situation, if the proper crops were introduced to the system. The crop which requires lesser water content than paddy and which generates sufficient income to the community can be introduced to the system to increase cropping intensity and to decrease the water demand in the system. The study reveals, using 105 days paddy for Maha and 105 days paddy and soya beans combination for Yala will increase cropping intensity by 25% and will decrease total water demand by 1.65%. However, the success of this option depends on the selection of the crops, farmer's willingness to shift to different crops and the income generated by the option. The reduction in water losses will be a proper adaptation measure. Storing more water during the rainy season will ease the scarcity of water. Storage enhancement and rainwater harvesting can be pointed out as better water capturing methods for the system, however, a comprehensive study should be carried out to identify the possibility of the storage enhancement.

Conclusion

The study clearly demonstrates the water resources in the Ethimale scheme will be affected by climate change causing serious impacts on food production, water availability, livelihood and economy of the system. Under scenario 2, 3 and 4, climate change will be likely to increase water demand, decrease yield and cropping intensity, while shrinking water supplies. According to the results, the cropping intensity can be increased by 25% by adapting to crop diversification (using the crops described in the paper). Since the livelihood of the majority of the population in the scheme depends on the agriculture, it is necessary to take adaptation measures as soon as possible. The study suggests several adaptation options such as reduction of MOL, crop diversification, efficiency improvements, storage enhancement etc. However, the selection of adaptation measures is a decision of the policy makers, which should be followed by a comprehensive study.

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Impacts, vulnerability and Adaptation of the Mangrove Ecosystems for Climate Change

M. G. Manoj Prasanna

Air Resource Management & National Ozone Unit,
Ministry of Mahaweli Development and Environment
mprasanna74@yahoo.com

Mangrove ecosystems have the ability to sequestrate more carbon per hectare than any other tropical forest. Therefore, degradation of mangrove ecosystems will result in the loss of carbon reserves. Sri Lanka has less than 0.23% mangroves out of the total land area, indicating the necessity to take conservation action.

Introduction

Global climate change is likely the greatest challenge which is faced by society this century. Although geological records show climatic changes throughout history, the present rate of global warming threatens the survival of all ecosystems. Coastal ecosystems are more vulnerable to these changes, and among the most highly affected ecosystems are the mangroves, coral reefs, and salt marshes (Khan, *et al*., 2012). Climate change components that affect mangroves include changes in sea level, high water events, precipitation, temperature, atmospheric CO_2 concentration, ocean circulation patterns and health of functionally linked neighboring ecosystems (Gilman, 2008). Of all outcomes, from changes in atmospheric composition to alterations of land surface, relative sea level rise may be the greatest threat to mangrove ecosystems (Khan, *et al.*, 2012).

Despite the exceptionality of mangroves to adapt to the intertidal and hard environmental conditions, they are mostly consisting of a group of salt-tolerant plant communities which are adapted to grow in estuaries, lagoons and sheltered sea coasts of tropical and subtropical regions (Mitra, 2013). Based on both macro and micro fossil records, it is evidenced that they have evolved in the late cretaceous or early tertiary around the Tethys Sea (Ellision *et al*., 1999) and considered to have originated after the first angiosperms, around 114 million years ago (Duke, 1992). In spite of its ability to fix a greater amount of CO_2 via photosynthesis which is similar to the action of phytoplankton in the tropical oceans (Kathiresan and Bingham, 2001), mangroves are classified among the most carbon rich forest ecosystem in the tropics. Moreover, the issues such as emission of green house gases and global warming can be addressed to mitigate the atmospheric CO_2 levels. In addition, they can tolerate these climate changes to some extent (Alongi, 2015) because of their physically and geologically dynamic intertidal environment which is primarily based on the interface between land and sea in the low latitudes.

Mangrove ecosystems are not only home to a wide variety of flora and fauna but they provide numerous benefits for local human communities which are known as ecosystem services. Mangrove ecosystems provide more than 70 direct benefits to mankind ranging from fuel wood collection to fisheries (Kathiresan, 2015) excluding other numerous socio economic benefits (Aksornkoae, 1993). The main and presently important ecosystem service is high carbon sequestration ability and productivity of this ecosystem. Comparatively mangrove ecosystems are the most productive ecosystems on earth more than all other tropical ecosystems, which is also 20 to 50 times greater than the average oceanic production (Mitra, 2013) and other tropical forests (Kathiresan, 2015) respectively.

Mangrove ecosystems are considered as the most carbon rich forest type among the tropics (Kathiresan, 2015). They store large quantities of organic carbon above and below ground (Shamsudin *et al.*, 2007). Mangrove ecosystems can sequestrate more carbon per hectare than other tropical forests such as rain forests and marshes. Due to their higher ability of storing large amounts of carbon, it was ranked as one of the most carbon rich ecosystems in the world (UNEP, 2014). In addition, the mangrove eco systems are able to store approximately 1000 tons per hectare over thousands of years (UNEP, 2014), and many researchers have confirmed that the mangroves are able to sequestrate carbon 50 times greater than other tropical ecosystems (Kathiretion, 2015).

It was estimated that the total above ground biomass of mangrove forests all over the world may be over 3700 trillion grams of carbon (Tg) and the direct sequestration of organic matter in to mangrove sediments is in the range of 14 -17 Tg of carbon per year (Kathiresan, 2015). It was reported that the soil from 0.5m to 3m in depth in the mangrove ecosystem is responsible for the storage of 49% - 98% of carbon. Thus, mangroves are capable of accumulating and storing carbon in the soil in large quantities, the mangrove ecosystem may have an important role to play in global carbon budgets and in the process of mitigating climate change. Loss of mangroves will affect the global C budgets significantly by losing stored C reserves which were fixed and stored by mangroves over a long time. Cebrain, 2002, concluded that a loss of about 35% of the global mangrove resulted in a net loss of 3.8 X 1014 g C which was stored as mangrove biomass (Kathiresan, 2015).

Threats and Issues

Mangrove habitats harbor much of the world's tropical biodiversity. Presently, 50% of the world's mangrove forests have been lost as a result of clearing and alteration of coastlines. Present global extensions of mangroves have been recorded as 15.2 million hectares (Pawar, 2012). Extreme climate change events such as sea level rise, changing ocean currents, increased storminess, increased air temperature, changes in precipitation and increased atmospheric CO_2 can cause extensive impact on mangrove ecosystems (Ward, *et al.*, 2016). All these factors are inter-related and affect the climate, geomorphology, biodiversity, forest structure and tidal range (Ward *et al.*, 2016).

1. A typical mangrove ecosystem 2. Densely grown stilt roots of *Rhizophora sp.* 3.Organic matters collected from mangrove soil. (Photographs by Manoj Prasanna)

Impact of Sea Level Rise on Mangroves

The global sea-level rise is one of the more certain outcomes of global warming and climate change which creates vast threats to mangrove ecosystems since the mangroves are sensitive to changes in inundation duration and frequency as well as salinity levels that exceed a species-specific physiological threshold of tolerance (Friess, *et al.*, 2012). Excessive flooding can lead to shoot or plant death at the seaward mangrove margins as well as shifts in species composition (Gilman, *et al.*, 2008), which ultimately leads to a reduction in productivity and ecosystem services. Mangroves have considerable resilience to fluctuations in sea level due to their ability to actively modify their environment through surface elevation change processes, and their ability to migrate inland over successive generations. Positive surface elevation change is influenced via the inputs of autochthonous and allochthonous organic matter as well as the trapping and retention of inorganic sediments and subsurface compaction (Ward, 2016).

However, the coastal development, human settlements and other anthropogenic activities have disturbed this natural process.

Impact of Storms and Hurricanes

Mangrove species possess physiological and biological characters that increase resilience to the damage caused by storms. These characters include large nutrient reserves, rapid nutrient turnover rates, and plant characters such as tolerance to inundation and salinity in some species (e.g., Avicennia *spp.*, Rhizophora *Spp.*). However, hurricanes and cyclones can substantially impact mangroves through wave activity at the seaward margins uprooting trees and the wind damaging branches and defoliating the canopy, but in extreme cases, these scenarios can lead to complete removal, or large-scale loss of the mangrove forests (Ward, *et al.*, 2016).

Impacts of Heavy Precipitations

Both extreme changes of precipitations such as heavy rains and droughts are likely to influence the distribution, extent and growth rates of mangrove forests. For example, extreme changes in rainfall may alter seasonal average salinity in the mangrove systems, although this will vary between fringe, estuarine and interior mangroves. Precipitation decreases and evaporation increases can lead to serious increases in water levels in soils and the affected soil salinity and resultant decreases in seedling survival, productivity, growth rates and resultant mangrove loss and conversion to hyper saline mudflats or salt marshes in the inter tidal zone. On the other hand, in high rain falls are also linked to a subsequent increase in mangrove area as a result of the landward migration of mangroves into the salt marsh or the mud flats which are occurring at the landward boundary of the mangrove ecosystems (Ward, *et al.*, 2016).

The responses to increases in rainfall could be favourable to the low saline loving species such as *Sonneratia* and *Brugieira*. They show high growth rates in response to increase in precipitation. Long term rainfall may change the species diversity, structure and species composition and the zonation pattern of the mangrove ecosystems. Increased precipitation can also result in decreased pore water salinity and sulfate concentration, which can increase mangrove productivity (Gilman *et al.*, 2007). Precipitation increases are also likely to increase riverine discharge, which in estuarine mangroves will increase allochthonous sediment inputs, mangrove surface elevation, and resilience to sea level rise (Ranasinghe, 2010).

Global Temperature Increase

Global temperatures are predicted to increase up to 4.8° C by 2081–2100 relative to 1986–2005 (IPCC, 2013, RCP8.5). This temperature increase is likely to influence mangrove species composition, phenology, productivity, and ultimately the latitudinal range of their distribution. At present, many mangroves are confined by minimum air temperature of the coldest month by 16° C (Saenger 2002)

in the tropical and few sub-tropical areas, but according to the predicted global warming patterns it will be distributed all over the world.

As in all other wetland ecosystems, mangrove ecosystems also emit a small amount of methane (CH_4) to the atmosphere. It is a greenhouse gas but when compared to the amounts of carbon sequestrations by the Mangrove ecosystems it is negligible. According to the research results of Purvaja and Ramesh (2000), which were conducted at Pichchawaram estuary in South India, the preliminary CH_4 emission estimates for the mangrove ecosystems along the Indian sub- continent and the tropical and subtropical coastline of the world by linear extrapolation was based on a surface area range of 0.05 to 0.37 and 2.8 to 19.25 Tg CH_4 year−1 respectively. Some research results also highlight the impact of human activities on future emission of methane from the mangrove ecosystems (Purvaja and Ramesh, 2000).

However, mangroves in Sri Lanka show a scattered distribution around the country in areas bordering lagoons and estuaries (Bambaradeniya, *et al.*,2002) which is a total extent of 15,670 ha and a proportion of less than 0.23% from total land area (Edirisinhe, 2012). Therefore, this is the time to conserve rehabilitation of mangrove ecosystems in the world to mitigate the climate change.

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දේශගුණික විපර්යාස වල අහිතකර බලපෑම් වලට අනුහුරුවීමේ (Adaptation) කටයුතු ජාතික සංවර්ධනයට සහ සැලසුම්කරණයට අදාළ කර ගැනීම

K.K. Shyamalie Priyanthi

Climate Change Secretariat, Ministry of Mahaweli Development and Environment
shyamalipri@yahoo.com

දේශගුණ විපර්යාස මගින් පරිසරයට හා මිනිසා ඇතුළු මුළු මහත් සත්ව ප්‍රජාවට ඇතිකරනු ලබන අහිතකර ප්‍රතිවිපාක වලට අද අපි මුහුණපාමින් සිටිමු. එමගින් රටක පාරිසරික සමාජ සහ ආර්ථික යන සියළු අංශයන්ට දැඩි අහිතකර බලපෑමක් ඇතිවේ. රටකට මෙම බලපෑම් වලින් පූර්ණ වශයෙන් බැහැරවීම කිසිසේත් ප්‍රයෝගික කටයුත්තක් නොවන අතර ඒ සඳහා විසඳුමක් ලෙස එම අහිතකර බලපෑම් වලට අනුහුරුවීම මේ සඳහා ඇති එක් විකල්ප ක්‍රියා මාර්ගයක් වේ. දේශගුණ විපර්යාස හේතුවෙන් ඇතිවන අවදානම ඇගයීම (Vulnerability Assessment) අනුහුරුවීම සම්බන්ධ ක්‍රියාමාර්ග නිශ්චය කිරීම සඳහා පදනමක් වන අතර එමගින් ලබාගන්නා තොරතුරු රටක සංවර්ධන ප්‍රතිපත්ති හා සැලසුම් ක්‍රියාවලියට අන්තර්ග්‍රහණය කිරීමේ වැදගත්කම මෙම ලිපියෙන් සාකච්ඡා කෙරේ.

දේශගුණ විපර්යාස මගින් ඇති කරන බලපෑම්

මානව ක්‍රියාකාරකම් වල ප්‍රතිඵලයක් වශයෙන් සිදුවන මිහිතලය උණුසුම්වීම හා එමගින් ඇතිවන දේශගුණ විපර්යාස හේතුවෙන් ගෝලීය පරිසරයට හා මිනිසා ඇතුළු මුළු මහත් සත්ව ප්‍රජාවට ඇති කරනු ලබන අනිටු බලපෑම පිළිබඳව අද වැඩි දෙනාගේ අවධානය යොමුවී ඇත. පසුගිය දශක ගණනාවක සිට එමගින් ඇතිකරනු ලබන අහිතකර ප්‍රතිඵල අප ද අද අත්දකිමින් සිටී. ඒ අනුව සාමාන්‍ය උෂ්ණත්වය ඉහළයාම, වර්ෂාපතන රටාවෙහි ඇතිවන වෙනස්කම්, මුහුදු ජල මට්ටම ඉහළ යාම, ආහාර නිෂ්පාදනයට වන බලපෑම්, ජලයේ ගුණාත්මක හා ප්‍රමාණාත්මක තත්ත්වයන්ට වන බලපෑම්, මහජන සෞඛ්‍යය ගැටළු වැඩිවීම, ආන්තික කාලගුණික තත්ත්වයන් නිසා ඇතිවන දරුණු නියගයන්, ගංවතුර සහ නායයාම් වැනි ස්වභාවික ආපදාවන් දැක්විය හැක. එම තත්ත්වයන් වඩාත් සුලභ වෙමින් හා තීව්‍ර වෙමින් පවතින අතර එමගින් ජන ජීවිතයට, දේපල වලට හා ස්වභාවික පරිසර පද්ධති වලට සිදුවූ හානි වැනි අප මෑත භාගයේදී මුහුණ දුන් සංසිද්ධීන් මේ සඳහා උදාහරණ ලෙස දැක්විය හැකිය. මෙවැනි හානි වීම් යථා තත්ත්වයට පත්කිරීම සඳහා රජයට දැරිය යුතු වන පිරිවැය ද දිනෙන් දින වැඩි වෙමින් පවතින අතර දේශගුණ විපර්යාස වලින් ඇතිකරන අහිතකර බලපෑම් රටෙහි පාරිසරික තත්ත්වයන්ට පමණක් නොව එය රටෙහි ජන සමාජයට, ආර්ථිකයේ විවිධ ක්ෂේත්‍ර වලට හා සංවර්ධන ක්‍රියාවලියට ද අහියෝගයක් එල්ල කරයි.

දේශගුණ විපර්යාස පිලිබඳ අවදානම් ඇගයීම (Vulnerability Assessment)

ඉහත දැක්වුණු දේශගුණ විපර්යාස වල අහිතකර බලපෑම් නිසා රටක හෝ යම් පරිසර පද්ධතියක හෝ යම් අංශයක සමාජ, ආර්ථික හා පාරිසරික තත්ත්වයන්ට අවදානමක් (Vulnerability) ඇතිවේ. මේ වන විට ශ්‍රී ලංකාවට මෙන්ම ලෝකයේ බොහෝ රටවල් වලට දේශගුණ විපර්යාස මගින් ඇතිකරනු ලබන අහිතකර බලපෑම් වල අවධානම වැඩිවීම හා ඒ සඳහා අනුහුරුවීමේ අවශ්‍යතාව අද වඩාත් ප්‍රබල ලෙස දැනෙන්ට පටන් ගෙන ඇති අතර මේ සඳහා අනුහුරු වීමේ ක්‍රියාමාර්ග ගැනීම කාලීන අවශ්‍යතාවයක් බවට පත් වී

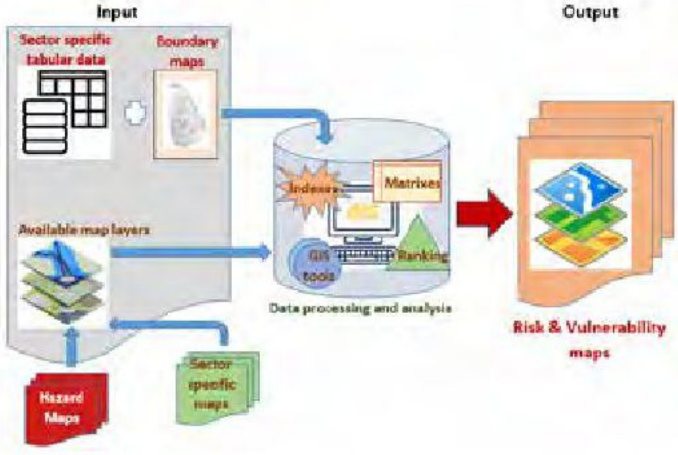
ඇති දේශගුණ විපර්යාස පිළිබඳ අවදානම් ඇගයීම් සිදුකිරීම මෙම අනුහුරුවීමේ ක්‍රියාමාර්ග ගැනීම සඳහා පදනමක් ලෙස භාවිතා කළ හැකිවේ. එනම් රටක හෝ යම් පරිසර පද්ධතියක හෝ යම් අංශයක හෝ එහි පාරිසරික, සමාජ, ආර්ථික මෙන්ම යටිතල පහසුකම් වැනි අංග වලට දේශගුණ විපර්යාස මගින් ඇතිකරනු ලබන අහිතකර ප්‍රතිවිපාක ඇගයීමක් සිදුකිරීම, ඒ සඳහා අනුහුරු වීමේ කටයුතු වලට අදාල තීරණ ගැනීමට, ක්‍රියාමාර්ග ගැනීමට මග පෙන්වීමක් වේ.

"රටක යම් ප්‍රජාවකට හෝ ක්ෂේත්‍රයකට හෝ ප්‍රදේශයකට දේශගුණ විපර්යාස මගින් ඇතිවිය හැකි ප්‍රතිවිපාක, අවදානම හා අහිතකර බලපෑම් වලට මුහුණදීමට ඇති හැකියාව විශ්ලේෂණය කිරීම" අවදානම් ඇගයීම ලෙස දැක්විය හැකිය.

මෙම අවදානම් තත්ත්වය හඳුනා ගැනීම සහ නිර්ණය කිරීම සඳහා එක් එක් ක්ෂේත්‍රයන් දේශගුණ විපර්යාස මගින් ඇතිකරනු ලබන අහිතකර ප්‍රතිවිපාකයන්ට නිරාවරණය වන මට්ටම (Exposure) එහි සංවේදීතාවය (Sensitivity) හා අහිතකර බලපෑම් වලට මුහුණදීමට ඇති හැකියාව (Adaptive Capacity) වැනි සංරචකයන් මත තීරණය වන අතර ගණිතමය වශයෙන් ඒ සඳහා පහත දැක්වෙන සමීකරණය උපයෝගී කර ගැනේ (McCarthy *et.al*., 2001)

Vulnerability = f(Exposure, Sensitivity, Adaptive capacity)

මෙම අවදානම ඇගයීම සඳහා එක් ක්‍රමවේදයක් ලෙස දර්ශක ප්‍රවේශය (Indicator Approach) භාවිතා කළ හැකිය. ඒ අනුව මෙම අවදානම් ඇගයීම ඉහත සඳහන් කළ සංරචකයන්ට බලපාන සාධක රැසක සාපේක්ෂ ප්‍රතිඵලයක් වේ. මෙහිදී එක් එක් ක්ෂේත්‍රයන්ට සම්බන්ධ ඉහත සඳහන් කළ සංරචකයන්ට අදාල වන විචල්‍යයන් හඳුනාගෙන ඒ හා අදාල දත්ත හා තොරතුරු රැස්කොට එම විචල්‍යයන් සඳහා ලැබෙන විවිධ අගයන් සාමාන්‍යකරණය (Normalization) කිරීම හා ඒවායේ අදාලත්වය හා වැදගත්කම අනුව එම විචල්‍යයන් බර තැබීමක් (Weighting) සිදුකෙරේ. එමගින් ලැබෙන ප්‍රතිඵල සංඛ්‍යාන හා සිතියම්, විද්‍යාත්මක ක්‍රම අනුසාරයෙන් දේශගුණ විපර්යාස වල අහිතකර බලපෑමේ අවදානමට ලක්වන ක්ෂේත්‍ර හා ප්‍රදේශ පුරෝකථනය කිරීමත් භූගෝල විද්‍යා තොරතුරු පද්ධති (Geographical Information System) අනුසාරයෙන් ඒ හා අදාල සිතියම් නිර්මාණය කිරීමත් මෙමගින් සිදුකෙරේ.



මෙම අවදානම ඉහත සඳහන් කළ සංරචක තුනෙහිම සාමාන්‍ය ප්‍රතිඵලයක් ලෙස නිර්වචනය කරනු ලබයි. ඒ අනුව දේශගුණ විපර්යාස වල අහිතකර ප්‍රතිවිපාකයන්ට නිරාවරණය වන මට්ටම වැඩි වන විට හා ඒ සඳහා සංවේදීතාවය වැඩිවන විට අවදානම වැඩි වන අතර ඊට ප්‍රතිවිරුද්ධව අහිතකර බලපෑම් වලට මුහුණදීමට ඇති හැකියාව වැඩිවන විට අවදානම අඩුවේ. එම නිසා මෙම දේශගුණ විපර්යාස වලින් සිදුවන අහිතකර බලපෑම් වල අවදානම අඩු කිරීම සඳහා ඒ සඳහා නිරාවරණය වන මට්ටම අඩු කිරීමටත්. සංවේදීතාවයට හා අහිතකර බලපෑම් වලට මුහුණදීමට ඇති හැකියාව වැඩිකිරීමටත් පියවර ගැනීමට සිදුවේ.

දේශගුණ විපර්යාස පිලිබඳ අවදානම් ඇගයීමේ ප්‍රයෝජන

මෙම දේශගුණ විපර්යාස හේතුවෙන් ඇතිවන අවදානම ඇගයීම දේශගුණ විපර්යාස මගින් ඇතිකරන අහිතකර බලපෑම් හඳුනාගැනීමටත් එමගින් ඇතිවන ප්‍රතිවිපාකයන්ට හැඩගැසීම සඳහා වූ තොරතුරු ලබාග ැනීමටත් ප්‍රයෝජනවත් වේ. එසේම මෙම අවදානම් ඇගයීම දේශගුණ විපර්යාස මගින් ඇතිකරන අහිතකර ප්‍රතිවිපාකයන්ට අනුහුරුවීම සඳහා කේන්ද්‍රීය සංරචකයක් වේ. එසේම මෙම අවධානම් ඇගයීම, දේශගුණ විපර්යාස මගින් ඇතිකරන අහිතකර ප්‍රතිවිපාකයන්ට අනුහුරුවිම සඳහා කුමක්, කෙසේ කළ යුතු ද යන්න නිර්ණය කිරීමට අදාලව තොරතුරු ලබා ගැනීම සඳහා මෙවලමක් ලෙස භාවිතා කළ හැකිවේ. තවද මෙමගින් යම් පරිසර පද්ධතියක ස්වභාවික තත්ත්වය පිළිබඳ වටහා ගැනීමටත් එම පද්ධතිය හානියට ලක්වීම පිළිබඳ කොතරම් මට්ටමක අවධානමක් පවතීද යන්න පිළිබඳව අවබෝධයක් ලබාගැනීමටත් උපකාරී වන අතර එම හානිය වලක්වා ගැනීමට හෝ අවම කර ගැනීමට අවශ්‍ය ක්‍රියාමාර්ග ගැනීම සඳහා එමගින් මග පෙන්වීමක් සිදුකරයි.

එසේම මෙම අවදානම් ඇගයීම දේශගුණ විපර්යාස හා සම්බන්ධව කටයුතු කරන වෘත්තීකයන්ට හා තීරණ ගන්නන් හට, වඩා අවදානම් ප්‍රදේශ, ක්ෂේත්‍ර හා සමාජ කණ්ඩායම් හඳුනා ගැනීමටත් උපකාරී වේ. එලෙසින්ම මෙම අවදානම් ඇගයීම තුලින් දේශගුණ විපර්යාස මගින් ඇතිකරන අහිතකර බලපෑම් වලට අනුහුරුවීමේ විශේෂිත ඉලක්ක ගත විකල්ප සංවර්ධනය කිරීමටත්, ඒවා ක්‍රියාත්මක කිරීමටත් අවස්ථාව සලස්වයි. ඒ අයුරින්ම මෙම දේශගුණ විපර්යාස හේතුවෙන් ඇතිවන අවදානම ඇගයීම, දේශගුණික විපර්යාස පිලිබඳ අවධානමක් ඇති ව්‍යාපෘති නිරාවරණය කර ගැනීමේ ක්‍රියාවලියට (Climate Risk Screening Process) මෙවලමක් ලෙස යොදා ගැනීමට ද හැකියාව ලැබේ.

අවදානම් ඇගයීම අනුහුරුවීමේ ක්‍රියාකාරකම් සඳහා අදාල කර ගැනීම

රටක එහි වෙසෙන ජනතාවගේ ජීවන තත්ත්වය නගා සිටුවීම සඳහා සංවර්ධනය අනිවාර්ය අංගයක් වන අතර එම සංවර්ධන ක්‍රියාදාමයේදී දේශගුණ විපර්යාස මගින් ඇතිකරන අහිතකර ප්‍රතිවිපාක පිළිබඳව අවධානය යොමු කිරීම අද කාලීන අවශ්‍යතාවයක් බවට පත්වී ඇත. රටක තිරසාර නොවන ආර්ථික සංවර්ධනයට දිර්ඝකාලීන පැවැත්මක් නොමැති බව අද තහවුරු වී ඇත. "තිරසාර සංවර්ධන" සංකල්පය අද ලොවම පිළිග න්නා අතර එය සාක්ෂාත් කර ගනු වස් එහි සංරචකයන් වන ආර්ථික, සමාජ හා පරිසර යන ක්‍රිත්වයන් පිළිබඳව දැඩි සැලකිල්ලක් යොමු කර ඇත.

ඒ අනුව දේශගුණ විපර්යාස වල අහිතකර බලපෑම් වලින් ජාතික සංවර්ධන ඉලක්ක අඩාල වීමට පවතින ඉඩකඩ අවුරා තැබීමට හෝ සංවර්ධන කටයුතු අඛණ්ඩව ක්‍රියාත්මක කිරීම සඳහා දේශගුණ විපර්යාස සඳහා අනුහුරුවීමේ ක්‍රියාකාරකම් ජාතික සංවර්ධනයට සහ සැලසුම්කරණයට අන්තර්ග්‍රහණය කිරීමේ ඒකාබද්ධ ප්‍රවේශයක අවශ්‍යතාවය අද අත්‍යාවශ්‍යයෙන්ම ඉස්මතු වී ඇත. ඒ අනුව ආර්ථික සැලසුම් සකස් කිරීමේදී,

සංවර්ධන ව්‍යාපෘති සැලසුම් පිළියෙල කිරීමේදී දේශගුණ විපර්යාස මගින් රටක සමාජ, ආර්ථික හා පරිසරයට ඇතිකරන අහිතකර බලපෑම් සැලකිල්ලට ගතයුතු වන අතර ඒ සඳහා තීරණ ගැනීමට මෙම දේශගුණ විපර්යාස හේතුවෙන් ඇතිවන අවදානම ඇගයීම අනිවාර්ය අංගයක් වේ.

එලෙසම ජාතික සංවර්ධන ප්‍රතිපත්ති සකස් කිරීමේ ක්‍රියාවලියේදී දේශගුණික විපර්යාස වලින් ඇතිකරනු ලබන බලපෑම් පිලිබඳ තොරතුරු අන්තර්ග්‍රහණය කිරීම තුලින් ප්‍රජාව තුළ දේශගුණික විපර්යාස වල අහිතකර බලපෑම් වලට මුහුණදීමට ඇති හැකියාව වැඩිදියුණු කිරීමට අවස්ථාව සැලසෙනු ඇත.

ඒ අනුව දේශගුණ විපර්යාස හේතුවෙන් ඇතිවන අවදානම ඇගයීම ශ්‍රී ලංකාවට අනාගතයේදී සිදුවිය හැකි දේශගුණික විපර්යාස වල අහිතකර ප්‍රතිවිපාක වලට හා අභියෝග වලට මුහුණ දීමට දරණ ප්‍රයත්නයට දායක වනු ඇත. මෙම අවදානම් ඇගයීම වෙනුවෙන් විශේෂ අවධානයක් යොමු කළ යුතු වන අතර එමගින් සොයා ගන්නා වූ තොරතුරු වලට අනුව, දේශගුණ විපර්යාස වල අහිතකර ප්‍රතිවිපාකයන්ට අනුහුරුවීම, ජාතික සංවර්ධනයට සහ සැලසුම්කරණයට සම්බන්ධව ගන්නා වූ තීරණ වලට අන්තර් ග්‍රහණය කළ යුතු වේ. එමගින් අප රටට, ජනතාවට හා සියළු සත්ව හා ශාක වර්ගයන්ගේ පැවැත්ම තහවුරු කරනු වස් ජාතික මට්ටමේ හා ප්‍රාදේශීය මට්ටමේ තීරණ ගැනීම සඳහා දායක වනු ඇත. ඒ අනුව ශ්‍රී ලංකාව තුළ තිරසාර සංවර්ධනය තහවුරු වනු ඇත.

නිගමනය

මිනිසා විසින් ඉවක් බවක් නොමැතිව වා තලයට මුදා හරින හරිතාගාර වායු වැඩිවීම හේතුවෙන් වර්තමානයේදී මිනිසාට මුහුණ දීමට සිදුවී ඇති දේශගුණ විපර්යාස වල අහිතකර ප්‍රතිවිපාක වලට අනුහුරුවීම සඳහා රටක් වශයෙන් අනුහුරුවිමේ ක්‍රියාමාර්ග ගැනීමටත්, දේශගුණ විපර්යාස මගින් රටක සමාජයට, ආර්ථිකයට හා පරිසරයට ඇතිකරන අහිතකර බලපෑම්, රටක ආර්ථික සැලසුම් හා සංවර්ධන ව්‍යාපෘති සැලසුම් වලට අන්තර්ග්‍රහණය කිරීම සඳහා පදනමක් ලෙස දේශගුණ විපර්යාස පිලිබඳ අවදානම් ඇගයීම යොදාගත හැකිවේ. එමගින් රටක ජනතාවගේ හා සියළු සත්ව හා ශාක වර්ගයන්ගේ පැවැත්ම තහවුරු කරනු වස් ජාතික මට්ටමේ හා ප්‍රදේශීය මට්ටමේ තීරණ ගැනීම සඳහා දායකත්වයක් මෙම අවදානම් ඇගයීම තුලින් ලැබෙනු ඇත.

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Sesame/ Thala (*Sesamum indicum L.*): a Potential Crop to Meet Challenges of Climate Change in Sri Lanka

Jinendra Dissanayake*, Sudheera Ranwala

Department of Plant Sciences, University of Colombo, Colombo 03
*jinenkd@yahoo.com

Better understanding of crop responses to short and long-term drought conditions contribute to developing of strategies for a climate change adaptation, sustaining economy and well-being of rural farmers. It was proven that different varieties/ cultivars of Sesame (Gingelly/ Thala) do not show a yield penalty when grown under drought conditions despite its difference in early growth responses.

Drought is the Most Frequent Natural Disaster in Sri Lanka

Climate change in Sri Lanka has brought about frequent and prolonged drought events over the last century causing severe damages to agricultural crops (MDM & WFP 2016; Gunda *et al.*, 2016). Food security is further challenged if drought events are frequent and intensified. Climate models forecast that the country's entire dry zone is markedly susceptible to drought during Yala season, while only the extreme localities in south-eastern and north-western regions are likely to be affected in Maha season (Chithranayana & Punyawardena 2009). Hence, dry zone of Sri Lanka is considered as a high priority area in drought mitigation plans and national development agenda (UNDP, 2012).

Drought Adaptation Strategies in Agriculture

Crop diversification, integration of climate models into crop, land and water management plans, choosing the best sowing dates and breeding and adopting of drought resistant varieties/ cultivars are the best agricultural practices suggested for drought mitigation plans (FAO, 2016). In this regard, availability of knowledge on crop performance in response to drought conditions is of paramount importance to screen the best yielding crops.

Different crops respond differently to given drought conditions, hence it is crucial to study drought effects on crops. Such work has already been extensively researched and insights have been made to develop new drought resistant varieties for major crops such as Rice, Wheat, Soy, Sorghum, Barley, and Maize, but many other economical crops are yet to be comprehensively studied.

Sesame : The Queen of Oil Seed Crops

Sesame (*Sesamum indicum* L., Family Pedaliaceae), also known as gingelly, is one of the most ancient oil crops, grown mainly in dry regions of the world. It is also a major oil seed crop cultivated in Sri Lanka. At present, Sesame is grown at different scales in 23 districts of which 14 belong to the dry zone and the total extent of land under Sesame cultivation remains around 13,120 ha at present (Socio Economic and Planning Centre 2014). Different Sesame varieties/ cultivars are being cultivated in different parts of the island. For instance, white seeded Sesame cultivars are mainly grown in Hambanthota (South-eastern) especially, in Yala season. Black seeded cultivars are commonly cultivated in Puttalam and Mannar districts (North-western) of the country, mainly in Maha season.

Sesame seed is a popular raw material in the confectionary industry and it is also being used for extracting vegetable cooking oil. Sesame oil is applied for enhancing skin fairness and healthiness. Both seeds and oil are used for culinary and medicinal purposes. Stems, roots, leaves, and seeds of Sesame plants are considered as valuables sources of medicines in the Asian indigenous medicinal industry (Jayaweera 1982; Ross 2007).

The international market for Sesame seeds has risen significantly and it has expanded by nearly 80% in the last 15 years (Hansen 2011). This is due to three major reasons: i) Sesame has high medicinal and nutritional value, ii) it is consumed in both oil and confectionary industries and iii) it yields high-grade oil with a high proportion of unsaturated fatty acids, protein content and antioxidants (Hegde 2012).

Investigating Drought Responses of Sri Lankan Sesame

A series of laboratory and field experiments were conducted on ten different Sesame varieties/ cultivars including Black seeded cultivars, improved cultivars (Uma and Malee), landraces (Idal and Pokuru) and its wild relatives to evaluate responses to simulated drought during germination and plant growth.

Sesame varieties were drought susceptible at a tension as high as -1.00 MPa during germination and seedling development stages. Amongst the tested varieties/ cultivars, improved cultivars (Uma and Malee) were shown to be the most drought tolerant at the germination stage and landraces (Idal and Pokuru) were the least susceptible to drought during seedling growth. Wild Sesame plants were highly sensitive to water deficit conditions during germination and seedling growth. According to Welbaum *et al.*, (1998), embryo cells accumulate solutes to increase in turgor pressure to overcome the resistance from surrounding tissues for radicle penetration during germination. A similar mechanism would have allowed Sri Lankan Sesame seeds to germinate in a water limited environment by facilitating water uptake through osmosis. In addition, seedlings of some Sesame varieties/ cultivars developed a morphological adaptation such as development of a deep root system to avoid drought stress.

Imposed drought conditions in the field revealed that Sesame showed a greater plasticity before they flower (vegetative period) in response to the simulated water stress levels. Drought treatments had a significant negative effect on plant height at maturity, plant root weight and root to shoot ratio. Drought effect on biomass partitioning was evident in mature plants of Sesame varieties/ cultivars as more biomass was reported in below ground parts than the above ground. Biomass partition is the process by which plants translocate their photosynthetic products (Photosynthates) among plant parts (above ground and below ground) and it occurs according to the function balance between the growth of these parts. However, yield parameters and the harvest index did not change among different drought intensities simulated. A significant varietal effect was also observed. Wild varieties showed a slow growth during the first two months and a significantly low yield, while significantly higher yields were reported from Uma, Malee, Idal, and Black seeded Sesame. Vegetative growth and yield performance of the tested Sesame varieties showed that it can tolerate low soil moisture content up to 81 % soil moisture depletion. Even though the vegetative growth of some cultivars (Black and Pokuru) was affected by the water deficit conditions, there was no negative difference reported on their yield.

Drought Tolerance of Sri Lankan Sesame

Findings of our studies have proven that Sri Lankan Sesame cultivars and wild varieties are well adapted to survive under the dry weather and show high tolerance to drought conditions. Studies in India and Pakistan by Garai & Datta (1999) and Nadeem *et al.*, (2015) have suggested that optimum Sesame yield can be obtained with only three irrigation events after planting. This is because drought tolerant plants optimize crop water uptake by allocating more biomass to roots during stress (Farooq *et al.*, 2012). Plants that increase root depth, root to shoot ratio and maintain water potential above that of the environment are termed as 'Water Spenders' (Bodner *et al*., 2015) and it is a morphological adaptation that plants develop to challenge drought stress.

Subject to the cultivar and developmental stages exposed to drought, Sesame expresses versatile morphological adaptations to survive drought including, but may not limited to, excessive root growth, maintaining high root to shoot ratio, reduced leaf area and stature, early maturity and high plasticity. In addition, increased cuticular wax deposition is evident in Sesame leaves grown in water limiting environments (Kim *et al.*, 2007). Furthermore, comprehensive studies conducted on Sesame plants of different genotypes to investigate the drought responses have shown that Sesame plants adapt various physiological strategies to survive drought periods and that include osmoregulation, antioxidant enzymatic defence systems, changes in plant water relations and increased chlorophyll b and total chlorophyll contents (Fazeli *et al.*, 2007; Mensah *et al*., 2009; Kadkhodaie *et al.*, 2014).

Promoting Sesame Cultivation in Sri Lanka

Nearly two-thirds of land mass in Sri Lanka is under the influence of dry weather. Hence, the findings on varietal resilience to drought stress are of immense importance to farmer and scientific

communities for selecting drought tolerant Sesame varieties for cultivation and scientific research. Besides improved cultivars (Uma and Malee), Pokuru, a landrace with great developmental plasticity, can be considered as a potential cultivar for cultivation in different regions. It also indicates the pressing need to conserve the genetic diversity of the tolerant local Sesame races and further improve their characteristics to obtain better harvest for Sesame. However, answers are also needed as to how drought tolerance could act upon the quality and quantity of Sesame oil content and other constituents, and disease resistance capacity of the cultivars. It will also be important to develop cultivars with indehiscent capsules or delayed dehiscence in capsules to lessen seed loss from firstly matured capsules. Due to its indeterminate nature of development, waiting for newly produced capsules at the top of the stem to mature causes a great loss in seeds from the already shattered capsules at the base.

Other than crop improvement, research on marketing development is also important at the national level to encourage farmers to engage in Sesame cultivation.

Conclusion

Drought is a major abiotic stress for crops that can be exposed to it at any time of the cultivation period. Due to climate change, more frequent and intense drought events are predicted to occur in future. Food production is already a challenge due to ever growing human population and limited availability of arable lands. Therefore, selection of suitable crops and cultivars is a key decision to make during cultivation. Sesame is a crop with multiple benefits providing substantial income to rural communities. Studies conducted on Sri Lankan Sesame showed that it has the potential to successfully survive under dry weather and that it shows high tolerance to drought conditions under which it is largely grown.

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The Impact of Drought on Coconut Productivity in Sri Lanka

C. Pathmeswaran*, E. Lokupitiya, K.P. Waidyarathne

Department of Zoology and Environment Science, University of Colombo
*charuni.p@gmail.com

This article is based on an undergraduate research project which assessed the impact of extreme weather events on coconut productivity in selected locations of Sri Lanka. The article specifically deals with how drought conditions in the country affect coconut productivity and the subsequent effect on the country's economy and the people's well-being.

Introduction

There has been a growing concern about the impact of extreme weather events on crop production across the globe, Sri Lanka being no exception. Coconut is becoming a rare commodity in the country, mostly due to the impacts of climate change and certain other socioeconomic reasons. The price hike in coconuts over the last few years is a good indication of how climate change is affecting the food crops. Most coconut trees are no longer bearing fruits and those that do, have nuts which are relatively very small in size.

The livelihood of most people living in humid tropics depend on the coconut palm (Peiris *et al.*, 1995). Indonesia, Philippines, India, Brazil, Sri Lanka and Thailand are the largest producers of coconut in decreasing order of importance (FAOSTAT, 2014).

Coconut in Sri Lanka

Coconut is one of the major plantation crops in Sri Lanka and is second only to rice in providing nutrition (Samita & Lanka, 2000). Coconut cultivation represents 21% of the agricultural land of the country and significantly contributes to Sri Lanka's Gross Domestic Product (GDP), export earnings and employment (Fernando *et al.*, 2007).

The highest coconut production of Sri Lanka, which is above 70% of the national production, comes from the Coconut Triangle (Fernando *et al.*, 2007). The Coconut Triangle is formed by Gampaha, Kurunegala and Puttalam districts which belong to three climatic zones: Wet, Intermediate and Dry, respectively.

Coconut Growth Cycle

The growth cycle of a coconut bunch lasts 38 months, from the initiation of the inflorescence primordium to full maturity of the nuts (Peiris *et al.*, 2008). Of the total period, pre-fertilization phase lasts 27 months in which the inflorescence is covered by a spathe (Figure 1). Fertilization and post-fertilization phases start with the spathe opening and last 11 months resulting in a mature bunch of coconuts (Figure 1); (Ranasinghe *et al.,* 2015). Of this, the first three months subsequent to inflorescence opening is said to be the period most vulnerable to climatic variation (Ranasinghe *et al.*, 2015). On average, one inflorescence opens every month of a year producing mature nuts ready to be harvested after nearly a year.

Figure 1: Development stages of a coconut bunch (Source: Coconut Research Institute, Lunuwila)

The coconut yield depends on climatic variables such as rainfall, temperature and relative humidity in addition to other external factors such as pest attacks, diseases, crop management, land suitability and nutrient availability (Peiris *et al.*, 2008). Optimum weather conditions for the growth of coconut include a well distributed annual rainfall of about 1500 mm, a mean air temperature of 27^{0}C and relative humidity of about 80-90% (Peiris *et al.*, 1995).

Impact of Extreme Weather on Coconut Productivity

The current study analysed the impact of occurrence of extreme weather events considering average monthly temperature and rainfall over a 21 year period (from 1995 to 2015) at selected coconut estates in wet, dry, and intermediate zones of Sri Lanka. Our study revealed that a drought can especially impact coconuts during the first four months after inflorescence opening, which had a negative impact on the productivity especially in the dry and intermediate zones (as revealed by the statistical analyses and the model relationships developed in this study). Considering the period from flowering to the harvest, the effect of a drought in the given year on coconut productivity will only become evident during the following year. Previous studies have shown that the exposure of

male flowers to high temperature could have a negative influence on pollen production, as shown by Burke, Velten, & Oliver (2004) with their analysis on cotton pollen germination. Similarly exposure of coconut flowers to drought conditions results in flower and fruit abortions (Nainanayake *et al.*, 2008).

Most of the time, the negative influence of very high temperatures on health (and productivity) of coconut trees was evident even from the appearance of the coconut palms (Figure 2).

Figure 2: Poorly developed coconut palms in a drought period in the intermediate zone (Hiriyala Estate, Kurunegala - photographed on 5th October 2016)

Drought conditions not only disrupt the physiological functions of the coconut palm, but also contribute to incidences of pest attacks. At present, the Coconut Black Beetle and the Coconut Red Weevil pose the greatest threat to coconut plantations in Sri Lanka. Drought conditions are very conducive for Coconut Black Beetles to pupate deep in the soil (Nirula, 1955).

When looking at weather data during the study period of 21 years, it is evident that the drought conditions are associated with El Nino Southern Oscillation (ENSO) phenomenon. The increased number of low rainfall days in the years 1997, 2002, 2006, 2009, 2014 and 2015 can be linked with the prevalence of an ENSO phenomenon in the respective years (Legler, 1998).

Implications of the Findings

This study reinforces the importance of being aware of the implications of climate change on crop productivity. The findings of this study can contribute to the coconut plantation sector in Sri Lanka. Those involved in this sector, including the superintendents of the estates as well as the labourers,

appeared to be aware of the warming trend of the climate. They have adopted soil moisture conservation methods such as mulching, burying coconut husks and growing cover crops to prevent extreme evapotranspiration. These are short term solutions. If we are to think about sustaining the coconut cultivation in the long-term, it is important to focus our efforts on developing drought-tolerant hybrids.

Global climate is projected to change continuously due to various natural and anthropogenic reasons. Policy makers and market decision makers can utilize the knowledge on how coconuts respond to drought conditions to formulate better policies and prices. This information can enable us to be better prepared and minimize loss and damage caused by a drought resulting from climate change.

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දේශගුණ විපර්යාස සහ සංචාරක කර්මාන්තය - ගෝලීය අභියෝග හමුවේ ප්‍රතිචාර දක්වමු

H.M. Priyanga Samarasekara

Marine Environment Protection Authority
email2piyanga @gmail.com

දේශගුණික සාධක සංචාරක කර්මාන්තයේ පැවැත්මට බලපාන්නා වූ ප්‍රධාන සාධක අතරින් ප්‍රමුඛ ස්ථානයෙහි ලා සැලකිය හැකිය. දේශගුණ විපර්යාස සහ ඒ හා බැඳුණු කාළගුණික තත්ත්වයන් ලොව ප්‍රධාන සංචාරක කලාපයන්හි පැවැත්මට බලපෑම් ඇතිකිරීම සංචාරක ආකර්ෂණය කෙරෙහි දැඩි ලෙස බලපෑම් ඇති කරයි. දේශගුණ විපර්යාස හේතුවෙන් පැන නඟින්නා වූ පාරිසරික ආර්ථිකමය සාමාජයීය ගැටළු වලට මුහුණදීම සඳහා සමස්ථ ලෝක ප්‍රජාවම ක්‍රමෝපායන් සොයමින් සිටිති. හරිතාගාර වායු විමෝචනය හේතුවෙන් පාරිසරික උෂ්ණත්වය ඉහළ යෑම නිසා එහි ප්‍රතිඵලයක් ලෙස ග්ලැසියර් සහ අයිස් දිය වීම නිසා සාගරයේ ජල මට්ටම ඉහළ යෑමේ තර්ජනයට සමස්ත ලෝක ප්‍රජාව මුහුණ දී සිටිති. කුඩා දූපත් සාගරයෙන් යටවීම ඉන් ඇතිවන ප්‍රධාන බලපෑමයි. සංචාරක කර්මාන්තයෙහි නියැලී සිටින බොහෝ රටවල් දේශගුණ විපර්යාස වල බලපෑමට ලක්ව ඇති අතර ඉන් මිදීමේ මාවත් සොයයි. තම ක්‍රියාකාරකම් පරිසර හිතකාමී ලෙස පවත්වා ගැනීමට සිදුකළ හැකි සියල්ල අවබෝධ කොටගෙන ක්‍රියාවෙහි යෙදවීමට කාලය පැමිණ ඇත.

හැඳින්වීම

වර්තමානයේ දේශගුණික විපර්යාස පිළිබඳ ජාත්‍යන්තර කථිකාවතක් ගොඩ නැගෙමින් පවතින කාලවකවානුවකි. එසේ හෙයින් ස්වාභාවික පරිසරය කෙරෙහිද මානව වර්ගයා සහ ඒ හා බැඳුණු ආර්ථික සාමාජයීය සෞඛ්‍යමය ආදී කරුණු සම්බන්ධවද විශේෂ අවධානයක් යොමු කරවීමට සමාජය උත්සහ දරමින් සිටියි. සංචාරක කර්මාන්තය යනු ලොව බහුතරයක් දේශයන්හි ආර්ථිකය රදා පවත්නා ප්‍රධාන අංශයකි. එසේම එය මානව වර්ගයා වෙත විනෝදාස්වාදය සහ විවේකය සපයන්නා වූ මාර්ගයක් ද වෙයි. මෙසා විශාල වූ කර්මාන්තයක පැවැත්ම කෙරෙහි බලපාන්නා වූ සාධක අතර දේශගුණය ප්‍රමුඛස්ථානයක් ලබයි. ලොව කාර්මික විප්ලවය සිදුවන්නට ප්‍රථම සියවස් ගණනාවක සිට පැවත එන දේශගුණික තත්ත්වයන් සහ වර්තමානයෙහි දේශගුණ ස්වභාවය අතර සාපේක්ෂ වෙනසක් දක්නට ඇති බවට සාධක බොහෝ වේ. එසේම විසි එක් වන සියවසත් එයින් පසුව එළඹෙන්නා වූ අනාගත කාල පරිච්ඡේදයන් තුළදීත් පෘථිවිය පුරා දේශගුණයෙහි වෙනස්කම් බොහෝමයක් සිදුවනු ඇතැයි පුරෝකථන සිදු කොට ඇති එසේ දේශගුණ විපර්යාස සිදුවීම කෙරෙහි පරිසර උෂ්ණත්වය ඉහළ යෑම ප්‍රධාන වශයෙන් බලපාන බව අන්තර් රාජ්‍ය දේශගුණ විපර්යාස මඩුල්ලේ ස්ථාවරය වී ඇත. එසේම ඔවුන්ගේ අධ්‍යයනයන්ට අනුව විසි වන සියවස වධ්‍යයේ සිට ලේකයේ පාරිසරික උෂ්ණත්වය ඉහළ යාම කෙරෙහි මානව ක්‍රියාකාරකම් ප්‍රමුඛව බලපෑම් ඇතිකළ අතර එහි ප්‍රතිඵලයක් ලෙස වායු යෝගලයෙහි හරිතාගාර වායුන්ගේ සාන්ද්‍රණය ඉහළ යෑම දැක්විය හැක. මේ අන්දමින් සාගර ජලයෙහි උෂ්ණත්වය ඉහළ යාම, මහද්වීපික උෂ්ණත්වයේ සාමාන්‍ය අගය ඉහළ යෑම, දුළං රටාවන්ගේ වෙනස් වීම් ආදියද ග්ලැසියර් දියවීම, අයිස් තට්ටු දියවීම. සාගර මතුපිට ජල ස්ථරයෙහි උෂ්ණත්වය ඉහළ යෑම සහ මුහුදු මට්ටම ඉහළ යෑම ආදී නොයෙක් අන්දමේ අසාමාන්‍යය දේශගුණ විපර්යාසයන්ට මුහුණ දීමට වර්තමානයේ මිනිසාට සිදු වී ඇත.

දේශගුණය සහ සංචාරක කර්මාන්තය අතර පවතින්නා වූ සහසම්බන්ධය

දේශගුණය සහ සංචාරක කර්මාන්තය යන අංශ දෙක සැලකීමේදී සංචාරක කර්මාන්තය රඳා පවත්නා වූ ප්‍රධාන සාධක අතර දේශගුණ සාධකය ප්‍රධාන වේ. තමන් වෙසෙන පරිසරය හැර වෙනත් පරිසරවල සංචාර සිදු කිරීම සඳහා මිනිසාට අවශ්‍යතාව මතුවීමට තමන් වාසය කරන හුරු පුරුදු පරිසරයෙන් ඇතිවන බලපෑමෙන් මිදී කාලය ගත කිරීම, සිය ශරීර සෞඛ්‍ය වර්ධනය කිරීම සඳහා සෞඛ්‍ය සම්පන්න පරිසරයක් කරා යාම, විනෝදාස්වාදය ලබාගැනීම සහ ක්‍රීඩා කටයුතු සඳහා යෝග්‍ය පරිසරයක් කරා ළඟාවීම යන කරුණු හේතුවන බව සිතිය හැක.

ඉතා යහපත් දේශගුණ තත්ත්වයන් යටතේ සිය සංචාර කටයුතු සිදු කිරීම ජනතාවගේ මූලික අපේක්ෂාව වේ. එහෙත් වර්තමානයේ පවතින්නා වූ දැඩි නියග හා ගංවතුර තත්ත්වයන් අධික සුළං සහ කුණාටු වැනි ස්වාභාවික ආපදා සංචාරක කර්මාන්තයට ප්‍රබල තර්ජනයක් වී ඇත. මේ හේතුවෙන් සංචාරක කර්මාන්තය සම්බන්ධයෙන් ප්‍රතිපත්ති සකසන්නන් ක්‍රමෝපායන් සලසන්නන් සහ කර්මාන්තයේ සංවර්ධනය සඳහා වෙහෙසෙන්නන් කර්මාන්තයෙහි පුර්වාරක්ෂාව සඳහා ක්‍රමවේද සකස්කළ යුතුව ඇත. සංචාරකයින් සිය ගමනාන්ත තෝරා ගැනීමෙදීත් අදාළ ස්ථානයෙහි රැඳී සිටිනා කාල සීමාව තීරණය කිරීමේදීත් යෙදෙන්නා වූ ක්‍රියාකාරකම් පිළිබඳ තෝරාගැනීම සිදුකිරීමෙදීත් ඊට අදාළ පරිසරයෙහි කාළගුණ සහ දේශගුණ රටාව පිළිබඳ සැලකිලිමත් වන බැවින් සංචාරක කර්මාන්තය සහ දේශගුණ රටාව අතර ඉතා සමීප අන්තර් සම්බන්ධතාවයක් ඇති බව මනාව පැහැදිලි වේ. පහත දැක්වෙන්නා වූ ප්‍රායෝගික ප්‍රවේශයන් තවදුරටත් කාළගුණ සහ දේශගුණ සාධක සහ සංචාරක කර්මාන්තය අතර සහ සම්බන්ධතාවය වඩාත් පැහැදිලි කරයි.

- දේශගුණ සාධක මත නිර්ණය වූ සංචාරක ක්‍රියාකාරකම්
- විනෝදාස්වාදය සඳහා වූ ක්‍රියාකාරකම් සඳහා සුදුසු කාල වකවානු නිර්ණය
- නෝදාස්වදය පිණිස වූ අදාළ ක්‍රියාකාරකම් කිරීම සඳහා කාළගුණ තත්ත්වයන් වැදගත් වීම

එසේම සංචාරකයින්හට සිය ක්‍රියාකාරකම් සිදු කිරීම සඳහා දේශගුණය බලපෑම් ඇති කරන අන්දම පහත දැක්වෙන කරුණු මගින් තහවුරු වේ.

- විවිධාකාර වූ දේශගුණ තත්ත්වයන් සහිත කලාප වෙත සංචරණය වීම සඳහා මිනිසා තුළ ඇති ආශාව
- සංචරණයේදී ආරක්ෂාකාරී ප්‍රවාහන මාධ්‍යක් සපයා ගැනීමේ අවශ්‍යතාව සහ පහසුව
- ජීවිතාරක්ෂාව-ස්වාභාවික ආපදා අවම වීම
- සංචාරක ගමනාන්ත කෙරෙහි ජනතා ආකර්ෂණය ඇති කිරීම
- සංචාරකියන් වෙත ස්වාභාවික පරිසරය වෙතින් ලැබෙන්නාවූ අත්දැකීම්

සංචාරක කර්මාන්තය කෙරෙහි දේශගුණ විපර්යාසවල ඍණාත්මක බලපෑම

කෙසේ වෙතත් වර්තමානයෙහි සංචාරක කර්මාන්තයේ දියුණුව කෙරෙහි දේශගුණ විපර්යාස නිසා ඇතිවන ඍණාත්මක බලපෑම ගැන පැහැදිලි විග්‍රහයක් සිදුකළ යුතුව ඇති ඉහත දැක්වූ කරුණු පරීදි දේශගුණය ''සංචාරක කර්මාන්තය කෙරෙහි ඇති කරන්නා වූ බලපෑම සංචාරය සඳහා ගමනාන්ත තෝරා ගැනීම" අදාළ ස්ථානයෙහි සංචාරකයා ගත කිරීමට අපේක්ෂා කරන කාල සීමාව සහ නිරත වීමට කැමැත්ත

දක්වන ක්‍රියාකාරකම් පිළිබඳ සාජුවම බලපායි. සංචාරකයින් ආකර්ෂණය කර ගැනීම සඳහා බහුලව හේතුවන දේශගුණික සාධක වලට උදාහරණ ලෙස ''හිම සහ අයිස් සහිත භූමි ප්‍රදේශ" වන ජීවී කලාප සහ ජෛව විවිධත්වය" ජලයේ ගුණාත්මකභාවය සහ ආරක්ෂාකාරී ලෙස ජල ක්‍රීඩාවල යෙදීම සඳහා සුදුසු නොගැඹුරු මුහුදු කලාප ආදිය ප්‍රශස්ථ මට්ටමින් පවත්වා ගැනීමට ආධාර කරයි. එසේම සංචාරකයින් අදාල කලාපයන්ගෙන් විකර්ෂණය කරන්නා වූ තත්ත්වයන් උද්ගත කිරීම සඳහාද දේශගුණය අවස්ථාව සලසයි. එනම් වසංගත රෝග තත්ත්වයන්, ලැව්ගිනි, කෘමි උවදුරු හෝ ජලජ වාසි පලිබෝධයන් (ජෙලි ෆිෂ්, විෂ සහිත ඇල්ගී වර්ග ආදිය) හා කුණාටු තත්ත්වයන් වේ. කෙසේ වෙතත් දේශගුණික විපර්යාස සංචාරක කලාපයන්ගේ පැවැත්මට, ඒවා අතර තරගකාරීත්වයට සහ තිරසාර පැවැත්මට ඇති කරන්නා වූ බලපෑම් සිව් වැදෑරුම් ආකාරයට බෙදා වෙන්කර දැක්විය හැකිය.

සෘජු දේශගුණික බලපෑම්

සංචාරක කර්මාන්තයෙහි ඉදිරි පැවැත්ම තහවුරු කිරීම සඳහා මූලික වන ප්‍රධාන සම්පත ලෙස දේශගුණය සැලකිය හැකිය. දේශගුණය, සංචාරක කර්මාන්තයේ විවිධ ක්‍රියාකාරකම් සඳහා එක් එක් කලාපයන්හී යෝග්‍යතාව සනාථ කරන අතර ලෝකයේ සංචාරක කරමාන්තයේ ක්‍රියාකාරකම් සඳහා වෙන්වූ කාල වකවානු පැහැදලිව නිර්ණය කරයි. එසේම කර්මාන්තයේ මෙහෙයුම් පිරිවැය සඳහාද බලපෑම් ඇති කරවයි. එනම් ආහාර සහ පානීය ජල සැපයුම්, සෞඛ්‍ය කටයුතු සඳහා ජල සම්පාදනය, කෘත්‍රිමව හිමපතනය නිපදවීම, රක්ෂණාවරණ වියදම් පරිසරය ප්‍රශස්ථ අන්දමින් උණුසුම් කිරීම සහ සිසිලනය සඳහා යන පිරිවැය ආදිය උදාහරණ ලෙස දැක්විය හැකිය. ලොව පුරා පැතිර පවත්නා වූ විශේෂිත වූ සංචාරක කලාපයන්ගේ සිදු කෙරෙන එකිනෙකට වෙනස් ක්‍රියාකාරකම් දේශගුණ විපර්යාස නිසා බලපෑමට ලක්වන අවස්ථා නිදර්ශන කිහිපයකින් දැක්විය හැකිය. යුරෝපයේ ඇල්ප්ස් කඳු ආශ්‍රිතව, උතුරු ඇමරිකාවේ නැගෙනහිර සහ බටහිර කලාපයන්හී, ජපානයෙහි සිදු කෙරෙන හිම මත ලිස්සා යෑමේ ක්‍රියාකාරකම දේශගුණ විපර්යාස හේතුවෙන් බලපෑමට ලක් වී ඇත. හිමපතනය අඩුවීම, හිමපතනය අධික වීම ආදී සිදුවීම් නිසා සංචාරක කර්මාන්තකරුවාට පෙර දශකයන්ට සාපේක්ෂව අමතර පිරිවැයක් දරන්ට සිදුවී ඇත. එසේම අදාල කලාපයන්ගේ විපර්යාසයන්ට මුහුණදීමට මැලිකමක් දක්වන සංචාරකයින් වෙනත් කලාප කරා සංචරණය වීම සිදු වේ. එසේම සමකාසන්න ප්‍රදේශයන්හී ඇතිවන්නා වූ දරුණු වර්ෂාපතනය, කුණාටු තත්ත්වයන්, නියඟ ආදිය නිසා යටිතල පහසුකම් විනාශ වීම, හදිසි අවස්ථාවන් සඳහා සුදානම් වීමට සිදුවීම නිසා අමතර වියදම් දැරීමට සිදුවීම, අධික මෙහෙයුම් පිරිවැයක් දැරීමට සිදුවීම (රක්ෂණාවරණ, අමතර ජලය ගබඩාකරණය, බලශක්තිය සම්පාදනය) සහ ව්‍යාපාරික වශයෙන් බිඳවැටීම් සිදුවීම ආදිය අපේක්ෂා කළ යුතුය.

වක්‍රව සිදුවන බලපෑම්

ජලය හිඟවීම, ජෛව විවිධත්වය හීන වීම, පාරිසරික වීම, පාරිසරික සෞන්දර්ය හීන වීම, කෘෂි නිෂ්පාදන ක්‍රියාවලීන් වෙනස් වීම, ස්වාභාවික ආපදා සිදුවීමේ ඉඩකඩ ඉහළ යෑම, මුහුදු බාදනය සහ ගංවතුර පීඩා ඉහළ යෑම, යටිතල පහසුකම් වලට හානි සිදුවීම, වසංගත රෝග පැතිර යෑම ආදිය සංචාරක ව්‍යාපාරය කෙරෙහි බලපෑම් ඇති කරයි. කඳුකර ප්‍රදේශ, දූපත් සහ වෙරළබඩ කලාප දේශගුණ විපර්යාස සඳහා අධික සංවේදී වන අතරම පාරිසරික වැදගත්කමකින් යුතු සංචාරක කලාප ලෙස එම ප්‍රදේශ සැලකිය හැකියි එක්සත් ජාතීන්ගේ සංවිධානය විසින් ලෝක උරුමයන් ලෙස සැලකෙන විවිධ සංචාරක කලාප ද වර්තමානයේ වන විට බලපෑම් වලට ලක්වී ඇත. නිදසුන් ලෙස ඉතාලියේ වැනිසිය - මුහුදු මට්ටම ඉහළ යෑම, මහා බාධක පරය, ඕස්ට්‍රේලියාව - කොරල්පරය විරංජලන වීම සහ මිය යෑම දැක්විය හැකිය.

මේ අනුව එක් එක් සංචාරක කලාපයන් සඳහා එකිනෙකට වෙනස් අන්දමින් බලපෑම් ඇති කරන්නා වූ විවිධ දේශගුණික තත්ත්වයන් පිළිබඳවද, එම තත්ත්වයන් වළක්වා ගැනීමේ එකිනෙකට වෙනස් වූ ක්‍රමවේදයන් පිළිබඳවද අවබෝධය ප්‍රතිපත්ති සම්පාදකයින් සතුව පැවතිය යුතුය.

වක්‍රව සිදුවන ආර්ථික සහ සාමාජයීය බලපෑම්

දේශීය ආර්ථිකය ප්‍රධාන වශයෙන් සංචාරක කර්මාන්තය මත රදා පවතින්නා වූ රාජ්‍යයන් කෙරෙහි දේශගුණ විපර්යාස සහ එහි අතුරුඵල ඍණාත්මක ප්‍රතිඵල ඇති කරයි. එහිදී ආර්ථිකමය බිඳවැටීම් සිදුවන්නා සේම දේශපාලනික වශයෙන්ද අස්ථාවර භාවයන් ඇති වීමටද ඉඩ ප්‍රස්ථාව සැලසේ.

දේශගුණ විපර්යාස වැළැක්වීම සඳහා අනුගමනය කළ හැකි ක්‍රියාමාර්ග සහ ප්‍රතිපත්ති

ලෝක සංචාරක සංවිධානය විසින් 2003 වසරේදී ටියුනීසියාවේදී දේශගුණ විපර්යාස සහ සංචාරක කර්මාන්තය පිළිබඳ ප්‍රථම වරට පවත්වන ලද සම්මන්ත්‍රණය සංචාරක කර්මාන්තය සහ දේශගුණ විපර්යාස අතර අන්තර් සම්බන්ධතාව පිළිබඳව සහ ඒ හා සම්බන්ධ පර්යේෂණ පිළිබඳව කතිකාවතක් ගොඩ නැගිණි.

Uemura සහ Kai ඇතුලු පිරිස (2003) ඇතුලු පිරිස සඳහන් කළ පරිදි දේශගුණ විපර්යාස වැළැක්වීමට හරිතාගාර වායූන් මෝචනය වීම අවම කිරීම සඳහා ක්‍රියාමාර්ග ගැනීම මූලිකවම සිදුකළ යුතුය. ඒ සඳහා පහත සඳහන් ක්‍රම අනුගමනය කරන්නේනම් මැනවි.

- බලශක්තිය භාවිතය අවම කිරීම
- යොදා ගන්නා බල ශක්ති වර්ගයේ කාර්යක්ෂමතාව වැඩි දියුණු කිරීම
- පුනර්ජනනීය බල ශක්ති සඳහා යොමු වීම
- සංචාරක කර්මාන්තය හේතුවෙන් පිටවන කාබන් ඩයොක්සයිඩ් අවශෝෂණය සඳහා වනාන්තර විනාශය අවම කිරීමට කටයුතු කොට වනාන්තර වගා කිරීමට පෙළඹීම

පරිසර හිතකාමී ක්‍රියාකාරකම් සඳහා මූලික අවධානය දෙමින් පරිසර හිතකාමී ක්‍රියාකාරකම් සංචාරක කර්මාන්තය තුළ ස්ථාපිත කිරීමට පියවර ගත යුතුය. ස්වාභාවික පරිසරයට මෙන්ම අවට ජීවත් වන ප්‍රජාවගේ සාමාජයීය සහ සංස්කෘතික අංග ලක්ෂණ ආරක්ෂා වන පරිදි කටයුතු කිරීම සංචාරක ව්‍යාපාරයේම අංගයක් ලෙස සැලකිය යුතුය. එසේම ජෛව විවිධත්ව සංරක්ෂණය, පරිසර පද්ධති ආරක්ෂණය යන ක්‍රියාවන් ද කර්මාන්තය හා සමගාමීව සිදුකළ යුතුය.

පාරිසරික අධ්‍යාපන දැනුම ලබා දීම සහ දැනුවත් කිරීමේ වැඩසටහන් ක්‍රියාත්මක කිරීම මගින් සංචාරකයන් මෙන්ම සංචාරක ව්‍යාපාරයේ පර්ශවකරුවන්ද පරිසර සංරක්ෂණය පිළිබඳව පරිසරය පිළිබඳව නිසි අවබෝධයකින් යුතුව කටයුතු කිරීමට පෙළඹවීමට හැකියාව ඇත.

දේශගුණ විපර්යාස වැළැක්වීම යන වදන් පෙළ යමෙකුට ඉතා සංකීර්ණ ක්‍රියාකාරකම් පෙළක් සිහිගැන්වුවද අප නොසිතා සිදු කරන ඉතා කුඩා ක්‍රියාකාරකමකින් වුවද පරිසරය සුරැකීමේ මහඟු මෙහෙවරට දායක වීමට ඉඩ ප්‍රස්ථාව සැලසෙන බව ඉහත සඳහන් කරුණු පිළිබඳ සැලකිමේදී හැඟී යනු ඇත. සංචාරක ව්‍යාපාරයේ එදිනෙදා ක්‍රියාකාරකම් හැකි උපරිම අන්දමින් පරිසර හිතකාමී ලෙස පවත්වාගෙන යෑම සඳහා එම ව්‍යාපාරයට දායක වී සිටින සෑම අයෙක්ම උනන්දු වන්නේ නම්, වර්තමානය වන විට දේශගුණික විපර්යාස හේතුවෙන්

සංචාරක ව්‍යාපාරයට සිදුව ඇති හානිය තීව්‍ර නොවනු ඇත. ක්‍රමානුකූලව සිදු කරන පරිසර සංරක්ෂණ ක්‍රියාදාමයකට සහභාගි වීම මින් සමස්ත ලෝකවාසීන් හට සිදුවන්නට යන මහා ව්‍යසනයන්ගෙන් වැළකී සිටීමට මඟ සැලසීමට හැකියාව ලැබෙනු ඇත.

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Lead Toxicity: A Leading Climate Change Issue

Hasula Wickremasinghe

Climate Change Secretariat, Ministry of Mahaweli Development & Environment
hasulaw@yahoo.com

This article discusses evidences to the presence of Lead in our environment and the potential for Lead toxicity in humans due to the increase in atmospheric temperature from global warming.

Background

Lead (Pb) is a bluish-white lustrous metal found naturally in the earth's crust, usually in ore with zinc, silver and copper. It is malleable and is a poor conductor of electricity. It is resistant to corrosion but tarnishes when exposed to air. It is extracted for many uses, primarily being the production of Lead acid batteries and paint. Another main use is in the glass of computer and television screens, where it protects the viewer from radiation. It is also found in many pesticides and in decorative paints. Further, Lead is added to cosmetics, Ayurvedic or other folk medicines, illegal drugs, spices or other foods, either to colour the product or to increase its weight. It occurs in the environment in the form of particulate matter as black carbon from the incomplete combustion of biomass, biofuels and fossil fuels. Therefore, Lead is present in soils, in outdoors, indoors and in the atmosphere.

Lead gets ingested very easily by children when they play with soil and from paint on furniture and walls. Adults are exposed through inhalation of Lead from the atmosphere and from their work places. According to the Centre for Disease Control, blood Lead level that indicates the need for medical intervention is 10µg/dL. Lead has a half-life of 25 days in the blood stream and 50 days in soft tissue.

Lead replaces iron and calcium within the body. Mainly, it gets deposited inside the bones. Hence, its capacity for treatment is limited. Even trace amounts have significant neurological and cardiovascular effects and large quantities are fatal. Lead in the blood stream kills brain cells and replaces calcium in the nervous systems and brain. Lead has the ability to reach the foetus and high Lead levels in expectant mothers have been linked to schizophrenia in their children. It has toxic impacts on organs such as the kidneys and liver. It produces anaemia by preventing the formation of haemoglobin inside red blood cells reducing the blood's ability to carry oxygen. It is also known to produce low IQ levels through brain damage.

Lead can be absorbed either through ingestion or through inhalation, and to a lesser extent from skin absorption, especially when the skin is sweaty. Children in particular, are more vulnerable to Lead toxicity, since their exposure to Lead is more. They ingest Lead through normal hand-to-mouth activity and are more able to absorb Lead through ingestion.

A Few Incidences of Lead Poisoning in Sri Lanka

Lead poisoning was reported in a study conducted on traffic policemen in 1996 where a mean of 53.07 µg/dL was reported causing wide concern over the use of leaded petrol. A study was also conducted of children living near a highly congested junction in Colombo in 2001 which revealed high Lead levels in blood. A case was reported of Lead poisoning of a 9 month child (Punchihewa *et al.*, 2000) where Lead was both inhaled and ingested during the process of smelting of vehicle batteries at home. Further, the Centre for Environmental Justice (2014) reported of enamel decorative paint brands sold in Sri Lanka containing more than 600 µg/dL of Lead. A study (Richardson *et al.*, 2015) of oil contaminated soils from power plant locations in Chunnakam, Jaffna, where plant effluents and oily wastes had been disposed to the nearby land plots over several years without any mandatory regulations being followed, also revealed high percentages of Lead in soils.

These are some studies that reveal the availability of high amounts of Lead in our environment. Subsequently, there are also many undocumented incidences of Lead toxicity through the smelting of Lead acid batteries as a home industry.

Measures Taken to Reduce Exposure to Lead and its Aftermath

Lead was used as an additive into fossil fuels until the ban in 2002. Despite the phasing out of Leaded petrol in countries, the Lead deposited by petrol combustion in fine particulate dust over decades remains a cause for concern. In situations where ambient moisture is low, soil (particularly, the finer grained soil most likely to be contaminated by gasoline Lead in the past 90 years) becomes re-suspended in the atmosphere making up over 50% of fine particle pollution. Soil re-suspension can contribute over 40% of atmospheric Lead content after Leaded gasoline has been phased out (Taylor, *et al.*,2009)

In a study conducted on traffic police wardens (Sebastiampillai *et al.*, 2015) of blood Lead levels after several years after the introduction of unleaded petrol showed a significant decline in mean blood levels by as much as 91%. But, there were 24.4% of wardens with blood Lead levels above the safety limit. This study also shows that Lead poisoning is still prevalent despite the cessation of a significant source of environmental Lead pollution.

A study conducted on blood levels of children before and after introduction of unleaded petrol (Senanayake *et al.*, 2004) revealed that there was no significant decrease in blood Lead levels in the younger age group (below 5 years of age) but there was a significant reduction in the older age group. In younger children the gut absorption of Lead is four times higher than adults and their exposure to Lead is also more.

In Sri Lanka, the Consumer Affairs Authority (CAA) set mandatory standards for the regulation of Lead in decorative paint in Gazette Extraordinary No 1725/30 on 30th September 2011 which directs

that "No Manufacturer, Importer, Packer, Distributer or Trader shall manufacture, import and use or distribute, pack, store or sell or display for sale, expose for sale or offer for sale, wholesale or retail any paints unless such paints shall conform to the corresponding Total Lead Content given hereunder as specified by the Sri Lanka Standard Institution for such paints (the permissible maximum Lead content- paints for toys, accessories for children –soluble in HCl acid, 90mg/kg; enamel paints 600mg/kg; emulsion paints for exterior use, 90 mg/kg; emulsion paints for interior use 90mg/kg; floor paints, 600 mg/kg). The Direction was to come into effect on January, 1st ,2013". A subsequent gazette was released in 2014 requesting the Lead level to be printed on the paint label. In a study conducted by the Centre for Environmental Justice (2015) two years after the regulation, certain brands of paint manufactured after 2013 contained less than 600 ppm of Lead. But, there were still paints on the shelves which were produced before 2013 and there were also some that were labeled as 'Lead Free' and manufactured after 2013 but which still contained more than 600 ppm of Lead.

Sri Lanka ratified the Basel Convention in 1992 and a Cabinet decision was obtained to prohibit the import of hazardous waste from all countries for final disposal or for recovery.

The National Environmental (Protection & Quality) Regulation No.1 of 2008 has prescribed discarded batteries containing Lead, Mercury, Nickel, Cadmium and Lithium and electrolytes from batteries and accumulations as hazardous waste that requires a license for handling. The National Electrical and Electronic Waste Management Policy in Sri Lanka of 2008 covers the waste collection, storage, transportation, treatment and disposal activities. Technical guidelines were prepared by the Central Environment Authority in 2005 on reconditioning and transportation of used Lead acid batteries.

In the disposal of e-waste, open burning and incineration methods are used. This results in the generation of gases and residue ashes such as 'bottom ash' and 'fly ash'. The bottom ash results in soil and ground water pollution and fly ash results in the release of greenhouse gases and air pollution. The leakage of heavy metals including Lead from landfill sites create soil and water pollution.

The improper recycling of Lead acid batteries using domestic smelting processes result in Lead poisoning of humans and contamination of soil, water and air.

However, the public is still not aware of disposal procedures, the list of collectors or collection points. Further, monitoring is not conducted of these recycling institutions to verify the use of correct procedures. There have been cases reported from certain areas where the battery recycling companies get villagers to smelt the batteries at home. Most Lead poisoned victims are then treated privately for chelation.

Impact of Global Warming on Lead Poisoning

The environment still contains particulates of Lead from the previous use of Lead based paints in households and from leaded fuels. These have also been deposited in soils besides the Lead from pesticides. Moreover, malpractices in waste disposal and smelting of batteries have also resulted in Lead poisoning of the environment.

The change in environmental factors such as temperature, precipitation and salinity will unavoidably affect the toxicity characteristics and behavior of trace metals. Increases or decreases of any climate change parameter would change their volatility.

These changes in environmental factors increase the release of Lead to the environment. Lead poisoning health effects are worsened by higher temperatures, and Lead stored in bones returns into the blood during ageing. This increases the burden of an ageing population which has slow reaction times, poor memory and hearing, balance problems, increased irritability, osteoporosis and mental decline.

Sri Lanka has seen an increase in atmospheric temperatures this year (2017) with a maximum temperature of 37.3°C at Polonnaruwa. Prolonged droughts and floods were also experienced this year. Droughts cause the fine silt particles containing Lead to disperse and subsequent floods cause residual Lead particles in soil to be uncovered and spread more widely.

Despite the fact that Sri Lanka is not one of the major contributors of global warming, the combustion of fossil fuels emitting CO_2 to the environment and black carbon which is a warming agent triggers global warming.

Within the energy sector in Sri Lanka, the highest (49%) of CO_2 is released from the transport sector. CO_2 is one of the main greenhouse gases which cause the greenhouse effect resulting in global warming. Which in turn accelerates the release of Lead to the environment. Further, 56% of total energy consumption in Sri Lanka is from biomass and hydro. Incomplete combustion of fire wood releases particulate matter in the form of soot to the environment. This too contains black carbon. Wood smoke ranges from 0.1-3.0mg/kg Lead emission of wood burned. Therefore, burning three tonnes of wood will result in between 0.3 and 9g of Lead emissions.

Abatement of Climate Change Will Cause Abatement of Lead Toxicity

Efforts to mitigate climate change through reduced carbon combustion will change the quantities of Lead available to be released into the environment, as well as reducing global warming. Both increased waste dispersion and increase of greenhouse gas emissions have significant implications for the management of Lead waste.

One of the most widely reported greenhouse gas contributors is coal. Since the phasing out of Lead petrol in most industrialized countries, coal-based power production has been a significant contributor to atmospheric Lead pollution and CO_2.

Global warming would be reduced through the use of alternative energy sources such as solar, wind, hydro and dendro. However, in the developing world's perspective, the priority should be reducing forest clearing, as not only does it produce 18% of greenhouse gas but over 5% of black carbon emission. Hence, some decline in Lead emission would ensue.

Climate change actions must also reduce exposure to Lead, the most common industrial contaminant or Lead poisoning rates will rise globally.

Best Practices for the Remediation of Lead

Two most common sources of Lead in garden soils are the past use of lead-based paint and leaded gasoline. Other less common sources include some types of pesticides, smelters, coal-based furnaces and Lead acid batteries.

A study conducted in the US by Prof. Ganga Hettiarachchi (2014) revealed that by adding organic matter-like compost to soils changes the absorption of Lead. Some substances in compost, notably phosphorous and iron oxides, can help holding Lead in soils, thereby reducing its availability to plants.

Hence, vegetables need to be washed thoroughly so that no soil gets ingested. Root vegetables should be peeled removing a thick layer of skin.

Further, chelation therapy which is the process to remove toxic metals and minerals from the body using chelating agents can be applied as a precaution to reduce absorption of Lead in the body. Ayurvedic chelating agents for Lead are coriander leaves and garlic (Pandey *et al*., 2016). Individuals who are iron and calcium deficient are more susceptible to Lead exposure. Eating healthy, low-fat foods high in calcium, iron and vitamin C will help to reduce intake of Lead.

In households where Lead based paints have been used previously, children should be prevented from chewing painted objects. If repainting is to be done, dry sandpapering should be avoided and the surface should be wet scraped or wet sanded to prevent the release of leaded dust into the air (Rubasinghe *et al*.,2014).

Children's hands and toys should be washed regularly to minimize ingestion from soil and toys. Floors should be wet mopped and window components wet wiped. It is best if sand boxes could be provided for children to avoid playing with soil. Shoes should be left at the door and washable entryway mats used to prevent soil being tracked into the house.

House hold water should be checked for Lead contamination and for use of taps made of material that contain Lead. If household water is a suspected source of Lead contamination, drinking or cooking with hot tap water should be avoided since Lead is more soluble in warm water.

Conclusion

There is a necessity to conduct more research on Lead toxicity of the environment and take preventive actions. There is a need to bring about systemized monitoring programmes and a third party certification scheme to verify the percentage of Lead in paints. The Consumer Affairs Authority needs to be stringent in checking constituents of Lead in food products that are both local and imported. Pesticides and other chemicals used in agricultural practices should also be tested for Lead. Despite the fact that there are recyclers of Lead acid batteries, the public is not aware of the availability of the collection centres. Therefore, these batteries end with the municipality waste. There is a need to create awareness among the public on disposal and hazard of Lead acid batteries. Further, there is also a necessity to monitor these recyclers to ensure that they follow correct procedures.

Furthermore, by decreasing the combustion of coal, reducing deforestation, reducing traffic congestion and reducing the combustion of fossil fuels, mitigation of climate change will occur, thereby reducing Lead toxicity of the environment.

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Health and Climate Change in Sri Lanka: Risks and Institutional Level Responses

Inoka Suraweera

Environmental and Occupational Health Directorate, Ministry of Health& Indigenous Medicine
isuraweera@yahoo.com

Climate change endangers human health, affecting all walks of life, and Sri Lanka is no exception. It is very important to identify the risks to human health to better manage the adverse effects. Health issues related to vector borne diseases, extreme weather events, air pollution and rising temperature have been identified as priority climate sensitive health issues in Sri Lanka. The Environmental and Occupational Health Directorate, being the focal point for climate change in the Ministry of Health, has taken a lead role in addressing the climate sensitive health issues with other intra sectoral stakeholders.

Introduction

Climate change endangers human health, affecting all walks of life and Sri Lanka is no exception. Changes in the greenhouse gas concentrations and other drivers alter the global climate and bring about adverse human health issues. The environmental consequences of climate change, both those already observed and those that are anticipated, such as sea-level rise, changes in precipitation resulting in natural disasters, heat waves and degraded air quality, affect physical, mental and social wellbeing of humans both directly and indirectly. Addressing the effects of climate change on human health is especially challenging because both the surrounding environment and the decisions that people make influence health.

Climate change adaptation and mitigation are receiving much attention, given the inevitability of climate change and its effects, particularly in developing country contexts, where the effects of climate change will be experienced most strongly and the response mechanisms require strengthening.

Expected Changes in the Climate in Sri Lanka

The climate in Sri Lanka is projected to change in a number of ways. These include:

- Gradual increase in ambient air temperature
- Changes in distribution pattern of rainfall
- Increase in frequency and intensity of extreme weather events
- Sea level rise

Health Priorities for Sri Lanka

In order for the health sector to start planning and responding to the health risks posed by climate change, it is very important to understand the current climate sensitive health issues in Sri Lanka. The following have been identified as priority climate sensitive health concerns of the country:

- Morbidity and mortality due to vector borne diseases
- Morbidly and mortality due to increased incidence of extremes weather
- Health risks due to pollutants that could affect the weather and climate.
- Health effects due to increased heat and thermal stress

Sri Lanka has reviewed the health impacts arising from climate change and identified the following areas for priority action:

- Vector borne diseases
- Extreme weather events
- Health risks due to air pollution
- Health issues related to rising temperature

Vulnerable Populations and Areas

Certain groups and specific areas are likely to feel the impacts of climate change more than others. In Sri Lanka, the most vulnerable populations are:

- Informal sector agricultural workers
- Urban poor
- Communities living near the coastal area
- Communities living in natural disaster prone areas
- Children, elderly and people with existing chronic diseases

Institutional Level Response for Climate Change Impacts on the Health Sector

Directorate of Environmental and Occupational Health

The Directorate of Environmental and Occupational Health of the Ministry of Health is the focal point for climate change at the Ministry of Health, Nutrition and Indigenous Medicine. The focal point liaises closely with the Climate Change Secretariat of the Ministry of Mahaweli Development & Environment. The Directorate has provided technical guidance on health aspects of climate change in developing national reports on Technology Needs Assessment and Technology Needs Action Plans on Climate Change Adaptation 2014, Technology Needs Assessment and Technology Needs Action Plans on Climate Change Mitigation 2014, Climate change Chapter of "Haritha Lanka Plan" 2014, National Climate Change Adaptation Plan of Sri Lanka 2016-2024 and report on Intended Nationally

Determined Contributions to name a few. The Directorate has held several meetings with the relevant stakeholders to facilitate the implementation of the Nationally Determined Contributions on adaptation for the health sector.

Capacity building of Public Health staff is vital in conducting activities on adaptation and mitigation to climate change at the grass root level. The Directorate has engaged in capacity building of health staff on climate change and health and trained around 450 persons. Workshops have been conducted in 14 districts throughout Sri Lanka to build the capacities of Medical Officers of Health, Additional Medical Officers of Health, Supervising Public Health Inspectors and Public Health Inspectors on climate change and health since 2014. They are expected to conduct awareness programmes for school children and communities in their respective areas. Additionally, climate change and health lectures have been incorporated into Postgraduate Medical Education namely, MSc in Community Medicine, Medical Administration and Diploma in Disaster Management.

The Directorate has developed IEC material on climate change and health to facilitate the process of community awareness. A poster and a chapter on climate change and health in an environmental booklet were developed.

Heat related issues have been observed during the recent past and the Directorate, together with the relevant stakeholders, initiated the development of a Heat Health Action Plan for Sri Lanka. The final draft has been prepared and it will be published in 2017. This action plan will pave the way for stakeholders to act in a concerted way in responding to heat health issues.

Epidemiology Unit

Epidemiology Unit is the main focal point for control and prevention of communicable diseases in Sri Lanka.

Sri Lanka has a well established, widely accepted, and successfully functioning communicable disease surveillance and control programme, which is mainly handled by the Epidemiology Unit of the Ministry of Health. Both preventive and curative health institutions in central, divisional and primary levels and designated health staff attached to these places are involved in proper functioning of the disease surveillance and control programme. Continuous collection, orderly consolidation and evaluation of data of communicable diseases with prompt dissemination of results to deploy remedial action to prevention and control are currently well established in Sri Lanka. Trends of climate sensitive vector borne diseases such as Dengue, Malaria and Leptospirosis are being monitored by the Epidemiology Unit. Additionally, food and water borne diseases are monitored closely. Epidemiology Unit has planned for using GIS to monitor communicable disease surveillance for the whole country.

National Dengue Control Unit and Anti Malaria Campaign

These national-level institutions in the health sector are mainly responsible for control of dengue and malaria respectively. National Dengue Control Unit is involved in Dengue surveillance, integrated vector management, social mobilization, inter sectoral coordination and facilitation of dengue case management. Even though Sri Lanka has eliminated malaria, the campaign is actively engaged in case surveillance, entomological surveillance and parasitological surveillance to maintain the malaria free status.

Disaster Preparedness and Response Unit **(DPRU)**

Possible impacts on the health of the people of Sri Lanka through emergencies and disasters that could be associated with climate change and its effects have been taken into consideration by the Health Sector of Sri Lanka. Health Sector Disaster Preparedness and Response capacity have been improved over the last decade in a systematic manner in order to enhance the ability of the health sector to disasters triggered by climate change.

Ministry of Health has identified the pivotal role that it has to play in disasters; hence a National Steering Committee for Health Sector Disaster Management has been established. Disaster Preparedness and Response Division (DPRD) has been established at the Ministry of Health to coordinate disaster preparedness and response operations. Focal points have been appointed to each major health institution in the country to liaise with the DPRD.

DPRU has conducted a number of training programs to enhance the capacity of the health staff on disaster preparedness and response triggered by climate change. Health Sector Disaster Management Diploma program has been established during which medical officers are exposed to climate change and its impacts on human health. In addition, disaster preparedness plans have been developed and tested in all major hospitals in the country. It should be highlighted that the disaster scenarios identified by Health Institutions in developing and testing their plans have taken in to consideration extreme weather conditions that could affect the Health Institutions as well as the communities they serve.

Safe Hospitals Initiative pioneered by the World Health Organization has been introduced by the Sri Lankan health sector as a tool to ensure the functioning of the Health Institutions before, during and after disasters. The concept has been integrated into the Strategic Plan for Health Sector Disaster Management according to which a national initiative has been launched to make Health Institutions safer.

Strengthening research and development is needed in the area of climate change and health. Monitoring of diseases due to climate altering pollutants, especially among vulnerable populations such as children, is important to identify trends. Generation of evidence on climate change and health in Sri Lanka will facilitate planning action to better serve our citizens.

Conclusion

Health sector has identified climate sensitive health issues in Sri Lanka, and has taken several measures to better manage these. However, further strengthening of the health programmes will pave the way for creating a more resilient health system in addressing climate sensitive health issues. Strengthening the capacities of the curative as well as preventive health sector in addressing climate health risks becomes vital in building a more resilient health system.

Health Sector Preparedness and Response to Climate Change Related Emergencies and Disasters - Global and Sri Lankan Perspective

N.W.A.N.Y.Wijesekara

Disaster Preparedness and Response Division
Ministry of Health, Nutrition and Indigenous Medicine
novil.wijesekara@gmail.com

Health sector will be called upon to respond to disasters and emergencies resulting from climate change. Different ways that health sector may be called in to perform during such disasters and emergencies are discussed. Best practices and lessons learnt from recent disasters and emergencies in Sri Lanka are shared. Recommendations are made to make health sector better prepared to face emergencies and disasters which may occur as a result of climate change.

Climate Change and Health

Climate change, health and disasters are closely linked [1,2]. This article will provide an overview of health sector preparedness and response to climate change related disasters and emergencies, from both global and Sri Lankan perspectives.

Disaster and Emergency

A disaster is defined as a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to human, material, economic and environmental losses and impacts. [3]. An emergency could be responded to using the resources available at hand, indicating that there is no need to request external assistance. A disaster, however, is characterized by impacts that overwhelm the capacities of local responders and place demands on resources which are not available locally [4].

Link Between Climate Change, Health Emergencies and Disasters

Temperature rise, sea level rise and altered weather patterns due to climate change could result in floods, landslides, cyclones, heat waves, disease outbreaks, food scarcity, water scarcity, displacement and violent conflict. Resulting emergency conditions, if not managed properly, would lead to disasters. Health response becomes an essential aspect in responding to any emergency or disaster (Figure 1).

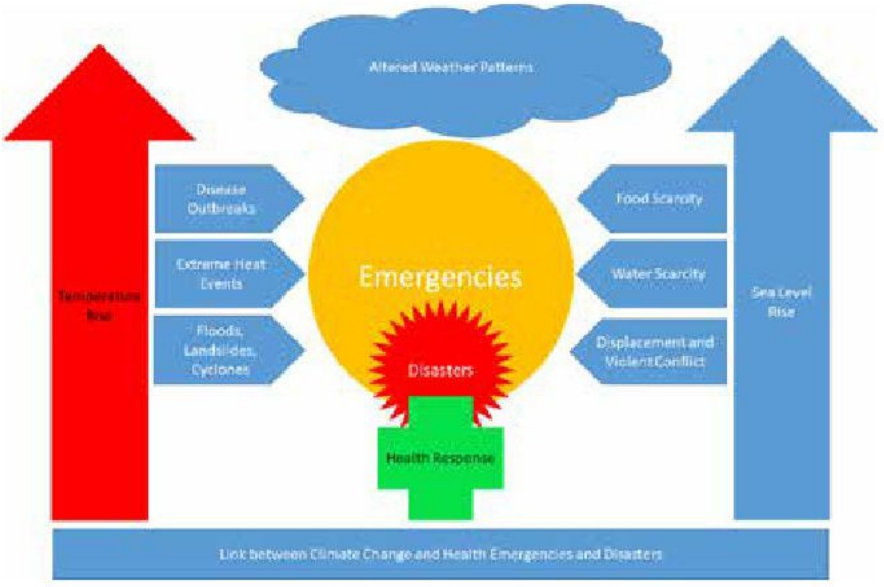

Figure 1 : Link between Climate Change and Health

Floods, landslides and cyclones which could occur as a result of climate change may have serious demands on the health systems. Health services will be required for the management of the casualties, diseased and displaced in the aftermath. During extreme heat, health systems may need to provide preventive and curative health services in partnership with other stakeholders.

Communicable diseases may increase with the rising temperatures, as mentioned in the latest report of the United Nations Framework Convention on Climate change which was presented to the governments during the last round of climate change negotiations held in Bonn from 8-18 May 2017 [5].

Food and water scarcity create challenging demands on health systems. During food scarcity, nutritional surveillance needs to be strengthened coupled with interventions to uplift the general nutrition status of the community, continuing good infant and young child feeding practices, targeted nutrition interventions for children with malnutrition, and blanket feeding programs for all children under the age of 5, irrespective of their nutritional status, could be organized depending on the severity of the food scarcity and level of malnutrition. Continuous community education, empowerment and mobilization are critical during conditions such as drought [6]. Water-borne disease surveillance and water quality surveillance need to be strengthened. Chlorination of bowser supplies, as well as boiling, filtration, solar disinfection and household chlorination, could be used. Purified water must be stored properly in proper storage containers to prevent contamination [7]. Climate-induced human mobility and resultant “Climate Refugees” will also have considerable socioeconomic costs with significant demands on health sector.

Towards a Climate Resilient Health Sector – Some Examples and Best Practices

Safe Hospitals Initiative

Health facilities such as hospitals need to withstand the effects of acute shocks (floods, landslides, cyclones) and chronic stressors (drought). Safe Hospitals Initiative pioneered by the World Health Organization is aimed at assessing and improving the structural, non-structural and functional aspects of hospitals. Strong and resilient building, robust life lines such as water, electricity and medical gases, and trained, knowledgeable and skilled staff who can execute emergency plans are key components of Safe Hospitals[8].

Ministry of Health has identified Safe Hospitals Initiative as a key strategy in its health sector emergency preparedness and response plan from 2015 – 2020 [9]. Advocacy for policy makers and training for health staff on Safe Hospitals Initiative are being done. Safe Hospitals concept will be integrated to the rebuilding of health institutions damaged by the floods and landslides in May 2017.

Integrating Disaster and Emergency Preparedness to Health Sector

Health sector is an active stakeholder of the post-Tsunami disaster management ecosystem of Sri Lanka [10]. A comprehensive program to build the capacity of health staff on disaster preparedness and response has been established. One solid example is the health sector disaster management diploma program administered by the Post Graduate Institute of Medicine supported by the Ministry of Health. Medical Officers are selected through a competitive examination for this training program. They receive six months of theoretical inputs from a multidisciplinary team of experts in the field of disaster management. They are then attached to hospitals to conduct a risk assessment, prepare a disaster management plan and to test the plan through a disaster drill. Financial support is provided by the Ministry of Health for the above drill [11].

In addition, many training programs are conducted to train other categories of health staff such as Nursing Officers, Public Health Midwives and Public Health Inspectors in the field of health sector disaster management. Inputs about Climate change and its link to health sector emergencies and disasters are being emphasized during these trainings.

Assessment of Drought Resilience of Health Institutions

Drought is a protracted emergency which does not attract much attention and resources as counterpart acute hydrometeorologicl disasters do. Effects of drought on health institutions too are often overlooked Ministry of Health with the support of the World Health Organization has commissioned a study to assess the drought resilience of health institutions in drought affected districts of Sri Lanka. Through this assessment, current status of water supply, electricity supply

as well as back up arrangements and coping mechanisms used by hospitals will be studied. Gaps identified through the above assessment will be communicated to the relevant authorities in order to lobby for attention and resources to bridge those gaps. Results of this assessment will be beneficial, especially in the backdrop of climate change, in planning health sector preparedness and response during protracted emergencies of drought.

Recommendations

Health sector is critical in managing climate change related disasters and emergencies when they occur. Following recommendations are made in order to ensure prompt and effective response by health sector during emergencies and disasters.

1. Smart Hospitals: Safe Hospitals Initiative needs to move into its next stage of Smart Hospitals. Smart hospitals will be safe as well as green [12]. During new hospital constructions, safety, as well as green elements, needs to be introduced. Opportunities to introduce such green concepts to established hospitals too need to be considered. Some green initiatives for health sector include solar energy, rain water harvesting, storm water recycling and used water recycling systems.

2. Early-warning systems for Climate Health Emergencies: The health effects of climate change are complex and dangerous. Early-warning systems need to be established to capture red flags of climate change related health emergencies and disasters. Some examples are the use of Heat Health Index [13], air pollution level and ultra violet radiation level that need to be communicated to the public to prevent exposure to Climate change related health exposures.

3. Community-based surveillance: Sri Lanka has a well-established health institution based disease surveillance system. Community-based surveillance systems can complement the existing health institution based disease surveillance system through improving the early detection and assessment of outbreaks [14]. At present, there is no well-established Community-based surveillance in Sri Lanka. Such Community-based surveillance systems could be used to capture suspicious health events such as occurrence of unusual diseases or clustering thereof, so that prompt action could be taken to curtail them. In addition, this could be a versatile strategy to enhance health and climate literacy of communities, as well as their empowerment.

4. Risk Communication: Climate change related risks, emergencies and disasters are often perceived by communities and decision makers as remote and insignificant. However, it is important that appropriate risk communication strategies are conducted targeting the whole of the society [15]. Health staff has a vital role to conduct risk communication on climate change related health risks. Conducting training programs to health staff, not only on climate change but also on correct risk communication strategies, is needed.

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Observed Climate Trends, Future Climate Change Projections and Possible Impacts for Sri Lanka

***Shiromani Jayawardena, Thanuja Darshika and Roshan Herath**

Center for Climate Change Studies, Department of Meteorology, Sri Lanka
*shirojaya2000@yahoo.com

A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes, and can result in unprecedented extremes. Increasing exposure of people and economic assets has been the major cause of long-term increases in economic losses from climate related disasters (IPCC SREX 2012). Information on climate and climate change used for decision making is typically provided by historical observations or model results of projected future conditions. Past climate trends based on historical data provide evidence of changing climate conditions. Knowing how the climate has already changed and how those changes have affected the vulnerable sectors such as water resources, agriculture and food security, human health and eco system provides insight into what may happen in the future.

Past Climate Trends

The trend analysis conducted using long-term and high-quality datasets for 19 meteorological stations, for a period between 1980 and 2015 indicated that annually averaged mean minimum temperatures are increasing across most of Sri Lanka. Diurnal temperature range (the difference between maximum and minimum temperatures) is decreasing, indicating that the minimum temperature is increasing faster than the maximum temperature. Decreasing trend of Diurnal temperature range is more significant in Maha season in the dry zone. It is evident that significant decrease in the annual occurrence of cold nights and increase in the annual occurrence of warm nights are also obvious.

Precipitation indices show evidence of changes. Some of the indices in this study can be good indicators for climate extremes in Sri Lanka. The annual total precipitation (Fig 1) has indicated a significant increase over 1980–2015. More than 80% of stations showed an increasing trend in precipitation indices. Nearly 75% and 65% of the stations showed significant increasing trend in annual total precipitation and number of days above 10mm rainfall at the 5% -10% level. There is an indication of more consecutive wet days, in inland areas, and less consecutive dry days especially over western coastal areas. Days above 10, 20 and 30 mm of rainfall show an increasing trend annually in many stations. For the extreme precipitation an increase in the annual highest daily amount and highest 5 consecutive days of precipitation were found at many stations.

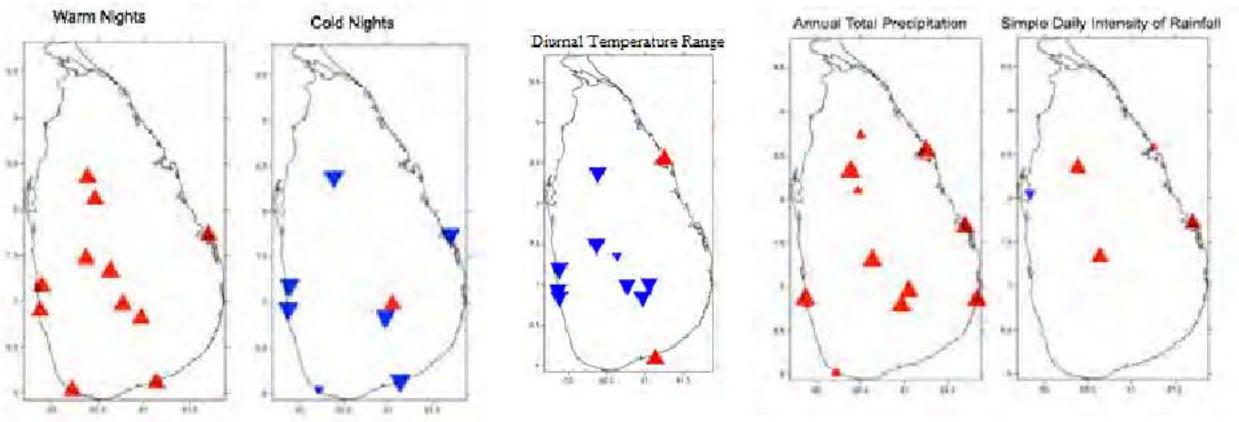


Fig 1 : Spatial distribution maps of observed trends for occurrence of warm nights, occurrence of cold nights, diurnal temperature range, annual Total Precipitation and simple daily intensity. The upward-pointing red triangles show increasing trends, while the downward-pointing blue triangles indicate decreasing trends. Significant changes at the 5% level are indicated by large triangles and 10% level are indicated by small triangles

Future Climate Projections

Climate models are mathematical representations of processes important in the Earth's climate system. In order to obtain climate change projections, the climate models use information described in scenarios of greenhouse gas (GHG) and air pollutant emissions and land use patterns. Key factors driving changes in anthropogenic GHG emissions are economic and population growth, lifestyle and behavioural changes, associated changes in energy use and land use, technology and climate policy, which are fundamentally uncertain. The standard set of scenarios used in the AR5 is called Representative Concentration Pathways (RCP). The RCPs describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. The RCP 2.6 represents moderate emission scenario, RCP 4.5 and RCP 6 represent moderate emission scenario while RCP 8.5 represents high emission scenario.

Climate change projections, also referred to as climate scenarios, are widely used for assessments of the potential impacts of climate change on natural processes and human activities, including assessments conducted at the local/regional scale. A number of different approaches are used to develop climate projections, and the strengths and limitations of each method must be taken into consideration when selecting projections for use in a specific application and when interpreting, comparing, and integrating outcomes from multiple assessment studies and impact analyses.

NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) data for 6 GCM climate models (25-kilometer (km) grid resolution) given in the table 1 were used to develop figure climate projections. The Representative Concentrated Pathways (RCP) RCP 8.5 and 4.5 scenarios from of

the IPCC AR5 2013, representing futures under high emission and moderate emission, respectively, were adopted, with three time periods—2030s, 2050s, and 2080s.

Table 1 CMIP5 Models used develop climate Projections for Sri Lanka	
CanESM2	The Second Generation Coupled Global Climate Model Canadian Centre for Climate Modelling and Analysis (2.8*2.8)
CNRM-CM5	National Centre for Meteorological Research/ Meteo-France (1.4 * 1.4)
CSIRO-MK3-6-0	Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Queensland Climate Change Centre of Excellence (QCCCE). (1.895*1.875)
GFDL-CM3	GeoPhysical Fluid Dynamic Laboratory NOAA, USA Coupled Climate Model (2 * 2.5)
MRI-CGCM3	Global Climate Model of the Meteorological Research Institute, Japan (1.132*1.125)
NCAR-CCSM4	National Center for Atmospheric Research, USA Coupled Climate Model (0.942 * 1.25)

Because of incomplete understanding of the physics of the climate system, different climate modelling groups around the world represent climate processes in different ways in their models. As a result, there are differences in the projections of future climate. This is therefore, a source of uncertainty in climate projections. In order to address this source of uncertainty, single climate projections from above mentioned climate models are used to generate a multi-model ensemble.

Multi-model ensemble projections indicated that the Annual rainfall anomaly is negative in Northeastern parts, and positive in Southwestern parts in 2020-2040, while Annual rainfall anomaly is positive and increasing there after under moderate emission scenario RCP 4.5. Annual rainfall anomaly is positive and increasing under high emission scenario RCP 8.5 with increasing anomaly is significant in the wet zone.

Southwest monsoon rainfall anomaly is positive and increasing in both moderate (RCP 4.5) and high (RCP 8.5) emission scenario with increasing anomaly is significant in the wet zone (Fig 2).

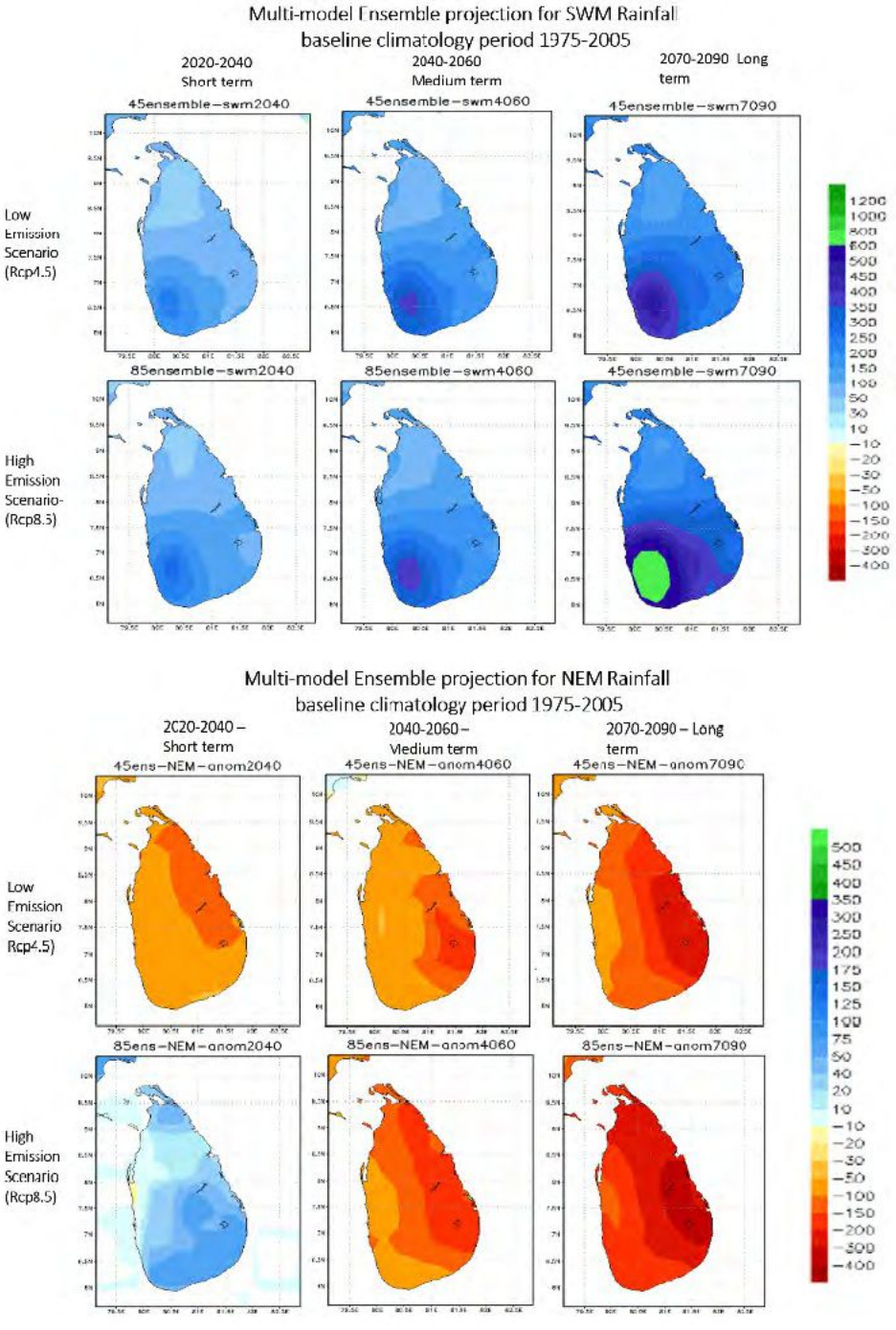


Fig 2: Multi model ensemble of change in Southwest-Monsoon rainfall (left) and Northeast -Monsoon Rainfall (right), relative to 1975-2005 for moderate emission scenario (RCP 4.5) (upper) and high emission scenario (RCP 8.5) for time periods (2020-2040), (2040-2060), (2070-2090).

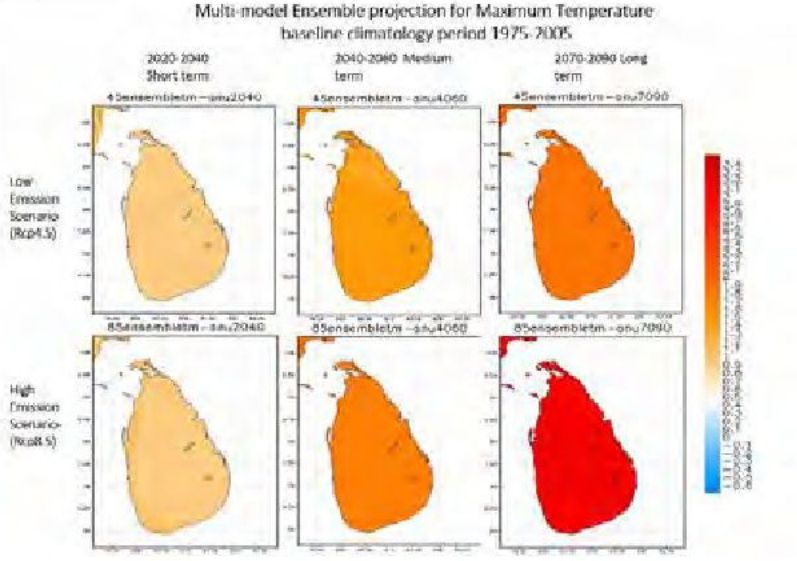
Northeast monsoon rainfall anomaly is negative for short term, medium term and long term projections and negative trend is observed under moderate emission scenario RCP 4.5. Northeast monsoon rainfall anomaly slightly positive in short term projection 2020-2040, and negative there after for medium term and long term projections under high emission scenario. A negative trend is observed for high emission scenario RCP 8.5. Decreasing anomaly is significant over the dry zone (Fig 2).

First Inter Monsoon rainfall anomaly is negative in 2020-2040 , slightly negative in 2040-2060 and positive except Northeastern parts under moderate emission scenario RCP 4.5. First Inter Monsoon rainfall anomaly is negative in all three time frames with no significant trend under high emission scenario RCP 8.5 .

Second Inter Monsoon rainfall anomaly is negative in Northeastern parts, and positive in Southwestern parts in 2020-2040. It is positive and increasing after that under RCP 4.5.

Second Inter Monsoon rainfall anomaly is positive and increasing under RCP 8.5 scenarios with significant increase of positive rainfall anomaly over the Southwestern and Southeastern parts

Multi model ensemble prediction indicates increase in Maximum temperatures as well as Minimum temperatures for all three time periods in 2020-2040, 2040-2060 and 2070-2090 for both moderate emission (RCP 4.5) and High emission scenarios. For moderate emission scenario Multi model ensemble prediction indicted that increase of minimum and maximum temperature in 0.7– 1.2 ^{0}C, 1.0-1.6 ^{0}C and 1.5-2.3 ^{0}C can be expected during 2020-2040, 2040-2060 and 2070-2090 respectively. For high emission scenario Multi model ensemble prediction indicted that an increase of minimum temperature in 1.1 – 1.5 ^{0}C, 1.6.-2.5 ^{0}C, and 2.4-3.5 ^{0}C while an increase of maximum temperature in 1.0 – 1.5 ^{0}C, 1.4.-2.3 ^{0}C and 2.2-3.2. ^{0}C, can be expected 2020-2040, 2040-2060 and 2070-2090 respectively (Fig 3).



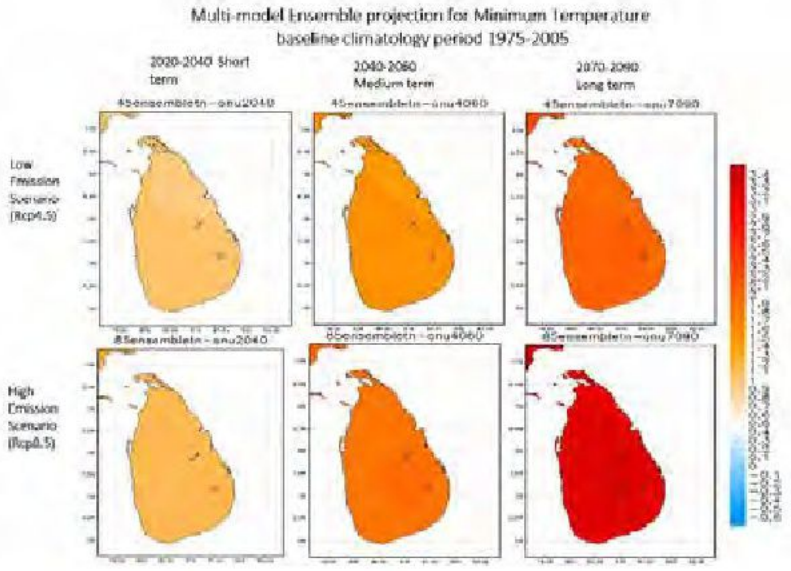


Fig 3 Multi model ensemble of change in Maximum Temperature (left) and minimum temperature (right) , relative to 1975-2005 for moderate emission scenario (RCP 4.5) (upper) and high emission scenario (RCP 8.5) for time periods (2020-2040), (2040-2060), (2070-2090).

Future Projections of Extreme Climate Indices for Three Climatic Zones

It is obvious that temperature indices such as maximum daily maximum temperature, maximum daily minimum temperature, minimum daily maximum temperature, minimum daily minimum temperature, occurrence of warm nights, occurrence of warm days and warm spell duration are indicates an increasing trend while occurrence of cold nights, occurrence of cold days, Diurnal temperature range and Cold spell duration indicates a decreasing trend, with statistical significance in future projection from 2020 – 2100 for all three climatic zones, for all models, for both moderate and high emission scenarios.

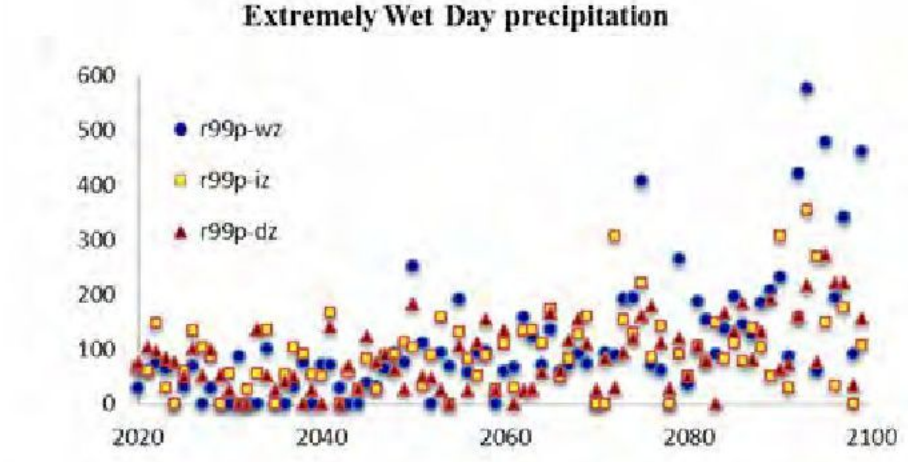


Fig 4: Extremely wet day precipitation from 2020 to 2100 in Wet Zone (Blue, circles), Intermediate zone (Yellow squares) and Dry zone (Red triangles) for High emission scenario (RCP8.5) (Multi Model Ensemble projection).

In contrast to the projected trends in the temperature indices in which all models have general agreement with statistical significance for all three climatic zones under both emission scenarios, trends in the precipitation indices are less consistent in this regard. Majority of other models projected statistically significant increasing trend in many precipitation indices except maximum 1-day precipitation amount, consecutive dry days, and consecutive wet days in all three climatic zone under moderate emission scenario and except consecutive wet days in all three climatic zone under high emission scenario.

Possible Impacts of Climate Change

Increases in air temperature observed in the recent past and expected to be continued in future projections have huge impact in evapotranspiration and urban and agricultural water demands. Significant decrease in the annual occurrence of cold nights and increase in the annual occurrence of warm nights observed in past as well as predicted in future will place a higher demand for energy. A rise in average temperature will increase energy requirements for irrigation in agriculture and for space cooling.

Increase in extreme maximum temperature indices may have impacted human health by occurrence of more frequent heat events. Vector-borne disease-carriers like mosquitoes respond to higher temperatures and increased humidity. With significant increasing trend in annual total precipitation and other extreme precipitation indices vulnerability to vector borne diseases like Dengue will be high in the wet zone. Under climate change, increase in rainfall intensity can cause water logging and thereby create favorable conditions for high mosquito breeding especially in the wet zone.

Changes in annual as well as southwest monsoon seasonal rainfall compare to the base line climatology, clearly indicate that positive rainfall anomaly in the wet zone will be risen with the time under high as well moderate emission scenarios. The western slopes of the central hills are prone to natural disasters like landslides, and while low lying areas in the Kelani, Kalu, Ginganga and Nilwala basins are vulnerable to floods.

Changes in northeast monsoon seasonal rainfall compare to the base line climatology, clearly indicate that negative rainfall anomaly especially in the dry zone will be fallen with the time under both high as well moderate emission scenarios. Reduction in northeast monsoon rainfall (Dec-February) may increase vulnerability of the agriculture sector as nearly 70% of the Paddy cultivate in Maha season (September to March) in the Dry zone of Sri Lanka. More frequent droughts can be expected in the dry and intermediate zones.

In addition, vulnerability of the health sector is amplified by other factors, including dumping of solid waste that contaminates surface water and groundwater and also creates vector breeding conditions; poorly managed urban drainage also enhances the spread of disease.

Climate model results provide the basis for projections of future climate change. Making decisions based on climate change projections requires an understanding of the sources and effect of uncertainty in future planning. Uncertainties associated with future climate projections include representation of the GHG emissions scenarios, uncertainties associated with future estimates of population growth, changes in land use, and the economic growth ect. Further uncertainties in climate modeling arise from uncertainties in initial conditions, boundary conditions (e.g., a radiative forcing scenario), observational uncertainties, uncertainties in model parameters and structural uncertainties resulting from the fact that some processes in the climate system are not fully understood or are impossible to resolve due to computational constraints.

Acknowledgement

Technical support provided by RIMES under the "Capacity building on generation and application of downscaled climate change projections" project funded by UN ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness in Indian Ocean and Southeast Asian Countries (LOA No. 2014-0036) is acknowledged. Climate scenarios used were from the NEX-GDDP dataset, prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth Exchange, and distributed by the NASA Center for Climate Simulation (NCCS) "

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Remote Sensing Techniques for Studying Coastal Environments

***S.M.D.Athukorala and P.B.Terney Pradeep Kumara**

Marine Environment Protection Authority
*smdathukorala@gmail.com

Rich natural resources and diverse ecosystems make the coastal environments important for economic development and ecological restoration. However, these are vulnerable ecosystems for climate change. Remote sensing techniques have proven to be powerful tools for the monitoring of the Earth's surface and atmosphere and this article introduces the methods for monitoring the coastal environment using remote sensing and GIS techniques.

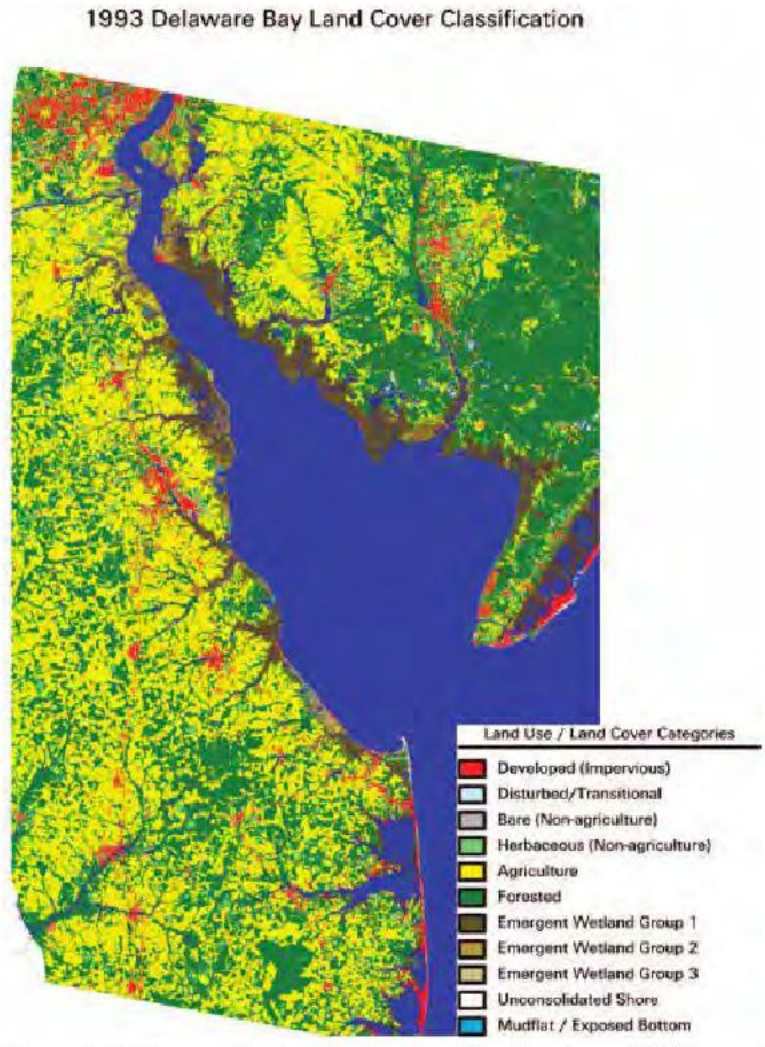

Figure 1. Delaware Bay landcover classification from 1993 based on Landsat TM imagery. Modified from Weatherbee (2000).

Introduction

Coastal ecosystems are diverse sensitive ecosystems which have been focused for protection due to various anthropogenic and natural disturbances. Adverse human impacts have led to climate change and subsequently global warming. Based on sea-level rise (SLR) predictions for next 100 years, it will cause serious long-term consequences on coastal ecosystems and to coastal economic development. For instance, intensified coastal flooding and erosion of beaches, as well as threats to waterfront properties may be experienced from rapid SLR. As the ocean surface water warms, stronger storms such as Katrina and Rita are also predicted for the coastal areas. One of the recent experiences was hurricane Irma which has been the most powerful Atlantic storm in a decade with wind speeds of up to 295km/h. (BBC, 2017)

For protecting coastal ecosystems it requires the ability to monitor their biophysical features and controlling processes at high spatial and temporal resolutions with remote sensing technology. Among the various remote sensing systems available, selecting the proper data source for observing land cover and coastal waters is challenging. There are four types of resolution: spatial, spectral, radiometric, and temporal. Spatial resolution is a measure of sharpness of spatial detail or it corresponds to the pixel size. Spectral resolution is a measure of the specific wavelength intervals that a sensor can record. Radiometric resolution is a measure of a sensor's ability to distinguish between two objects of similar reflectance. Temporal resolution is a measure of how often the same area is visited by the sensor. Ecosystem health indicators that can be observed using remote sensors are natural vegetation cover, wetland loss and fragmentation, wetland biomass change, percentage of impervious watershed area, buffer degradation, and changes in hydrology, water turbidity, chlorophyll concentration, eutrophication level, salinity, temperature, etc. Major components for studying coastal environments using remote sensing include:

Mapping Coastal Wetlands and Watersheds

A combination of models is used to study the impact of land runoff on estuarine and coastal ecosystems. Amount and type of runoff can be predicted with input regarding how the land cover is changing, together with other inputs like slope and precipitation. The Landsat TM with its 30-m resolution and spectral bands and SPOT (20 m) has been a reliable source for land cover data. High-resolution imagery (0.6 m to 4 m) can also be obtained from satellites, such as IKONOS and QuickBird.

Monitoring Wetland Changes and Land Cover Trends

Time series of remotely sensed imagery have to be analyzed to identify long-term trends and short-term variations, such as the impact of rising sea levels and cyclones on wetlands. Changes may occur in both time and spectral content. The imagery must be acquired under similar environmental conditions (e.g. same time of year, sun angle, etc.) and in the same or similar spectral bands.

Shoreline Topography and Bathymetry

Studies on near shore geomorphology, hydrology, and sedimentary processes are essential in order to plan sustainable coastal development, implement effective beach erosion control and coastal ecosystem protection strategies. To map long-term changes of the shoreline time series of historical aerial photographs and topographic maps have been used. The GPS combined with light detecting and ranging (LIDAR) technique have been used for shoreline position analysis, beach erosion studies and to study the bathymetry of submerged coastlines. The interferometric synthetic aperture radar (InSAR) technique jointly with GPS and altimeter data is also a good candidate for change detection both on land and in coastal areas.

Submerged Aquatic Vegetation and Coral Reefs

The health of most of the coral reefs has been declining. Coral reefs thrive in a narrow range of environmental conditions and are very sensitive to small changes in temperature, light, water quality and hydrodynamics. Mapping submerged aquatic vegetation, coral reefs and general bottom characteristics requires high-resolution (1–4m) multispectral/ hyperspectral imagery. With the advances in hyperspectral sensors, scientists can measure the spectral states of a reef that can be used as indicators of coral health.

Remote Sensing of Ocean Chlorophyll and Productivity

Ocean biological productivity can be estimated by measuring the ''chlorophyll a'' concentration. Satellites with multispectral and hyperspectral imagers, such as sea-viewing wide-field-of-view sensor (SeaWiFS) and MODIS, were specifically designed to monitor ocean chlorophyll concentrations and sea temperatures on a global scale. For estimating primary productivity, a calibration and validation approach must be used. Ocean color sensors and thermal infrared imagers have been used quite successfully to monitor these upwelling areas and estimate their productivity. Using platforms such as ocean gliders, remotely operated vehicles(ROVs) and autonomous under water vehicles(AUVs), with advanced optical and acoustic sensors, marine scientists can now perform high-resolution three-dimensional measurements of biological and physical ocean features such as planktonic distribution and biological productive zones at various depths.

Sea Surface Temperature (Sst)

Accurate large-scale, long-term observations of SST are important for a wide range of oceanographic studies such as, for estimating the source of heat at the air–sea boundary, water boundary currents, to monitor the health of the Earth's coral reefs, to identify upwelling zones where rising cold water brings nutrients to the surface and to study habitats of fish and wildlife over many parts of the globe. Examples of long-term studies include the changes in SST patterns associated with such inter-annual climate variations as the La Niña and El Niño cycles. Thermal infrared (TIR) sensors such as AVHRR, or ocean color sensors, including SeaWiFS and *etc*. have been deployed to provide images of SSTs.

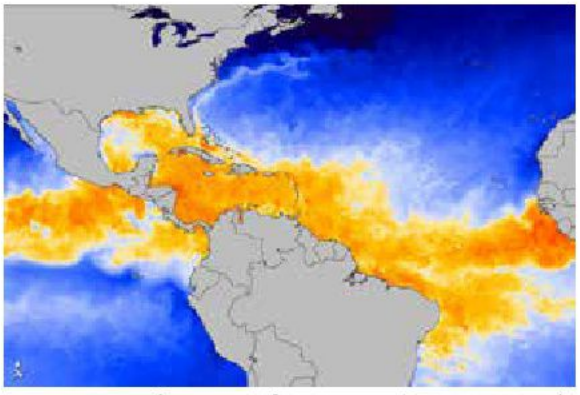

Figure 2 :Sea Surface Temperatures at the Start of 2010 Hurricane Season by NASA Earth Observatory image using AMSR-E and MODIS

Observing Eutrophication and Hazardous Algal Blooms

Algal blooms are harmful in that they cause eutrophic conditions, depleting oxygen levels needed by organic life and limiting aquatic plant growth by reducing water transparency. Some species of algae contain potent toxins that can propagate through the food chains. Seabirds, marine mammals, and even humans are at risk of illness or death if they eat shellfish tainted with algal toxins. Most algal blooms can be observed from satellites because of their distinct color, location, or repetitive seasonal appearance. Concentrations of ''chlorophyll a'' and total suspended sediments can be used as indicators of the severity of eutrophication and turbidity, respectively. Progress of a bloom can be tracked as it moves in from offshore. Due to high turbidity, the drift and dispersion of coastal plumes and ocean-dumped waste have been tracked with multispectral satellite imagery with small number of multispectral bands. However, to detect the composition and concentration of their content is difficult, even with hyperspectral images.

Sea Surface Salinity (SSS)

Sea surface salinity is critical for determining the global water balance, for understanding ocean currents, and for estimating evaporation rates. Also, low-salinity water is frequently indicative of fresh water sources. Airborne microwave radiometers can measure sea surface salinity and have been used in many applications. Sea surface salinity has been the most important oceanic variable that until recently has not been measured from satellites. For instance, the European Soil Moisture and Ocean Salinity satellite retrieves salinity with an accuracy of 0.1–0.2 precision salinity units (psu) at a resolution of about 50 km.

Oil Spill Detection and Tracking

For oil spill emergencies the fast turn-around time and frequent imaging of the site to monitor the dynamics of the spill are needed. Remote sensors on satellites and aircraft meet these requirements by tracking the spilled oil at various resolutions and over wide areas at frequent intervals through multi-temporal imaging. Most of these sensors use electromagnetic waves, acoustic sensors on boats and cameras on submerged robot-like vehicles to view the subsurface behavior of the oil. Oil sheen shows up as silvery and reflects light over a wide spectral region. Heavy oil appears brown while mousse looks red-brown.

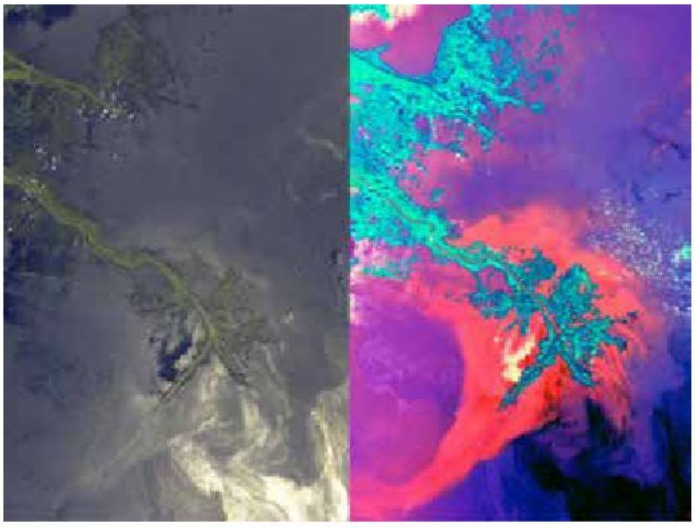

Figure 3 : Satellites and aircraft are used to track the movement of oil from the Deepwater Horizon spill in the Gulf of Mexico in 2010 by NASA

Satellite and airborne remote sensors can now map and measure coastal ecosystems and their changes cost effectively at appropriate scales and resolutions, minimizing the need for extensive field and ship measurements. New satellites, carrying sensors with fine spatial (1–4 m) and spectral (200 narrow bands) resolutions, are providing the means for more accurately detecting changes in coastal ecosystem health. Hence, coastal managers and scientists will have better means for assessing the impacts of alternative management practices on coastal ecosystems and taking corrective action early, as it is most effective.

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දේශගුණ කතිකාව
The Climate Discourse

Leel Randeni

Environment Planning and Economics Division
Ministry of Mahaweli Development and Environment
leelrandeni@gmail.com

"The Value of Nothing" 

Thirty spokes share the wheel's hub; it is the centre that makes it useful.
Shape clay into a vessel; It is the space that makes it useful.

Cut doors and windows for a room; it is the wholes that makes it useful.
Therefore profit comes from what is there; usefulness from what is not there.

Quote from Tao Te Ching, a book written by Lao Tzu, Chinese Philosopher who lived in 604 BC

''නැති කඩෙ ඇති අගය''

රෝදය මැද බෙදා ගන්නා ගරාදි තිහකින එහි මැද නිසයි අපට වැඩ සැලසෙන්නේ.
මැටිටෙන් බඳුනට හැඩය දෙයින මැටි තුළ ඇති ඉඩ නිසයි බඳුන් තැනිය හැකි.

කාමරයක ජනේල හා දෙර කවුළුත කාමරයේ ප්‍රයෝජනය කවුළු නිසයි.
ඇති දෙය ලාභය ගෙන ආවත්ත සැබෑ ප්‍රයෝජනය සලසන්නේ එතැන නැති දෙයි.

ක්‍රිස්තු පූර්ව 604 පමණ චීනයේ විසූ දාර්ශනිකයෙක් වූ ලා ඔත් සේ ගේ කාඕ තේ චින් ග්‍රන්ථයෙනි.

කොළඹට පැවරී තිබුනේ පරිසරය සම්බන්ධයෙන් ප්‍රතිපත්ති සම්පාදනය කරනු ලබන ආයතනයකට සේවය කිරීමටයි. පෘථිවියේ විසිපස් වෙනි තැනට විශාල දූපත වූ ඔවුන්ගේ ජන්මභූමිය පිහිටියේ ජෛවවිවිධත්වයෙන් පොහොසත් පෙදෙසකයි. බොහෝ අවස්ථාවල බොහෝදෙනා ඔවුන්ගේ මුතුන්මිත්තන් පරිසරය සමග සහජීවනයෙන් විසූ ජාතියක් යැයි පවසනු කොළඹ අසා ඇති අතීතය එසේ වුවද, වර්තමානයේ දී පරිසරයේ ක්‍රියා රිද්මය වන දේශගුණය පවා මහත් විපර්යාසයකට ලක්වී ජන ජීවිතයම බරපතල අන්දමින් අනතුරේ වැටී වියවුලක් වී ඇති වසර කිහිපයක සිට ගංවතුර හා නියඟය ජනයා පෙලන්නට පටන් ගෙන ඇත. වසරේ යහපත් දේශගුණයක් ඇති දින ගණන අතේ ඇඟිලි වලින් ගිනීමට වුවද හැකි මට්ටමකට අඩුවී ඇත. කලට වේලාවට ගොවිතැනට ජලය නොලැබීමෙන් කොළඹ වෙසෙන පෙදෙසේ ජනයා කුඹුරු වගා කිරීම පවා අත් හැර දමා ඇත. පසුගියදා ඇතිවූ දැඩි නියං සමයේ ජල බවුසර මඟින් පානීය ජලය බෙදීමට පවා සිදුවිය. කොළඹ බලවත් කණ්ඩායම්වලටත් කම්පනයටත් වෙහෙසටත් පත්වී සිටියේය. එහෙත් ඔහු සතුව විසඳුම්

නොමැති බැවින් හේ අසරණය. පසුගිය වසරේ රට මැද මධ්‍ය කඳුකරයෙන් ඇරඹී අගනුවර අසළින් සයුර හා එක්වන දිවයිනේ ප්‍රධානම ගංගාවක් පිටාර ගලා නිවෙස් ජලයෙන් යටවී මහත් විනාශයක් වියි අරුණ උදා වෙද්දී බොහෝ දෙනාට හිමිව තිබුනේ හැදිවත පමණකි. ඔවුන් සතුව තිබූ බොහෝ දේ ජල රකුසා බිලිගෙන තිබුණි.

ඡායාරූප අන්තර්ජාලයෙනි

ලිපිය ලියාගෙන යද්දී පසුගිය වසරේ වූ සිදුවීමට වඩා දරුණු ඛේදවාචකයකින් සමස්ථ දිවයිනම කම්පනය වී තිබුනි. දිවයිනේ නිරිත හා දකුණු දිග පෙදෙස් දරුණු ගංවතුර තර්ජනයකින් ඇළලී ගොස් තිබුනි. කඳු පෙදෙස් වලට වරු තුනත් පමණ ලැබුනු වර්ෂාව මහත් විනාශයක් සිදු කොට තිබුනි. මිනිසුන් පවුල් පිරින් නාය යන පස් කඳු යට සඳහට වැළලී ගොසිනි. ඇතැමුන් ගංගා පිටාර ගලන සැඩ පහරේ අතුරුදන් වී ගොසිනි. සොබාදහම වියරු වී ඇත. කොළුවා ඒ පෙර කිසිදා නොවිදි දරුණු ක්ෂිතිමය අත්දැකීමක් විය.

දේශගුණ විපර්යාසයන් සම්බන්ධයෙන් ඒවායේ අහිතකර බලපෑම් වලට අනුහුරු වීම යනුවෙන් හඳුන්වන සංසිද්ධියක් වෙයි. හැඩගැසීම හෝ ඔරොත්තු දීමේ හැකියාව වැඩි දියුණු කර ගැනීම ලෙසින් මෙය පැහැදිලි කළ හැක. මේ කතිකාව ඒ පිළිබඳවයි. ඉතින් කොළුවා ට කළ හැකි එකම හා හොඳම දෙය ලෙස සලකා කතිකාව ඇරඹීමට තීරණය කලේය.

දේශගුණය අරභයා සක්‍රිය කතිකාවක් ඇරඹිය හැක්කේ එය ඉඩක් ලෙස ගැනීමෙන් පමණක් ය යන්න කොළුවා ඒ පිළිබඳ දරන අදහසයි. එක් සිතක එක් විටක තිබිය හැක්කේ එක් සිතිවිල්ලක් පමණි. සිතිවිලි දෙකක් හෝ කිහිපයක් තිබිය නොහැක. ලාභය හා ප්‍රයෝජනය ගැන පැහැදිලි කිරීමක් ඇති චීනයේ විසූ ලා ඔත්සේ තුමාගේ ආප්තෝපදේශයක් කොළුවා ඉහළින් උපුටා දක්වා ඇත. ලාභය හඹා යාමෙන් ප්‍රයෝජනය සමාජයට අහිමි වී ඇති බව ඔහුට ප්‍රත්‍යක්ෂ වී ඇත.

ලාභය හඹායාම පරමාදර්ශය වූ සමාජයකට ප්‍රයෝජනය අහිමි වන ආකාරය පැහැදිලි කිරීමට කොළුවා බලාපොරොත්තු වේ. මිනිසා සමාජ සත්වයෙක් බැවින් මිනිසාගේ ප්‍රයෝජනය යනු සමාජයේ ප්‍රයෝජනයයි. එහෙත් පුද්ගලයින් තනි තනිව ලාභය හා තෘප්තිය උපරිම කර ගැනීමට පොරබදන විට ප්‍රයෝජනය ගිලිහී

යයි. දේශගුණය වැනි භාත්පසින් ක්‍රියාත්මක වන පරිසර පද්ධතියේ ක්‍රියාරිද්මය ඇත්තේ විශාල ඉඩකයි. එහෙත් ඒ ආකාරයෙන් දේශගුණය පිළිබඳ හැඳෑරීමක් කොළුවා විසූ දූපතේ නොවූ බැවින් දේශගුණය අරභයා අර්ථවත් පොදු සමාජ ක්‍රියාවක්ද නොවීය. තිබූ එකම දෙය නම් අගක් මුලක් නොමැති දුක් විඳීමම පමණකි. ඔවුන් එය සංසාරය යනුවෙන් හඳුන්වති.

එහෙත් ඒ දිවයින අතීතයේ ලොව ජය කෙහෙළි නැංවූ විද්‍යාවනට තිඹිරිගෙය විය. ඔහුගේ මුතුන් මිත්තන් ලාඔත්සේ කියූ අයුරින්ම නැති දෙයක් වටා එක්රොක් වූහ. නැති දෙය තුළ සියල්ලම විය. පරිසරය සුවදායක විය. ගස් වැල් පලබර විය. කලට වැසිපලද හිරුගේ ආශීර්වාදයද නොමඳව ලැබුනි. දේශගුණය මිත්‍රශීලී විය. ජීවිතය සංසාරයම පමණක් නොව විමුක්තියද විය. ඔවුන්ට දේශගුණයේ වෙනස්කම් කල් ලබා දැනුනු අතර වන සතුන්ගේ මෙන් ඔවුන්ගේ ඉව ප්‍රබල විය.

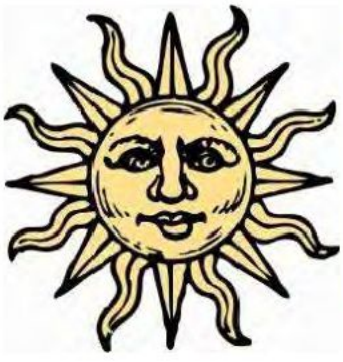
ඔවුන්ගේ ජීවනෝපායයන් පරිසරයේ ක්‍රියා ඉඩ ඉක්මවා නොයාම කොළුවා කියවන්නේ තීරණාත්මක සංසිද්ධියක් ලෙසිනි.

" ඒ දවස්වල අපි පොළොවේ ගොවිතැන් කලත් අහස දිහා බලාගෙන වැඩ කළේ ! ඒ කියන්නේ අහසෙ පායන ඉර දෙයියෝ තමයි අපට බත සරි කළේ''. ඒ දේශගුණ විපර්යාසයන්ගේ අහිතකර බලපෑම් වලට ඔරොත්තු දීම සඳහා ප්‍රජාවේ සංරක්ෂණ හැකියාවන් වැඩිදියුණු කිරීම සඳහා වන ක්‍රියාන්විතයේදී කොළුවාට වියපත් වැඩිහිටි ගොවියෙක් පැවසූ කතාවකි. වෙනස් අදහසක් බැවින් එයින් කොළුවාගේ කුතුහලය ඇවිස්සුනි.

කොළුවා පෙරළා විමසූ විට ඔහුට මෙවැනි පිළිතුරක් ලැබුණි.

" අපි කලට වෙලාවට ආහාර ටික හදාගත්තා ඉර දෙවියොත් එක්කයි අපි ගමන ගියේ. අපිට ඉර දෙවියො වෙලාව කිව්වා අපේ කුඹුරු අපි හැදින්නුවේ "ඉරවල්ල" කියලා. අපි සූර්ය මාස දොළහකට අවුරුද්ද බෙදලා සූර්යයාගේ ගමනට ගැලපෙන දේ කළා. එච්චරයි. අපට කවදාවත් වැරදුනේ නෑ පුතේ!!!.....දැන් තමයි වැරදිලා තියෙන්නේ... අපේ සූර්ය මාස, චන්ද්‍ර මාස ලිත් වලට අනුවයි අපි වැඩ කළේ.

අහසෙ පායන ඉර දෙයියන්ට වඩා කෙනෙක් අපිට කොහෙන්ද? ඔහුගේ බස වේගවත්ය, ප්‍රාණවත්ය. අපි ලාභය හොයාගෙනම ගියෙ නෑ. අද වගේ. අපි ඉරත් එක්ක ජීවත් වුනා. ඉතින් අපිට ලාභයත් හැමදේමත් තිබුනා. අපිට පාඩු වුනේ නෑ කවදාවත්ම. යහපත් දේශගුණය අපි අවුරුද්ද පුරාම අත් වින්දා. ඉදහිට ගංවතුරක් නියගයක් නාවා නෙවෙයි. ඒත් අද වගේ මහ විනාශ වුනේ නෑ. ගංවතුර හිමිහිට බැහැල ගියා. අපේ කුඹුරු සරු කළා. මේ පින් බිමේ අපි කවුරුවත් මං දන්න කාලෙක හාමතෙන් මැරිල නෑ කවදාවත්ම. අද දේශගුණය අපට පාඩු කලත් ඒ කාලෙ දේශගුණය අපිට හැමදාම ලාභයක් වුනා.



ඡායාරූප අන්තර්ජාලයෙනි

පොළොව සරු කරන්න කියලා අපි කවදාවත් පොළොවට ඔය දැන් වගේ වස විස ගොඩ කලේ නෑ. ඉර දෙයියො ඒකත් අපිට කරල දුන්නා."

"ඒ කොහොමද? මට තේරෙන්නේ නෑ" කොළුවා ඇසීය. මන්ද කොළුවා උගත් කෘෂිකර්මයට අනුව පොළොවට පොහොර දැමිය යුතුය. රසායනික පොහොරත් කාබනික පොහොරත් මනා අනුපාතයකින් යෙදීමෙන් බෝග ශාක හොඳින් වැඩේ. ඉතින් කොහොමද පොහොර නොයොදා වගා කරන්නේ?

"මං කියන්නම් ඒක කොහොමද වුනේ කියලා.... අපි ඉරේ ශක්තියෙන් පොළොව සරු කළේ මෙහෙමයි.

අහසෙන් වැටෙන හිරුරැස් වල ශක්තිය අපේ ගොවිබිම් වලට ගෙනත් දුන්නේ අපේ ගව සම්පති අපි හැමෝම කුඹුරු ගොවිතැන් කලා. අපේ බල ශක්තිය වුනේ ගව සම්පත. හැම ගෙදරකම අඩු තරමින් එක හරක් බානක් වත් හිටියා. අපි මහ කන්නෙ විතරයි වගා කලේ. මාස හයක් විතර. ඉතුරු මුළු කාලෙම ඒවා අපි ඔක්කොගෙ'ම ගව සම්පතේ තණ බිම වුනා. ඒකාලේ කුඹුරු යායවල් බලන්න ලස්සනයි. හරි සිරියාවන්තයි. එක එක පාටවල් වල එළ හරක් පැටව් එළදෙන්නු මහගොන් කුඹුරු යායවල් පුරාම හිටියා. මී හරක් නිසා මඩ වලවල් රැකුනා. ඒ ගොල්ල තමයි පොළොවේ වතුර රැකලා දුන්නේ. අහසෙන් එන හිරුගේ හැම රැස් දහරක්ම ඒ ගොල්ල පොදු තණ බිමේ හැම අස්සක් මුල්ලකම ගැවසෙමින් පොළොවට එකතු කලා. කුඹුරු පුරන් කාලෙට හැම උදයකම හැම සවසකම ඒ ගොල්ලන්ගේ රාජකාරිය වුනේ ඒක තමයි. ඒත් අද පුරන් කාලෙට කුඹුරු යායවල් සොහොන් පිට්ටනි වගේ. මහ පාළුයි.

ඉස්සර අපි කුඹුරේ ගොයම් තියෙන කාලෙට හරක් ගොඩට ගේනවා. අපි ඒකාලෙට නියරවල් වල වැවෙන තණකොළ කපලා හරක්ට කන්න දෙනවා. ඒකාලෙ තණකොල හරි වටිනවා. නියරෙ තණකොළ කපාගෙන ඇවිත් හරක්ට කන්න දෙනවා කියන්නේ ඒ කාලෙට කුඹුරට වැටෙන හිරුගේ ශක්තිය ගොඩට ගෙනත් අපේ පොහොර මැෂින් වැඩ කරවනවා කියන එකයි. ගොඩ බිමේ ගස්වලට කණු කරන ගවයින්ගේ ගොම මුත්‍රා ගොඩ බිම සරු කලා. තණකොළ කපන්න බැරි තද වැහි කාලෙ අපි හරක්ට පිදුරු කන්න දුන්නා. ඒ කාලේ පිදුරුත් හරි වටිනවා. හැම ගහකම වගේ හොඳට වළු අල්ලලා ගෙඩි හැදුනා. වැසි කාලෙ මහ වැසි එන කොට අපි කුඹුරු කරන්න පටන් අරන්. නියරවල් රැහැලා මඩ තියලා කුඹුරට එන රොන් මඩ රැක ගන්න උපාය යොදලා අපි එතකොට. නියරවල් පළලට උසට ශක්තිමත් විදිහටයි බැන්දේ. මහ වැහි වලට ගොඩ තියෙන කොළ රොඩු ගොම ගව මුත්‍රා එක්ක මිශ්‍රවුනු මතුපිට සරු පස් සේරම හෝදාගෙන පහත් බිම් වල කුඹුරු වලට ගිහින් උස නියරවල් අතරේ කුඹුරු වල තැන්පත් වුනා. කුඹුරු හාලා පෝරු ගාලා වතුර බැඳලා තියෙන කොට ඒවා ජලාශ වගේ පිටාර ජලය රැස් කර ගත්තා. වැස්සෙන් එන වතුර එක පාරටම ඔයවල්, ගංගාවල් වලට ගලාගෙන ගියේ නෑ. කුඹුරු වල නියර හොඳට හදලා තිබුනු නිසා පොහොර රොන් මඩ කුඹුරේ රැඳුනා වගේම ගංවතුරත් වැළකුනා. කුඹුරු වල රැඳෙන වතුර ජල උල්පත් පෝෂණය කලා. ඒ කාලෙ කුඹුරු යායක් කියන්නේ විශාල ජලාශයක් වගේ. බලන්න ලස්සනයි.

ඡායාරූප අන්තර්ජාලයෙනි

Rollers
(Scarabaeus gangeticus)

හරක් ටික වල් වැවෙන්න නොදී පොළොව රැක්කා. අද වගේ වස විස වල් තෙල් අපිට ඕනෙ වුනේ නෑ. පොළොවේ පනුවෝ යට ඉඳන් පස සරු කළා. ඒ කාලේ කුඹුරු යායවල් අද වගේ පාළු නෑ. කුඹුරෙදි මිනිස්සු එකතු වුනා.

ඉතින් දැන් පැහැදිලියි නේද කොහොමද ඉරේ ශක්තියෙන් පොළොව සරු වුනේ කියන එකී අපි වැටෙන හැම හිරු රැස් දහරක්ම අපිට පිහිට ලැබෙන විදිහටයි ජීවත් වුනේ. ඉතින් අපිට කිසිම ආපදාවක් වුනේ නෑ. අපි ඉතින් අස්වනු නෙලාගෙන ඉරු දෙවියන්ට ස්තුති කළා, කංකාරි, ගම්මඩු නටලා, මුරුතැන් පුදලා. එහෙමයි පුතේ අපි ඉර දෙවියොත් එක්ක ගනුදෙනු කළේ."

ඔහු දිගින් දිගටම අතීතයෙන් අතීතයටම යයි. ඒ හැම විටම ඔහුගේ වියපත් දෙනෙත් දිප්තියෙන් බැබළෙයි. සිරුර වියපත් වුවත් මේ මහළු මිනිසාගේ මනස කොතරම් ප්‍රභාමත්දැයි කොළුවාට සිතුනි.

ඔහුට දැනුනේ වියපත් වැඩිහිටියාගේ වදන් පැටි වියේ කියැවූ සුරංගනා කථාවක රසවත් කොටසක් මෙනි. මේ මහපොළොව මතම ඔවුහු ශ්‍රී විභූතියෙන් අනූන කාලයක් ගෙවා ඇත. ලා ඔත්සේ ගේ උපහැරණයට ප්‍රායෝගික උදාහරණයක් කොළුවාට හමුවී ඇති ඔහුගේ පැරැන්නන්ට නැති ඉඩක ඇති අගයක පිහිට හැම විටම ලැබී ඇත. එහි ලාභයද තිබී ඇත. ඔවුන් අද ඔවුන්ගේ මුනුබුරන්, මී මුනුබුරන් මෙන් ලාභය පමණක් හඹා ගොස් සැබෑ ඉඩ අහිමි කර නොගත්හ.

දේශගුණ විපර්යාසයන්ගේ අහිතකර බලපෑම් වලට අනුහුරුවීම ඇරඹීමේ ලක්ෂය මෙය විය යුතු යැයි කොළුවාට හැඟුනි. දේශගුණ විපර්යාස අරභයා වූ එක්සත් ජාතීන්ගේ රාමුගත සම්මුතිය පැරිස් ගිවිසුමත් සමග විප්ලවීය පියවරක් පෙරට තබා ඇති එහි තීරණාත්මක පියවරක් ලෙස හරිත සුහුරු ගම්මාන නිර්මාණයට කොළුවාගේ රාජ්‍යයද වගවී ඇත.

සිය දිවයින සිසාරා නිර්මාණය කලයුතු හරිත සුභූරු භූමි දර්ශනය මේ වියපත් වැඩිහිටියා සුන්දර සිතුවම් පටයක් ලෙසින් කොළුවා ඉදිරිපිට චිත්‍රනය කළේය. ඔවුන්ට පෑයූ හිරුම අඳත් සෑම දිනකම පෙරදිගින් පායා අපරදිගින් සයුරේ ගිලෙයි. එහෙත් ඒ බිම, ඒ ඉරවල්ල අතුරුදන් වී ඇත. කුඹුරු යාය සැරසූ ගවයින් නොමැත. මිනිසුන් සසර දුක් සයුරේ ගිලෙමින් ආන්තික සැපයක් පතා පොර බඳිති. විමුක්තිය අකාලික වී ඇති දිවිය අරුත් සුන් වී ඇත.

කොළුවාට දිගු සුසුමක් පිට වියී එහෙත් ඒ ප්‍රභාතයේ දී පෙරදිගින් නැගී ආ සූර්යයා ගෙන ආ ජීව ගුණය කොළුවා දිරිමත් කලේය. හිරු කොළුවාට කොඳුරා කීවේ මෙබඳු වදනකි. ඔව්! ඔබට යමක් කළ හැකියි. බලන්න ! ඒ ඉඩ මගේ ක්‍රියාව තුළයි තියෙන්නේ.

"ඔව්! ඒක තමයි එකම මාර්ගය". යහපත් දේශගුණයක් උරුම වන්නේ ඒ මග යාමෙන් පමණක්ම බව කොළුවාට පසක් විය.

වැඩිහිටියාට වැඳ ආචාර කල කොළුවා ධෛර්යයෙන් නැගී සිටියේය.

ඡායාරූපය අන්තර්ජාලයෙනි

இலங்கையின் கால நிலை மாற்றமும் அதனை எதிர்க்கொள்ளலும்

(Building resilience to secure livelihood for rain-fed farmers in Sri Lanka)

Prashanthini Mayavatharan

Climate Change Adaptation Project, Ministry of Mahaweli Development & Environment
prashamaya27@gmail.com

Adaptation is a way of building resilience to climate change. This article discusses strategies and techniques employed by the project on Climate Change Adaptation to minimize the effect of climate change inputs and to secure community livelihood and food security.

சுருக்கம் : - ஒரு குறிப்பிட்ட பிரதேசத்தில் பொதுவாக நிகழும் அல்லது நீண்ட காலமாக நிகழ்ந்து கொண்டிருக்கும் வானிலையே கால நிலை எனப்படுகின்றது. கால நிலை மாற்றத்தினால் ஏற்படும் இயற்கை அனர்த்தங்களால் மக்களின் உயிர்களுக்கு அச்சுறுத்தல் ஏற்படுகின்றது. எனவே, அதனை எதிர்க்கொள்ளும் திட்டங்களை வடிவமைப்பதும், செயற்படுத்துவதும் மிகவும் அத்தியாவசியமானதாகும். இலங்கையில் கால நிலை மாற்றத்தை எதிர் கொள்ளும் கொள்கைகளும், செயற்பாடுகளும் நடை முறைப்படுத்தப்பட்டுக் கொண்டிருக்கின்றன. அவற்றில் "கால நிலை மாற்றத்தினை எதிர் கொள்ளும் திட்டம் (c - cap)" என்பதும் ஒன்றாகக் காணப்படுகின்றது. "மாற்றம் ஒன்றே மாறாதது" என்பதற்கிணங்க, கால நிலை மாற்றத்தை எம்மால் தடுக்க முடியாது. ஆனால், அதனால் ஏற்படும் சீர்க்கேடுகளைத் தவிர்ப்பதற்கோ அல்லது குறைப்பதற்கோ ஏற்ற திட்டங்களை வகுத்துச் செயற்படுத்துவதன் மூலமும், மக்களுக்கு அது தொடர்பான விழிப்புணர்வை ஏற்படுத்துவதன் மூலமும் கால நிலை மாற்றத்தை எதிர் கொள்ளும் சூழலையும், சமூகத்தையும் உறுவாக்கலாம்.

இலங்கையானது, இயற்கை வளங்கள் நிறைந்த, இந்தியாவின் தென் திசையில் 5^0 55’ – 9^0 50 வடக்காகவும், 79^0 42’ – 81^0 53’அமைந்துள்ள, நாற்புறமும் கடலால் சூழப்பட்ட ஒரு சிறிய தீவாகக் காணப்படுகின்றது. இதன் மொத்த நிலப் பரப்பு 65,610 சதுர கிலோ மீற்றர்களாகும். 2016 ஆம் ஆண்டின் கணக்கெடுப்பின் படி, மொத்த சனத் தொகை 21 மில்லியனாகக் காணப்படுவதுடன், வளர்ச்சி வீதம் 0.78% ஆகக் காணப்படுகின்றது. இலங்கையானது மழை வீழ்ச்சியின் அடிப்படையில், உலர் வலயம், ஈர வலயம் மற்றும் இடைப்பட்ட வலயம் என மூன்று வலயங்களாகப் பிரிக்கப்பட்டுள்ளது. இலங்கையில் நூற்று மூன்று நதிகள் காணப்படுவதுடன், அவற்றுள் அதிகமானவை மத்திய மலை நாட்டிலிருந்து ஊற்றெடுக்கின்றன.

அத்துடன், அங்கு 30,000 நீர்த் தேக்கங்கள் காணப்படுகின்றன. அவற்றில் அநேகமானவை இயற்கையான நீர்த்தேக்கங்களை விட செயற்கையானவையாக மனிதனால் நிர்மாணிக்கப்பட்டவையாகவே காணப்படுகின்றன. இலங்கையானது, வெப்ப வலயத்தைச் சேர்ந்த ஒரு நாடாகக் காணப்படுகின்றது. அதன், வருடாந்த வெப்ப நிலை சராசரியாக 27^0 செல்சியஸ் ஆகக் கரையோரத் தாழ் நிலங்களிலும், 16^0 செல்சியஸ் ஆக மத்திய மலைப் பிரதேசத்திலுள்ள நுவரெலியாவிலும் காணப்படுகின்றது. தாழ் நிலப் பகுதிகளில் ஒரு சீரான வெப்ப நிலையும், உயர் நிலப் பகுதிகளில் குறைந்து செல்லும் வெப்ப நிலையாகவும் காணப்படுகின்றது. மாதாந்த சராசரி வெப்ப

நிலையகைக் கருத்திற் கொண்டு நோக்குமிடத்து, பொதுவாக ஜனவரி மாதம் மிகவும் குளிரான மாதமாகக் காணப்படுகின்றது. அது போன்று, வெப்பம் கூடிய மாதங்களாக ஏப்ரல் மற்றும் ஆக்ஸ்ட் மாதங்கள் காணப்படுகின்றன. வேறுபட்ட வருடாந்த சராசரி வெப்ப நிலை நாட்டின் வெவ்வேறு பகுதிகளில் காணப்படுதலானது, தனித்துவ நிலையாகக் காணப்படுதல், நாட்டுக்கு அந்நிய செலாவணியை ஈட்டித் தரக்கூடியதாகவும் காணப்படுகின்றது.

வருடாந்த சராசரி மழை வீழ்ச்சி 900 மில்லி மிற்றரை விடக் குறைவாக உலர் வலயப் பிரதேசங்களிலும், ஈர வலயப் பிரதேசங்களின் வருடாந்த சராசரி மழை வீழ்ச்சி 5000 மில்லி மீற்றரை விட அதிகமாகவும் காணப்படுகின்றது.

வளி மண்டலவியல் காரணிகளான வெப்ப நிலை, காற்று, மழை வீழ்ச்சி போன்றவை ஓரிடத்தில், குறிப்பிட்ட காலத்திற்கு, குறிப்பிட்ட அளவிற்கு, நிலை கொண்டு காணப்படுவதும் கால நிலை என்று வரைவிலக்கணப்படுத்தலாம். இக் கால நிலையானது, கடந்த காலத்தில் மாறிக் கொண்டிருந்ததைப் போல், தற்போதும் மாறிக் கொண்டிருக்கின்றது. மேலும், எதிர்க்காலத்தில் மாறுவதும் திண்ணம். கால நிலை மாற்றமானது, சில வேளைகளில் பாதிப்புகளை ஏற்படுத்தாத போதும், ஒரு சில வேளைகளில் பாரதூரமான பாதிப்புகளை அல்லது இயற்கை அனர்த்தங்களை ஏற்படுத்துகின்றது. இவ்வாறான கால நிலை மாற்றத்தினால் ஏற்படும் பாதிப்புகளை உயிரினங்கள், நீர் வளம், உட்கொள்ளும் உணவு, சுகாதாரம் மற்றும் பல்வேறு காரணிகளிலும் காணக் கூடியதாகவுள்ளது. இக் கால நிலை மாற்றத்தினால் மிகுந்த பாதிப்புக்குள்ளாவது அபிவிருத்தியடைந்து வரும் மற்றும் அம் மட்டத்திற்குக் கீழுள்ள நாடுகளைச் சேர்ந்த ஏழ்மை நிலையிலுள்ள மக்களாகும். கால நிலை மாற்றத்தினால் ஏற்படும் சீர்க்கேடுகளில் வரட்சி, வெள்ளம். சூறாவளி, காற்று மாசடைதல், நிலம் மற்றும் நீர் மாசடைதல், காடழிதல், காட்டுத் தீ, கடல் மட்டம் உயர்தல், பூகோளம் வெப்பமாதல் போன்றவை அடங்கும். நிலையான அபிவிருத்திக்கான கொள்கைகளை உறுவாக்குவதன் மூலமாகவும், மக்களுடனான தொடர்பாடல் மூலமாகவும் சுற்றுச் சூழலைப் பாதுகாத்தலுடன், மனித வாழ்க்கைத் தரத்தையும் மேம்படுத்த முடியும்.

இலங்கையானது, ஒரு சிறிய தீவாகக் காணப்படுவதுடன், அபிவிருத்தியடைந்து வரும் நாடொன்றாகவும் காணப்படுவதுடன், மிகப் பாரியளவில் கால நிலை மாற்றங்களினால் பாதிப்புக்குள்ளாகும் நாடாகவும் காணப்படுகின்றது. கால நிலை மாற்றத்தின் விளைவுகளான வெப்ப நிலை உயர்வு, மழை வீழ்ச்சி மாறுபடுதல், கடல் நீர் மட்டம் உயர்வடைதல் ஆகிய காரணிகள் நம் நட்டின் பொருளாதார மட்டத்தில் பாதிப்பை ஏற்படுத்தியுள்ளது. பாரதூரமான கால நிலை மாற்றங்களான நீண்ட கால வரட்சி, வெள்ளம் மற்றும் மண் சரிவு போன்ற இயற்கை அனர்த்தங்கள் மக்களின் உயிருக்கும், வாழ்வாதாரத்துக்கும் அச்சுறுத்தலாக அமைகின்றன. UNFCCC (United Nations Framework Convention on Climate Change) இலங்கையின் கால நிலை மாற்றத்தினையும், அது தொடர்பான சீர்க்கேடுகளையும் எடுத்துரைப்பதாயுள்ளது.

கால நிலை மாற்றமானது, இரு வகையான கோட்பாடுகளை அடிப்படையாகக் கொண்டது. அவையாவன, கால நிலை மாற்றத்தை தடுத்தல் (கட்டுப்படுத்துதல்) மற்றும் அதனை எதிர் கொள்ளுதலுமாகும்.

இலங்கையின் தேசிய கால நிலை மாற்றத்தினை எதிர்கொள்ளும் திட்டம் (NAP)

இலங்கையின் மகாவலி அபிவிருத்தி மற்றும் சுற்றாடல் அமைச்சு இலங்கைக்கான தேசிய கால நிலை மாற்றத்தை எதிர் கொள்ளும் வியூகம் ஒன்றை 2010 இல் வகுத்ததுடன், 2012 இல் ஏற்றுக்

கொள்ளப்பட்ட தேசிய கால நிலை மாற்றக் கொள்கையினை விருத்தி செய்வதிலும் முன்னிலை வகிக்கின்றது. இதற்கான அடுத்தபடியே இந்த தேசிய கால நிலை மாற்றத்தினை எதிர் கொள்ளும் திட்டமாகும். இத் திட்டமானது, பல்வேறுபட்ட கொள்கைகளுடன் தொடர்புடையதாக அமைகிறது. அவையாவன,

1) தேசிய கால நிலை மாற்றத்திற்கான கொள்கை - 2012
2) தேசிய கால நிலை மாற்றத்தினை எதிர் கொள்ளல் தொடர்பான யுக்தி (2011 - 2016)
3) "ஹரித லங்கா" நிகழ்ச்சிக்கான தேசிய செயற் திட்டம்
4) இலங்கையின் முழுமை வாய்ந்த பேரிடர் முகாமைத்துவம் நிகழ்ச்சி 2014 - 2018 (SLCDMP)
5) இலங்கையின் நில மாசடைவைத் தடுப்பதற்கான தேசிய செயற்பாட்டு நிகழ்ச்சி (NAP - CLD)
6) கடற்கரையோர வயலத்தின் முகாமைத்துவத் திட்டம் (CZMP)
7) தேசிய பௌதீகவியல் திட்டம் 2011 – 2030 (NPP)
8) இலங்கை நீர்ப்பாசன அபிவிருத்தி அறிக்கை 2010 (SLWDP)
9) தேசிய விவசாயக் கொள்கையின் உருவரைவு

இவ்வாறான பற்பல திட்டங்களும், கொள்கைகளும் காணப்படினும், இவற்றில் எதுவுமே கால நிலை மாற்றத்தினை எதிர்கொள்ளுதலை முன்னிலையாகக் கொண்டதாகக் காணப்படவில்லை. இவ்வாறு, காணப்படும் சில கொள்கைப் பத்திரங்களும் கால நிலை முழுமையாக எடுத்துறைப்பதாக இல்லை, அவை ஓரளவிற்கே கால நிலை மாற்றத்தை விளக்கப்படுத்துவதாயுள்ளது. தேசிய கால நலை மாற்றத்தினை எதிர்கொள்ளும் திட்டமானது (National Adapatation Plan - NAP) மற்றைய கொள்கைகளான ஹரித லங்கா, SLCDMP, CZMP, NAP – CDL மற்றும் CNMPஆகியவற்றைக் கருத்திற் கொள்வதுடன், "கால நிலை மாற்றத்தை எதிர்கொள்ளல்" என்பதை முன்னிலைப்படுத்தி, அதனையே சிறப்பு நோக்கமாகக் கொண்டு செயற்படுகிறது.

இலங்கையில் அவதானிக்கப்படுகின்ற பொதுவான கால நிலை மாற்றங்கள்

வெப்ப நிலையைப் பொறுத்த வரையில், கடந்த கால தகவல்களின் படி, நாட்டின் பல்வேறு பகுதிகளிலும் வெப்ப நிலையானது, படிப்படியாக உயர்ந்து வருவதை அவதானிக்கக் கூடியதாகவுள்ளது. பகல் மற்றும் இரவு நேரங்களில் நிலவும் சராசரி வெப்ப நிலையின் அளவுகளும் அதிகரித்தவாறே உள்ளது.

ஆசியாவின் சில பகுதிகளில், வருடத்திற்கு 1 - 3 மில்லி மீற்றர் அளவில் கடல் மட்டத்தின் உயர்ச்சி காணப்பட்டுள்ளது. இது உலகளாவிய ரீதியி காணப்படும் கடல் மட்டத்தல் நிலவும் வருடாந்த உயர்ச்சியினை விடவும் அதிகமானதாகும். ஆயினும், இலங்கையின் கரையோரப் பகுதிகளைச் சுற்றி நிலவும் கடல் மட்டத்தின் உயர்ச்சி குறித்து தனிப்பட்ட ரீதியில் இன்னும் ஆரய்ந்து அறியப்படல் வேண்டும்.

நாட்டின் அடுத்தடுத்து வரும் வெப்பம் கூடிய நாட்களில் வெப்ப நிலையில் அதிகரிப்பினையும், மழை வீழ்ச்சி கூடிய நாட்களில் மிகுந்த வீழ்ச்சியினையும் காணக் கூடியதாகவுள்ளதாக ஆய்வாளர்கள் அறிக்கை வெளியிட்டுள்ளனர். வெப்ப நிலையைப் போன்று, மழை வீழ்ச்சியின் மாற்றத்தில் ஏற்படும் ஒரு குறிப்பிட்ட அமைப்பை சரியாக் கூற முடியாதுள்ளது. சராசரி மழை வீழ்ச்சி குறைவடைந்து வருவதையும் அறிவியலாளர்கள் கண்டறிந்துள்ளனர. இருப்பினும், அணமைக் காலத்தில்ம் அதிக மழை வீழ்ச்சி மத்திய உயர் நிலப் பகுதிகளில் அடுத்தடுத்து காணப்படுவதாகவும் அறிக்கைகள் வெளியிடப்பட்டுள்ளன. இருப்பினும், காலத்திற்கேற்ப மழை வீழ்ச்சியில் ஏற்படும் மாற்றமும் அதிகரித்து வருவதாக அறிவியலாளர்கள் அறிக்கை வெளியிட்டுள்ளனர்.

கால நிலை மாற்றமும் மனித சுகாதாரமும் :

கால நிலை மாற்றத்தினால் பாதிப்புறும் முக்கியமானதொன்றாக சுகாதாரம் கொள்ளப்படுகிறது. உலகளாவிய ரீதியிலான ஆராய்ச்சிகள், மாறும் கால நிலைக்கேற்ப சுகதாரத்தில் ஏற்படும் பிரச்சினைகளும் அதிகரித்தவாறேயுள்ளது.

நோயுடன் தொடர்புடைய நோய்க் காரணிகளின் வாழ்க்கைக் சக்கரமானது, வானிலை அல்லது கால நிலை தொடர்பான காரணிகளுடன் மிகுந்த தொடர்புடையதாகவுள்ளது. பற்பல நாடுகளில் அதிகரித்து வரும் வெப்பத்தாலும், மற்றும் ஏனைய இயற்கைப் பேரழிவுகளாலும் மனித உயிருக்கு ஆபத்து அதிகரித்துள்ளது. ஏனைய நாடுகளுடன் ஒப்பிடுகையில், இலங்கையின் சுகாதாரத்தில் நல்லதோர் முன்னேற்றத்தைக் காணக் கூடியதாகவேயுள்ளது. இருப்பினும், மாறி வரும் கால நிலையையும், சுற்றாடலையும் கருத்திற் கொண்டு பார்க்கும் போது இன்று நோய்கள் பரவும் தன்மை அதிகரித்து வருவதை கண் கூடாகப் பார்க்கக் கூடியதாயுள்ளது. இதற்கு "டெங்கு நோய்" ஒரு சிறந்த உதாரணமாகும். கால நிலை மாற்றத்தால், நோய்க் காவிகளின் பெருக்கம் அதிகரிப்பதுடன், அது ஏற்படுத்தும் நோய்களும் அதிகரித்து வருகிறது. இது சுகாதாரத்திற்கு மிகுந்த அச்சுறுத்தலாக விளங்குவதால், இதிலிருந்து மீள்வதற்கு மிகுந்த அச்சுறுத்தலாக விளங்குவதால், இதிலிருந்து மீள்வதற்கு தகுந்த நடவடிக்கை எடுக்கப்படுதல் மிக அவசியமானதொன்றாகும்.

கால நிலை மாற்றமும் உணவுப் பாதுகாப்பும் :

நம் நாட்டில், கால நிலை மாற்றத்தை கருத்திற் கொண்டு நோக்கும் போது, உணவுப் பாதுகாப்பு மிகவும் அவதானத்திற்குறியதாகக் கொள்ளப்படல் வேண்டும். கடந்த கால அறிக்கைகளின் படி, விவசாயமே கால நிலை மாற்றத்தால் பாரியளவில் பாதிப்புக்குள்ளாகியுள்ளது. மனித வாழ்வாதாரம் உணவிலேயே தங்கியிருப்பதால், உணவுப் பாதுகாப்பு மிக முக்கியமானதொன்றாகக் கருதப்பட்டு, கால நிலை மாற்றத்தினால் ஏற்படும் பாதிப்புகள் உணவுப் பாதுகாப்புக்கு இடையூறு செய்வதைத் தவிர்ப்பதற்கு வழி வகை செய்தல் வேண்டும்.

கால நிலை மாற்றத்தினை எதிர் கொள்ளும் செயல் திட்டம் :
(Project on Climate Change Adaptation - C - CAP)

கால நிலை மாற்றத்தை எதிர்கொள்ளும் செயற் திட்டமானது, "இலங்கை மகாவலி வடி நிலம் வாழ் நலிவுற்ற விவசாய சமூகங்கள் மீதான கால நிலை மாற்றத்தின் தாக்கங்களை எதிர்கொள்ளல் திட்டம்" என்றும் கூறப்படும். ஐக்கிய நாடுகள் சபையின், (Adaptation Fund (AF) இனால் நிதி வழங்கப்பட்டு, உலக உணவுத் திட்டத்தினால் (World Food Program - WPF) நடை முறைப்படுத்தப்பட்டு, இலங்கையின் மகாவலி அபிவிருத்தி மற்றும் சுற்றாடல் அமைச்சினால் நிறைவேற்றப்படும் ஒரு பெரியளவிலான செயற் திட்டமாகும். இச் செயல் திட்டத்தின் பெறுமதி, 7.9 மில்லியன் அமெரிக்க டொலர்களாகும். அதாவது இலங்கை நாணயப் பெறுமதியின் படி, ஏறத்தாழ ரூபா 1000 மில்லியன் பெறுமதியானதாகும். இது, மூன்று வருட கால வரையறையைக் கொண்டுள்ளதாகும். இது, இலங்கையில் இரண்டு மாவட்டங்களிலுள்ள, மூன்று பிரதேசங்களை மையமாகக் கொண்டு இயக்கப்படுகிறது. அவையாவன, பொலன்னறுவை மாவட்டத்திலுள்ள லங்காபுர, மெதிரிகிரியா மற்றும் நுவரெலியா மாவட்டத்திலுள்ள வலப்பனை போன்ற பிரதேசங்களாகும். இப் பிரதேசங்கள் பாரியளவில் வறட்சி, வெள்ளம் மற்றும் மண் சரிவுக்குள்ளாகும் பிரதேசங்களில் சிலவாகும்.

இச் செயல் திட்டமானது, மகாவலி கரையோரப் பிரதேசங்களில் வசிக்கின்ற, கால நிலை மாற்றத்தின் பாதிப்புக்குள்ளான விவசாயிகளுக்கு நன்மையளித்து, அவர்களை கால நிலை மாற்றத்தினை எதிர்கொள்வதற்கு வழி வகுப்பதையே மையமாகக் கொண்டு செயற்படுகிறது. இச் செயல் திட்டத்தின் முக்கிய நோக்கமானது, நிலம் மற்றும் நீர் வளங்களை சிறந்த முறையில் முகாமை செய்வதன் மூலமாக, மகாவலி ஆற்றின் வடி நிலங்களில் வாழ்கின்ற மக்களுக்கு கால நிலை மாற்றங்களுக்கு ஈடு கொடுக்கும் வாழ்க்கை முறையை ஏற்படுத்திக் கொடுப்பதாகும். இச் செயல் திட்டமானது, இரு வகையான ஆக்கக் கூறுகளை / பாகங்களைக் கொண்டதாகும். அவையாவன ;

1) மழையை நம்பி வாழும் விவசாய சமூகங்களுக்கு தம் இல்லம் சார் உணவுப் பாதுகாப்பினை மேம்படுத்துவதன் மூலமாக அவர்களின் வாழ்வாதாரத்தைக் கட்டியமைத்தல்.

2) நிறுவனம் சார் பயிற்சி முறைகளையும், சேவைகளையும், கிராமங்களிலும், உள்ளூரிலும், வட்டாரங்களிலும் அமைத்து, மாறும் கால நிலையின் விளைவான மழை வீழ்ச்சியில் மாறுபாடுகளினால் ஏற்படும் அனர்த்தங்களைக் குறைத்தல்.

இச் செயல் திட்டம் மூலமாக, நீர்ப்பாசன புனரமைப்புத் திட்டங்கள், காடு வளர்ப்பு, அனர்த்த முகாமைத்துவம், செடி மற்றும் விதை வழங்கல், விவசாய உபகரணங்கள் வழங்கல், விவசாய பாதைகளைக் கட்டியமைத்தல் அல்லது புனருத்தாரணம் செய்தல், பயிற்சி வகுப்புகள் நடத்தல், பசுக்கள் வழங்குதல், ஏனைய உபகரணங்கள் வழங்குதல் மற்றும் பெண்களுக்கான வாழ்வாதாரத்தை மேம்படுத்துதல் போன்ற இன்னும் பல செயற்பாடுகள் வடிவமைக்கப்பட்டு, நடை முறைப்படுத்தப்பட்டும் வருகிறது.

கால நிலை மாற்றத்தினை எதிர் கொள்வதற்கான நடவடிக்கைகள் :

கால நிலை மாற்றம் குறித்த நோக்குநர்களின் கருத்துப்படி, அம் மாற்றத்தினை எதிர் கொள்வதில் பல காரணிகள் தடையாக இருப்பது ஏற்றுக் கொள்ளப்பட வேண்டியதொன்றாகும். ஆயினும், திட்டமிடப்பட்ட அணுகு முறை அல்லது திட்டமிடப்பட்ட எதிர்கொள்ளும் முறைகள் மூலமாகவும் மற்றும் கால நிலை மாற்றத்தை எதிர் கொள்ளும் தகைமை மூலமாகவும் அத் தடைகளைக் களைத்து முன்னேற்ற முடியும்.

வெள்ள அபாயம் உள்ள பகுதிகளில் பாதுகாப்பிற்கான உபகரணங்கள் / தொழில் நுட்பங்களைப் (Early Warning Systems / Alarms) பயன்படுத்தலாம். வறட்சியைத் தாங்கக் கூடிய தாவரங்களை வளர்க்கலாம், பைங்குடிவமைத்தல், மண்ணரிப்பைத் தடுக்கும் தாவரங்கள் வளர்த்தல், கல்வேலியமைத்தல், வடிகாலமைத்தல், மழை நீர் சேகரிக்கும் தொட்டியமைத்தல், நீர்ப்பாசன அமைப்புகளைக் கட்டுதல் / புனரமைத்தல், வெள்ளத்திலிருந்து பாதுகாக்க பாதைகளைப் புனரமைத்தல், பாதிப்புக்குள்ளாகும் பிரதேசங்களை வரைபடம் மூலம் இனங் காணல், பாதிப்புகளை மதிப்பீடு செய்யும் முறைகளைக் கண்டு பிடித்தல் அல்லது கருத்தாய்வு செய்தல், கழிவு நீரைச் சுத்திகரிக்கும் முறைகளைக் கையாளல், குடி நீர் வழங்கல் தொடர்பான செயற் திட்டங்களை மேற் கொள்ள, நிலத்தடி நீர் இறைக்கும் இயந்திரங்கள் அமைத்தல், முன்னெச்சரிக்கையாக இயற்கை அனர்த்த அபாயமுள்ள பிரதேசங்களிலிருந்து மக்களை அகற்றுதல் போன்ற பல முறைகளைக் கையாளுவதுடன், இது தொடர்பாக மக்களுக்கு அறிவுறுத்துவதும், தகுந்த பயிற்சிகள் அளிப்பதும் அவசியமாகும்.

இறுதிச் சுருக்கம்

எதிர்கொள்ளுதல் அல்லது இசைவாக்கமடைதல் என்பது, பாதிப்புகளைத் தவிர்த்துக் கொள்ளும் முகமாக அல்லது குறைத்துக் கொள்ளும் முகமாக சிற்சில ஒழுங்குகளை மேற்கொண்டு, தம்மை தயார்படுத்திக் கொள்ளுதலாகும். ஒரு மாற்றத்திற்கேற்ப விரைவாகவும், வெற்றிகரமாகவும் துலங்கும் தகைமையுள்ள சமூகமே அதிக எதிர் கொள்ளும் தகைமையுள்ள அல்லது இசைவாக்கமடையக் கூடிய சமூகமாகும். இவ்வாறான சமூகமே தொடர்ந்து வாழக் கூடியதோரு நிலைக்கு தம்மை தயார்படுத்திக் கொள்கிறது. இதுவே, உயிரியலாளர் சார்ள்ஸ் டாவினின் கொள்கையின் சாராம்சமுமாகும். ஆகவே, கால நிலை மாற்றத்தின் பாதிப்புகளையோ அல்லது அதனால் ஏற்படும் அனர்த்தங்களையோ ஒரு முடிவாகக் கருதாமல், அதனை ஒரு சவாலாக ஏற்று, அவற்றிலிருந்து மீண்டு வரும் திட்டங்களை வடிவமைத்து, மீண்டும் அப் பாதிப்புகள் தொடராத வண்ணம் திட்டமிட்டு, வரும் பாதிப்புகளை எதிர் கொள்ளும் திட்டங்களையும் வரவேற்று, எம் நாட்டை முன்னேற்றப் பாதையில் இட்டுச் செல்ல வழி வகுப்போமாக !

(சுபம்)

Climate Change Secretariat
Ministry of Mahaweli Development and Environment
416/C/1, Robert Gunawardena Mawatha,
Battaramulla,
Sri Lanka