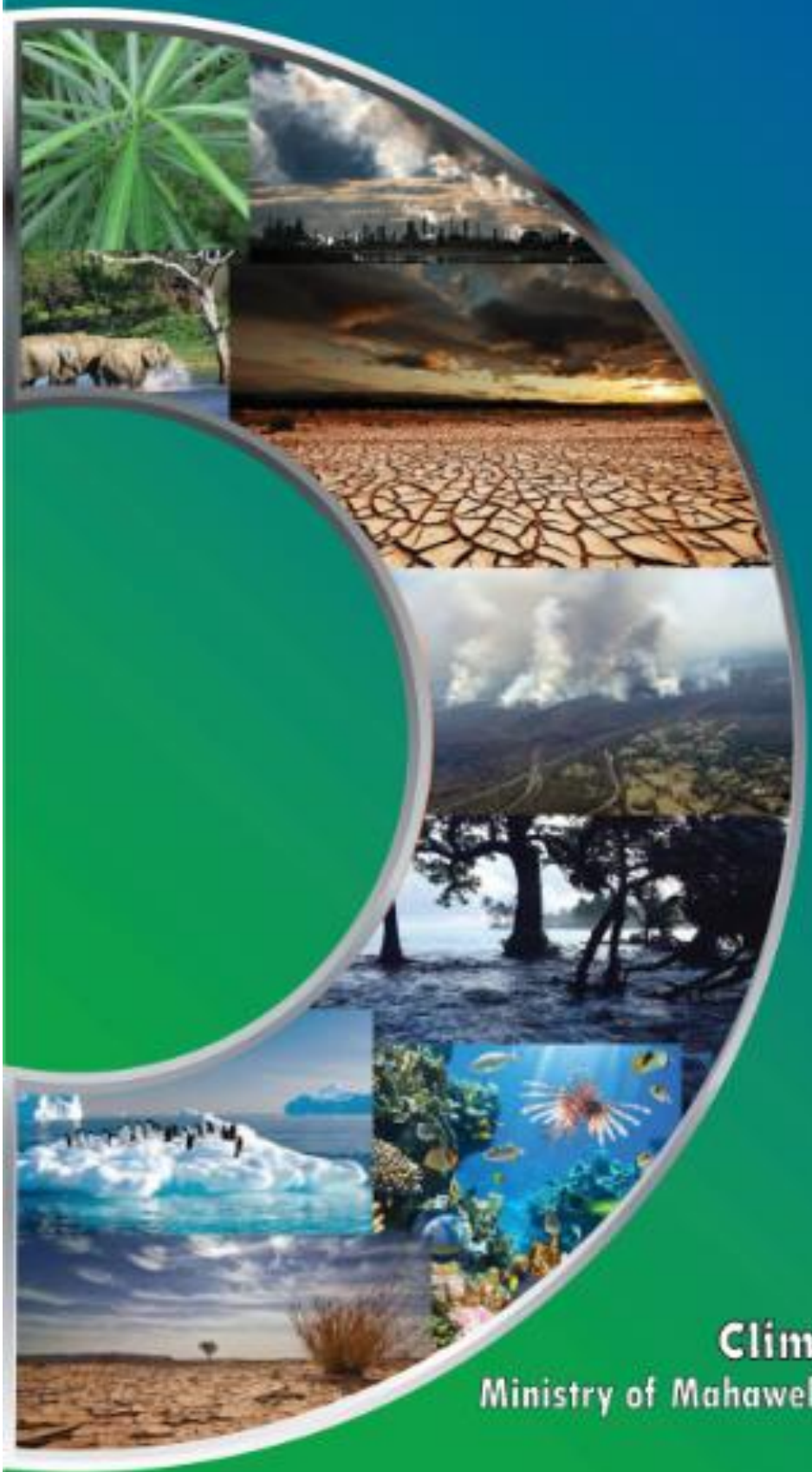
NeelaHaritha

The Climate Change Magazine of Sri Lanka



Climate Change Secretariat
Ministry of Mahaweli Development and Environment

NeelaHaritha

The Climate Change Magazine of Sri Lanka

2016

Inaugural Volume

Climate Change Secretariat

Ministry of Mahaweli Development & Environment

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The Message of His Excellency the President

Climate change is a global phenomenon the negative impacts of which are severely felt by developing countries. Countries like Sri Lanka are more vulnerable because of their high dependence on natural resources and limited capacity to cope with climate variability and extremes and climate change could undo decades of efforts for sustainable development and alleviation of poverty. While restoring and maintaining key ecosystems that could help communities in their efforts to support livelihoods and well being, it is of paramount importance to make an awareness among them to move towards a low carbon society for a safer environment and a sustainable economy. With this in mind, it is my pleasure to deliver this congratulatory message at the launching of the first publication of *NeelaHaritha*, the Climate Change magazine of Sri Lanka.

Sri Lanka, being a signatory to the Paris Agreement and a party that ratified this agreement, is fully committed to uphold the resolutions that had been agreed upon by world leaders to limit the rise of global warming and to reduce emission of greenhouse gasses. This commitment was made in view of the fact that Sri Lanka is highly vulnerable to adverse effects of climate change that affect all social, economical and development activities.

Although, the global effort is for a green economy, we have gone one step beyond a 'green economy' and are striving to have a 'Blue–Green Economy' combining both the sea and the land for sustainable development. The first step in this development is the declaration of 'Sri Lanka NEXT – A Blue Green Era' commencing a blue-green development strategy. The Climate Change Ehibition held together will the 5th Asia Pacific Climate Change Adaptation Forum from 17th to 19th October at the BMICH Colombo is a follow up to show case Sri Lanka's initiatives in these spheres. This publication coincides that and will add more colour to our efforts.

I wish to extend my appreciation to those who took the initiative to publish this volume to make an awareness among the community on issues related to climate change and I hope that their efforts will become fruitful in the very near future.

Maithripala Sirisena
President of the Democratic Socialist Republic of Sri Lanka,
and
Minister of Mahaweli Development & Environment.

The Message of Hon. Deputy Minister

It is my pleasure to send this message to appreciate the efforts of the Climate Change Secretariat of the Ministry of Mahaweli Development and Environment to launch this inaugural volume of *NeelaHaritha*, the Climate Change magazine of Sri Lanka.

Global warming and climate change have become main issues of global concern as, with the intensive burning of fossil fuels and anthropogenic activities and the resultant increase of greenhouse gas emissions into the atmosphere, the detrimental impact of climate change is being felt by all living beings. This is particularly relevant to Sri Lanka, an island nation vulnerable to potential dangerous consequences of climate change that affect the livelihoods of people and cause damage to ecosystems, environment, culture and economy. Hence, there exists a need to protect and advance the right of the people to a healthful ecology in accordance with rhythm and harmony of nature and to protect the climate system for the benefit of the humankind on the basis of climate justice.

It is this noble concern that prompted H.E. the President to declare the national policy, 'Sri Lanka Next – A Blue Green Era' where an opportunity has been afforded to the people of Sri Lanka to more fully participate in the protection of ecosystems and environment. Under Blue or Ocean economy, sustainable development strategies will be utilized for the utilization of Oceanic, marine and coastal fish, biological and mineral resources and for the development of sports, industries, energy and medicine while concentrating on research on maritime archaeology and anthropology. Under green development, attention will be paid to Green Industries, Agriculture, Energy, Constructions, Transport, Employment and Green Cities/Villages. We are happy to note that the necessary awareness is being created by both governmental and non governmental agencies on the the need for adaptation and mitigation efforts to achieve sustainable development.

In view of these developments, it is most opportune that a magazine of this nature is providing valuable information on climate change and its adverse effects are coming into light. It is my sincere hope that this be continued to encourage the general public to make efforts to minimize the impacts of climate change for the betterment of our environment, society and the economy.

Anuradha Jayaratne M.P.
Deputy Minister of Mahaweli Development & Environment

Message of the Secretary

Launching the first volume of *NeelaHaritha*, the climate change magazine of Sri Lanka, coincides the first ever mega national exhibition and conference on 'Sri Lanka Next – A Blue Green Era'. Creating awareness among the public on the need to protect the environment and the advantages of the Blue Green Economy is the main objective of both these events and it is with great pleasure that I take this opportunity to congratulate those who are instrumental in this endeavour.

Though small in size, Sri Lanka was in the forefront among 178 world leaders who signed the Paris Agreement on Climate Change at the Head Quarters of the United Nations on 22nd April 2016 and was one of the first few countries to ratify the same on 22nd September, 2016 at the same venue. Our commitment is further illustrated by the declaration of the national policy 'Sri Lanka Next – A Blue Green Era' and the related activities initiated in keeping with the vision and guidance of H.E. the President.

Sri Lanka's activities in this sphere illustrate that, instead of being apprehensive, we take climate change as an opportunity for change. Necessary legal framework for setting up of a Climate Change Commission has been initiated, a draft Climate Change Act has been prepared and it will be submitted soon to the Parliament for approval. We are working in collaboration with international organizations to stop deforestation and improve our forest cover, protect the ocean and use marine and coastal resources sustainably and to conserve mangroves as a means to reduce carbon emissions.

Development of green smart villages and cities has commenced while establishment of green energy sources such as large scale wind power farms, solar power plants, biomass and waste to energy plants to reduce our dependency on thermal and coal power, is being vigorously pursued. Eco friendly industrial production, green agriculture, green constructions, green transport and green employment are other areas that we concentrate on.

The process to combat climate change has thus commenced and it is our responsibility to keep the public informed of all developments to enable them to build resilience to adverse impacts. Launching this publication is important in this context and I wish to thank all those who have contributed immensely to make it a success.

Udaya R. Seneviratne
Secretary
Ministry of Mahawali Development & Environment

Foreword

Natural disasters that took place in Sri Lanka in the recent past causing damage to valuable lives, ecosystems and economic resources as well as major environmental hazards such as air pollution, water pollution, marine pollution, soil pollution and degradation which were due mainly to anthropogenic activities of a rising population opened our eyes to adverse impacts of climate change and made us think that something worthwhile needs to be done to face the challenges that threaten our very existence. With the advent of the Paris Agreement at COP 21, the global community became aware that mitigation and adaptation measures should be adopted in order to mitigate greenhouse gas emissions and global warming and to adapt to certain adverse situations to build resilience among humans to face challenges of climate change. Sri Lanka is a prominent player in this exercise.

Since activities of humans are the root cause of climate change and related disasters, correcting social, economic and physical development strategies and its directions is a great service for the sustainability of future generations. Thus it is timely and most opportune to educate the community to be mindful of their activities and to participate in the endeavours of the state to follow low carbon pathways for sustainable development.

It is with this thought that we, in the Climate Change Secretariat, took the initiative to publish *NeelaHaritha*, the Climate Change Magazine that contains many scholarly and scientific articles on climate change, its impacts and remedies and sustainable development for the benefit of the reading public. We hope that it will be well received encouraging us to continue its publication for many years to come.

This would not have seen the light of the day if not for the support of many individuals who took a keen interest to make this a success. Mr. Udaya Seneviratna, Secretary, Mnistry of Mahaweli Development and Environment not only took a keen interest in guiding us in this endeavour but also helped us in providing the services of his closest associates. Foremost among the rest are the editors, Prof. W.L. Sumathipala, Mr. Gamini Gamage and Dr. Athula Senaratne who undertook the task of selecting and editing the articles and Mr. Pradeep Jayatunga, the language editor for a job well done. My sincere appreciation goes to them.

I am also thankful to Ms. Thamila Dulani, Ms. Hasula Wickremasinghe and Ms. Methmali Rajaguru and many others of the Climate Change Secretariat of the Mahaweli Development & Environment Ministry for coordinating, proof reading and enabling the publication of this magazine.

Dr. R.D.S. Jayathunga
Director (Climate Change)
Ministry of Mahawei Development & Environment

Editorial

In general, climate change refers to alterations of normal weather and occurrence of extreme weather events with high frequency and magnitude. It is a global problem that affects the whole world irrespective of developed or developing countries or geographical demarcations. Climate change related natural disasters are causing enormous damage and hardships to individuals and nations. In order to overcome this problem and protect life and natural resources, it is necessary that everybody understands the gravity of the problem without ignoring or leaving it to scientists and decision makers only. The need to educate and create awareness among the general public must take a high priority.

The Paris Agreement at the twenty first conference of parties (COP 21) in 2015 is a testimony that the whole world has recognized this grave problem. Sri Lanka has initiated 'Sri Lanka NEXT- Blue Green Era" as the way forward for a low carbon pathway for national development with sustainable use of natural resources. In order to achieve this plan every citizen of this country needs to understand the problem and support it whole heartedly in order to become a prosperous country in the shortest possible time.

Recent surveys indicate that a majority of the country is not aware of climate changeor its impacts on environment and natural resources. Even those who have some knowledge are not properly informed about its long term consequences. As remedy to this, the Climate Change Secretariat of the Ministry of Mahaweli Development and Environment decided to publish this magazine targeting the public and students. The aim of the magazine is to take climate related problems to the public in a simple and easy to understand manner, and to change attitudes so individuals become climate change responsible citizens.

In this inaugural issue, we have selected articles that will give background information about climate change, its impacts and actions being taken at an international and national level including mitigation and adaptation. It also includes a section; 'Observations' which provides ideas for future research. Though many of the contributions are in English, it is planned to continue with more articles in swabasha and to include local aspects in the future in order to reach to large masses in the country.

Views and ideas expressed in articles are entirely the view of the authors. We hope to make this magazine a platform for a lively discussion on climate change and look forward to receiving your feedback in order to improve quality and to take the message to all corners of society. We will try to include all aspects of climate change and would like to request you to submit articles on this vast subject for consideration in future issues.We express our sincere gratitude to all authors who contributed the valuable articles published in this issue.

Editors
Prof. W.L. Sumathipala
Dr. Athula Senaratne
Mr. Gamini Gamage
Dr. R.D.S.Jayathunga
Ms. Thamila Dulani

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වර්තමාන ලෝකය මුහුණ දී ඇති ප්‍රධානතම පාරිසරික ගැටළු වලින් එකක් ලෙස දේශගුණ විපර්යාස නිසා ඇතිවන ව්‍යසන හඳුන්වා දිය හැකිය. ප්‍රධාන වශයෙන්ම මානව ක්‍රියාකාරකම් මුල් කරගෙන ඇතිවී තිබෙන මෙම ගැටළුව සඳහා ගෝලීය වශයෙන් වූ විසඳුමක් අවශ්‍ය වන අතර මේවන විටත් සියළුදෙනාගේ අවධානය ඒ සඳහා යොමුවී ඇත.

කාර්මීකරණයත් සමග අධික ලෙස පරිසරයට මුදාහරිනු ලබන හරිතාගාර වායු විමෝචනය නිසා පරිසරයේ සමතුලිතභාවය බිඳ වැටීම හේතුකොටගෙන සිදුවන මෙම විපර්යාස වල අහිතකර බලපෑම් හා කටුක අත්දැකීම් විඳ ගැනීමට මුළුමහත් ලෝකයටම සිදුවී ඇත. වර්තමානයේ ලෝකයේ විවිධ ප්‍රදේශවලින් මෙන්ම ලංකාවේද බහුලව අසන්නට ලැබෙන ස්වාභාවික ව්‍යසනයන් බොහොමයකටම මූලික පදනම වී ඇත්තේ දේශගුණ විපර්යාස නිසා ඇතිවන අහිතකර බලපෑම්ය.

දේශගුණ විපර්යාස සිදුවන්නේ කෙසේද යන්නත්, එමගින් පරිසරයට හා ජීවීන්ට ඇතිවන බලපෑම හා ඒවා අවම කරගන්නේ කෙසේද යන්නත් පිළිබඳ දැනුවත් වීම ඉදිරියේදී ඇතිවන මෙවැනි ව්‍යසනයන් යම්තාක් දුරකට වලක්වා ගැනීමටත් ඒවාට සාර්ථක ලෙස මුහුණ දීමටත් ඉතා වැදගත් වන අතර මෙම ලිපියේ මූලික අරමුණ වන්නේ දේශගුණ විපර්යාස පිළිබඳ මූලික කරුණු කෙරෙහි අවධානය යොමු කිරීමයි.

කාලගුණය හා දේශගුණය

එක් ස්ථානයක කෙටි කාලයක් තුල පවතින වායුගෝලයේ ස්වභාවය කාලගුණය යනුවෙන් හඳුන්වන අතර වර්ෂාපතනය, වායුගෝලයේ පීඩනය, පරිසරයේ සාමාන්‍ය උෂ්ණත්වය, ආර්ද්‍රතාවය, සුළං තත්වය හා වලාකුළු ආවරණය ආදියෙහි වෙනස්වීම් කාලගුණය තීරණය කරන සාධක වේ.

වායු ගෝලයේ දිගුකාලීනව පවත්නා තත්වයේ වෙනස්වීමක් ලෙස දේශගුණ වෙනස්වීම ලෙස ඉතා සරලව අර්ථ දැක්වුවද එක්සත් ජාතීන්ගේ සම්මුතියේ අර්ථ දැක්වීම අනුව එය "සෘජු හෝ වක්‍රව සිදුවන මානව ක්‍රියාකාරකම් මඟින් වායු ගෝලයේ සංයුතියේ ඇති කරන වෙනස්කම් හේතුවෙන් දේශගුණයේ ඇතිවන විපර්යාස දේශගුණ වෙනස්වීම් නම්වේ." දේශගුණ ක්‍රියාවලිය සංකීර්ණ, එකිනෙක සමග අන්තර්ක්‍රියා කරන එකිනෙක සමග සම්බන්ධතාවයක් ඇති, වායුගෝලය, ගොඩබිම, අයිස් හා හිම, සාගර හා අනිකුත් ජල පද්ධති වලින් සමන්විත වුවකි. සූර්ය කිරණ මගින් දේශගුණ පද්ධතිය සඳහා අවශ්‍ය ශක්තිය ලබාදේ.

දේශගුණ විපර්යාසවලට හේතු

දේශගුණික විපර්යාසයන් සඳහා හේතු සෙවීමට විද්‍යාඥයින් ශතවර්ෂ ගණනක් උත්සාහ කළ අතර ඒ සඳහා ඔවුන් දේශගුණික විපර්යාසයන්ට හේතුවන විවිධ චක්‍ර සහ ක්‍රියාවලින්ද අධ්‍යයනය කළේය. නමුත් පරිසර උෂ්ණත්වය ඉහළ යාමේ ප්‍රමාණය සහ පිළිවෙල සැලකිල්ලට ගැනීමේදී එය මෙම චක්‍ර හෝ ක්‍රියාවලින් වලින් පමණක් පැහැදිලි කිරීමට නොහැකි බව ඔවුන්ට පෙනීගිය කරුණක් විය. එමනිසා ගෝලීය උණුසුම්වීම පැහැදිලි කිරීමට ඔවුන් මිනිසා විසින් වායුගෝලයට මුදාහරින හරිතාගාර වායුන්වල බලපෑමද යොදා ගත්තේය.

ගෝලීය උණුසුම්වීම සඳහා හරිතාගාර වායු කිහිපයක් දායකවන බවත්, මෙම වායුන් මිනිසා විසින් විවිධ ක්‍රම මගින් පරිසරයට මුදාහරින බව ඔවුන් ප්‍රධාන ලෙසම හඳුනා ගන්නා ලදී. ප්‍රධානතම හරිතාගාර වායුවක් වන කාබන්ඩයොක්සයිඩ් වායුව (CO_2) පිටකිරීම සිදු වන්නේ පොසිල ඉන්ධන දහනය මගිනි. හරිතාගාර වායු සහ එරෝසොල් (කුඩා අංශු) දේශගුණය වෙනස්වීමට දායක වන්නේ පෘතුවියට වැටෙන සූර්ය කිරණ හා පිටවී යන

අධෝරක්ත කිරණ අතර වෙනසක් ඇති කිරීම් මගිනි. කාර්මීකරණයත් සමග වායුගෝලයේ පැවති හරිතාගාර වායු ප්‍රමාණය වැඩි වීම නිසා සමතුලිතතාව නැතිවීමට පටන්ගත් අතර එම නිසා පසුගිය කාලයේ දේශගුණයේ සැලකියයුතු වෙනසක් දක්නට ලැබුණි.

මෙම සියලු තොරතුරු ඒකරාශී කිරීම සඳහා එක්සත් ජාතීන්ගේ සංවිධානය විසින් දේශගුණ විපර්යාස පිළිබඳ අන්තර් රාජ්‍ය මණ්ඩලය (IPCC) නමින් විද්‍යාඥයින් රාශියකගෙන් සැදුම්ලත් කමිටුවක් පිහිටුවන ලදී. මෙම විද්‍යාඥයින් අවුරුදු කිහිපයකට වරක් ඒකරාශී වී ගෝලීය උණුසුම්වීමට අදාළ අලුත්ම තොරතුරු භාවිතයට ගනිමින් වාර්තාවක් සැදීම සිදුකෙරේ.

හරිතාගාර වායුන්

හරිතාගාර වායු යනු වායුගෝලයේ ස්වාභාවිකවම ඇති සහ කෘතිමව නිපදවා ඇති, හිරුගේ සිට පැමිණෙන හෝ පෘතුවි පෘෂ්ඨයෙන් පරාවර්තනය වන විකිරණ අවශෝෂණය කිරීමට සහ ඒවා නැවත පරිසරයට මුදාහැරීමට හැකියාව ඇති වායුන්ය. එක්සත් ජාතීන්ගේ දේශගුණ පිලිබඳ රාමුගත සම්මුතියේ (UNFCCC), 2012 වර්ෂයේ දෝහා හිදී පවත්වනු ලැබූ පාර්ශවකරුවන්ගේ සැසිවාරයේදී (COP) හරිතාගාර වායුන් ලෙස කාබන්ඩයොක්සයිඩ් (CO2), මීතේන් (CH_4), නයිට්‍රස්ඔක්සයිඩ් (N2O), හයිඩ්‍රොෆ්ලෝරෝකාබන් (HFCs), පර්ෆ්ලොරෝකාබන් (PFCs), සල්ෆර් හෙක්සාෆ්ලෝරයිඩ් (SF_6) සහ නයිට්‍රජන්ට්‍රයිෆ්ලෝරයිඩ් (NF_3) යන වායු වර්ග හඳුනා ගන්නා ලදී.

හරිතාගාර ආවරණය යනු කුමක්ද?

1824 දී Joseph Fourier නමැති විද්‍යාඥයා වායුගෝලයක් නොමැති වුවහොත් පරිසරයේ උෂ්ණත්වය දැනට වඩා බොහෝසේ අඩුවන බව පෙන්වා දෙනතෙක් විද්‍යාඥයින් හරිතාගාර ආවරණය පිළිබඳව දැන නොසිටියේය. පෘතුවියේ දේශගුණය රඳාපවතින එක් සාධකයක් ලෙස හරිතාගාර ආවරණය දැක්විය හැක. එය නොමැති වුවහොත් පෘතුවියේ මතුපිට උෂ්ණත්වය18^0C තරම් සාමාන්‍ය උෂ්ණත්වයක රැඳෙනු ඇත. මෙය ඉතා පහල උෂ්ණත්වයක් වේ. එමනිසා පෘථිවියේ ජීවීන්ට ජීවත් වීමට හරිතාගාර ආවරණය අවශ්‍ය වේ. 1895 දී ස්වීඩන් ජාතික රසායන විද්‍යාඥයකු වන Svante Arrhenius විසින් මිනිසා විසින් CO2 මුදාහැරීම මගින් හරිතාගාර ආවරණය යන ක්‍රියාවලියට සක්‍රියව දායක වනබව පෙන්වාදෙන ලදී.

පෘථිවි ඉතිහාසය තුලද හරිතාගාර වායු සාන්ද්‍රණයේ වෙනස්වීම් සිදුවී ඇත. නමුත් මෑතක් වනතුරු ඒවා සාමාන්‍ය අගයක පැවතී ඇත. එමනිසා ගෝලීය උෂ්ණත්වයද සාමාන්‍ය අගයක පවතී ඇත. මිනිසා විසින් පොසිල ඉන්ධන දහනය සහ අනිකුත් ක්‍රම මගින් හරිතාගාර වායුන් මුදාහැරීම නිසා හරිතාගාර ආවරණය නමැති ක්‍රියාවලිය මේ වනවිට වැඩිවී ඇත.

සූර්යයාගෙන් පිටවන කිරණවලින් වැඩි ප්‍රමාණයක් ආලෝකය ලෙස පෘථිවියට ලඟා වේ. නැවත පෘතුවි පෘෂ්ඨයෙන් එම ශක්තිය වායුගෝලයට පරාවර්තනය කරන්නේ අධෝරක්ත කිරණ ලෙසටය. මේ ක්‍රියාව සමතුලිත වීමට පෘතුවියට තාප තරංග පැමිණීම මෙන්ම සහ පෘතුවියෙන් අභ්‍යවකාශයට අධෝරක්ත කිරණ පරාවර්තනයද සිදුවිය යුතුය. නමුත් පෘථිවි පෘෂ්ඨයෙන් පරාවර්තනය වන අධෝරක්ත කිරණ වායුගෝලයේ ඇති හරිතාගාර වායු අණු මගින් රඳවා ගනී. මෙසේ රඳවා ගන්නා ශක්තිය නැවත පෘතුවි වායුගෝලයටම මුදා හැරේ. එවිට පහල වායුගෝලයේ උෂ්ණත්වය ඉහල නැගීම සිදුවේ. වර්තමානයේ මෙම හරිතාගාර වායු ප්‍රමාණය වැඩිවීම නිසා පහල වායුගෝලයේ උණුසුම වැඩිවී ඇත. මෙය හරිතාගාර ආවරණයයි.

පෘථිවියේ උෂ්ණත්වය ඉහල යාම නිසා ඇතිවන ප්‍රතිවිපාක

පෘථිවියේ උෂ්ණත්වය ඉහල යාමේ එක් ප්‍රතිවිපාකයක් ලෙස ලොවපුරා ඇති ග්ලැසියර දියවීයාම දැක්විය හැක. විශේෂයෙන් උත්තරධ්‍රැවයේ ඇති අයිස්, බටහිර ඇන්ටාටිකාවේ හා ග්‍රීන්ලන්තයේ ඇති අයිස්තට්ටු සහ ආක්ටික්හි ඇති මුහුදු අයිස් දියවීයාම නිසා මුහුදු ජල මට්ටම ඉහල යාම මගින් මාලදිවයින් වැනි කුඩා දූපත් ජලයෙන් යටවීමේ ප්‍රවනතාවය සිදුවිය හැක. තවද අධික උෂ්ණත්වයක් සහිත දිනයන් ඇතිවීම සහ අධික තීව්‍රව වැසි ලැබීම හේතුවෙන් ගං වතුර, නායයෑම් ආදී අපදා තත්වයන් නිතර ඇතිවීම දක්නට ලැබේ. මෙවැනි හදිසි අපදා වලදී සිදුවන ජීවන හා දේපල හානි මෙන්ම ස්වභාවික පරිසර පද්ධතීන්ට සිදුවන හානියද ඉතා විශාලය.

එමෙන්ම දේශගුණ රටාවන් වෙනස්වීම හා ආන්තික කාලගුණික තත්ත්ව වැඩි වශයෙන් සිදුවීම නිසා මිනිසාගේ දෛනික කටයුතු වලට විශේෂයෙන්ම කෘෂිකර්මාන්තයට බලපෑම් එල්ල වී ඇත. වෙනස්වන කාලගුණ සංරචක නිසා බොහෝ කාලයක් තිස්සේ ඒ ඒ ප්‍රදේශ වල වගා කරමින් පැවතුණු භෝග තවදුරටත් වගා කල නොහැකි තත්වයට ද පත්වී ඇත. මෝසම් රටාවන් වෙනස් වීම තුළින් නිසි කලට වැසි නොලැබී යාම සහ දීර්ඝ නියං තත්ත්වයන් හේතුවෙන් ජලය හිඟවීමේ අවධානමක් ඇතිවී ඇත. මිනිසාගේ පරිභෝජන රටාවට සරිලන පරිදි ජලය නොලැබී යාම නිසා ආහාර සුරක්ෂිතතාවයට සහ මානව සෞඛ්‍යයට ද අනිසි බලපෑම් එල්ල වීම ද පෘථිවියේ උෂ්ණත්වය ඉහල යාමේ ප්‍රතිවිපාකයකි.

දේශගුණ විපර්යාස වල ප්‍රතිඵල ලෙස උෂ්ණත්වය ඉහළ යාම නිසාත් වර්ෂාපතන රටාවේ වෙනස්කම් ඇති වීම නිසාත් ඩෙංගු, මැලේරියා වැනි රෝග පැතිර යාමේ ප්‍රවණතාවය ඉහළ යාම, සුළිකුණාටුවල ප්‍රභලතාව වැඩිවීම, අන්‍යෝන්‍ය සහයෝගීත්වයෙන් ජීවත්වන ජීවීන් විශේෂවල ජීවන රටා වෙනස්වීම එනම් පරාගනයට අදාළ කෘමීන්ගේ ක්‍රියාකාරිත්වයට පෙර ශාක මල්ඵල ගැන්වීමට සුදානම් වීම නිසා අස්වැන්නට බලපෑම් ඇති වීම සහ පරිසර පද්ධති වෙනස්වීම ද පෘථිවියේ උෂ්ණත්වය ඉහල යාමේ තවත් ප්‍රතිවිපාකයන් වේ.

දේශගුණ විපර්යාස පිලිබඳ ගෝලීය ප්‍රවේශය

එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිලිබඳ රාමුගත සම්මුතිය 1992 වර්ෂයේදී බ්‍රසීලයේ රියෝ සමුළුවේදී ඇති කර ගත් අතර එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිලිබඳ රාමුගත සම්මුතිය ගෝලීය වශයෙන් නිසි පරිදි ක්‍රියාත්මක කිරීම සඳහා නීත්‍යානුකූල පදනමක් සහිත කියෝතෝ සන්ධානය 1997 වර්ෂයේදී ඇති කර ගන්නා ලදී.

එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිලිබඳ රාමුගත සම්මුතියෙහි පාර්ශවකරුවන්ගේ 21 වන සම්මේලනයේදී ගෝලීය උෂ්ණත්වය ඉහළ යාම 2^0C මට්ටමට වඩා අඩුවෙන් රඳවා ගැනීමේ අරමුණ පෙරදැරිව පැරිස් ගිවිසුම සම්මත කර ගැනීම ද දේශගුණ විපර්යාස අවම කිරීම සඳහා ගත් තවත් පියරකි.

හරිතාගාර වායු විමෝචනය අවම කිරීම හා දේශගුණ විපර්යාස නිසා ඇතිවන බලපෑම් වලට අනුහුරුවීම සඳහා ශ්‍රී ලංකාව තුල ක්‍රියාත්මක වන වැඩ පිළිවල

දේශගුණ විපර්යාස ලේකම් කාර්යාලය 2008 වර්ෂයේදී පිහිටු වීම, 2010 දී දේශගුණ විපර්යාස සඳහා අනුවර්තනය වීමේ ජාතික ක්‍රමෝපාය සකස් කිරීම සහ 2012 දී ශ්‍රී ලංකාවේ දේශගුණ විපර්යාස පිලිබඳ ජාතික ප්‍රතිපත්තිය සකස් කිරීමත් මේ සඳහා ගෙන ඇති ඉතා වැදගත් ප්‍රධාන පියවර කීපයකි. එසේම 2000 සහ 2012 දී මුලික හා දෙවන ජාතික සන්නිවේදන වාර්තා (Initial and Second National Communications) සකස් කොට එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිලිබඳ රාමුගත සම්මුතියට ඉදිරිපත් කර ඇති අතර තෙවන ජාතික සන්නිවේදන වාර්තාව සකස් කිරීමට අවශ්‍ය කටයුතු සැකසෙමින් පවති.

දේශගුණ විපර්යාස හේතුවෙන් ඇතිවන අවධානම ඇගයීම (Vulnerability Assessment) සහ කෘෂිකර්මය හා ධීවර, ජලය, සෞඛ්‍ය, ජෛවවිවිධත්ව හා පාරිසරික පද්ධති සහ නගර සංවර්ධනය, මානව ජනාවාස සහ යටිතල පහසුකම් යන ක්ෂේත්‍ර 05 සඳහා අවධානම් පැතිකඩ (Vulnerability Profile) සැකසීමත් සිදුකර ඇති අතර ශ්‍රී ලංකාවේ දේශගුණ විපර්යාස වලට අනුහුරු වීම සහ හරිතාගාර වායු විමෝචනය අවම කිරීම සඳහා තාක්ෂණ අවශ්‍යතා ඇගයීමක් ද (Technology Need Assessment) සිදු කර ඇත. එසේම හරිතාගාර වායු විමෝචනය අවම කිරීමට බලශක්ති අංශය සඳහා ජාතික යෝග්‍ය හරිතාගාර වායු විමෝචන අවම කිරීමේ ක්‍රියාකාරකම් (Nationally Appropriate Mitigation Actions) සකස් කිරීම සහ ක්‍රියාත්මක කිරීම දේශගුණ විපර්යාස අංශය මගින් සිදු කර ඇති තවත් කටයුතු කීපයකි.

එසේම දේශගුණ විපර්යාස සම්බන්ධ විවිධ ව්‍යාපෘති කීපයක් ද ක්‍රියාත්මක අතර ලෝක ආහාර වැඩසටහන අනුග්‍රහයෙන් සිදු කරනු ලබන මහවැලි ගංගා ද්‍රෝණිය ආශ්‍රිත ගොවි ජනපදවල වැසි ජලයෙන් යැපෙන කෘෂිකාර්මික ප්‍රජාව දේශගුණ විපර්යාස වල අහිතකර බලපෑම්වලට අනුහුරු කරවීමේ ව්‍යාපෘතිය මැදිරිගිරිය, ලංකාපුර හා වලපනේ ප්‍රාදේශීය ලේකම් කොට්ඨාශවල දැනටමත් ක්‍රියාත්මක වේ.

ශ්‍රී ලංකාව දේශගුණ විපර්යාස වල බලපෑම් සඳහා අනුහුරුවීමේ ජාතික සැලැස්ම (National Adaptation Action Plan on Climate Change Impacts) 2016-2025 සකස් කර ඇති අතර දේශගුණ විපර්යාස පිලිබඳ කමිටු

කීපයක්ද ස්ථාපිත කර ඇති අතර ඒවා මගින් අවශ්‍ය තාක්ෂණික දැනුම හා උපදෙස් ලබාගනී. දේශගුණ විපර්යාස පිලිබඳ ජාතික සම්බන්ධීකරණ කමිටුව, දේශගුණ විපර්යාස සඳහා අනුවර්තනය වීමේ ජාතික විශේෂඥ කමිටුව හා දේශගුණික විපර්යාස අවම කිරීම පිලිබඳ ජාතික විශේෂඥ කමිටුව මේ කමිටු අතර වේ.

ඉතා මෑත කාලයේදී ශ්‍රී ලංකාව සිදු කරන ලද ඉතාම වැදගත් කාර්යක් වන්නේ, ශ්‍රී ලංකාව 2016 දී දේශගුණ විපර්යාස පිලිබඳ පැරිස් ගිවිසුමට අත්සන් තැබීම හා එය අපරානුමත කිරීමයි.

සියල්ල දේශගුණ විපර්යාස අවම කිරීම සඳහා දායක වීම

දේශගුණ විපර්යාස අවම කිරීම සඳහා ගෝලීය වශයෙන් දායකත්වය සපයන අතරතුර, එදිනෙදා සිදුකරන කාර්යයන්වලදී අපට ද මේ සඳහා පෞද්ගලිකව හෝ ආයතනික වශයෙන් සහය දැක්විය හැක.

ඒ අතර ඉහළ බලශක්ති කාර්ක්ෂමතාවයෙන් යුතු උපකරණ භාවිතා කිරීම, අඩු බලශක්තියක් වැය වන විදුලි බුබුලු භාවිතා කිරීම, අනවශ්‍ය විදුලි පහන් නිවා දැමීම, හැකි සෑම විටම පොදු ප්‍රවාහන සේවා සඳහා නැඹුරු වීම, පරිසර හිතකාමී දෙමුහුන් වාහන සහ විද්‍යුත් වාහන භාවිතා කිරීම, පරිසර හිතකාමී ප්‍රවාහන මාධ්‍යක් වන පා පැදි භාවිතයට හුරුවීම, සිසිල් පරිසරයකදී වාහනයේ වායුසමීකරණ ක්‍රියා විරහිත කර ස්වභාවික පරිසරයෙහි සිසිල විඳ ගැනීම, මෝටර් රථයේ එන්ජිම නිකරුනේ පණ ගන්වා තැබීමෙන් වැලකීම, හැකි සෑම විටම විදුලි ආලෝකය වෙනුවට ස්වභාවික ආලෝකය භාවිතයට හුරු වීම, දේශීය නිෂ්පාදන සඳහා නැඹුරු වීම, දේශගුණ විපර්යාස පිළිබඳ තමන් සතු දැනුම අන් අයට ලබා දීම, ගෙවත්ත තුලම වගා කිරීමට හුරු වීම, නිවසේ අපතේ යන කාබනික අපද්‍රව්‍ය වලින් කොම්පෝස්ට් නිපදවා ගැනීම, විකල්ප බලශක්ති සඳහා යොමුවීම, පරිසර සහතික ලත් හරිත දෑ මිලදී ගැනීම, හැකි උපරිමයෙන් ගස් සිටුවීම සහ සිටුවන ලද ගස් සුරක්ෂිත කර රැක බලා ගැනීමට කැපවීම දැක්විය හැක.

காலநிலை மாற்றம் ஆபத்தானதா?

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20 ஆம் நூற்றாண்டின் இறுதிப் பகுதி முதல் காலநிலை மாற்றமும் அதன் விளைவுகளும் தீவிரமாக உணரப்பட்டதன் விளைவாக '*காலநிலை மாற்றம்*' என்ற விடயம் உலகளாவிய ரீதியில் மிக அதிகமாகப் பேசப்பட்டு வருகின்றது. இக்காலநிலை மாற்றத்திற்கு இயற்கை செயற்பாடுகளான சூரிய சக்தியில் ஏற்பட்ட மாற்றங்கள், எரிமலை வெடிப்புக்கள், காட்டுத் தீ போன்றனவற்றுடன்சில மானிட நடவடிக்கைகளும் காரணமாகவுள்ளன.

'**காலநிலை மாற்றம்**'என்பதனை,'குறித்த பிரதேசத்தின் காலநிலைத் தன்மைகளை, புள்ளிவிபரத் தரவுகள் போன்றவாறான விடயங்களின் அடிப்படையில் நோக்கும் போது சாரசரி மற்றும் (அல்லது) காலநிலை மூலகங்களின் தன்மைகளில் நீண்ட கால அடிப்படையில் குறிப்பாக பத்து அல்லது பத்துக்கு மேற்பட்ட வருடங்களில் ஏற்பட்டுள்ள மாற்றம்'என வரைவிலக்கணப்படுத்தலாம் (IPCC, 2007).

காலநிலை மாற்றத்திற்கான மானிட காரணங்கள்

1. காடழிப்பு: சூழல் சமநிலையைப் பேணுகின்ற காடுகளானவை, விவசாய நடவடிக்கைகளை மேற்கொள்ளல், விறகுத் தேவைகளைப் பூர்த்தி செய்தல், நகராக்கம், வீதிகள் மற்றும் கட்டிடங்களை அமைத்தல்,பொழுது போக்குக்குத் தேவையான இடங்களை அமைத்தல் போன்ற பல்வேறு காரணங்களுக்காக துரிதமாக அழிக்கப்பட்டு வருகின்றன. இச்செயற்பாடானது அதிகளவிலான CO_2 வளிமண்டலத்தைச் சென்றடையக் காரணமாகின்றது. 20 ம் நூற்றாண்டின் இறுதிப்பகுதியில் காடழிப்பு வீதமானது வருடத்திற்கு 13 மில்லியன் ஹெக்டயர்கள் என்ற அளவில் காணப்பட்டுள்ளது (FAO, 2005). எனினும் அறிக்கைகள் மற்றும் பிரதேச அடிப்படையில் காடழிப்பு வீதம் மாறுபடுகின்றமையும் குறிப்பிடத்தக்கது. தென் அமெரிக்காவில் 2000 – 2010 களுக்கு இடைப்பட்ட காலத்தில் காடழிப்பு வீதம் வருடத்திற்கு 4 மில்லியன் ஹெக்டயர்கள் என்ற அடிப்படையில் காணப்பட்டதாகவும் ஆபிரிக்காவில் வருடாந்தம் 3.4 மில்லியன் ஹெக்டயர்கள் என்ற அடிப்படையில் காணப்பட்டதாகவும் தெரிவிக்கப்படுகின்றது (FAO, 2010).

2. உயிர்ச்சுவட்டெரிபொருள் பாவனை: நிலக்கரி, இயற்கை வாயுக்கள் மற்றும் எரிபொருட்கள் போன்றனவற்றை மின் மற்றும் வெப்பச் சக்தியைப் பெற்றுக் கொள்வதற்காக எரிப்பதால் பெருமளவிலான CO_2 வளிமண்டலத்தைச் சென்றடைகின்றது. உயிச் சுவட்டெரிபொருள்களின் பாவனை மற்றும் சீமெந்து உற்பத்தி என்பனவற்றின் காரணமாக 1751 ஆம் ஆண்டு முதல் 337 பில்லியன் டொன் காபன் வளிமண்டலத்திற்கு விடப்பட்டுள்ளதாகத் தெரிவிக்கப்படுகின்றது (CDIAC, 2012).

3. பச்சை வீட்டு வாயுக்களின் வெளியேற்றம்:காடழிப்பு, வாகன பாவனை, விலங்கு வளர்ப்பு, கைத்தொழிற்சாலை நடவடிக்கைகள், உயிர்ச்சுவட்டெரிபொருள் பாவனை போன்றன காரணமாக அதிகளவிலான பச்சை வீட்டு வாயுக்கள் வளி மண்டலத்திற்கு விடப்படுகின்றது. கடந்த முப்பது வருடங்களாக பச்சை வீட்டு வாயுக்கள் வருடத்திற்கு சுமார் 1.6 சதவீதம் என்ற அடிப்படையில் அதிகரித்துள்ளதுள்ளதுடன் உயிர்ச் சுவட்டெரிபொருட்களின் காரணமாக வெளியிடப்படுகின்ற காபனீரொட்சைட்டின் அளவு வருடாந்தம் 1.9 சதவீதத்தால் அதிகரித்துள்ளது (IPCC, 2007).

காலநிலை மாற்றத்தின் விளைவுகள்

'நாசா (NASA)நிறுவனமானது,'புவி மேற்பரப்பானது 1880 களில் இருந்தே வெப்பமடைய ஆரம்பித்துவிட்டது. எனினும் 1970 களின் பின்னரே புவி அதிகமாக வெப்பமடையச் செய்யப்பட்டது'

எனத் தெரிவிக்கின்றது.மேலும் 1980 களின் முதல் பகுதிகளில் இருந்து வெப்பநிலைத் தரவுகளை எடுத்து நோக்கும் போது 2012 ஆம் ஆண்டானது மிக வெப்பமான ஆண்டாகக் குறிப்பிடப்படுவதுடன் இதனை 20ம் நூற்றாண்டின் சராசரி ஆண்டு வெப்பநிலையான 13.0^0C (57.0^0F) என்ற நில மற்றும் கடல் மேற்பரப்பு வெப்பநிலையுடன் ஒப்பிடும் போது, இது 0.57^0C (1.03^0F) அதிகமாக உள்ளது(NOAA, 2012). மேற்குறித்த வித்தில் புவி வெப்பநிலை அதிகரித்துச் செல்வதானது பின்வரும் விதத்திலான பல்வேறு தாக்கங்கள் ஏற்பட வழிவகுத்துள்ளது.

1. இயற்கை அனர்த்தங்கள் அதிகரித்தல்: வரட்சி, சூறாவளி, காட்டுத் தீ, வெள்ளப் பெருக்கு, போன்ற பல தாக்கங்கள் முன்னைய ஆண்டுகளுடன் ஒப்பிடும் போது அண்மைக் காலங்களில் அதிகரித்துள்ளதாகக் குறிப்பிடப்படுகின்றது. உ–ம்: 1970 கள் முதல் வட அத்திலாந்திக் பகுதிகளில் அயனச் சூறாவளிகளின் அதிகரித்துள்ளன (IPCC, 2007).

2. பாலைவனமாதல்: பாலைவனப் பரவலானது ஆபிரிக்காவில் 7 மில்லியன் சதுர கிலோ மீற்றர்களுக்கும் அதிகமான பகுதிகளில் தாவரங்களின் உள்ளார்ந்த உற்பத்தியை 25 சதவீதத்தால் குறைவடையச் செய்துள்ளது (IPCC, 2012). மேலும் ஆபிரிக்காவில் அதிகரித்த மேய்ச்சல் காரணமாக மூன்றில் இரண்டு பகுதியளவிலான நிலப்பகுதி ஏலவே பாலைவனமாதலுக்கு உட்பட்டுள்ளதாகவும் மிகுதி ஒரு பகுதியானது விவசாயத்திற்கோ அல்லது காடாக்க நடவடிக்கைகளுக்கோ உகந்ததாக இல்லை என்றும் தெரிவிக்கப்படுகின்றது (UNEP, 1997).

3. நீர் தட்டுப்பாடு: NASAவிஞ்ஞானிகளினால் ஏழு வருடங்களாக செய்மதி மூலமாகப் பெறப்பட்ட தரவுகளின் அடிப்படையில் டேர்க்கி, சிரியா,ஈராக் மற்றும் ஈரான் ஆகிய நாடுகளின் சில பகுதிகளில் அதிகளவிலான நீர் குறைவடைந்துள்ளமை தெரிய வந்துள்ளது. மேலும் ஐ. நாவின் விஞ்ஞானிகள் (2007) 2020 ஆம் ஆண்டாகும் போது 75 – 250 மில்லியன் ஆபிரிக்க மக்கள் நீர் பற்றாக்குறையை எதிர்கொள்வர் எனக் குறிப்பிட்டுள்ளனர்.

4. பனிப்படலங்கள் உருகலும் கடல் நீர் மட்டம் அதிகரித்தலும்: 20 ஆம் நூற்றாண்டின் போது உலகில் சராசரியாக கடல் மட்டம் வருடத்திற்கு சுமார் 1.7 மி.மீ என்ற அளவில் உயர்ந்துள்ளதாகவும் 2090 ஆம் ஆண்டாகும் போது கடல் மட்டமானது வருடத்திற்கு சராசரியாக 4 மிமீ என்றளவில் அதிகரிக்கலாம் (IPCC, 2007) என்றும் எதிர்வு கூறப்பட்டுள்ளது. ஐக்கிய அமெரிக்காவின் சூழல் பாதுகாப்பு மையம் (2012),1960 – 2011 களுக்குட்பட்ட காலத்தில் ஐக்கிய அமெரிக்காவின் கரையோரப் பகுதிகளிலும் கடல் மட்டம் உயர்வடைந்துள்ளது என்றும் குறிப்பாக மத்திய அத்திலாந்திக் கரை, கல்ப் கரையோரப் பகுதிகளின் சில இடங்களில் 8 அங்குலங்களுக்கும் அதிகமானளவில் கடல் மட்டம் உயர்வடைந்துள்ளதாகவும் பசுபிக்கின் வடமேற்குப் பகுதிகள் போன்ற சில இடங்களில் கடல் மட்டம் குறைவடைந்துள்ளதாகவும் தெரிவித்துள்ளது.

5. படிவு வீழ்ச்சியின் அளவு மாற்றமடைதல்: 1900 – 2005 வரையிலான காலப்பகுதியில் வட மற்றும் தென் அமெரிக்காக்களின் கிழக்குப் பகுதிகள், வட ஐரோப்பா, வட மற்றும் மத்திய ஆசியாவின் சில பகுதிகளில் சராசரி படிவு வீழ்ச்சியின் அளவு அதிகரித்துள்ளதுடன் சாஹேல், தென் ஆபிரிக்கா போன்ற சில பகுதிகளில் சராசரி மழை வீழ்ச்சி குறைவடைந்துள்ளது (IPCC, 2007). சில இடங்கள் காலம் தப்பிய மழையை அனுபவித்து வருகின்றமையும் குறிப்பிடத்தக்கது. இலங்கையின் அண்மைக்கால சில அனுபவங்களைக் கூட இதற்கு உதாரணமாகக் குறிப்பிடலாம்.

6. தாவர விலங்கினங்கள் அழிவடைதல்: காலநிலை மாற்றத்தின் விளைவாக 70 வீதமான தாவரங்கள் அழிவை நோக்கிச் செல்லும் (UN, 2007).

காலநிலை மாற்றத்தை அல்லது காலநிலை மாற்றத்தின் தாக்கங்களைக் குறைக்க மேற்கொள்ளப்பட்ட நடவடிக்கைகள்.

"உயிரின வாழ்க்கையை நிலைநாட்டியுள்ள ஒரேயொரு கோளான புவியை, நிலைத்து நிற்கக் கூடிய அபிவிருத்தியின் அடிப்படையில் பாதுகாத்து எமது அடுத்த தலைமுறையினருக்குக் கையளிக்க

வேண்டிய பாரியதொரு பொறுப்பு காணப்பட்ட போதும், அதனை பொருட்படுத்தாது இப்புவிக் கோளத்தை ஏனைய மலட்டுக் கோள்களைப் போன்று மாற்றியமைக்கும் நோக்கில் மனிதர்களாகிய நாம் எமது செயற்பாடுகளை மேற்கொண்டு வருகின்றோம்"என்றால் அதனை யாராலும் மறுக்க முடியாது. மனிதன் சூழலை கவனத்திற் கொள்ளாத விதத்தில் மேற்கொள்கின்ற நடவடிக்கைகள் மீண்டும் மனிதனையே பாதிக்கின்றன என்பதால் புவியை பாதுகாக்கும் பொறுப்பையும் மனிதனே ஏற்றுக்கொள்ள வேண்டியதாயிற்று. இவ்விதத்தில் காலநிலை மாற்றத்தின் விளைவுகளை கட்டுப்படுத்த மேற்கொள்ளப்பட்ட ஒரு சில முக்கிய அம்சங்களை அல்லது நடவடிக்கைகளை *அட்டவணை 1* காட்டி நிற்கின்றது.

***அட்டவணை:1*: காலநிலை சம்பந்தமாக நடைபெற்ற சில மாநாடுகள், பிரகடனங்கள்**

வருடம், திகதி	மாநாட்டின் பெயர்	கவனத்திற் கொண்ட முக்கிய எண்ணக்கரு (காலநிலையுடன் தொடர்புபட்ட விதத்திலான)	நடைப்பெற்ற இடம்
1972 (ஜூன் 5 - 16)	மனித - சூழல் பற்றிய ஐ.நா (ஸ்டொக்ஹோம்) மாநாடு	சூழல்,UNEP உருவாகியமை,CFCs மற்றும் ஓசோன்	சுவீடன் - ஸ்டொக்ஹோம்.
1977 (ஆகஸ்ட் 29 – செப்டெம்பர் 9)	பாலைவனமாதல் சம்பந்தமான ஐ.நா மாநாடு	பாலைவனமாதல்	கென்யா – நைரோபி
1992 (ஜூன் 3 - 14)	UNCED (சூழல் மற்றும் அபிவிருத்தி சம்பந்தமான ஐ.நா மாநாடு) (ரியோ மாநாடு அல்லது புவி உச்சி மாநாடு 1992)	சூழல், காலநிலை மாற்றம், காலநிலை தொடர்பான ஐ.நா பிரகடனம் கைச்சாத்து,UNFCCC தோற்றம் பெற்றமை	பிறேசில்- ரியோ-டி-ஜெனிரோ
1997 டிசம்பர் 11	'கியோட்டோ பிரகடனம்'		ஜப்பான் - கியோட்டோ
2003 (செப்டெம்பர் 29 – ஒக்டோபர் 3)	WCCC (World Climate Change Conference)	காலநிலை மாற்றம்	ரஷ்யா – மொஸ்கோ
2008 (ஜூலை 7 - 9)	G-8 Summit	எதிர்காலத்தில் ஏற்படக் கூடிய காலநிலை மாற்றத்தைக் குறைப்பதற்கு பொருளாதார சிக்கல்கள் மற்றும் பச்சை வீட்டு வாயுக்களின் வெளியேற்றம் என்பனவற்றினைக் குறைத்தல்	ஜப்பான் - ஹொக்கைடோ
2012 டிசம்பர் 08	"கியோட்டோ மாநாட்டின் டோஹா திருத்தம்"(Doha Amendment to the Kyoto Protocol) ஏற்றுக் கொள்ளப்பட்டது.	காலநிலை மாற்றம்	டோஹா
2012 (ஜூன் 20 - 22)	நிலைத்ததிருக்கக் கூடிய அபிவிருத்தி சம்பந்தமான ஐ.நா மாநாடு (Rio + 20)	காலநிலை மாற்றத்தை உள்ளடக்கிய நிலைத்திருக்கக் கூடிய அபிவிருத்தியின் பல்வேறு நோக்குகள்	பிறேசில்- ரியோ-டி-ஜெனிரோ
2015 டிசம்பர்	காலநிலை சம்பந்தமான பரிஸ் மாநாடு (COP21)	வெப்பநிலை உயர்வைக் கட்டுப்படுத்தல். இந்நூற்றாண்டில் வெப்பநிலை உயர்வை 2 பாகை செல்சியசால் குறைக்க இணக்கம் தெரிவிக்கப்பட்டது.	பிரான்ஸ் - பரிஸ்

2016 (ஏப்பிரல் 22)		இலங்கையின் தேசிய நோக்கங்களை உள்ளடக்கிய விதத்திலான (INDC) தம்மால் மேற்கொள்ள முடியுமான செயற்பாடுகளை வகுத்து மீள ஒப்படைத்தல்	
2016 (செப்தெம்பர் 21)		பரிஸ் உடன்படிக்கையை ஏற்றுக்கொள்ளல்	

மூலம்: http://newsroom.unfccc.int/and http://www.geni.org/globalenergy/issues/global/environment/climate-change/global-climate-change/unfccc.int/doha-conference-november-2012/index.shtml.

மேற்குறித்தவற்றுடன் ஓசோன் படையைப் பாதுகாக்கும் தினம், மர நடுகைத் தினம், புவி தினம், சூழல் தினம் போன்ற பல தினங்கள் கொண்டாடப்படுவதன் ஊடாகவும் நேரடியாகவோ மறைமுகமாகவோ காலநிலை மாற்றத்தை தடுப்பதற்கான நடவடிக்கைகள் மேற்கொள்ளப்படுகின்றன. வெளியீடுகள், சமவாயங்கள், ஒப்பந்தங்கள் போன்றனவும் ஏற்படுத்தப்படுகின்றன. வெளியீடுகளுக்கு உதாரணமாக IPCC மற்றும்ஐ.நா வின் காலநிலை சம்பந்தப்பட்ட அறிக்கைகையைக் குறிப்பிடலாம். காலநிலை மாற்றத்திற்கு ஒத்துழைக்கும் விதத்தில் நாமும் மரங்களை இயலுமானளவு நடல், அத்தியவசியத் தேவைக்காகவன்றி மரங்களை வெட்டாதிருத்தல் போன்றவாறான சில நடவடிக்கைகளை மேற்கொள்ளலாம்.

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From Rio to Paris, a History of Climate Change Negotiations

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Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in any country irrespective of the country of origin. Consequently, action by one country to reduce emissions will do little to slow global warming unless other countries act as well. Ultimately, an effective strategy will require commitments and action by the major emitting countries.

This article gives an overview of the milestones of climate negotiations and aims at providing a comprehensive picture of recent developments up to present.

In 1979, the first World Climate Change Conference recognized climate change as a serious problem and called on all governments to address it. A number of intergovernmental conferences focusing on climate change were held during 1980-1990. The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change and it was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP). It issued their First Assessment Report in which it confirmed the existing scientific evidence for global climate change.

1992: Rio Earth Summit adopts UN Framework Convention on Climate Change (UNFCCC), UN Convention to combat Desertification and UN Convention to Biological Diversity.

At the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted. It opens for signature at the Earth Summit in Rio, bringing the world together to curb greenhouse gas emissions and adapt to climate change. It acknowledged the existence of human-induced climate change and gave industrialized countries the major part of responsibility for combating it. UN Convention on Biological Diversity and the Convention to Combat Desertification are the sister conventions of these Rio Conventions.

The UNFCCC entered into force on 21 March 1994 and 197 countries that have ratified the Convention are called Parties to the Convention. The Conference of the Parties (COP) was established under Article 7 of the UNFCCC as the supreme body of the Convention with the mandate to adopt the decisions necessary to promote its implementation. The first Conference of the Parties (COP 1) met in Berlin in 1995.

Sri Lanka ratified the Nations Framework Convention on Climate Change (UNFCCC) in November 1993.

1997: Kyoto Protocol, the world's first Greenhouse gas emissions reduction treaty

An amendment to the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1997and entered in to force in 2005, establishes specific targets for reducing emissions of carbon dioxide and five other gases. Under this, three mechanisms are identified such as Emission trading (The Carbon market), Clean Development Mechanism (CDM) and Joint Implementation (JI)

The United States signed the treaty, but the U.S. Congress did not ratify it. Therefore, the U.S. is not a party to Kyoto. However, 160 other countries have signed and ratified this agreement to reduce their carbon dioxide emissions.

Sri Lanka ratified the Kyoto Protocol in September 2002 and in keeping with the obligations of the UNFCCC, the Government of Sri Lanka submitted its Initial National Communication in 2000.

2001: Marrakech –COP 7

Parties agreed on a package deal, with key feathers including rules for ensuring compliance with commitments, consideration of LULUCF (Land Use Land Use Change and Forestry) principles in reporting of such data and limited banking of units generated by sinks under the Clean Development Mechanism (CDM). The meeting also adopted the Marrakech Ministerial Declaration as an input into the World Summit on Sustainable Development in Johannesburg.

2005: Montreal - COP11

COP 11 addressed issues such as capacity building, development and transfer of technologies, the adverse effects of climate change on developing and least developed countries, and several financial and budget –related issues, including guidelines to the Global Environment Facility (GEF), which serves as the Convention's financial mechanism. The COP also agreed on a process for considering future action beyond 2012 under the UNFCCC.

In 2005, the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) at its first meeting in Montreal, established the Ad Hoc Working Group on Further Commitments for Annex 1 Parties under the Kyoto Protocol (AWG –KP). The aim of the AWG-KP is to discuss future commitments for industrialized countries under the Kyoto Protocol.

2007: COP 13 adopts the Bali Road Map, which lays out focuses on mitigation, adaptation, technology and financing

At COP 13, which was held in Bali, Indonesia, parties agreed on the Bali Road Map. In 2007, the Conference of the Parties in Bali (COP 13) decided "to launch a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action", with the aim of reaching an agreement two years later (Bali Action Plan)

The Bali Action Plan identified five key building blocks; Shared vision, Mitigation, Adaptation, Technology and Financial resources, for strengthened future response to climate change beyond 2012.

2009: COP 15 failed to reach post-Kyoto commitment. Copenhagen Accord adopted to limit the global temperature rise to 2^0C.

The Copenhagen accord called for all the nations to reduce emissions, invest in clean energy technology and practices and help people adapt to the effects of climate change. The accord also, for the first time, acknowledges that staying below 2 degrees Celsius may not be sufficient and includes a review in 2005 of the need to potentially aim for staying below 1.5 degrees Celsius or an atmospheric CO_2 concentration of 350ppm.

2010: COP 16 establishes Green Climate Fund, the Technology Mechanism and the Cancun Adaptation Framework

Although no comprehensive agreement was reached under the Bali Action Plan, Parties at COP 16 in Cancun in 2010 agreed on several important decisions which became to be known as the "Cancun Agreements". Cancun Agreement consist of five main elements; Financing through Green Climate Fund, Reducing Emissions from Deforestation and Forest Degradation (REDD+), Increasing transparency through Monitoring, Reporting and Verification(MRV), Formalizing the emissions reduction pledges made at COP 15 in Copenhagen, Denmark and creating a new Adaptation Framework

The COP recognized that deep cuts in global greenhouse gas emissions were required to limit the increase in the global average temperature below 2 C^0 above pre-industrial levels. The Parties agreed on enhanced action on adaptation and called for nationally appropriate mitigation commitments and actions. The Cancun Agreements established a mechanism for technology transfer, consisting of the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN), a mechanism for climate finance, the Green Climate Fund (GCF) and the Cancun Adaptation Framework including the Adaptation Committee.

2011: COP 17 launches Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP)

At COP 17 in Durban in 2011, a dedicated body was established to develop a new, broad agreement under the convention; the "Ad Hoc Working Group on the Durban Platform for Enhanced Action".

In Durban, it was also decided to establish a second commitment period under the Kyoto Protocol. One year later, this second commitment period was agreed on at COP 18 in Doha, as an amendment to the Kyoto Protocol known as the Doha Amendment.

2013: COP 19 in Warsaw establishes REDD+ and loss and damage mechanism

The climate change conference in Warsaw in November 2013 marked important progress in the preparation of a new agreement. Parties were invited to initiate or intensify domestic preparations for their Intended Nationally Determined Contributions (INDCs) to a new agreement.

At the same conference, the Warsaw International Mechanism for Loss and Damage was established. This mechanism addresses loss and damage associated with impacts of climate change, including extreme events and slow onset events. The mechanism aims at enhancing the knowledge and understanding of comprehensive risk management approaches, at strengthening the dialogue and coordination among relevant stakeholders and at enhancing action and support, including finance, technology and capacity building.

In the area of REDD+ (Reducing Emissions from Deforestation and Forest Degradation, including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries), the Warsaw framework for REDD+ was established. It consists of a package of decisions addressing monitoring, reporting and verification of REDD+ activities, establishing an information hub to publish results and payments, and encouraging financial entities, including the Green Climate Fund to channel adequate and predictable results-based finance.

2014: COP 20 unveils new negotiating text in anticipation of 2015

In 2014, at an important international event prior to the conference in Lima, UN Secretary General Ban Ki-moon invited leaders from government, business and civil society to a climate summit in New York in September 2014. During that event, several industrialized and developing countries announced mitigation targets and some Parties pledged contributions to the Green Climate Fund. These announcements were seen as a starting point for more statements to be made at the climate change conference in Lima and beyond.

2015: COP 21 in Paris deadline for new post –Kyoto climate treaty

The 21st Conference of the Parties (COP 21) took place in Paris from 30 November to 11 December 2015. A draft agreement has been prepared by the "Ad Hoc Working Group on the Durban Platform for Enhanced Action" (ADP) and negotiated during the conference. The Paris conference also served as the meeting of the Parties to the Kyoto Protocol and as meeting of the subsidiary bodies under the UNFCCC.

World leaders consented to the Paris Agreement which is a universal agreement which possesses a legally binding effect to all its parties. The Paris agreement covered the main topics mitigation, adaptation, finance, technology, capacity building and transparency. As regards mitigation, the aim of the agreement is to commit all Parties to limiting or reducing their greenhouse gas emissions. In the run-up to the Paris conference, the Parties have been invited to communicate their Intended Nationally Determined Contributions (INDCs). In their INDCs, Parties commit themselves to greenhouse gas emission reductions compared to a base year or compared to a business as usual scenario, mostly for the period until 2025 or 2030.

The Main objective of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping global temperature rise in this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

As per the Article 20 of this Agreement, itis open for signature for a period of one year, from 22nd April 2016 to 21st April 2017. Sri Lanka was among the 175 countries that signed the Paris Agreementat the High Level Signing Ceremony on 22nd April 2016.

As per the Article 20 of this Agreement, it is open for signature for a period of one year, from 22nd April 2016 to 21st April 2017. Sri Lanka signed the Paris Agreement at the High Level Signing Ceremony on 22nd April 2016 and ratified on 21st September 2016. Out of 197 Parties to the Convention, 75 Parties have ratified.On 5th October 2016, the threshold for entry into force of the Paris Agreement was achieved. The Paris Agreement will enter into force on 4th November 2016. The first session of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA1) will take place in Marrakech in conjunction with COP 22 and CMP 12.

According to the decisions taken in previous Conference of Parties (COP) to UNFCCC parties submitted their INDCs well before COP21. INDCs are the primary means for governments to communicate internationally the steps they will take to address climate change in their own countries.

INDCs will reflect each country's ambition for reducing emissions, taking into account its national priorities, circumstances and capabilities and Sri Lanka's submitted INDCs comprise of following four areas such as Mitigation, Adaptation, Loss and Damage and Means of Implementation.

COP 21, The Paris Agreement & Future Directions for Sri Lanka (Mitigation)

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Scientists were able to show and convince the governments during the 1970-1980 era that the climate is changing due to human activities. Therefore, over 24 years ago United Nations Framework Convention on Climate Change (UNFCCC) was initiated at the Earth Summit at Rio de Janeiro in 1992. The aim of the UNFCCC was to take action for stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

It took several years and UNFCCC came into force on March 21, 1994 and the first Conference of Parties (COP 1) was held in 1995 at Berlin from March 28 to April 7. Afterwards COPs were held every year at various locations of the world. Since the aim was to stabilize GHGs in the atmosphere there were discussions and debates at these COPs about how to achieve this task. There were basically two groups that engaged in the debate. One group was the developed or the industrialized countries who emitted a substantial amount of GHGs due to burning of fossil fuels for their economic development. The other group represented developing countries and their emission were small and negligible in some cases but suffered the most due to climate change related events and frequent and powerful natural disasters. Although emission reduction of GHGs is the prime need to prevent climate change, who has to take action and in what proportion, method, time and amount were debated at these COPs mostly by taking into account reports and projections of future scenarios by the Intergovernmental Panel on Climate change (IPCC).

Developing countries are strongly arguing that developed countries are responsible for climate change due to historical emission of enormous amount of CO_2 into the atmosphere. Therefore they are also responsible for reducing emission, preventing climate change and supporting developing countries to overcome the consequence and suffering due to aggravated natural disasters and damage (under the convention 37 industrialized countries are in this category). Developed countries on the other hand argue that developing countries are emitting substantial amounts of GHGs especially BRICS (Brazil, Russia, India, China, South Africa) countries who are still in the developing country category (Group of 77 and China are in this group).

However In 1997 at COP 3 in Japan, Kyoto Protocol (KP), a legal instrument of UNFCCC, was initiated with the aim of reducing emission of GHGs by developed countries. KP was to reduce emission of GHGs by developed countries by 5.2% of their 1990 level during 2008-2012 period. However this target was never achieved. While the agreement was in force the emissions increased and disasters related to climate change were observed world over.

During COP 17 in Durban in November 2011, it was decided to have an agreement bringing everybody in UNFCCC together for a successful remedy for climate change. After continuous discussion at every COP, in 2015 at COP 21 in Paris, with the participation of many heads of states, a remarkable landmark

agreement was reached. It is a unique agreement as all 197 countries who are party to UNFCCC agreed unanimously to the decisions of the COP 21. The goals of the agreement are to keep global temperature rise well below 2^0C abovepre-industrial temperatures while pursuing efforts to limit it to 1.5^0C; increase the ability to adapt; and make finance flows consistent with a pathway towards low emissions and climate-resilient development.

Although, the mandate for negotiating agreement from COP 17 envisaged it to come into effect and to be implemented from 2020, the agreement will come into force 30 days after the date on which at least 55 parties (countries) to the UNFCCC amounting to at least an estimated 55% of the total global GHG emissions have deposited their instruments with the depository at the secretariat.

According to this, there are two targets for long-term temperature goals. For most nations the plan was to hold temperature rise below 2^0C. However, 1.5^oC was included in Paris mainly due to the strong push by vulnerable countries like Small Island Developing States (SIDS) and Least Developing States (LDS) and others. The problem here is that according to models in order to keep the temperature below 2^0C the concentration of atmospheric CO_2 should be below 450 parts per million (ppm) while if it is to be limited to 1.5^0C this value should be below 350 ppm. At present this value is around 400ppm and increasing steadily. Therefore to limit the temperature rise at 1.5^0 C, CO_2 in the atmosphere should be removed in some way.

In order to achieve the aim of this agreement every country (Party) whether developed or developing has a role to play should global emission of GHGs be reduced. The agreement also states that developing countries have to be helped to achieve reduction through sustainable development. It also eludes to the fact that the “loss and damage” aspect due to climate change must be considered.

A major part of this agreement is to be achieved through Nationally Determined Contributions (NDCs) that are to be submitted by all countries. This agreement is considered to be a win-win situation for all countries and ensures that mother earth will be a habitable planet for future generation as well. Countries’ emission reduction will be gathered through NDCs and it is hoped that it will be possible to estimate future global emission amount which will help to predict temperature rise in time to come.

In Sri Lanka the GHG emission is not high. Emissions come mainly from power generation, transport sector, solid waste disposal and industry. Other areas are agriculture with chemical fertilizer usage and use of machinery and the forestry sector where deforestation and forest degradation lead to increased emission and reduced absorption of CO_2 leading to increased retention in the atmosphere.

Sri Lanka has already submitted its Intended Nationally Determined Contributions (INDCs) before signing the agreement. If countries are not submitting NDCs after signing the agreement, then INDCs will be considered as NDCs. NDCs need to be communicated every five years and put in place domestic measures to achieve, and Sri Lanka as a developing country is entitle to receive support for mitigation actions. Parties are allowed to adjust existing NDCs at any time to enhance its level of ambition. It is noteworthy that co-benefits resulting from adaptation actions or economic diversification efforts can also be counted towards mitigation contribution.

While some emission reduction is envisaged to be achieved voluntarily, there are several activities to be fulfilled with the assistance from outside either multilaterally or bilaterally to complete NDCs fully. It must be noted that if intended emission reduction is achieved by taking in to consideration a sustainable development pathway it will help Sri Lanka in the long term. For an example, if renewable energy such as Solar, Wind, Bio Mass, Ocean Waves and Ocean Thermal Energy Conversion (OTEC) are used it will be possible to generate sufficient and environmental friendly power for the country. This will lead to reduction in fossil fuel imports and will help economic development. At present, a major portion of national budget goes out as foreign exchange to import fossil fuels. This also will help Sri Lanka to have a pollution free clean environment which in turn will provide for healthy living and reduce health costs for the government. When electricity is generated through renewable sources in an environment friendly manner which is sustainable, transport systems, both railways and road can be converted to use electricity, clean energy which will have zero emission. For the future direction of Sri Lanka especially in the mitigation direction, it will be possible to achieve emission reduction while helping economic development which will have advantages in economy, environment and social aspects. There needs to be a proper and well prepared action plan and activities to benefit from emission reduction and assistance from the outside world.

Even through the main focus of Paris agreement is to reduce emission and mitigate climate change, it also considers sustainable development and the help will be available for developing countries. Some of the emission reduction activities not only help mitigate climate change but help in adaptation aspect as well. For example, in Sri Lanka if Solar energy can be developed to a level that it takes a major share of energy need of the country, then water in reservoirs can be used for agriculture during drought conditions as an adaptation measure to climate change. During drought conditions with bright sunlight solar power generation will be high.

For a satisfactory outcome, the general public has to be educated every step of the way and support and agreement of masses obtained in order to prevent any objections and anticipated obstacles. If this can be achieved Sri Lanka can be an example to the world while achieving sustainable development.

Role of INDCs in the 'Blue Green Era' of Sri Lanka

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The Intended Nationally Determined Contributions (INDCs) came into the global climate change negotiation table at the 19th session of the Conference of Parties (COP 19) to the United Nations Framework Convention on Climate Change (UNFCCC) with the determining by the global community at the 17th session of the Conference of the Parties (COP 17) by the decision of 1/CP.17 to develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties at the 21st session of the Conference of the Parties (COP 21) and for it to come into effect and be implemented from 2020.

Parties to the UNFCCC were invited by the decision of 1/CP.20 to communicate their intended nationally determined contributions well in advance of the 21st session of the Conference of the Parties (COP 21) in a manner that facilitates the clarity, transparency and understanding of the INDCs. In this context, Sri Lanka, as a party to the UNFCCC, initiated the process of preparing INDCs and submitted its INDCs by October 2015.

The INDCs of Sri Lanka consist of reducing Greenhouse Gas (GHG) emission as **Mitigation,** building resilience of vulnerable communities, areas, and sectors to meet the adverse impacts of climate change as **Adaptation**, identifying the need of resources mobilization to implement Adaptation and Mitigation actions as **Means of Implementation** (finance, technology development and transfer, capacity building) and minimizing the risk and impacts of climate induced disasters as **Loss and Damage**.

The INDCs submitted by the Parties are the commitments of the Agreement which was reached in December 2015 in Paris, France, as per the previous COP decisions on adopting a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties. This universal agreement called **Paris Agreement** was adopted at COP 21 with the objective of holding the global average temperature well below 2^0C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5^0C above pre-industrial levels by 2100, recognizing that this would significantly reduce the risks and impacts of climate change.

As a result of agreeing to the Paris Agreement by Sri Lanka, His Excellency the President of Sri Lanka launched the **Sri Lanka NEXT - Blue Green Era** programme on 6th of January 2016 in order to implement the INDCs submitted to the Paris Agreement with the objective of ensuring the national economic development in a low carbon development pathway to achieve a sustainable development goals target.

Sri Lanka NEXT – Blue Green Era is mainly focusing more deeply on environment friendly oceanic and terrestrial economic development potential of the country with special attention on marine biological resources, minerals along the coastal belt and offshore, potential ocean navigational facilities, Ocean

energy potential as well as greening the industries, agriculture, transportation system, energy generation, infrastructure development, manufacturing and entrepreneurship and green constructions and buildings *etc*.

Blue-Green Era is to establish sustainable development pathways to minimize environmental degradation, while maximizing resources efficiency through introducing innovative technology with combining best traditional knowledge and practices and ultimately, changing the behavior of production chain and lifestyles.

Sri Lanka's mitigation INDCs covers five major greenhouse gas emission reducing areas such as energy generation and efficiency, transportation, industry, waste and forestry.

Energy generation capacity will be strengthened to meet the country's growing demand through renewable energy sources like hydro, solar, wind, biomass, tidal waves and biogas *etc*. Investment in these areas to meet the commitment under the Paris Agreement will fulfil the green energy component of the Blue Green Era.

In order to reduce greenhouse gas emission in the transport sector, modification of transportation systems has been focused on submitted transport sector INDCs. Implementation of these INDCs could be supported for greening the transportation systems, which has been fully underlined as one of major components to be achieved as the set objective of the Blue Green Era.

Reducing greenhouse gas emission from industrial process and increasing energy efficiency in industries are the main characters of INDCs which have already been submitted in this sector. Greening the industries is reducing GHG emission to minimize adverse effects of climate change while stabilizing the potentiality of products to be competitive in the national and international markets. This is one of the aims of Blue Green Era in the terms of greening the industries.

Improved waste management practices will be introduced to minimize the emission of one of the main greenhouse gases, Methane (CH_4) under the submitted INDCs in the sector. Capturing methane to generate electricity is one of renewable energy sources that could be ensured the green energy generation referred to in the Blue Green Era concept while producing organic fertilizer to improve the agricultural production system for further greening.

Increasing the natural forest cover from 29.6% to 32% by 2030 is one of main targets given in the forest sector INDCs. By achieving this target, carbon sequestration could be increased and environmental services such as purification of water and air, reducing soil degradation, increasing the biodiversity and the capacity of medicinal pool could be ensured.

The significance of implementing the aforementioned mitigation INDCs is two fold. The foremost factor is to save the planet earth together with the global community effort by contributing GHG emission reduction though the per capita emission of Sri Lanka is negligible. The other factor is the improving of

local air quality to assure nation's healthiness while saving foreign exchange spent for importing fossil fuels that could be utilized for improving the quality of life of the people of the country. Furthermore, the new green investments would create the green employment opportunities and ensure the stabilization of the Blue Green economy in the country.

Most vulnerable sectors to adverse effects of climate change have been incorporated in Sri Lanka's Adaptation INDCs. They are the agriculture, fisheries, and livestock in term of ensuring food security of the country, water and irrigation that are highly essential for survival of human being and ecosystem services that could fully support the continuous flow of food production, threat to human health with the spreading of vector and air borne diseases, coastal and marine resources depletion, loss of biodiversity and ecosystems, infrastructure and natural monuments dedicated for tourism and recreation, urban, city planning and human settlements due to extreme weather and low onset events such as prolonged draughts with the changes of Monsoon pattern, flash floods due to intensive rainfalls and rising sea level and temperature.

Although building resilience of above vulnerable sectors to meet the adverse effects of climate change is a commitment under the Paris Agreement, it is a national obligation. However, the national capacity of the country to meet the incremental cost for remedial adaptation measures is not adequate. Therefore, in order to implement the potential mitigation options and adaptation measures in the country, means of implementation should be provided by the developed countries as per the Convention following the common, but differentiated responsibilities and respective capabilities, equity, right to development and historical responsibilities. Considering the necessity of the above external supports, means of implementation have been incorporated in Sri Lanka's INDCs as one of major components. Building the capacity of each vulnerable sector to meet the adverse effects of climate change is fully supportive to encounter the objectives of Blue Green Era. Further, reducing the risks and impacts of climate induced disasters through improving the existing national disaster management mechanism with the Warsaw International Mechanism on Loss and Damage which was established at COP 19 has been incorporated in the Sri Lanka's INDCs as **Loss and Damage;** that is also directly supportive to Sri Lanka NEXT - Blue Green Era.

Sri Lanka as a Party to the UNFCCC, the Paris Agreement signed on 22nd April 2016 and ratified it on 21st of September 2016. Consequently, Sri Lanka has committed to implement the above INDCs under the Paris Agreement when it enters into force.

By the time this article was written, news on the Paris Agreement appeared that 75 out of 197 parties have ratified the Agreement and it has come early into force before 4th November 2016 reaching the expected condition of "*at least 55 Parties to the Convention accounting in total for at least an estimated 55% of the total global greenhouse gas emissions have deposited their instrument of ratification, acceptance, approval or accession with the Depository"* of the Paris Agreement.

After ratifying the Paris Agreement by a party, the submitted Intended Nationally Determined Contributions (INDCs) become the Nationally Determined Contributions (NDCs) of the respective party.

As Sri Lanka has already ratified the Paris Agreement, Sri Lanka's INDCs have become Sri Lanka's NDCs. Also, the Paris Agreement will enter into force soon. Sri Lanka has to be prepared to implement the above NDCs within the time period by achieving the set targets.

In these circumstances, Sri Lanka has to revisit the prepared "Readiness Plan for Implementation of Intended Nationally Determined Contributions" from 2017 to 2019 and expedite the readiness strategy. Also, in order to implement the Sri Lanka's NDCs, expected Means of Implementation (Finance, Technology Development and Transfer, Capacity Building) should be obtained from the external sources while making a strong voice at the global climate change negotiation table as a developing country. Further, in order to implement Sri Lanka's NDCs efficiently and effectively, it is required to build the capacity of relevant stakeholders, conduct technology need assessments, mobilize appropriate technologies and establish a solid regulatory institutional setup such as proposed "Climate Change Commission" through National Climate Change Act that could fully support to achieving the ultimate objectives of Sri Lanka NEXT – Blue Green Era.

A Blue Green Economy: Low carbon pathways for sustainable development

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The 21st session of the Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) was held in Paris, France from 30th November to 11th December 2015 with the participation ofmany world leaders who consented to the Paris Agreement. Fostering climate resilience and low greenhouse gas emissions development, holding the increase in the global average temperature to well below 2 degree Celsius above pre industrial levels, pursuing efforts to limit the temperature increase to 1.5 degrees Celsius above pre industrial levels in the context of sustainable development and making efforts to eradicate poverty are the major concerns of this agreement.

Consequently, member countries to the UNFCCC have consented to control the rise of global temperature by publishing their Intended Nationally Determined Contributions (INDCs) and implement them after the Paris Agreement becomes force. Sri Lanka is a signatory to the Paris Agreement signed by 178 world leaders in April this year. Since ratification of this agreement is mandatory to become an active participant, approvals of the Cabinet of Ministers and the Parliament have been obtained and, on the invitation of the Secretary General H.E. Ban Ki Moon, H.E. the President Maithripala Sirisena has attended the Ratification Ceremony in New York on the 21st of September 2016.

Energy, Transport, Industries, Agriculture & Livestock, Forestry and Waste Management are the main sectors that contribute to greenhouse gas emission and resultant increase in global warming. Thus, in order to mitigate greenhouse gas emission from these sectors, Sri Lanka has identified its targets and submitted them to the UNFCCC Secretariat.

Having submitted the INDCs and having completed the ratification of the Paris Agreement, Sri Lanka has become a fully committed nation to uphold the consensus reached by world leaders.

INDCs: Mitigation Sector.

Sri Lanka's INDCs Report consists of Mitigation, Adaptation, Means of Implementation (finance, technology, development and transfer, capacity building and loss and damage) and mainly five sectors have been identified where greenhouse gas emission could be reduced. They are Energy, Transport, Industries, Forests and Waste sectors. INDCs for mitigation intend to reduce GHG emissions against Business As Usual (BAU) scenario by 20% in energy sector, (4% unconditionally and 16% conditionally) and by 10% in other sectors (transport, forests and waste) by 3% unconditionally and 7% conditionally.*

* "Unconditionally" means INDCs that will be implemented fully or partially with national capacity and without external support while "Conditionally" means INDCs to be implemented with external support.

INDCs : Adaptation Sector.

Adaptation is the only key strategy that a developing country can choose for facing the adverse effects of climate change. Climate adaptation is widely defined as actions taken to moderate, cope or take advantage of experienced or anticipated changes in climate.

Ocean and related Coastal and Marine resources and Bio diversity and Eco Systems fall into Sri Lanka's ambitious strategy of mainstreaming climate change adaptation and are in line with the Paris Agreement and Cancun Adaptation Framework (CAF). Based on these, National Climate Change Adaptation Strategy (NCCAS) and National Adaptation Plan have been developed and Sri Lanka believes that proper adaptation can prevent losses and damages while creating a conducive environment for low carbon development

Consequently, five major broader adaptation targets have been identified. They are:

1. Mainstreaming climate change adaptation into national planning and development
2. Enabling climate resilient and healthy human settlements
3. Minimizing climate change impacts on food security
4. Improving climate resilience of key economic drives
5. Safeguarding natural resources and biodiversity from climate change impacts

Health, Food Security (Agriculture, Livestock and Fisheries), Water, Irrigation, Coastal and Marine, Biodiversity, Tourism and recreation and Urban, City planning and human settlements have been identified as the most vulnerable sectors to the adverse effects of climate change and Proper adaptation can prevent losses and damages while creating a conducive environment for low carbon development.

With the submission of these INDCs, Sri Lanka gave a clear message to the world community that it is serious about the ways in which impacts of climate change could be handled. One would note that these INDCs are more or less identical with the sustainable development goals of the United Nations. The basic concern of the world community is a green economy, but, being an island nation Sri Lanka has gone one step further, thanks to the vision and commitment of H.E. the President.

Blue Green Economy:

Sri Lanka Next – A Blue Green Era' is a national campaign initiated by H.E. the President Maithripala Sirisena to lead Sri Lanka towards a low carbon environment and sustainable development in keeping with the tenets of the Paris Agreement for mitigation of greenhouse gas emissions and adaptation of measures to minimize adverse effects of climate change. It was strongly felt that correcting social, economic and physical development strategies and its directions for the existence of humans as well as flora and fauna is a great service for the sustainability of future generations. Thus, it is most timely and opportune to adopt a blue-green development strategy for the sustainable development of Sri Lanka in order to provide a more fruitful, happy and healthy livelihood for the populace.

In the Blue Development Strategy, oceanic fish resources, other marine biological resources, oceanic mineral resources, oceanic navigation and port facilities, development of tourism industry utilizing coastal and oceanic resources, promoting beach and oceanic sports, maritime archaeology and

anthropology, centre for the Security of the Ocean, oceanic energy and production of medicine using oceanic resources are being considered as potential areas for sustainable development.

Green development strategy has green industrial production, green agriculture, green energy, green constructions, green transport, green cities/villages and green employment that, one would note, coincide with the published INDCs. In other word, these establish our commitment to pursue intended pathways to reach sustainable developments.

The government, of course, has taken positive steps by introducing national policies, strategies and actions to realize its targets. In addition to the Climate Change Secretariat established in 2009, several other initiatives including the declaration of National Climate Change Policy of Sri Lanka, National Climate Change Adaptation Strategy for Sri Lanka, while preparation of the Climate Change Commission Act, introduction of green constructions and establishment of green smart villages are some other initiatives that the government embarked on.

Furthermore, the government is working closely with international organizations to achieve its objectives; UN-REDD and REDD + (Reducing Emissions from Deforestation and Forest Degradation), is such a program that is being carried out as an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. This program helps Sri Lanka to improve its forest cover from the present 29% to the anticipated 32% in the near future. Similarly, the rehabilitation of degraded agricultural lands in Kandy, Badulla and Nuwara Eliya Districts in the Central Highlands is presently being carried out.

It has been observed that coastal areas and marine environment are being polluted and causing adverse effects on the sensitive marine ecosystems and some ocean related industries such as fisheries and tourism. Hence, systematic awareness programs to create awareness among all concerned and to obtain their active participation were designed and the International Coastal Clean up Day is celebrated every year on Saturday of the 3rd week of September while from this year National Marine Resources Conservation Week will also come into action from Saturday of the 3rd week to Saturday of the 4th week of September to propagate the International Coastal Cleanup Programme all over Sri Lanka.

In view of these, it is clear that Sri Lanka is committed not only to abide by the Paris Agreement but, also to follow low carbon pathways for the benefit of this generation as well as future generations. It is of paramount importance that this information should reach the populace for the success of this exercise depends on their fullest cooperation and participation.

Note: *The author has drawn material from the Paris Agreement, INDCs of Sri Lanka and the 'Sri Lanka Next- A Blue Green Era' Policy Declaration for the preparation of this article and is indebted to its authors.*

Addressing Climate Change: A Legal Perspective

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Introduction

As a developing nation the contribution of Sri Lanka to atmospheric pollution and the country's GHG emissions on a global scale is negligible. However, as an Island Nation it is impacted by the adverse effects of climate change in a disproportionate manner. Therefore, maintaining credibility and legitimacy at international negotiating tables is vital for a country like Sri Lanka if it is to be heard in terms of international environmental law policy making. To this end particularly, and also for other reasons, it is important that Sri Lanka complies with the international obligations set on it by international conventions.

This article looks at key environmental treaties that are relevant to climate change to which Sri Lanka is a Party or a signatory *i.e.* the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement. The article also seeks to focus on how the obligations relate to them and the measures taken by the Sri Lankan government at a domestic level to comply with the standards set under international law.

United Nations Framework Convention on Climate Change

The United Nations General Assembly established the International Negotiating Committee (INC) for a Framework Convention on Climate Change in 1990. The INC drafted the Convention and was adopted at the UN Headquarters of New York. It was opened for signature at the Rio de Janeiro Earth Summit from 4th to 14th June 1992. The Convention on climate change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases.

The Conference of the Parties (COP) is the "supreme body" of the Convention, as its highest decision-making authority. It is an association of all the countries that are Parties to the Convention. The Convention established two permanent subsidiary bodies: the (SBSTA) and the (SBI). These bodies give advice to the COP, and each has a specific mandate. They are both open to participation by any Party, and governments often send representatives, who are experts in the fields of the respective bodies. To date, the COP has had twenty one meetings, and at its last, held in Paris, countries agreed to the Paris Agreement.

Kyoto Protocol

The Conference of the Parties (Article 7), the Supreme Body of the UNFCCC Convention, held its third session in December 1997 and adopted the Kyoto Protocol, which commits developed countries (Annex

I parties) to reduce their collective emissions of greenhouse gases by at least 5% of the 1990 level by the period 2008 –2012.The major distinction between the Protocol and the Convention is that while the Convention encouraged industrialised countries to stabilize GHG emissions, the Protocol commits them to do so.

Three Kyoto mechanisms have been proposed by the protocol to achieve the Kyoto targets in reducing greenhouse gases (GHG) from the atmosphere. These mechanisms guide developed as well as developing countries to take collaborative efforts to fulfil the protocol commitments. These market based mechanisms include Emission Trading (ET), Clean Development Mechanism (CDM) and Joint Implementation (JI)

The Meeting of Parties (CMP) is the "supreme body" of the Kyoto Protocol. It is an association of those Parties to the Convention that have also ratified the Kyoto Protocol. The CMP meets every year during the same period as the COP. The Annex 1 parties (Developed Countries) to reduce their collective emissions of greenhouse gases by at least 5%of the 1990 level by the period 2008 –2012.

The Ministry of Environment & Natural Resources established the Sri Lanka Carbon Fund to actively participate in the carbon trading process. The fund is a private company, which will facilitate CDM project development within the country and will facilitate the potential CDM project developers in project development, facilitate financing and other related matters. It will also participate in Carbon Market schemes and to obtain maximum benefit to the country via carbon trading.

Three Kyoto mechanisms are proposed by the protocol to achieve the Kyoto targets in reducing greenhouse gases (GHG) from the atmosphere. Clean Development Mechanism projects are viable among developing countries and developed countries. Sri Lanka being a developing nation, no direct commitment under the Kyoto protocol is enforced. However, Sri Lanka has volunteered to participate in CDM projects.

The National Environmental Act (NEA) No 47 of 1980 (amended in 1988 and 2000) was enacted primarily focusing on environmental protection and management. The emission of pollutants into the atmosphere is prohibited under section 23 of the National Environmental Act and the National Environmental (Protection and Quality) Regulations of 1990, Motor Traffic (emission control) Regulation Number 817/6 dated 3rd May 1994, Ozone Depleting Substances and National Environmental (Ambient Air Quality) Regulations 1994. Gazette Notification Number 850/4 dated 20th December 1994, Amended Regulations (Air Emission, Fuel and Vehicle Importation standards) Gazette Notification Number 1137/35 dated 23rd June 2000, Amendment to Gazette Notification Number 1295/11 dated 30th June 2003, National Environmental (Air Emissions, Fuel & Vehicle Importation standards) Amended Regulations. Gazette Notification Number 1295/11 dated 30th June 2003, Extra Ordinary Gazette No 1557/14 dated 09th July 2008 and National Environmental (Ambient Air Quality) Regulations 850/4 dated 20.12.1994, amended by extra ordinary Gazette No 1562/22 dated 15.08.2008.

Doha Amendment to the Kyoto Protocol was adopted in 2012 for a second commitment period which commences in 2013, and extends to 2020. However, this is yet to enter into force with 114 instruments being needed for the amendment to come into force.

Paris Agreement

The Paris Agreement builds on the UNFCCC, and was agreed to by Parties to the UNFCCC at the COP 21 held in Paris in 2015. For the first time, the Agreement brought together all nations into a common cause to take up ambitious targets on reducing GHG emissions, and to combat climate change and to adapt to its adverse effects.

The Paris Agreement focuses on strengthening the global efforts on climate change, and keeping the temperature rise this century to well below 2 degrees Celsius above pre-industrial levels. It also provides to pursue efforts to limit the temperature increase to 1.5 degrees Celsius. This was one of the key demands from the country groups which represented those most vulnerable to the impacts of climate change.

In addition to this, the Agreement focuses on the provision of financial flows, a new technology framework and capacity building, as well as loss and damage which were declared and a separate element on their own and not treated together with adaptation as previously had been done. The Paris Agreement also focuses on a robust transparency and accountability framework which will be the key to compliance, and requires countries to put their best efforts when addressing emission reduction through nationally determined contributions (NDCs).

Ratifying the Paris Agreement

At the ceremony convened by the Secretary General of the United Nations on 22 April 2016, the world saw 174 States and the European Union signing the Paris Agreement. The Agreement will enter into force based on the dual requirement that needs to be satisfied.

In accordance with Article 21, paragraph 1 of the Paris Agreement, “the Agreement shall come into force the thirtieth day after the date on which at least 55 Parties to the Convention accounting in total for at least an estimate 55% of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the Depository.”

This explains that the ratification on its own by a country will not be sufficient for the Paris Agreement to enter into force at the global level. The ratifications by the countries need to be communicate accordingly, and the relevant instruments deposited with the Depository.

Application of International Climate Change Related Law in Sri Lanka

The 1969 Vienna Convention on the Law of Treaties provides that the States are bound to comply in good faith with the treaties that the countries have ratified, and to comply with such treaties according

to the international law principles. The Constitution of Sri Lanka, in the Chapter on Directive Principles of State Policy refers to the state obligation to respect the international law; as per Article 27(15) state is meant to 'endeavour to foster respect for international law and treaty obligations in dealings among nations'.

Sri Lanka, with the other Parties to the UNFCCC, signed to be a party to the Paris Agreement, and in September 2016, with the approval of its parliament, ratified the Paris Agreement. This entails the country being bound by the obligations of the Paris Agreement, and the submissions made to the UNFCCC for the voluntary emission reduction targets in the form of Intended Nationally Determined Contributions (INDCs).

Having already moved forward in complying with the requisites of a Party to the UNFCCC, the country has already submitted its National Adaptation Plan (NAP), and a Readiness Action Plan for the Implementation of the INDCs of Sri Lanka, and is in the process of preparing a Climate Commission Act which will provide for the institutional structure to facilitate the implementation of the Paris Agreement. As previously mentioned after the dual requirements of 55% of the global emissions is represented by those countries that have ratified the Paris Agreement, and 55 countries have ratified the Paris Agreement. And, Sri Lanka has pro-actively engaged to implement the Paris Agreement, and the international laws relevant to climate change in the country, so as to contribute to the global efforts to mitigate the impacts of climate change.

Implication of existing legal regimes on climate change in Sri Lanka

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Introduction

Climate change is one of the burning environmental issues, which has attracted more attention from the global community in this century. It means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.[1]

Climate change poses profound challenges for lawmakers, as physical, ecological, social and economic impacts of climate change will be significant and it needs to be addressed in a very cautious manner[2]. It, is noteworthy that climate change demands a high capacity of environmental decision making from both international and domestic legal frameworks.

Admittedly, in last few decades many scholars have taken many attempts to prevent and combat the adverse impact of climate change in an International level. Unfortunately, we are still experiencing more drastic changes in global climate due to the direct involvement of human activities on environmental pollution. Thus, it is evident that incorporating and implementing international standards into domestic legal regime is very much essential to manage destructive human activities as a sensible solution.

Therefore, the main aim of this paper is to identify the international legal framework of climate change and evaluate the strengths and lacunas of the current Sri Lankan legal mechanism pertaining to climate change issues.

International Legal Framework of Climate change

The United Nations Framework Convention on Climate Change (UNFCCC) in 1992 was the first universal convention, which identified the prevention of dangerous human

interference with the climate system.[3]According to the Article 3 of the UNFCCC, the parties should protect the climate system for the benefit of present and future generations of the humankind and they should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects.

[1]United Nations Framework Convention on Climate Change (UNFCC), Article 1
[2] Mc Donald, Jan and C Styles , Magan, Legal Strategies for Adaptive Management under Climate Change, Journal of Environmental Law, 2014, p.26
[3] Before UNFCCC, The Vienna Convention for the Protection of Ozone Layer was adopted in 1985. In 1987 the Montreal Protocol on Substances that deplete the Ozone Layer was adopted.

So, it is notable that UNFCCC has encouraged and facilitated the binding parties to prevent dangerous levels of climate change by introducing effective monitoring systems. The Kyoto Protocol is one of the successful international agreements which linked to the UNFCCC in relating to emission reduction. The Protocol emphasizes the common, but differentiated, responsibilities of the states which embodied in Article 3 of the UNFCCC. The significant feature of the Kyoto Protocol is its three key mechanisms on International Emission Trading, Clean Development Mechanism (CDM) and Joint Implementation (JI).

In addition to the UNFCCC and Kyoto Protocol, it is notable to highlight some most recent steps which have been taken for addressing emerging issues of the climate change. In 2007, the Bali Road Map was introduced for a secure climate future. The Cancun Agreements in 2012 was aimed to reduce greenhouse gas emissions, and to help developing nations protect themselves from climate impacts and build their own sustainable futures[4]. Durban Outcomes, Doha Climate Gateway and Warsaw outcomes are some other steps which corroborate the importance of international and domestic level contribution to prevent climate change.

The global community has agreed to bridge the gap between policies and climate-neutrality before the end of the century in Paris Climate Conference (COP 21) in 2015. As a result, the Paris Agreement has come into the arena as an agreement within the framework of UNFCCC. According to the Article 2 of the Agreement, it is aimed to hold the increase in the global average temperature to well below 2 Centigrade above pre industrial level through the implementation of UNFCCC. Thereby increasing the ability to adapt to the adverse impact of climate change and foster climate resilience and low greenhouse gas emission development and finally, making finance consistent with pathway towards low greenhouse gas emission and climate resilient development.

Hence, it is clear that the international legal regime on climate change has developed a wide monitoring process and effective mechanisms forcountries by forcing them to combat against the issues of climate change. Particularly, the Paris agreement can be identified as a historic turning point in the goal of reducing global warming.

The Scope of Climate Change Legal Regime in Sri Lanka

As a developing country, Sri Lanka cannot ignorethe fact that we are highly vulnerable to the adverse impact of climate change such as increases in the frequency and intensity of disasters like droughts, floods and landslides, variability and unpredictability of rainfall patterns, an increase in temperature and sea level rise among others.[5]According to Sri Lanka's National Communication to the Inter-governmental Panel on Climate Change (IPCC) in 2000, land use change and forestry, energy and transformation industries and other industries are the biggest contributors to greenhouse gas emissions in the country.[6]Accordingly, it is apparent that there should be a strong climate change legal regime in Sri Lanka to combat against this global challenge.

[4]http://unfccc.int/key_steps/cancun_agreements/items/6132.php
[5] National Climate Change Adaptation Strategy for Sri Lanka, 2011- 2016, at p.1
[6] Judges Environmental Law; A Hand Book for Sri Lankan Judiciary, Environmental Foundation Ltd, 2009, at p. 60

Presently, Sri Lanka does not have a separate law on climate change. Even though Sri Lanka has ratified the UNFCCC on November 1993, due to the dualist approach of the country, international law is not binding as a part of our domestic law until it incorporates into domestic law through an Act of Parliament. However, Article 27 (15) of the Constitution of Sri Lanka imposes a duty on the State to respect international law and treaty obligations in its dealing among States. In ***Eppawala Phosphate Mining case***, Supreme Court of Sri Lanka held that even if the international environmental law principles have not been incorporated into domestic law through Acts of Parliament, as a member of the United Nations, such principles cannot be ignored by Sri Lanka and can be made binding and become a part of the domestic law by adoption by the superior courts.[7] Accordingly, it can be argued that Sri Lanka cannot ignore the responsibility of preventing and mitigating climate change impacts imposed under the UNFCCC and Kyoto Protocol.

In general, National Environment Act (NEA) is the umbrella legislation on environment protection in Sri Lanka. Under NEA, it is hard to find provisions which are directly relevant to the prevention of climate change, although certain provisions of the NEA can be identified as preventing mechanisms against the issues of climate change. For instance, part IV B of the NEA deals with 'Environmental quality'. It prohibits any person from carrying out the polluting activities listed in this part of the statute. The prohibited activities include polluting inland waters[8], atmosphere[9], soil[10] or the surface of any land, making or emitting excessive noise[11] and the disposal of litter.[12] So, it is evident that, the NEA provides some authority to address the issue to a certain extent.

In addition to the statutory provisions, National Environmental (Protections and Quality) Regulations have been introduced to enhance the effectiveness of these legal mechanisms. Introducing emission standards for in-use vehicles is one of the progressive steps implemented under National Environmental (Air Emission, Fuel and Vehicle Importation Standards) Regulation No 1 of 2003 as amended by Regulations of 2008. This regulation specifies the maximum permissible amounts in the ambient air of pollutants such as carbon monoxide, nitrogen dioxide, ozone and sulphur dioxide and particular matters.

Ozone Depleting Substances and Natural Environmental (Ambient Air Quality) Regulations No. 850/4 identified and listed out the ozone depleting materials and substances which will endanger the quality of the environment and are prohibited in any process, trade or industry with effect from 1st January 2000. Also, National Environmental (Noise Control) Regulations No.1 of 1996 demarcated land into various zones and listed the maximum permissible noise levels for each type of those areas.

Besides above statutory obligations and regulations, Sri Lankan government has developed some national policies and action plans relating to climate change. National Climate change policy, National Climate Change Adaptation Strategy for Sri Lanka 2011-2016, National Policy on Clean Development

[7] ***Bulankulama v. Secretary, Minister of Industrial Development*** (2000)3 SLR 243 at 274
[8] NEA, Sec. 23 A
[9] NEA, Sec. 23 J, K
[10] NEA, Sec. 23 N
[11] NEA Sec. 23 P,Q,R
[12] NEA Sec. 23 S

Mechanism and National Strategy for Clean Development Mechanisms (CDM) are some of the policy decisions which have been taken for the purpose of monitoring this issue. CDM can be considered as one of the progressive and significant steps which proposed to implement the Clean Development Mechanism under Article 12 of the Kyoto Protocol. On the other hand, as a national focal point for UNFCCC and Kiyoto Protocol, the Climate Change Secretariat has been established under Ministry of Environment and Natural Resources, to fulfill the vision of "an environment conscious nation and a prosperous Sri Lanka with high level of resilience to global climate change".

Thus, all the above mentioned statutory provisions, regulations and national policies directly or indirectly coverthe scope of climate change legal regime in Sri Lanka. However, when comparing the risk and vulnerability of the predicted impacts of climate change, we have a question that whether the existing Sri Lankan legal regime on climate change is adequate to address this 'greatest challenge of our time'.

Conclusion and Recommendations

According to the scientific evidence, future climate change is likely to affect agriculture, marine and coastal eco systems, human health and risk of hunger and water availability.[13] So, it is evident that every country should tie up their laws at a stronger level to prevent and monitor the vulnerable factors and impacts of the climate changes. Unfortunately, in Sri Lanka we do not have a separate piece of legislation to extensively address the issues of climate change.

As per the Executive Secretary of the UNFCCC, "Domestic legislation on climate is the absolutely critical, essential linchpin between action at the national level and international agreements. It is absolutely at the centre."[14]Also, most notable fact is that, many state parties of the UNFCCC have already implemented climate change legislations into their domestic laws. For instances, UK Climate Change Act is one of the effective legislations which aims to reduce emissions of GHGs by at least 80% from 1990 levels by 2050. South Korean Framework Act on Low Carbon Green Growth in 2010 is another good example, creating legislative framework for mid- and long-term targets, cap and trade, carbon tax and expansion of renewable energy.

Accordingly, it is noteworthy that Sri Lanka is in a position to accelerate its battle against the adverse impacts of climate change. According to my point of view, we need a strong climate change legislation to incorporate the obligations attached to the UNFCCC and Kyoto Protocol, as well as the Paris Agreement, to fulfill that task. In that case, international environmental law principles like sustainable development, precautionary principle, polluter pays principle, the concept of trusteeship can be used extensively. Moreover, monitoring authorities should be empowered to control dangerous human activities like deforestations, high emissions, pollutions *etc.*

[13] Judges Environmental Law; A Hand Book for Sri Lankan Judiciary, Environmental Foundation Ltd, 2009, at p. 61

[14]Christiana Figueres, Executive Secretary of the UNFCCCSpeaking at the 1st GLOBE Climate Legislation Summit London, 14 January 2013

As UN secretary Ban Ki- Moon onceemphasized, “Climate change does not respect borders, it does not respect who you are - rich and poor, small and big. Therefore, this is what we call ‘global challenges’ which require global solidarity”. So, we should not wait any longer, but should get ready to overcome this global challenge with a strong legal regime.

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Loss and Damage from Climate Change: The Way Forward

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Loss and damage was one of the key elements that were at the forefront in the lead up to the Paris Agreement. The relevance to loss and damage to the issue of climate change, and the importance of integrating it to the sections of the Paris Agreement became a key point of the negotiations of the 21st Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).

However, this does not mean that mitigation and adaptation are not to be addressed. They still remain as key elements of the combat against adverse impacts of climate change as efforts on mitigation and adaptation can reduce avoidable losses and damages (Verheyen, 2012). But, in some cases losses and damages will be incurred despite mitigation and adaptation efforts, thus there will be some losses and damages that will not be avoided (*Ibid*). Due to this the concept of loss and damage in the climate change discussions is vital.

While we discuss the way to reduce the impacts of climate change, it is equally important that there are ways to address the impacts already felt and the losses and damages caused by the impacts of climate change. This article will observe the progress made on the issue of loss and damage, and the way forward on the issue at the national and the international level.

The Concept of "Loss and Damage"

The first mentions of the concept of loss and damage came up in 1991 when Vanautu submitted a proposal on behalf of the Alliance of Small Island States (AOSIS) proposing the need to establish both an international fund to support measures to address the impacts of climate change, as well as an insurance pool to provide insurance against sea level rise.

The proposal presented a suggestion that a funding pool for impacts felt to vulnerable countries due to climate change needs to be set up, for which the developed countries would be making mandatory contributions. This was under the principles of compensation based on the premise that the impacts of climate change were caused by the developed countries due to their high emissions through industrial development, which has caused see level rise impacting the small islands and other vulnerable communities. In brief, the aim of the proposal was to establish a compensation fund that would redress direct damage from the adverse effects of sea level rise (Linnerooth-Bayer *et al*., 2003). However, these suggestions were not incorporated to the UNFCCC.

The issue of insurance which was silent during the early COPs resurfaced in COP 7 in Marrakesh when Decision 5/CP.7 decided to "consider, at its eighth session, the implementation of insurance-related actions to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change". But there was no concrete outcome that was made on the issue in the next COP which was held in Delhi.

The term "loss and damage" was introduced to the UNFCCC process in COP 13, where the Bali Action Plan was created. Article 1c of Decision 1/C.P 13 calls for enhanced action on adaptation including: "Disaster risk reduction strategies and means to address loss and damage associated with climate

change impacts in developing countries that are particularly adverse to the impacts of climate change." [UNFCCC, (2008).

From Bali to Cancun, the negotiations on the concept of loss and damage progressed. COP 16 in 2010, established a work program to consider approaches to address loss and damage in developing countries particularly vulnerable to the impacts of climate change (UNFCCC, 2011a). The programme was divided into three key areas which included firstly assessing the risk of loss and damage associated with the adverse effects of climate change and the current knowledge on the same, secondly a range of approaches to address loss and damage associated with the adverse effects of climate change, including impacts related to extreme weather events and slow onset events, taking into consideration experience at all levels and as the third the role of the Convention in enhancing the implementation of approaches to address loss and damage associated with the adverse effects of climate change [UNFCCC, (2011b).

The Warsaw International Mechanism on Loss and Damage

COP 19 of the UNFCCC held in Warsaw saw the establishment of the International Mechanism on Loss and Damage. Days after Typhoon struck his homeland Naderev (Yeb) Sano, the head of the Philippine delegation, made an impassioned plea for swift action to address climate change at the opening plenary of COP 19 in Warsaw (Vidal and Vaughan, 2013). And after two weeks of negotiations, the decision reached in COP 19 provides that "loss and damage associated with the adverse effects of climate change includes, and in some cases involves more than, that which can be reduced by adaptation" (UNFCCC, 2014).

The WIM was established to promote "implementation of approaches to address loss and damage associated with the adverse effects of climate change…in a comprehensive, integrated and coherent manner". The preamble of the Warsaw decision on loss and damage highlights the "contribution of adaptation and risk management strategies towards addressing loss and damage associated with climate change impacts") and "that loss and damage… in some cases involves more than that which can be reduced by adaptation".

The initial two-year work plan for the Warsaw International Mechanism (WIM) was approved at COP 20 in 2014 and outlines the activities that the Expert Committee on the WIM ExComm will coordinate in 2015 and 2016. This consists of nine action areas, and has multiple activities described within each. The activities will be initiated as early as January 2015, and continue to December 2016, whereby in COP 22 in 2016 a five-year rolling work-plan will be considered on the work of the WIM.

When summarized, the 9 areas of work listed out for the WIM consists of focusing on vulnerable populations, risk management, slow onset events, non-economic loss and damage, capacity building and coordination, migration, displacement and human mobility, financial instruments to address loss and damage, involving other organisations working on loss and damage, and finally the five year rolling plan.

Loss and Damage in the Paris Agreement

In Paris, at the COP21, Parties agreed on loss and damage being considered as a separate element of the Agreement and not being merged with adaptation, as it was previously done. Article 8 of the Paris Agreement provides that, "Parties recognize the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events

and slow onset events, and the role of sustainable development in reducing the risk of loss and damage."

Further it focuses on the WIM, and provides, "The Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement and may be enhanced and strengthened, as determined by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement"

The Agreement provides that "Parties should enhance understanding, action and support, including through the Warsaw International Mechanism, as appropriate, on a cooperative and facilitative basis with respect to loss and damage associated with the adverse effects of climate change". The areas of cooperation and facilitation to enhance understanding, action and support were identified as (a) Early warning systems; (b) Emergency preparedness; (c) Slow onset events; (d) Events that may involve irreversible and permanent loss and damage; (e) Comprehensive risk assessment and management; (f) Risk insurance facilities, climate risk pooling and other insurance solutions; (g) Non-economic losses; (h) Resilience of communities, livelihoods and ecosystems.

It was further agreed that the WIM "shall collaborate with existing bodies and expert groups under the Agreement, as well as relevant organizations and expert bodies outside the Agreement."

Further paragraphs 48–52 (Loss and Damage) of Decision -/CP.21 (The COP,) provide that the COP decides on "the continuation of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts, following the review in 2016," and "requests the Executive Committee of the Warsaw International Mechanism to establish a clearinghouse for risk transfer that serves as a repository for information on insurance and risk transfer, in order to facilitate the efforts of Parties to develop and implement comprehensive risk management strategies."

In what is considered as a drawback for most developing countries paragraph 52 "agrees that Article 8 of the Agreement does not involve or provide a basis for any liability or compensation," which has led many to question the progress made in gaining compensation for losses and damages resulting from climate change. Had the developing countries paid a high price in agreeing to this wording, in order to succeed in getting loss and damage considered as a separate element of the Paris Agreement?

Loss and Damage: Sri Lankan Initiatives

In Sri Lanka's Intended Nationally Determined Contributions (INDCs), submitted to the UNFCCC in October 2015, the country has included as one of its INDCs; one of loss and damage. According to the National Disaster Relief Centre the total relief expenditure for the period of 2007-2011 in Sri Lanka was LKR1, 786 million which is around US$12.94million that is based on a calculation that does not include damage to infrastructure, allocated from the national budget. According to an integrated post flood assessment conducted by the Disaster Management Centre of the Ministry of Disaster Management Sri Lanka in 2010, the total flood related damages and losses were calculated at approximately US$ 38.46 million. Further, the on-going post disaster needs assessment has highlighted the sector wise damage and loss in key sectors being approximately LKR 90 billion which is about USD 620 million.

The INDCs of Sri Lanka on loss and damage include, among others, improving of forecasting capabilities, enhancement of the existing automated observational network, implementation of lightning detection

network, improvement of numerical weather prediction capacity with data assimilation, improvement of weather forecasting capabilities, analysis of total loss and damage of climate induced disasters from year 2000 and the gap not compensated/recovered.

The INDCs further include the country taking actions to contribute to the discussions of the WIM, and making recommendations as well as establishing a local mechanism in line with WIM at the national level.

Conclusion

While the outcomes of the Paris Agreement are seen as victories when discussing the way forward in addressing losses and damages caused due to climate impacts, one needs to realise that these are merely the first steps of a longer process. There remains a vast amount of work to be done, and finances mobilised to address the loss and damage of climate impacts. One of the key issues we need to discuss in the coming years, will be how the WIM could contribute to the national level mechanisms as proposed by the INDCs of Sri Lanka, and also finding out how national mechanisms could contribute to making the WIM at the international level a more effective and efficient, as well as a mechanism that represents the ground realities faced by those at the forefront of climate impacts, and with increased vulnerabilities.

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Climate Change and El Nino

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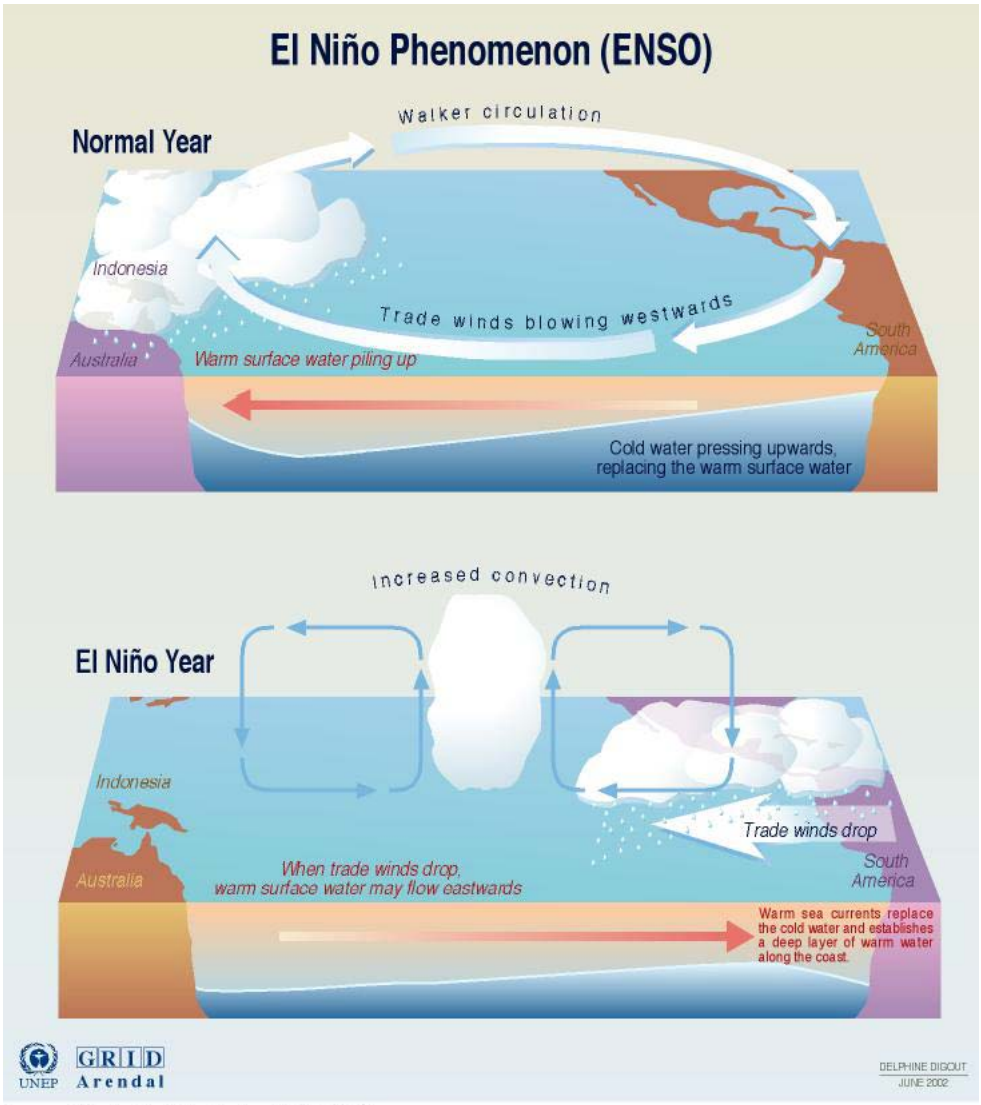
Within our lifetimes, the most dramatic phenomenon linked to climate change is the anomalies in the Pacific Ocean known as the El Nino Southern Oscillation, dubbed as ENSO (Cane 2004). This phenomenon has been taking place even as far back as 10,000 years ago during the Holocene period (Outavas *et al*. 2006). However, the El Nino did not receive much public attention until 1997-98 when Peru and Ecuador experienced heavy floods, Indonesia and Australia faced ghastly droughts and Southeast Asia had to shut down some of their airports due to the thick clouds of smoke arising from forest fires in the region.

In Spanish, 'El Nino' directly translates as "The Little Boy" referring to the 'Christ Child' as this phenomenon usually occurs during Christmas time. The seasonal arrival of warm water in the Pacific Ocean during the month of December prompted the South American fishermen to call it El Nino. El Nino and La Nina ('Little Girl') are opposite phases of the ENSO cycle which describes the variations in temperature between the ocean and atmosphere in the Equatorial Pacific. El Nino is the warm phase while La Nina is the cold phase of the ENSO.

An upwelling or upward movement of ocean water can mix upper levels of seawater with lower levels bringing cool and nutrient rich water from the bottom of the ocean to the warmer surface where it supports large populations of phytoplankton, zooplankton, fish and fish-eating seabirds. Every few years normal upwelling in the Pacific Ocean is affected by ENSO. During an ENSO, the prevailing winds, called trade winds, blowing east to west weaken. This allows warmer waters of the Western Pacific to move towards the Western coast of South America which suppresses the normal upwellings of cold nutrient-rich water.

This leads to a disruption of the marine food chain. Warm waters send fish to cold deep water. The seals are left to suffer as they are deprived of their food source. Similarly fishing economies of countries like Peru and Euador also dwindle as a result of this.



Sources: Climate Prediction Center-NCEP; NOAA.

Let us have a look at how climate change relates to the above mentioned phenomenon. Climate change refers to any significant change in the measures of climate lasting for an extended period of time. It includes changes in the atmospheric temperature, precipitation and wind patterns. One of the contributing factors to climate change is global warming. The ongoing increase in the average global temperature at the earth's surface is caused by an increase in the amount of greenhouse gases, such as carbon dioxide (CO_2), in the atmosphere.

A rise in global temperatures leads to an increase in sea surface temperatures thereby facilitating the El Nino phenomenon. The relationship between El Nino and climate change is somewhat cyclic. Oceans act as carbon sinks; *i.e.*they capture and store carbon as dissolved CO_2. Carbondioxidedissolves more readily in colder waters. During El Nino there is an increase in sea surface temperatures. This causes less CO_2 to

be dissolved in the oceans. As a result there is more CO_2 in the atmosphere which causes global warming and this inevitably leads to climate change. Bush fires which occur as a result of the El Nino effect release large amounts of CO_2 which again leads to global warming.

ENSO is one of the most important phenomena related to the global climate. This is because of its impact on the atmospheric circulation which ultimately leads to variations in temperature and precipitation. The equatorial Pacific climate behaves as a 'coupled system'. This is because the state of the ocean and the state of the atmosphere depend on each other.

El Nino events are increasing in both intensity and frequency, resulting in increased extreme weather events. In the recent past, Sri Lanka has experienced very hot weather, with certain regions reaching record temperatures, and we have also had very high precipitation. These extreme events would cause severe damage to agricultural crops thereby depriving farmers of a stable income. Fishermen would also face a grave situation when heavy precipitation prevents them from going to sea. Natural disasters such as floods and landslides would become more frequent leading to loss of lives and property, as we saw very recently. Other consequences include spread of diseases, road obstructions, hike in food prices and damage to infrastructure.

Climate change cannot be prevented, but its impacts can be reduced. It is time we became more environmentally conscious because there may come a day when the climate may change so drastically that this planet would no longer be habitable.

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The El Niño event of 2015/16 in Sri Lanka
Predictions, Preparedness, Communication and Impacts

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Historical El Niño Impacts in Sri Lanka

El Niño has significant impacts on rainfall, temperature, wind and associated climatic features. There have been many studies over the last two decades to establish clear impacts on the climate by various authors(Rasmusson E.M. & Carpenter T.H. (1983); Ropelewski C.F. & Halpert M.S. (1987); Fernando T.K., Jayatillake Banda P.M. & Chandrapala L. (1995); Suppiah R. (1996); Kane R.P. (1998); Punyawardena B.V.R. & Cherry N.J. (1999); Malmgren *et al*. (2003); Zubair *et al*. (2008 & 2010); Journal from the Sri Lanka Department of Meteorology (2016). There are discernible and documented impacts on Sri Lanka's water resources, hazards including drought, landslides, floods; and on agriculture, health and coral reefs. Among them floods, droughts, landslides, cyclones, storm surges and coastal inundation are more common (Zubair, 2004a). Water borne diseases and those that are affected by water availability for transmission such as malaria and dengue, are concerns.

El Niño influences within Sri Lanka are not as straightforward as in other regions as they vary from event to event, by region, by decade and season. In particular, the El Niño influences on rainfall changes by season with more rainfall in May, and October to December and less in June to August, and January to April. The temperature remains warmer during all seasons during an El Niño event. El Niño influences are considerably modulated by Madden Julian Oscillation, Indian Ocean Dipole and warming Indian Ocean conditions. It is important to note that there have been recent major droughts and floods which did not coincide with El Niño.

All of this makes the communication of El Niño information quite challenging. What is needed is a high degree of nuance; informed and careful interpreters and continuous updates based on monitored conditions and updated predictions.

In spite of these challenges, if one looks at past history, there is considerable information in an El Niño which should be communicated. For example:there is a higher chance of bad droughts and floods occurring due to El Niño (this depends very much on the rainfall in May). Rainfall in May is highly variable and this can either lead to ameliorate the dry conditions that have built up or to a 9-month dry spell until August. Again, there are also many bad droughts, which are not due to El Niño. Indeed during the 2015/2016 event, the rainfall behaved very much as expected – and the temperature was warmer as expected but much more than in the past. El Niño provides clearer and reliable predictions related to land and sea temperatures.

National Preparedness

Sri Lanka is emerging from three decades of conflicts and terrorism. This affects the resources allocated to infrastructure, community trust in government in some regions, the level of scientific advance and the unregulated private construction, all of which affect social and environmental vulnerability. Population rise from 10 million (1960) to 20 million (2014) has also pushed more and more people into vulnerable locations which are prone to flood, landslide or coastal inundation.

National preparedness for El Niño is within the umbrella of the Ministries in charge of Disaster Management, Water Resources, Science and Technology and Agriculture. These Ministries do not coordinate the action related to El Niño, although, the Departments under them may share the information. The Department of Meteorology is in charge of climate predictions in Sri Lanka and communicating authoritative information, but progress has been slow in adopting prediction methods (Zubair, 2002, 2004b) until the recent decade.Motivated individuals in other Departments also pay attention to El Niño events and to climate variability in general. During the 2002 event, communication about the El Niño and likely impacts were provided by the Department of Agriculture to their field officers.

There are no dedicated funds for El Niño preparedness from national resources. The Disaster Management Agency, the Department of Agriculture and the Department of Meteorology have ongoing funding to deal with climate variability.There has not been a coordinated response to El Niño since the abortive attempt in 1997 led by the Ministry of Science and Technology. The recent event was no different.

El Niño Impact Predictions for Sri Lanka

The Department of Meteorology relies on Global Forecast Centers (the WMO, ECMWF, IRI and others) for El Niño predictions; and its officers participate in the South Asia Climate Outlook Forum (SASCOF) which has been recently active. The SASCOF of April 2014 predicted a dry tendency for the Southwest (summer) monsoon over Sri Lanka. In April 2015, The SASCOF of 2015 predicted a drier tendency for most of Sri Lanka except in the Northern region, which had a near-normal tendency. The SASCOF held in October 2015 predicted wetter conditions for October and November, and normal conditions thereafter.

The Department of Meteorology does provide month ahead predictions which are not disseminated widely. In addition, the global prediction centers are not that skilled in predicting the climate in the Indian Ocean rim, particularly, in regions that have both wet and dry seasons. Thus the climate models from Global Forecast Centers do not represent the dynamics in the Indian Ocean too well. The Indian Ocean is particularly consequential for Sri Lanka.

The Foundation for Environment, Climate and Technology (FECT) provides seasonal statements to water managers, and *via* social media (fectsl.blogspot.com @fectlk, and facebook.com/fectsl). Both these are limited efforts.

In general, apart from newspaper reports, no preparatory actions have been reported since the communication failures for the 1997-98 El Niño. The reports in the Sinhala and Tamil media are even

less than in the English media, although, it is through these languages that the majority of the country is reached. The official communications and warnings from the Department of Meteorology remain only in Sinhala and English with little in Tamil.

Climate during the El Niño event

Overall in Sri Lanka, the rainfall for 2015/2016 climate followed that of historical norms, with increased rainfall in May, and October to December and decreased in other months, and increase temperature in all months. There was flooding in 2014. The rice cultivation was not affected in the 2015 *Yala* season (April to September) because of the high rainfall in May 2015. (Figure 1).

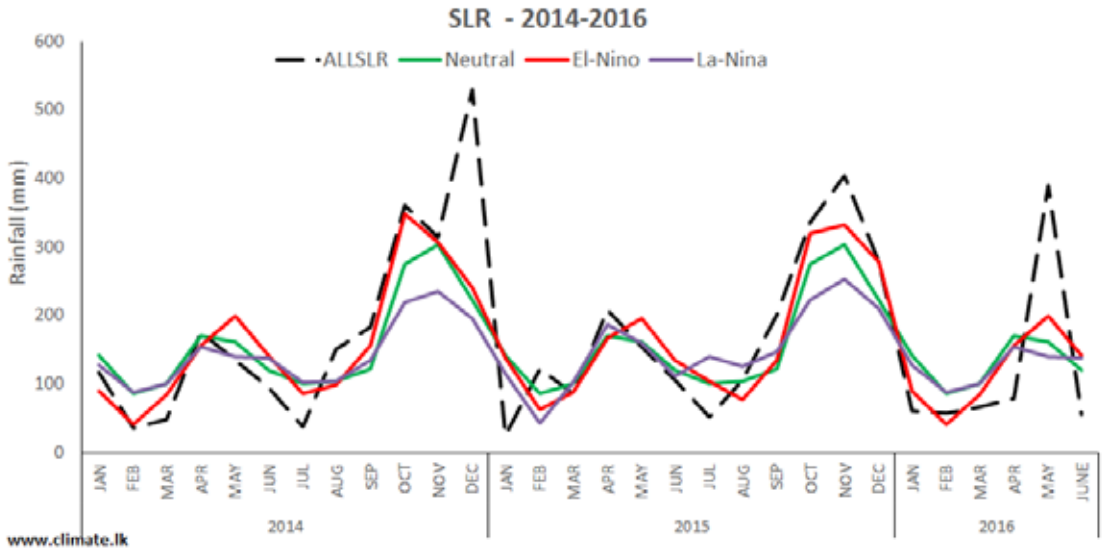


Figure 1*: This analysis is based on results presented in Adhikari et al (2010) and Zubair et al., (2008). All Sri Lanka rainfall (SLR) has been constructed using the average from 15 well distributed rainfall stations. The average monthly rainfall climatology for Sri Lanka during El Niño (red line), Neutral (green) and La Niña (blue) is shown along with SLR (dashed black line) from Jan 2014 to June 2016 for comparison. The El Niño episode appeared briefly in mid-2014 and subsided later on. A fresh El Niño event started in May 2015. (Image source: FECT).*

The strongest climate impact from El Niño in Sri Lanka is due to rising temperatures. Sri Lanka was much warmer during the 2015/16 El Niño than what is usually observed during an El Niño. (Figure 2). The rise in Indian Ocean sea temperatures was responsible.

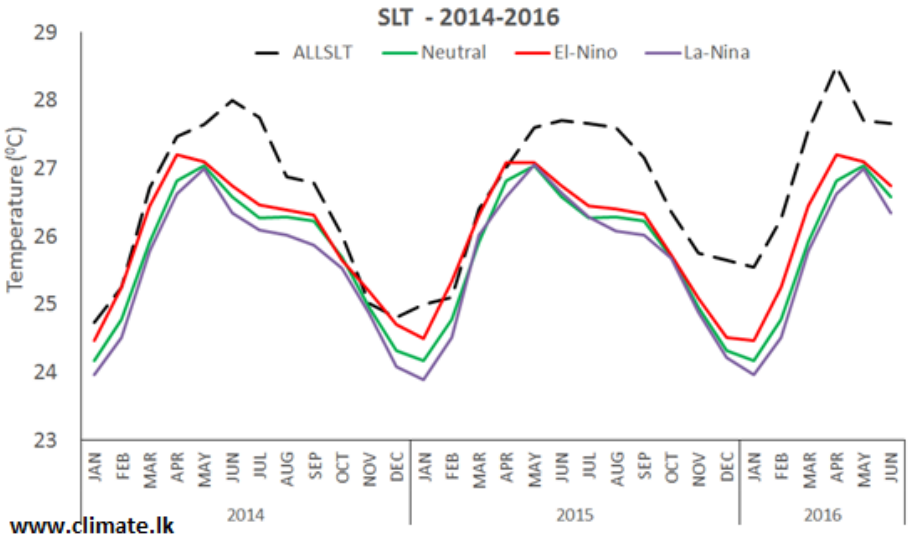
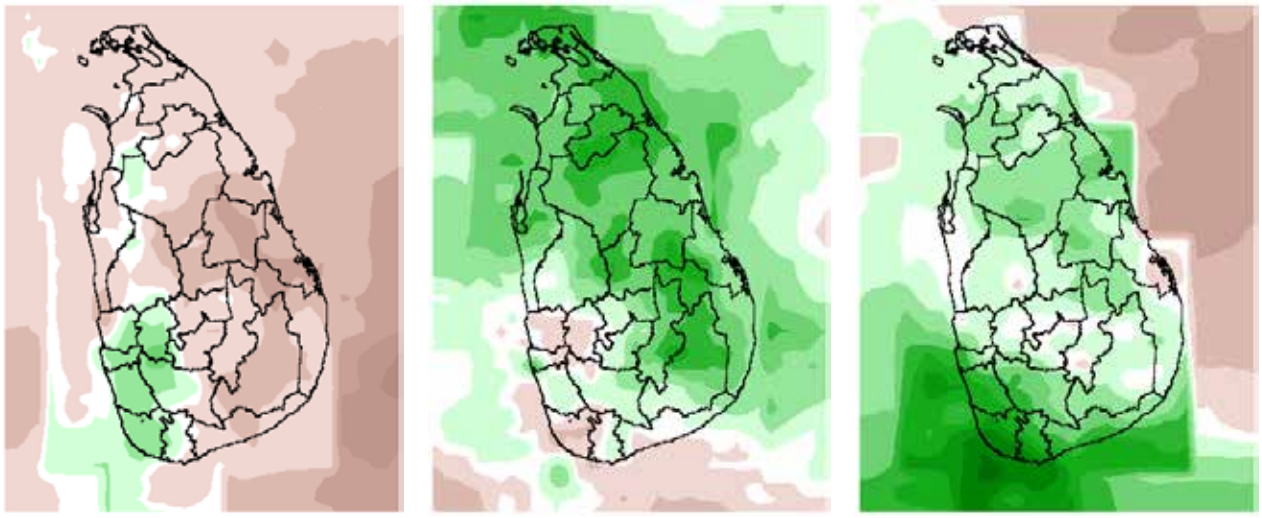


***Figure 2**: This analysis is based on results presented in Zubair et al. (2016, in draft). All Sri Lanka temperature (SLT) has been constructed using the average from 15 well distributed temperature stations. The average monthly temperature climatology for Sri Lanka during El Niño (red line), Neutral (green) and La Niña (blue) is shown along with SLT (dashed black line) from Jan 2014 to June 2016 for comparison. (Image source: FECT).*



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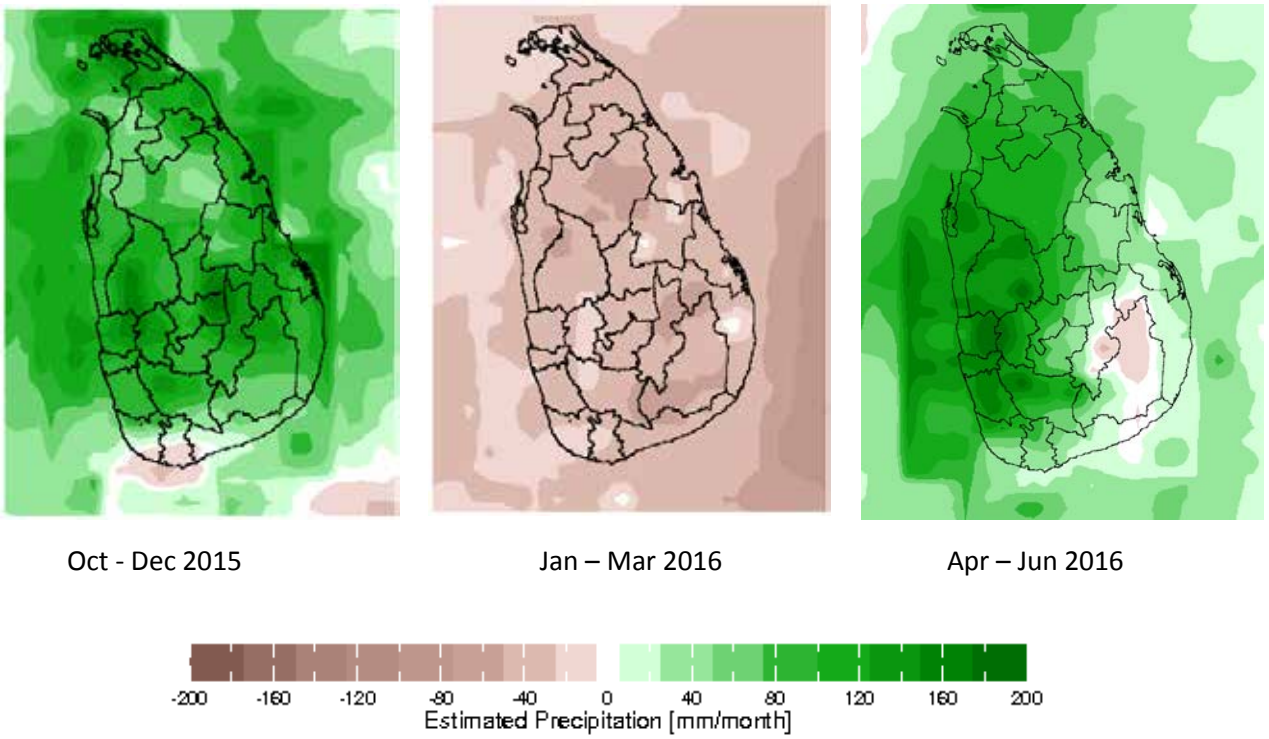

Oct - Dec 2015 Jan – Mar 2016 Apr – Jun 2016

Figure 3: *Quarterly seasonal precipitation anomalies for Sri Lanka for 2015 to Mid-2016. Top Row - Rainfall departures from historical averages (anomalies) for January-March (late Maha), April-June (early Yala), July-September (late Yala) for 2015. Bottom Row - October-December 2015 (early Maha), and January-March (late Maha), April-June (early Yala) for 2016. The historical average rainfall was calculated for January 2001-2016. (Image source: FECT).*

There is much regional and seasonal variation in El Niño influences as seen in the above maps. Some of theseconditions are expected from the historical averages and could have been anticipated – but not all. There are events such as the cyclonic events of May 2016 that overwhelm the modest departures expected due to El Niño alone.

Communication via the Mass-Media

There was quite a keen sense of awareness of drought hazards during this El Niño; thus there was great interest in the media in relation to causes that can be explained, and the sensitivity to climate anomalies. As much as the El Niño event this led to a hunger for climate related articles from news outlets.

Due to past failures in predicting impacts in Sri Lanka and in communicating them, concerns over levels of uncertainty hold back robust communication and action based on El Niño predictions. For example, during the 1997-98 El Niño, drought was predicted and communicated in Sri Lanka without any nuance about seasons. This resulted in the wrong mitigation action taken, such as growing chilies and not harvesting tea. In the ensuing wetter than normal conditions in 1997-98, there were massive losses in agriculture due to poor communication.

There were occasional reports on the El Niño for Sri Lanka in the media starting in 2014 which reported incidentally on the El Niño that were taken from statements of the officials from the Department of Meteorology during their media briefings which did not contain substantive communication of El Niño impacts for Sri Lanka.

Given the reticence amongst scientists to communicate the complex nature of El Niño evolution and its impacts, others have filled in the space. There were articles about the El Niño in the middle of 2014 in the national newspapers warning of an El Niño and drought impacts (Pathfinder Foundation of Colombo (2014)). This warning was a false alarm and even as the El Niño event died out, the warning was not updated. This sort of one-off warning by non-scientists and through the media brought back the specter of mal-communication of El Niño as in 1997.

News coverage did not report on the understanding of El Niño impacts on climate, and on socio-economic activities but simply warned of dire outcomes.Overall, if the media coverage is taken as a whole, the average person would have obtained confusing information which would not have helped with preparedness or mitigation actions.

Impacts of the 2015/2016 El Niño

During the El Niño event, the incidence of dengue rose in mid-2016 after dropping substantially in 2015; tea production dropped; there were floods in May 2016; rice production increased for the Yala of 2015; hydropower production was consistently higher than usual, there was coral bleaching particularly in the South-West. There is the signature of El Niño in these impacts which needs to be carefully teased out – so as to be better prepared in the future.

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Providing climate services for water management in Sri Lanka

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Introduction

Climate variability and change directly affects the livelihoods, welfare and security of communities. Extreme weather events such as high intensity rainfall, flash floods and landslides, and extended dry periods resulting in water scarcity are becoming more common (Climate Change Secretariat, 2013). Climate information can play a crucial role in national development planning, for managing risks. Timely communication of climate information helps to mitigate adverse impacts.

Climate services are the dissemination of climate information to the public or a specific user. They involve strong partnerships among providers for the purpose of interpreting and applying climate information for decision making, sustainable development, and improving climate information products, predictions, and outlooks.

The Foundation for Environment, Climate and Technology (FECT) has produced weekly climate advisories for Sri Lanka for the Water Management Secretariat (WMS) of the Mahaweli Authority of Sri Lanka (MASL)since 2008 based on a decade of research. This hydro-climatic advisory has been developed as the outcome of a collaborative research project on producing useable climate information for water resources management in a decade-long collaboration between MASL and the International Research Institute for Climate and Society (Zubair, *et al*., 2003).

The WMS convenes a multi-institutional panel (Department of Irrigation, Ceylon Electricity Board, Mahaweli Authority, National Water Supply and Drainage Board) for water management and this panel has been provided a weekly bulletin for its review over the last five years. The bulletin provides daily, dekadal (10-day) and monthly satellite derived estimates for monitored rainfall, wind and temperature observations and weekly Sea Surface Temperature anomalies.

Local and International Collaborators for the Weekly Hydro-Meteorological Advisories

This weekly report incorporates inputs from Sri Lanka Department of Meteorology, India Meteorological Department (IMD), the International Research Institute for Climate and Society (IRI), the National Center for Environment Prediction (NCEP) of National Oceanic and Atmospheric Administration (NOAA) Australian Bureau of Meteorology, and Asia Pacific Climate Center.

Monitoring of Rainfall, Temperature, Wind and Sea Surface Temperature

The monitoring section of the report comprises daily satellite derived rainfall estimates (Figure 1-Left), monthly rainfall estimates (Figure 1-Middle), dekadal (10 day) satellite derived rainfall estimates (Figure 1-Right), and weekly average Sea Surface Temperature anomalies (Figure 2).

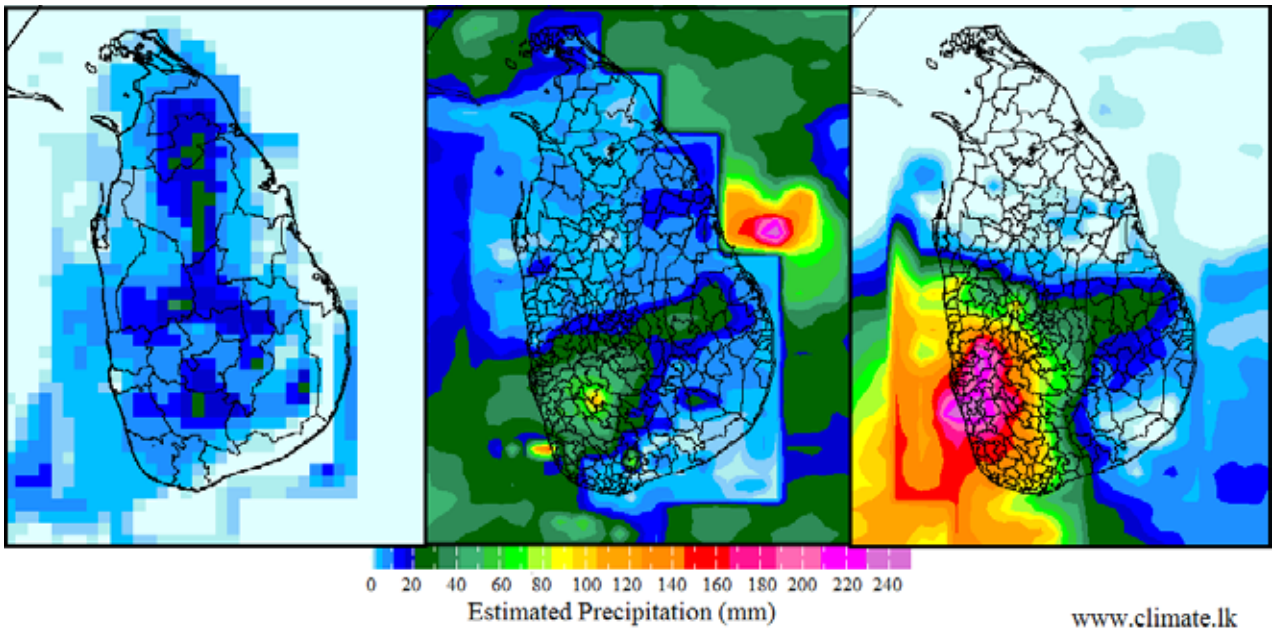

Figure 1: *Daily satellite derived rainfall estimate for 4th March 2015 (left), Monthly rainfall estimate for September 2016 (middle) and dekadal (10 day) satellite derived rainfall estimate for the period of 21-30 May 2016 (right) (Image Source: FECT)*

Daily satellite derived rainfall estimates for previous week (*i.e.* last 7 days) are presented in this advisory in a gridded map format that helps the reader identify where rainfall occurred in the previous week. Monthly rainfall estimates the total rainfall in the previous month in the country as well as the rainfall anomaly (whether rainfall in each region is above or below average).Dekadal (10 day) satellite derived rainfall estimates elaborates the cumulative rainfall received approximately for previous 10 days in Sri Lanka. Using these figures, an overall picture of the rainfall conditions in the previous month is given to the reader.

The average minimum and maximum temperature conditions, wind direction and speed in the previous week are also given. Weekly average sea surface temperature (SST) anomaly map is provided as it is useful in its own right and also helps predict rainfall, temperature and wind based on El Niño/ La Niña conditions and Indian Ocean dynamics.

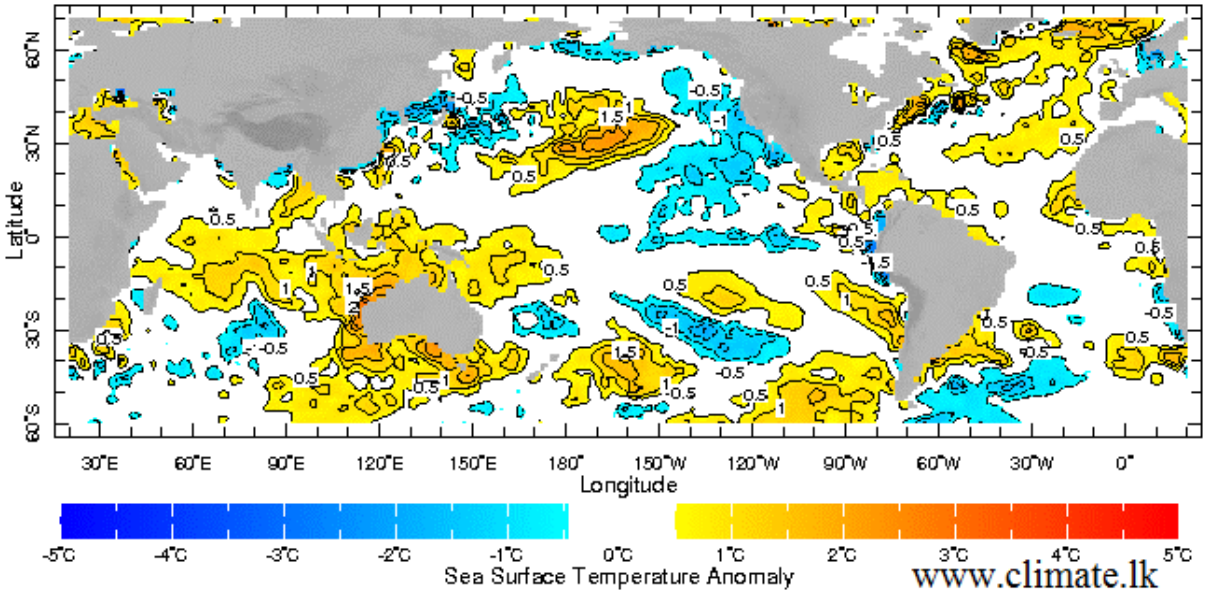

Figure 2: *Weekly average Sea Surface Temperature anomalies for 17th-23rd February 2013*

This includes what conditions are likely in the coming week using weekly predictions from Indian Meteorological Department (IMD), National Oceanic and Atmospheric Administration (NOAA) and seasonal predictions from International Research Institute for Climate and Society (IRI), European Center for Medium Range Weather Forecast (ECMWF) and APEC Center. These predictions are up to 3 days to 3 months ahead from various agencies and climate models. A 30-day prediction by Paul Roundy of the State University of New York, Albany and Lareef Zubair (Zubair, *et al*., 2015) (Figure 3). This prediction is based on observed cloud cover and atmospheric waves. These predictions are for the entire country including separate figures for 6 regionals (*i.e.* Northern, Southern, Eastern coast, Eastern slopes, Western coast and the Western slopes). These predictions were found to be skillful for up to a lead time of 6 days (Zubair and Agalawatte, 2012)

Crisis of Sri Lankan Tea Smallholders: Investment potentials and Adaptation capacity to the climate change consequences

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The development transition of Sri Lanka from lower-middle income to upper-middle income reflects the shrinking of agricultural sector against industrial and service sectors. However, the Gross Domestic Product (GDP) of the country is still being significantly contributed by agricultural sector. The recent studies have revealed that more than seventy five percent (75%) of the country is considered as rural where agricultural sector is predominant (CBSL, 2013). Tea small holding sector is the backbone of rural commercial agriculture, especially in Kalutara, Rathnapura, Galle and Matara districts which recorded exponential growth in tea smallholder sector during last two decades due to favorable incentives given by successive governments.

Though tea smallholder sector is such a leading economic contributor in the current context, its emergence was recorded in first decade of the twentieth century and it developed slowly as subsistence farming families within the vicinity of commercial plantations (Sivapalan and Nalini, 2009).The information on census of 1983 has reflected that the sector has achieved a considerable expansion but is still performing at a poor rate due to lack of technical support, poor facilities for the transportation of green tea leaves and unavailability of an adequate number of processing factories. The establishment of Tea Smallholding Development Authority (TSHDA) in 1975 was the turning point of the sector's development up to current status by addressing most of the above mentioned issues at reasonable standard (TSHDA, 2012). The remarkable development of tea smallholding sector compared to the large plantations has challenged the validity of the conventional theory of Economics of Scale. As viewed by Wickramasinghe and Cameron (2003) though tea smallholding sector adopts a poor economic scale in terms of size of lands and number of labour units compared to estate plantations, it succeeded in achieving higher economic gains by contributing a higher proportion of output reflected as seventy three percent (73%) of national tea income in 2013.

According to the agricultural experts, climate change adaptation is the main challenge in future. Since productivity of agriculture depends on soil and climate, the climate change consequences such as rainfall variations, temperature rise and increased carbon dioxide concentrations have significant impact on productivity. Small holder tea lands face a number of negative impacts due to above mentioned climate change consequences related to carbohydrate assimilation, respiration, evapo-transpiration, pest and disease infestation, drought, flood, soil erosion and soil degradation. It should be emphasized that possible adaptation packages against above mentioned climate change consequences need to include rainwater harvesting techniques, shade trees planting and irrigation systems development, simultaneously with other different agronomic practices to ensure reasonable results. However, tea smallholders are facing continuous rising of labour cost and other inputs which ultimately deteriorate their re-investment capacity on their own plantations.

This situation has been further aggravated by unstable prices for their green tea leaves which remained around 50 rupees per kilo on average for the past few years.

As per the calculations of Tea Research Institute(TRI) the production cost of one kilogram of tea is around 43 rupees by which tea smallholders could generate around 7 rupees profit margin per kilogram of green leaves. The study on effectiveness of smallholder tea cultivation as a sustainable livelihood in Kalutara district (Bandula, 2012) has revealed that the higher significant percentage of small holder farmers consider the industry as their main livelihood. Thus, the research has further revealed the poor diversity of livelihood options in tea smallholder families and poor commitment shown by them to take some practical initiatives towards livelihood diversification. This situation has forced them to use the limited profit from the industry to address their typical family needs rather than to invest sufficiently against the adverse impacts of climate change on their tea plantations.

It is emphasized that strong policy decisions are needed to motivate tea smallholders to adequately adapt to the climate changes and related challenges. Introduction of innovative and cost effective adaptation strategies aligned with their rural resource bases may be a strong practical adaptation in this regard. It is compulsory to keep the industry sustained for another few decades where four hundred thousand (400,000) rural families manage their livelihood while making a significant contribution to the national economy of Sri Lanka.

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Negombo Lagoon Sea Entrance – Vulnerable to climate change?

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Being the most productive brackish water body of the country, Negombo Lagoon plays a vital role in subsistence lagoon fishery of Sri Lanka. The lagoon mouth or the sea entrance is the anchorage for over 3000 sea-going fishing crafts of different type and size. Munnakkarai, one of the islets of the unique eco-geographic islet complex, which consist thirteen islets at the marine entrance, is a densely populated semi-urban human settlement. Three other islets are also already inhabited by fisher folks while the rest remain as mangrove forest covers. In essence, the Negombo lagoon provides many goods and services to the riparian community and the area of the lagoon mouth is well-known as the most important fisheries hub of the country. A unique fishing method, called Stake Net or *Kattu Del* operates at the canal systems to catch seaward moving shrimp by three traditional families, is a lucrative business in existence over several centuries.

Figure 1: A Google Earth image of the islet complex at Negombo Lagoon sea entrance.

Apart from socio-economic uses such as fisheries and housing for fisher folks, this unique islet complex plays a significant ecological role as a breeding, spawning and nursery grounds for many aquatic organisms including fin-fish and shell-fish. Several *in-situ* problems such as pollution, water quality degradation, sedimentation, habitat alteration and societal problems have been aggregated in this islet complex. Nevertheless, the most insidious issue of the 21st century, the climate change and the subsequent sea level rise and its effects on this significant venue was still not been identified properly. According to global scale studies which have been conducted so far in the context of climate change driven sea level rise, it has been revealed that Sri Lanka lies on a vulnerable region. The climate change driven sea level rise is a result occuring by the expansion of oceanic water molecules and melting of polar and non-polar ice caps owing to the rising of global atmospheric temperature. Being a coastal state responsible for a coastline of more than thousand kilometers, Sri Lanka is at risk of losing specific coastal locations including the marine entrance of the Negombo lagoon, in terms of ecology and socio-economic benefits.

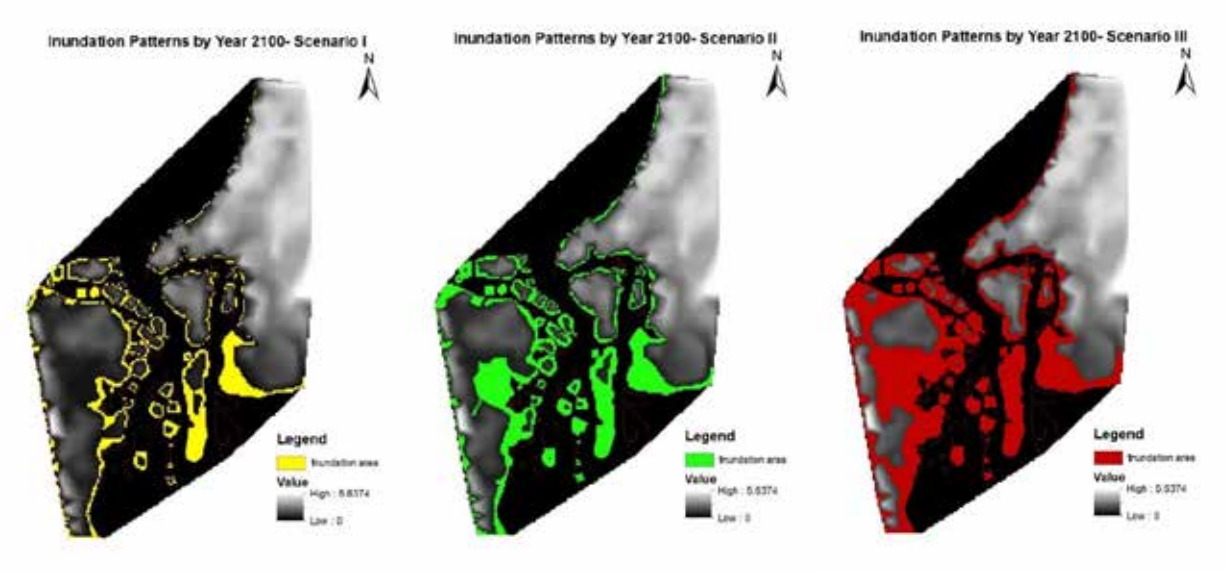

Figure 2: Inundations patterns for the three relevant scenarios

A recent study conducted by Uva Wellassa University on the effects of global climate change driven sea level rise in the Indian Ocean on Negombo lagoon marine entrance by using three sea level rise scenarios developed based on Representative Concentration Pathways (RCPs) of Intergovernmental Panel on Climate Change (IPCC), found that 18.2% 27.5% and 42.2% of the periphery of the Munnakkarai island will be inundated under thee inundation scenarios (I: 0.28 m, II: 0.53 m & III: 0.98 m) respectively, while displacing human settlements and commercial premises by the end of this century. With respect to ecosystems, the elimination of mangrove forest due to the inundation of pneumatophores by year 2100 will be 79.7%, 99.2 % and 100% under the three sea level rise scenarios respectively.

Representative Concentration Pathways (RCPs), are a set of four new pathways developed for the climate modeling community as a basis for long-term and short-term modeling by the Intergovernmental Panel on Climate Change. There are four representative concentration pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6. The focus of the three scenarios developed during the study was to cover the most probable sea level rise cases, which may occur by the year 2100 in an acceptable manner. Scenario I was selected as the most acceptable rise of sea level, which was described by the lower limit of RCP 2.6, can occur under the lowest GHG emission rates. Scenario III was selected as the worst case of sea level rise, which may occur due to the highest emission GHG rate of RCP 8.5 whereas, Scenario II was a mid-value of sea level rise lying between the most fortunate and worst case scenarios.

It is expected that the results of this study would become an eye opener to the climate change policy arena of the country in order to adapt the communities in this fisheries hub for future changes. Shifting from multidiscipline to inter-discipline is a need in novel approaches for such studies, in order not only to gain effective results in the context of research but also to be effective and efficient in dissemination, adaptation and policy development.

හරිතමය ලොවක් තුළ ජීවය තහවුරු කරගැන්මට එක්වෙමු

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වසර ගණනාවක් පුරා ගෝලීය දේශගුණික රටාවන් හි සිදු වූ අහිතකර වෙනස්කම්, දේශගුණික විපර්යාස යනුවෙන් විද්‍යාඥයෝ විසින් හඳුන්වනු ලබති. මිනිසාගේ විවිධ ක්‍රියාකාරකම් හේතුවෙන් වායුගෝලීය කාබන් ඩයොක්සයිඩ් ප්‍රධාන කොටගත් සෙසු හරිතාගාර වායූ සාන්ද්‍රණ ඉහළ යාම, පෘථිවි වායුගෝලය උණුසුම්වීම වේගවත් කර තිබේ. එහි අහිතකර බලපෑම් වන ග්ලැසියර සහ හිම වැස්ම දියවීම, මුහුදු මට්ටම ඉහළ යාම, නියඟ හා ලැව්ගිනි තත්ත්වයන්, ධාරානිපාත වර්ෂා සහ කුණාටු තත්ත්වයන්, රෝග හා වසංගත ව්‍යාප්තිය, ගංවතුර ඇතිවීම ආදිය දිනෙන් දින ඉහළ යමින් පවතී. මෙම වෙනස්කම් පෘථිවියේ වාසය කරන සියලු ජීවීන්ගේ දිවිපැවැත්මට බලපාන අතර ආහාර සුරක්ෂිතතාවය, ජෛව විවිධත්වය ආරක්ෂාකර ගැනීම සහ ආර්ථිකය පවත්වා ගැනීමට ද අභියෝගයක් බවට පත්වී හමාරය.

ගෝලීය උණුසුම හමුවේ වැඩිවන කාබන්ඩයොක්සයිඩ් මගින් හරිතාගාර වායූන් වෙත එල්ලවන බලපෑම
මූලාශ්‍රබෂඟස්ඛුක් පිටුව, *REDD+* ශ්‍රී ලංකා වැඩසටහන

2014 වර්ෂයේ මුල භාගයේ දී දේශගුණ විපර්යාස පිළිබඳ අන්තර් රාජ්‍ය මණ්ඩලය නිකුත් කරන ලද වාර්තාවකට අනුව, "විවිධ මිනිස් ක්‍රියාකාරකම් හේතුවෙන් වායුගෝලය උණුසුම්වීම නොවැලැක්විය හැකි බවත් එමගින් ඇතිවන දේශගුණ වෙනස්වීම් සීමා කිරීමට නම් හරිතාගාර වායු විමෝචනය අවම කළ යුතු බවත්" දක්වා ඇත.

වායුගෝලයේ පැවැතිය යුතු කාබන් ඩයොක්සයිඩ් ප්‍රමාණය සාමාන්‍යයෙන් වායු කොටස් දස ලක්ෂයකට කාබන් ඩයොක්සයිඩ් කොටස් 200300 අතර ප්‍රමාණයක් විය යුතු නමුදු වර්තමානයේ එය වායු කොටස් 400 ක් ඉක්මවා ගොස් ඇත. මේ මගින් හරිතාගාර ආවරණය තීව්‍ර වී තිබේ. එය දේශගුණික විපර්යාස ප්‍රබල කරවන ප්‍රධාන සාධකයයි.

ස්වාභාවික හේතූන් මත කාබන් ඩයොක්සයිඩ් වායු ගෝලයට එක් වීමේ ප්‍රණතාවය අවම වූවත් පොසිල ඉන්ධන දහනය හා වන විනාශය මගින් වායූගෝලීය කාබන් ඩයොක්සයිඩ් ප්‍රමාණය විශාල වශයෙන් ඉහළ නැංවී ඇති බව අනාවරණය වී ඇත. හරිතාගාර වායු විමෝචනය හා වායුගෝලය උණුසුම්වීමත් දේශගුණ විපර්යාස පිළිබඳව හා එමගින් ඇතිවන්නා වූ බලපෑම් පිළිබඳව ත් ලොව විද්‍යාඥයින්ගේ අවධානය යොමු වන්නට පටන් ගත්තේ 1980 දශකයේ දීය. එහි ප්‍රතිඵලයක් ලෙස දේශගුණ විපර්යාස මගින් ඇති වන බලපෑම් අවම කරගැනීමට හා වළක්වා ගැනීමට අවැසි පියවර ගැනීම සඳහා 1992 දී එක්සත් ජාතීන්ගේ මැදිහත් වීමෙන් අන්තර්ජාතික එකඟතාවයක් සඳහා සාමාජික රටවල් විසින් අත්සන් තැබීම සිදු විය. සම්මුතියෙහි පාර්ශවකරුවන් විසින් 1995 වසරේ සිට වාර්ෂිකව පවත්වනු ලබන ජාතීන්ගේ සමුළුවල දී (Conference of Parties) දේශගුණ විපර්යාස පිළිබඳ වැඩ කටයුතුවල ප්‍රගතිය නිරතුරුව විමසා බලන ලදී.

Sri Lanka UN-REDD Programme

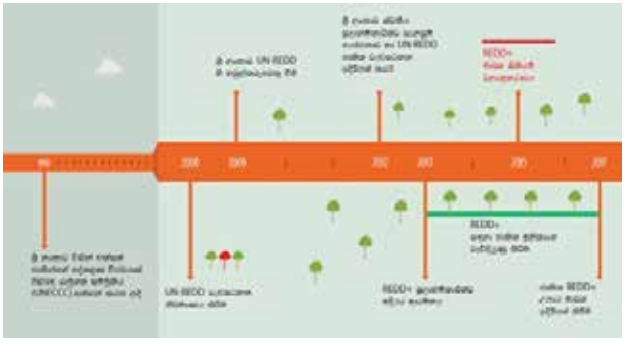
1997 පැවැති කියෝතෝ සමුළුව මගින් සංවර්ධිත රටවලට ඔවුන්ගේ හරිතාගාර වායු විමෝචනය අවම කිරීමට "නෛතික බැඳීමක්" ඇති කරගනු ලැබීය.

2010 වසරේ පැවැති කැංකුං සමුළුවේ එකඟතාය මගින් අනාගතයේ වායුගොලය උණුසුම්වීම කාර්මික විප්ලවයට පෙර පැවැති මට්ටමට සාපේක්ෂව අංශක 2 කට අඩුවෙන් පවත්වා ගැනීමට එකඟවන ලදී. දේශගුණ විපර්යාස පිළිබඳ නෛතික රාමුවකට සියලු ජාතීන්ගේ සහභාගිත්වය ලබා ගැනීමට හැකි වූයේ 2015 දෙසැම්බරයේ ප්‍රංශයේ පැවැති එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ 21 වැනි සමුළු වාරයේ දී ය. මෙහි දී ගෝලීය උණුසුම පාලනය කිරීම සඳහා වන යෝජනාවන් එක් එක් රටවල ජාතික දේශගුණික කමිටු විසින් සැලැස්මක් ලෙසින් ඉදිරිපත් කල යුතුව තිබිණි. මෙම සැලසුම් දේශීය වශයෙන් නිර්ණය කරන ලද දායකත්වය හෙවත් Intended Nationally Determined Contributions (NDCs) ලෙස දක්වා ඇත. මේ මගින් තම රටෙහි කාබන් විමෝචනයන් කවර ආකාරයෙන් හා කුමන ප්‍රමාණයන්ගෙන් අවම කරන්නේ ද යන්න පිළිබඳවත් ඒ සඳහා ගන්නා ක්‍රියාමාර්ගයන් පිළිබඳවත් ප්‍රකාශයට පත්කෙරෙයි.

2015 වසරේ ඔක්තෝම්බර් මාසයේ දී ශ්‍රී ලංකාව ද තම සැලසුම් පැරිස් සමුළුවට ඉදිරිපත් කරන ලදුව ගෝලීය උණුසුම්වීම සෙල්සියස් අංශක දෙකකට වඩා අඩු මට්ටමකින් පවත්වා ගැනීම සම්බන්ධයෙන් වූ යෝජනාවට අත්සන් තබන ලදී. එමගින් වසර 2100 වන විට ගෝලීය උණුසුම වැඩිවීම පූර්ව කාර්මික විප්ලව අවධියට වඩා සෙල්සියස් අංශක දෙකකට වඩා අඩුවෙන් පවත්වා ගැනීමට අවැසි පියවර ගන්නා බවට ජාත්‍යන්තර ප්‍රජාව හමුවේ එකඟත්වය පළකරන ලදී. ඒ අනුව අප ක්‍රියාත්මක විය යුතු අතරම මෙම අරමුණ වෙත ළඟාවීමට අවැසි සැලසුම් සකස් කිරීමේ වගකීම ද යුතුකම ද දැන් අප සතුව පවතී.

දේශගුණ විපර්යාසවලට ප්‍රතිචාර දැක්වීමේ ප්‍රවේශ දෙකක් හඳුනාගත හැකි අතර, ලිහිල් කිරීමේ පියවර (Mitigation) හෙවත් වායු විමෝචනයන් අවම කිරීම සහ වායුගෝලීය උණුසුම වැඩි කිරීමට බලපාන වායූ ස්ථායී මට්ටමකට පත් කිරීමට උත්සාහ කිරීම එක් ප්‍රවේශයකි. අනෙක නම් අනුවර්තනය හෝ අනුහුරුවීමේ (Adaption) ප්‍රවේශයයි. මේ මගින් දැනට පවත්නා හෝ ඉදිරියේ දී ඇති වේ යැයි අපේක්ෂා කරන දේශගුණික විපර්යාසවලට හැඩගැස්වීම අපේක්ෂා කෙරෙයි.

මෙයින් හරිතාගාර වායූ අවම කිරීමේ ප්‍රවේශයට අප දැනටමත් පිවිස ඇති බව කිව හැකිය. ඒ පැරිස් ප්‍රඥප්තිය තුළිනි. වායුගෝලයට හරිතාගාර වායු මුදාහැරෙන මූලාශ්‍ර අවම කිරීම සහ වනාන්තර වැනි හරිතාගාර වායූන් උරා ගන්නා ප්‍රභව වැඩි කිරීමට පියවර ගැනීම ප්‍රධාන උපක්‍රම දෙකකි. 1992 වර්ෂයේ පැවැති රියෝ ද ජැනෙයිරෝ සමුළුවේ දී දේශගුණ විපර්යාසය සඳහා විසඳුම් සෙවීමට එක්සත් ජාතීන්ගේ දේශගුණ විපර්යාස පිළිබඳ රාමුගත සම්මුතිය (UNFCCC)පිහිටුවා ගන්නා ලද අතර, හරිතාගාර වායු විමෝචනය අවම කරගැනීමට අවැසි ප්‍රවේශයක් ලෙසින් වන විනාශයෙන් හා වන හායනයෙන් සිදු වන වායු විමෝචනය අවම කිරීමේ ක්‍රමෝපායන් සකස් කිරීමේ හෙවත් REDD (Reducing Emissions from Deforestation & Forest Degradation) වැඩසහටහන ආරම්භ කරන ලදී.



ජාතික REDD+ *ක්‍රියාමෝපායන් සැකසීමේ කාල රාමුව*
මූලාශ්‍රය:ෆේස්බුක් පිටුව, *REDD+ ශ්‍රී* ලංකා වැඩසටහන

වන හරණය හා වන හායනය මඟින් පෘථිවි වායූගෝලයට කාබන් ඩයොක්සයිඩ් එකතුවීමට 12% ක පමණ දායකත්වයක් ලබා දෙයි. එය දෙවැනි වන්නේ බලශක්තිය ලබා ගැනීමට භාවිත කරන ප්‍රභවයන්ගෙන් මුදා හැරෙන කාබන් ප්‍රමාණයට පමණි.

මේ නිසා වන විනාශය තුළින් සිදුකෙරෙන කාබන විමෝචනය අවම කිරීමට වැඩි අවධානයක් යොමු කළ යුතු බව ලෝක ප්‍රජාව අවධාරණය කර ගන්නා ලදී 2009 වර්ෂයේ දී ශ්‍රී ලංකාව එක්සත් ජාතීන්ගේ REDD වැඩසටහනේ සාමාජිකත්වය ලබා ගැනීම පිණිස අයදුම් කරන ලදී . 2012 වර්ෂයේ දී REDD+ ජාතික ක්‍රියාමෝපායන් සකස් කිරීමට අවශ්‍යයි තාක්ෂණික සහය ලබා ගැනීමට අපට හැකි වූ අතර , එක්සත් ජාතීන්ගේ ආහාර හා කෘෂිකර්ම සංවිධානය ,

එක්සත් ජාතීන්ගේ සංවර්ධන වැඩසටහන සහ එක්සත් ජාතීන්ගේ පරිසර වැඩසටහන යන ආයතනයන්ගේ දායකත්වයෙන් ප්‍ර තිපත්ති හා සැලසුම් සම්පාදනය සිදු කෙරෙමින් පවතී

REDD+ සූදානම්කාරිත්ව අවධියේ කටයුතු වල නියුතු REDD+ වැඩසටහනේ ප්‍රධාන පාර්ශවකරුවන් ලෙස වන සංරක්ෂණ දෙපාර්තමේන්තුව (Forest Department), වන ජීවී සංරක්ෂණ දෙපාර්තමේන්තුව (Department of Wildlife Conservation) සහ දේශගුණ විපර්යාස පිළිබඳ ලේකම් කාර්යාලය (Climate Change Secretariat) ප්‍රතිපත්ති හා සැලසුම් සම්පාදනයේ දී තම දායකත්වය ලබා දෙමින් සිටියි

ඒ අනුව, ශ්‍රීස ලංකා UN-REDD වැඩසටහන මගින් මේ වන විටත් දේශගුණික විපර්යාස පිළියමක් ලෙසින් ලිහිල් කිරීමේ ප්‍රවේශය අනුගමනය කරමින් ක්‍රියාමෝපායන් නිර්මාණය කිරීමේ හි නියුක්ත වී සිටියි ඒ අනුව, ශ්‍රී ලංකා REDD+ හි මූලිකාංග මෙසේ දැක්විය හැකිය.

වන හරණයෙන් සිදුවන්නා වූ වායු විමෝචනය අවම කිරීම	වන හායනයෙන් සිදුවන්නා වූ විමෝචනයන් අවම කිරීම	වනාන්තර කාබන් සංචිත සංරක්ෂණය	තිරසාර වන කළමනාකරණය	වනාන්තර කාබන් සංචිත ඉහළ නැංවීම
				

REDD+ ක්‍රමෝපායන් තුළින් ස්වභාවික පරිසර පද්ධතිය සමඟ මිනිසා නිරන්තරව ගැටීම වැළැක්වීමටත්, පරිසර පද්ධතිය තුළ දේශගුණික විපර්යාස අවම කරගැනීමට අවැසි සාධක ගොඩනැගීමටත් අවැසි පසුබිම සැකසීම කෙරෙහි අවධානය යොමුකොට තිබේ. නිර්ණය කරන ලද කාලරාමුවක් තුළ හරිතාගාර වායු විමෝචනය අවම කරගනිමින්, වායු ස්ථායි මට්ටමින් පවත්වා ගැනීමට අවශ්‍ය පසුබිම සැකසීමට උත්සාහ කෙරෙයි. තව ද තිරසාර සංවර්ධන උපාය මාර්ග කෙරෙහි බාධා ඇති නොවීමටත්, ආහාර සුරක්ෂිතතාවය ඇති කරගැනීමට, ජීවන පැවැත්ම තහවුරු කරගැනීමටත් අපේක්ෂා කෙරෙයි. ඒ අනුව "වනාන්තර හා ඉන් ඔබ්බට; හරිතමය ශ්‍රී ලංකාවක් තුළ ජීවිත හා ජීවන වෘත්තීන් තහවුරු කිරීම" යන ශ්‍රී ලංකාවේ REDD+ දැක්ම ගොඩනැගී ඇත්තේය.

ශ්‍රී ලංකාවේ වන හරණය සහ වන හායනය සඳහා බලපාන ප්‍රධාන සාධක හඳුනා ගැනීම, ශ්‍රී ලංකාවේ REDD+ පාර්ශවකරුවන්ගේ සහභාගීත්වය හා උපදෙස් ලබා ගැනීමේ යාන්ත්‍රණය, ශ්‍රී ලංකාවේ REDD+ ප්‍රතිපත්ති හා සැලසුම් ප්‍රමුඛතාගතකරණය, ශ්‍රී ලංකාවේ REDD+ සැලසුම් හා ප්‍රතිපත්ති සමාලෝචනය, REDD+ ක්‍රියාවට නැංවීමේ මූල්‍යමය යාන්ත්‍රණය, REDD+ සඳහා පෞද්ගලික අංශයේ දායකත්වය සහ REDD+ ක්‍රියාවට නැංවීමේ ක්‍රමෝපායන් යනාදී අංශ සඳහා අවශ්‍ය මූලික අධ්‍යයනයන් සිදු කිරීම සහ අවශ්‍ය වාර්තාවන් සකස් කිරීමත් ඒ ඔස්සේ ශ්‍රී ලංකාවේ පාරිසරික, සමාජීයය, ආර්ථික හා සංස්කෘතික අංශයන් සලකාබලමින් REDD+ ප්‍රතිපත්ති හා සැලසුම් සකස් කිරීම සුදානම්කාරිත්ව අදියරේ දී අපේක්ෂා කෙරෙයි.

මේ සඳහා රාජ්‍ය අංශය, පෞද්ගලික අංශය මෙන් ම සිවිල් සංවිධාන සහභාගිත්වය ලබා දෙන අතර දිස්ත්‍රික්ක මට්ටමේ සිවිල් සමාජ සංවිධාන, පර්යේෂකයින් හා උසස් අධ්‍යාපන ක්ෂේත්‍රයේ නියුතු වූවන් මෙන් ම ශ්‍රී ලංකාවේ ආදිවාසී ජනතාවගේ ද සහභාගීත්වය ලබාගන්නා අතර ඔවුන්ගේ අදහස් හා යෝජනාවන් පිළිබඳව සලකා බලමින් ප්‍රතිපත්ති හා සැලසුම් සකස් කිරීම සිදු වෙයි. ශ්‍රී ලංකාවේ REDD+ සැලසුම් හා ප්‍රතිපත්ති ක්‍රියාත්මක කිරීම තුළින් අප රටෙහි තිරසර වන සංරක්ෂණයට නව ප්‍රවේශයක් ලබා දීමට අපට හැකිවනු ඇත.

දැනට අප සතුව තිබෙන්නා වූ වන බිම් නිසියාකාරයෙන් කළමනාකරණය කිරීම තුළින් ඒවායින් ලබා ගත හැකි ආර්ථික ප්‍රයෝජන තිරසර ලෙස ලබා ගැනීමටත් ඉහළ ශක්‍යතාවයක් ඇත. තව ද පාරිසරික වශයෙන් අප සතුව තිබෙන්නා වූ ජෛව විවිධත්වය සංරක්ෂණ ක්‍රියාමාර්ගයන් හි තිරසර පැවැත්ම සහතික කිරීමටත්, වන බිම්

හායනය නිසා තර්ජනයට ලක්ව තිබෙන්නා වූ සත්ත්ව හා ශාක වාසභූමිවල පැවැත්ම සුරක්ෂිත කරගැනීම, වන බිම්වල ඇති ගුණාත්මකභාවය තහවුරු කරගැනීම යන ප්‍රතිලාභ අත්පත් කර ගැනීමට හැකියාව ලැබෙනු ඇත.

ගෝලීය වශයෙන් සලකා බැලූ කල්හි හරිතාගාර වායූ විමෝචනය සහ ඒ සම්බන්ධ අධීක්ෂණය, වනාන්තර සම්බන්ධ තොරතුරු ආරක්ෂණ පද්ධතියක් ස්ථාපිත කිරීම, එක්රැස් කරන ලද වනාන්තර සම්බන්ධ දත්ත කළමනාකරණය හා නිසි අයුරින් ඒවා වාර්තා කිරීම, යාවත්කාලීන කිරීම, මූල්‍ය තොරතුරුවල විනිවිදභාවය පවත්වා ගැනීම ආදිය සම්බන්ධ ප්‍රතිලාභ ලබා ගැනීම ද මේ ඔස්සේ අපේක්ෂා කෙරෙයි.

REDD+ විශ්වවිද්‍යාල කථිකාචාර්යවරුන්ගෙන් සහ පර්යේෂකයන්ගෙන් සමන්විත විද්වතුන්ගේ දායකත්වය: ශ්‍රී ලංකා UN-REDD වැඩසටහන

බිම් මට්ටම නියෝජනය කරන්නා වූ සිවිල් සමාජයේ සිට ප්‍රතිපත්ති හා සැලසුම් සකස් කිරීමට දායකත්වය ලබා දෙන්නා වූ රාජ්‍ය හා රාජ්‍ය නොවන අංශයන් හි නියෝජිතයින් දක්වා සියලු ම අංශයන් හි දායකත්වය ලබාගනිමින් ප්‍රතිපත්ති හා සැලසුම් නිර්මාණය කිරීම ශ්‍රී ලංකා REDD+ වැඩසටහනේ විශේෂිත්වයයි. තව ද ශ්‍රී ලංකාවේ වන ආවරණය 32%ක් කරා ඉහළ නංවා ගැනීමේ අරමුණ ද තිරසර සංවර්ධන ක්‍රියාවලියට අවැසි පාරිසරික අංශයේ කළමනාකරණය ද සපයා දීම මගින් ආර්ථික හා ආර්ථික නොවන ප්‍රතිලාභ රැසක හිමිකරුවන් බිහිකිරීමටත් මේ ඔස්සේ හැකියාව ලැබෙනු නිසැකය.

ඒ අනුව, මෙම ප්‍රතිලාභ ලබා ගැනීමට නම් අප මේ ලැබී තිබෙන අවස්ථාවෙන් උපරිම ප්‍රයෝජන ගත යුතුය. පරිසරය හා එක්ව කටයුතු කරමින් ගෝලීය උණුසුම අවම කරගැනීමේ ප්‍රතිපත්ති හා සැලසුම් ක්‍රියාත්මක කිරීමටත් වන බිම් රැක ගනිමින් කාබන් විමෝචනය අවම කිරීමටත් ඒ ඔස්සේ ආර්ථිකමය හා පාරිසරික ප්‍රතිලාභ ලබා ගැනීමටත් අපට හැකි වනු ඇත්තේ REDD+ ක්‍රමෝපායන් ක්‍රියාවට නැංවීම තුළිනි. ඒ සඳහා ක්‍රියාත්මක විය යුතු කාලය එළැඹ ඇත්තේය. ඒ සඳහා අප සැමදෙනාම එකාමෙන් ඉදිරියට ගමන් කරමු!

Child-Centered Climate Change Adaptation: Time Critical for Sri Lanka

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Introduction

Climate change is no longer a distant prospect. Its adverse impact is already being felt in island nations globally, including Sri Lanka, where extreme weather events and irregular climate trends are occurring regularly, and causing substantial physical, social, human and economic damage and loss. These events often have long lasting impacts – the May 2016 urban floods and landslides in Sri Lanka, triggered by heavy rain reversed years of development activity.

In Sri Lanka children and young people, who represent approx. 30 per cent of Sri Lanka's total population[1], are the most vulnerable to natural and human-made disasters including climate change induced extreme weather events. Yet they are also the generation that will be required to deal with the adverse impacts of climate change in the future, including as leaders. It is therefore essential that they are involved in decision-making now.

Why children should be in the centre for Climate Change Adaptation?

Children bear the brunt of climate change and its adverse impact[2], facing death, injury, displacement and separation from their family, which leaves them vulnerable to trafficking, exploitation and abuse. In the past decade within the South Asian region,child death and injury have outnumbered those of adults in the majority of disasters[3]. In 2015 alone, over 7.7 million children in South Asia were directly affected by earthquakes (Nepal), cyclones (Bangladesh), conflict (Afghanistan), floods (Afghanistan, Jammu and Kashmir) and drought (Pakistan Sindh Province)[4]. Research undertaken by Save the Children in 2009 estimated that, "*over the next decade, around 175 million children will be hit by climate-related disasters every year, and that climate change could ultimately lead to an additional 250,000 child deaths a year in South Asia and sub-Saharan Africa alone*"[5].

When a disaster hits, children are disproportionately affected by the breakdown of critical systems and services like health, nutrition, education and protection. In a region with existing vulnerabilities including poverty, malnutrition, inequality, and exclusion, this impact is magnified. Further, repeated cycles of natural shocks and disasters exacerbate these vulnerabilities and have a devastating impact on the well-being, physical security and development of children.

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[1]Department of Census and Statistics (2012), *Census of Population and Housing 2012*, <http://www.unicef.org/srilanka/Fast_facts.pdf> (accessed 04/10/2016)

[2]UNICEF Office of Research (2014). 'The Challenges of Climate Change: Children on the front line', Innocenti Insight, Florence: UNICEF Office of Research. <http://www.unicef.org/publications/index_74647.html> (accessed 04/10/2016)

[3]SAARC (2015) *South Asia Regional Policy Framework for Child-Centered Disaster Risk Reduction*

[4]Ibid.

[5]Ibid.2

Whilst climate change will ultimately impact all children, today over 660 million children live in zones that are at extreme risk of floods or drought[6].With the majority of scientific research indicating that climate change will increase the frequency of droughts, floods and severe weather eventsthe risk to these children, and the infrastructure needed for their well-being is critical. Droughts and flooding can destroy crops, disrupt water systems and contaminate water reserves. Food insecurity, rising air pollution, increased risk of vector-borne diseases, acute respiratory infections, diarrheal diseases and malnutrition can have a significant detrimental impact on a child's early development. The World Health Organization (WHO) and UNICEF joint publication reveals that "*in 2015, malaria is estimated to lead to 438,000 deaths, of which more than two-thirds were children under 5 years of age*". Children are also more vulnerable than adults to undernutrition while diarrhoeal diseases are a major cause of under-five mortality with an estimated 530,000 child deaths in 2015 alone[7].

Despite increased recognition of the disproportionate impact of disasters on children, most climate change adaptation (CCA) and disaster risk reduction (DRR) policies and programmes within the South Asian region still tend to overlook the special needs of children and their potential capacities to become leaders in building disaster resilience within their communities. Most disaster risk assessments and climate change impact analyses rarely include data about children. In Sri Lanka, availability of gender and age disaggregated data during and after disasters is a constant challenge for those involved in disaster risk management. In addition, no analysis of how climate change had been affecting the children living in Sri Lanka has yet been carried out. This lack of data and evidence has also posed challenges in assessing child vulnerability and exposure to climate change, at national and local levels which therefore negatively impact the country's level of preparedness. Hence, understanding the special risks posed by climate change and disasters to children and empowering them to withstand recurrent shocks is a critical ingredient in building future disaster resilience.

Current CCA and DRR Policy Framework for Children in Sri Lanka

Both the*National Climate Change Policy of Sri Lanka (NCCP)* and the *National Climate Change Adaptation Strategy for Sri Lanka 2011 - 2016 (NCCAS)* do not explicitly refer to or address the high vulnerability of children to climate change. Both however, acknowledge the need to empower children to cope with climate change through education and awareness raising. Nevertheless, children are still not involved in CCA decision-making, resulting in a lack of child-focused policies and action planning to mitigate the adverse impacts of climate change.

Whilst everyone deserves protection from the adverse impacts of climate change, it should be noted that children have contributed the least to climate change, yet will suffer its effects longest. Therefore, children must have the opportunity to voice their concerns and be part of the decision making process that will impact their lives

[6]UNICEF (2015) *Unless We Act Now: The Impact of Climate Change on Children*. <http://www.unicef.org/publications/index_86337.html> (accessed 04/10/2016)
[7]UNICEF (2015) *Unless We Act Now: The Impact of Climate Change on Children*. <http://www.unicef.org/publications/index_86337.html> (accessed 04/10/2016)

A Child-Centered Approach to Climate Change Adaptation

A child-centered approach to CCA targets activities that help to reduce the vulnerability of children to climate change. It requires a specialized understanding of the risks and the negative impact posed by climate change, and provides solutions to prevent or mitigate their impact. Many of the potential solutions for reducing vulnerability of children are low cost and already well known. For example, distributing insecticide-treated mosquito nets in areas of high prevalence of malaria or dengue substantially reduces the possibilities of vector-borne diseases. Providing incentives to poor families to ensure school enrolment and ensuring that schools feature water, sanitation and hygiene programmes, help to both boost school attendance and results in greater resilience among children to disasters. UNICEF studies in Maldives have revealed that mainstreaming DRR and CCA into school curriculum, together with comprehensive teacher and relevant stakeholder training, securedreal benefits. In Niger , the development and roll out of the concept of 'community gardens' has ensured that children have access to a nutritious and balance food basket even during the off-season.In Bangladesh, basic swimming lessons, given to children aged between 5 – 17 years have ensured that children have critical survival skills needed to protect them from drowning. In the Philippines, mangrove rehabilitation by children to restore their local ecosystem demonstrated the important role young people can play in "*risk communication and promoting behavioural change to reduce disaster risks*"[8].

The economic argument for investing in child-centered approaches to climate change adaptation are threefold[9]:

a) such investments would reach a large proportion of the global population over a longer period of time as children constitute the largest group at risk from climate change;
b) building resilience means reducing the long term economic losses associated with degradation of health, education and protection caused by climate change among the children;
c) many child-centered climate change adaptation interventions to reduce children's vulnerabilities are the lowest cost options and are already well established, such as insecticide treated mosquito nets, and water, sanitation and hygiene training.

Though there are many child-focused DRR or CCA activities at community level, it is imperative that the lessons learned from those activities are adequately reflected in DRR and CCA policies at the national level. Therefore, it is high time to change the conventional approaches and use innovation to engage future leaders to be part of the climate change adaptation.

[8]UNICEF and Plan International (2011) *The benefits of a child-centered approach to climate change adaptation.*<https://www.unicef.org.uk/Documents/Publications/ClimateChange_child_centred2011.pdf>(accessed 04/10/2016)
[9]Ibid.

Children as Change Agents for Climate Change Adaptation

The 'Children in a Changing Climate Coalition'[10] is a partnership of leading child-centered development and humanitarian organizations, each with a commitment to share knowledge, coordinate, and work with children as agents of change, in full recognition for their capacity to prepare for and respond to shocks and stresses. The coalition encourages states to adopt the following child-centered DRR and CCA approaches:

- Prioritization of children's safety, survival, development and participation;
- Processes that are locally owned and include the meaningful participation of children;
- Programs that focus on the most marginalized and vulnerable children, including children with disabilities and from ethnic minority groups, among others;
- National accountability processes that take children into account and include mechanisms for independent review, including national planning, budgeting and monitoring systems
- Disaster-related information that is child-friendly, gender-sensitive, and age-appropriate for children

Conclusion

Children will bear the brunt of climate change for a longer period than today's adult generation. Therefore, their rights and interests should be a key element of climate change policy, advocacy and research. However, children continue to be overshadowed and neglected in decision and policy making on CCA and DRR. Hence, UNICEF actively encourages governments to adopt a child-centered approach for CCA and DRR where children as key participants in decision-making and are empowered to be the catalysts for resilience.

At the global level, UNICEF has integrated DRR into the '*Core Commitments for Children in Humanitarian Action*', UNICEF's central policy on how to uphold the rights of children affected by humanitarian crises. UNICEF is increasing its investment in both preparedness and in reducing risk through its response and early recovery work. In Sri Lanka, UNICEF is working to integrate DRR and CCA into its programming, focusing particularly on building partnerships with governments and civil society from the national to the community level. This involves integrating DRR and CCA into both UNICEF's regular country plans and into the overarching United Nations Development Assistance Framework (UNDAF), so that risks are assessed and monitored as part of the planning processes. In countries and regions with a high risk of disaster, UNICEF promotes explicit approaches to reducing risks through all of its core programmes. UNICEF works to promote and help ensure an adequate and specific focus on the rights and vulnerabilities of girls, boys, adolescents and women in all DRR initiatives.

UNICEF strongly promotes a child-centered approach to CCA and DRR in Sri Lanka, and supports the government in achieving its commitment to the*South Asian Association of Regional Cooperation (SAARC) Regional Policy Framework on Child-Centred Disaster Risk Reduction* which provides guidance to the eight member countries on a coherent approach in anticipating and addressing concerns regarding

[10]Members of the coalition are ChildFund Alliance, Plan International, Save the Children International, UNICEF and World Vision International.

disaster risks as they impact children across the region. Accordingly, UNICEF is committed to strengthen the capacity of the Government of Sri Lanka in implementing a child-centered approach for CCA and DRR with complementary technical support to put innovative measures for disaster response in place, such as cash transfers in emergencies, as well as to scale up good practices in child-centered DRR and CCA in areas of high risk including research on children's specific vulnerabilities for climate change and disasters.

In a world where climate change is inevitable, preparedness and adaptation is key for survival. The earlier we start preparedness and adaptation, the better our ability to continue a healthy and long life. Unless we act now to prepare against climate change, we will not only endanger ourselves but also jeopardize the future of our children.

Biochar Production Technology and Climate Change Mitigation

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Biochar refers to black carbon produced by heating biomass in an oxygen-free or low oxygen environment (pyrolysis) so that it does not or only partially combusts (Bridgwater, 2003). In this process, bio oil and syngas are produced along with biochar, all three of them potentially valuable products: the bio oil can be used as fuel, the syngas as energy input to the pyrolyser unit and the biochar as a soil additive. Biochar is a porous carbonaceous solid whose properties are determined by the degree of thermo-chemical conversion of organic materials during production and the feedstock type used.

Use of biochar as a soil additive is practiced as a means to simultaneously mitigate climate change and improve soil fertility. However, focus is given here on climate change mitigation but many proven records are available elsewhere on soil fertility improvement. Physico-chemical properties of biochar are suitable for the safe and long-term storage of Carbon (C) in the environment. This is mainly given by the fact that biochar is highly stable in nature and once deployed into the soil it sequesters atmospheric C in stable soil C pools. Thus, biochar can exist in the soils for at least several thousand years. As regard to the C sequestration, different strategies are discussed, ranging from wide-spread afforestation and reforestation in terrestrial ecosystems to pumping of CO_2 into deep oceans and geological layers (IPCC, 2000). Nevertheless, the most sustainable approach can be the soil application of biochar as it offers both a large and long-term C sink in the soil. Conversion of biomass to biochar fundamentally alters the transformation dynamics with respect to C sequestration. According to Lehmann *et al.* (2006), conversion of biomass-C to biochar-C leads to sequester about 50% of the initial C compared to the low amounts retained after burning (3%) and biological decomposition (<10% after 5 years), therefore, yielding more stable soil C than burning or direct land application of biomass. This efficiency of C conversion of biomass to biochar highly depends on the type of feedstock, but might not be significantly affected by the pyrolysis temperature.

Recent research has confirmed the climate change as one of the most critical challenges faced by many of the countries. As such, temperature increase has been unequivocally proven and is occurring at an unprecedented rate (IPCC, 2001). CO_2, CH_4 and N_2O are important drivers of the anthropogenic greenhouse gas (GHG) effect and such gases are released both through burning of fossil and biomass fuel as well as decomposition of above- and below-ground organic matter. Efforts are thus made to reduce avoidable GHG emissions or off-setting unavoidable emissions through sequestration of C in the environment. In that context, ability of biochar to mitigate above gas emissions is vital. Soil C sequestration strategy through biochar application to soils will not only be affected by the longevity of biochar-C itself but also by protecting native organic matter present in the soil. In general, every ton of C lost from soils adds 3.67 tons of CO_2 to the atmosphere (Winsley, 2007). Soils losing C are also losing N, including N_2O and other forms. Therefore, given the C sequestration mechanisms of biochar, use of this technology can give considerable benefits. Since biochar remains in soil for a considerable time, it prevents immediate release of C to the atmosphere. Herath *et al.* (2015) determined that >50 % of added biochar-C remains after 100 years from the soil application while none of the feedstock-C remains after a few years of soil application. Lifting the C:N ratio in soils has the effect of increasing N retention and therefore, reducing N_2O emissions and nitrate leaching. Adding biochar to soil may prevent or limit the anaerobic production of N_2O.

In many agricultural and forestry production systems, waste is produced in significant amounts from many residues such as forest, mill, and field crop residues and urban wastes. Most of these residues can be used to produce biochar even under Sri Lankan context. Therefore, investigation of potential benefits can be considered as a timely important investment. There is however a number of logistic and financial constraints (*e.g.* high production cost) limiting the immediate adoption of biochar as a GHG mitigation strategy, but looking into possible opportunities to avoid such issues is needed. Exploiting benefits such as soil C sequestration, GHG emission mitigation, soil fertility improvement, and agricultural & forest waste management, by biochar application, is suggested for a sustainable environment existence.

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Black Carbon and Climate Change Mitigation in Sri Lanka: Effects of using Biomass as an energy source in household cooking

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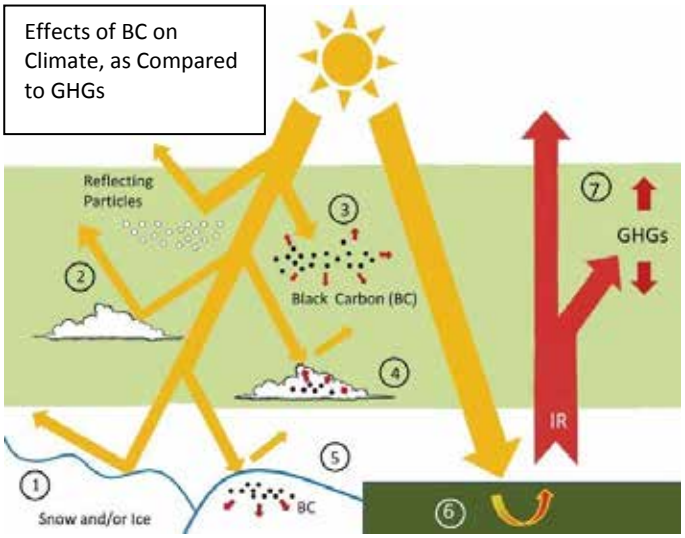
Black Carbon has recently emerged as a frequently used term in the Climate Change jargon although it is not a new term in the vocabulary. It has gained its significance as a considerable contributor to Global Warming. With the successfully concluded COP 21 in Paris in December 2016 and the resulting Paris Agreement, more attention may be drawn to Black Carbon by researchers, policy makers and implementers in the coming days.

What is Black Carbon?

Black Carbon refers to the tiny, elemental carbon substance formed during incomplete combustion of fuel. These fuels could be fossil fuels, biofuels, and biomass or forest fires. Incomplete combustion can be natural or due to human activities and occurs due to lack of air (oxygen) or lower temperatures. This results in forming soot where Black Carbon comes out as a major component of soot.

Climate Change is driven by the concentration of greenhouse gases (GHG) in the atmosphere. The main component among the GHGs is Carbon Dioxide (CO_2). Therefore, reducing CO_2 emissions is essential to avert the significant negative impacts of climate change. But CO_2 has a long atmospheric lifetime. It takes several decades for CO_2 concentrations to begin to stabilize after their emissions reductions begin. Accordingly, the reduction of GHG emissions would not change the concentration of GHGs in the atmosphere over short periods of time.

Effects of BC on Climate, as Compared to GHGs

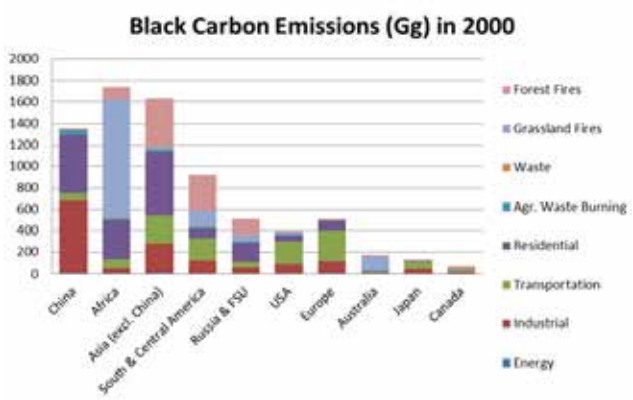


In contrast to CO_2, Black Carbon has a very short life time or residence time, which is upto only a few weeks in the atmosphere. Therefore, reducing Black Carbon emissions can bring about a more rapid climate response with its ability to delay and retard the rate of Global Warming. This leads to reducing Black Carbon emissions resulting in more immediate impacts on Climate Change which is a unique near term opportunity to postpone the effects on Climate Change. It also should be noted that because Black Carbon remain in the atmosphere for a shorter period, its climate effects are strongly regional and its climate effects would dissipate quickly with the reduction of Black Carbon emissions.

After staying in the atmosphere for upto couple of weeks, Black Carbon falls back to the earth's surface by settling and by precipitation. In both places, that is, while suspended in the atmosphere and after it returns to the earth's surface, Black Carbon can have different effects on the climate.

When suspended in air, Black Carbon absorbs all wave lengths of solar radiation from the short wave ultraviolet light waves to longer infrared waves. Furthermore, black carbon converts ultraviolet to infrared which it reradiates to the atmosphere around the particle. This warms the atmosphere at higher altitudes and creates a dimming effect on the surface which can result in lower temperatures in the lower atmosphere. An expert says that although ordinarily, airborne particulates seed clouds, Black Carbon particles can get hot enough to vaporize water and prevent clouds from forming at all. Therefore, this type of warming of air can affect regional cloud formation and precipitation patterns. When Black Carbon returns to the earth's surface and deposited on snow and ice, it absorbs sunlight, again generating heat, which warms both the air above and the snow and ice below, thus accelerating their melting which could lead to other climate effects.

The soot produced by partial combustion of fuels can contain Black Carbon, organic carbon and brown carbon. One way of differentiating these substances by their light absorbing properties. Black carbon absorbs all wave lengths, organic carbon scatters light, and brown carbon has light absorbing properties between black carbon and organic carbon. Generally, the blacker the soot, the more of a warming agent it is. Generally, fossil fuel and biofuel soot are blacker and soot from biomass burning is generally more of a brownish color. It has been estimated that majority of Black Carbon emissions come from the developing world. China and India together are estimated for some 25% – 35% of global Black Carbon emissions while same by United States is estimated to be around 6%.



In most developing countries, food is cooked at homes using open hearths and low quality solid fuels including fuelwood. The fuel used can also be wet. These circumstances results in inefficient combustion of fuels taking place at lower temperatures and with poor burning characteristics. This leads to health and climate damaging emissions, including a short-lived climate pollutant, Black Carbon. Global Alliance for Clean Cook Stoves estimates that up to 25% of black carbon emissions come from burning solid fuels for household energy needs. Wood cook stoves are identified as the main source of Black Carbon emission in the developing countries.

Effects on Indoor air quality by fuelwood based cooking

According to the census of population and housing of Sri Lanka in the year 2012, over 78% of the households in Sri Lanka use firewood as their cooking fuel. The researches have revealed that cooking fuels are the main source of indoor air pollution in Sri Lanka and that it is unlikely for there to be a shift to cleaner fuels in the near future. The researches also reveal that most of the traditional local stoves using firewood have incomplete combustion resulting in high pollutant emissions. This leads to higher levels of Black Carbon emissions.

Indoor air pollution and indoor air quality related research is the closest research conducted in Sri Lanka which has a relevance to Black Carbon emissions from domestic cooking. Sri Lankan researchers may have paid much attention to the aspects of indoor air quality, partly because of adverse health implications such as pulmonary diseases and respiratory infections and heavy death toll due to indoor air pollution. The World Health Organization had estimated that the number of deaths attributable to

indoor air pollution in Sri Lanka in the year 2004 was 4,300 which is a considerable number for a country of a population of nearly 20 million.

The reason for past research to be in line with indoor air pollution and not on Black Carbon emissions may be due to the fact that 'Black Carbon' is a new subject discussed at international level, and even then, it is mostly from a climate change perspective. Indoor air pollution or indoor air quality studies in Sri Lanka have focused mainly on health impacts, particularly of women and children who are considered as most vulnerable groups exposed to health implications due to poor indoor air quality due to cooking. For example, a study of assessing exposure in kitchens using firewood with traditional stoves has reported that average particulate matter to be PM2.5 (its size is 2.5 micrometers in diameter and smaller) with concentrations exceeding 1,200 µg per m^3. Further,we know that Black Carbon is a component of particulate matter emissions. This type of information can be used to extend such studies into the domain of 'Black Carbon' using correlations or other means.

Possible effects of Black Carbon	
Health	**Climate**
asthma lung cancer cardiovascular problems birth defects premature deaths	warm atmosphere melt snow and ice affecting reflectivity and stability of clouds alter precipitation

Options for a cleaner kitchen

We have many options available to curtail Black Carbon emissions in Sri Lanka from the domestic cooking. It is a known fact that conversion efficiencies of solid fuels are lesser than liquid fuels and efficiencies of gaseous fuels are better than that of liquid fuels. Accordingly, the cleanliness and convenience of using cooking fuels also increase from solid fuels to liquid fuels and from liquid fuels to gaseous fuels. This is clearly reflected in what we call the '*energy ladder*'. Therefore, one obvious choice left for Sri Lankans is to shift from using biomass for cooking and use cleaner energy options such as LP gas, biogas or electricity. However, these options also have their demerits.

LP gas has the risk of dependence on imports which is partly a political issue affecting energy security of the country. It also leads to an economic issue due to foreign exchange drain. On the other hand, LP gas is produced as a by-product of the petroleum industry. Depletion of oil and hence oil industry, would make a full stop to LP gas supplies in the future. Possible escalation of prices and affordability of increased costs would be a different issue for the households.

Biogas is an energy source that could be generated at the domestic level itself using the organic waste such as food, vegetable, and fruit wastes and human excreta from an ordinary household. However, the amount of biogas that could be produced may not be sufficient to meet all cooking energy demands of a household due to the limitation of the amount of organic waste available. Considering the sustainable consumption and production or cleaner production concepts and the waste management practices of reducing, reusing and recycling of waste, we have to discourage waste generation which may result in the reduction of per capita availability of organic waste over the future horizon. Therefore, the biogas option is limited only to those who would have access to a sufficient quantity of organic waste.

Using electricity for cooking, from an energy perspective, is hard to be recommended due to lower efficiency considering the equipment and appliances currently being used and cooking practices in Sri Lanka. On the other hand, Black Carbon emissions would be reduced or eliminated from generating electricity only if electricity is produced using renewable sources of energy. If coal or diesel is used for generating electricity, using electricity for cooking would indirectly emit Black Carbon into the environment.

Despite the benefits of above options, we still should not forget the fact that the majority of Sri Lankan populace use biomass for cooking, which are mainly sourced from their home gardens, neighborhoods and at times from commercial sources. These are comparatively cheap and easily available for many, particularly for those living in rural and semi-urban setups. On the other hand, what if biomass is sourced sustainably and used efficiently?

How can we mitigate Black Carbon emissions from household cooking?

Being a tropical country with a good rainfall and fertile soil, Sri Lanka can embark on biomass as a source of energy including for domestic cooking purposes. Therefore, improved efficiency of cooking (a combination of efficient cooking stoves and good cooking practices) that leads to less solid fuels being consumed and better combustion would help reducing Black Carbon emissions. This, coupled with a supply of cooking biomass fuels from sustainable sources, would further contribute towards net reduction of Black Carbon emissions. The researchers have found that about 27% of Sri Lankan households use biomass fuel for cooking inside the main building which does not have a chimney. Therefore, some other factors that need to be considered in using biomass for cooking include providing better ventilation and use of a chimney (natural draft) and, if possible, supply air through a blower (forced draft). These would enhance combustion efficiencies and reduce producing Black Carbon.

As for selection of fuel wood stoves, it is recommended to deviate from using open hearths (the 3 stoned) and at-least resort to using improved efficient cooking stoves which are available in the market or made *in-situ*. On the other hand, there are a couple of wood gasifier stoves available in the market, which may need further technical improvements to be fully commercialized and reliable. These stoves have a better combustion efficiency as biomass is first partially combusted producing Carbon Monoxide and the heat for cooking is produced in the second phase, which is from combustion of Carbon Monoxide which is a gas. Therefore, these cooking stoves demonstrate the properties of both solid fuel and gaseous fuel based cooking stoves. If these are developed to a stage where they demonstrate the features of the LP or biogas cooking stoves, which use gaseous fuels, these could contribute to significant reduction of Black Carbon emissions.

Sri Lanka Standards Institution, in the year 2013, has released national standard code of practice for a type of improved and better efficient clay cooking stoves (SLS 1475). They are also in the process of developing national standard code of practice for sustainably produced fuel wood which is released for public comments at the time of writing this article. This may come into effect by end of 2016 or early 2017. Accordingly, practical application of these standards by households and biomass suppliers respectively would contribute towards reduction of Black Carbon emitted from domestic cooking.

In conclusion, Sri Lanka's domestic level cooking may be emitting Black Carbon to a considerable level contributing towards Climate Change. However, simple and proven remedies could be adopted to reduce such emissions. Reducing Black Carbon emissions brings about not only a win-win scenario from climate and health perspectives, but also helps in enhancing access to affordable household energy and

safe cooking solutions. We already have simple technologies to meet these demands and we should adopt best behavioural patterns. It would have a quicker cooling effect on the Climate Change, delaying temperature increases in the short run and reduce indoor air pollution providing public health co-benefits in the long run, ultimately helping to build a happy and healthy community.

Further research and recommendations

Power and transport sectors may already contribute more than the household cooking sector to Black Carbon emissions in Sri Lanka. However, the contribution made by household cooking should be further investigated. Quantity of Black Carbon emitted has to be studied under different circumstances preferably along with health impact studies. Economic, social and environmental analysis has to be carried out. While the researchers at international level conduct further scientific research on Black Carbon and its impacts, local researchers can join them and contribute to such interventions to enhance the knowledge and experience.

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International shipping and climate change: Measures for mitigation

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Shipping is the most cost-effective mode of transportation in the world, which carries over 80% of the volume of the global merchandise trade. 71% of the earth surface is covered by the oceans, out of which international shipping routes occupy a significant space. In spite of the fact that shipping has made people's lives much easier, it generates negative environmental externalities that have to be borne by the entire society.

Climate change is a consequence of global warming, caused by increased concentrations of greenhouse gases (GHG) in the atmosphere. Excessive amounts of GHG and black carbon aerosols absorb and trap heat within the lower atmosphere, making it warmer for a long period of time. Due to this reason, earth's average surface temperature has drastically increased over the past century. This leads to severe environmental conditions such as shifting rainfall patterns, melting of polar ice caps, disease outbreaks, sea-level rise, prominent floods and droughts, habitat alteration, and species extinction *etc*.

Just like any other transportation mode, Ships emit CO_2 as a byproduct of combustion of fossil fuel. CO_2 is an effective heat-trapping agent and is capable of remaining in the atmosphere for a longer period. To reduce fuel costs, many ships are using Heavy Fuel Oil (HFO), which is inexpensive but high in sulfur content. Burning of this dirty oil produces SO_x, NO_x and particular matters which induce atmospheric acidification and health related issues. However, Ocean-going ships are responsible for around 3% of global GHG emissions, which is around 1 billion tons a year. This amount is rather low compared to the road transportation, which produces around 17% of the global total GHG emissions. However, considering the fact that ship sizes are getting much bigger while global trade continues to expand, more regulations have to be placed in order to control ships' emissions.

In order to cope with the global GHG reduction trends, the International Maritime Organization (IMO), which is the regulatory organization of international shipping, has identified specific technical, operational and market-based measures to be introduced to ships. Here, the most important initiative has been recognized as the enhancement of ships' energy efficiency, which simply reduces the fuel consumption and GHG emissions, while saving associated costs. In this regard, the IMO has introduced "Energy Efficiency Design Index (EEDI)" for the newly constructed ships and the "Ship Energy Efficiency Management Plan (SEEMP)", for the ships currently in operation. EEDI is a technical measure, which sets minimum energy efficiency standards for newly built ships from 2013 onwards. EEDI is to be optimized by innovative modifications of ships' design, load capacity and speed. Hull optimization, propeller upgrading, cleaner and alternative fuels and highly efficient engines with integrated power systems are among the popular attempts to reach targeted EEDI levels. SEEMP is an operational measure, focused on improving ships energy efficiency in a cost effective manner. Ships that are currently in operation are required to have an onboard energy management plan, which allows long term monitoring of its energy

performances. This encourages ship owners to retrofit their ships with innovative technologies for power saving.

SEEMP popularly focuses on hull and propeller maintenance, trim optimization, weather routing, slow steaming, efficient supply chain management and human resource development to achieve best practice and energy efficient operations.

All vessels above 400 GT are mandated to obtain International Energy Efficiency Certificate (IEEC) issued by classification societies to demonstrate their compliance with the EEDI and SEEMP. MARPOL Annex VI (Regulations on the prevention of air pollution from ships) has been amended to make the EEDI and SEEMP mandatory to all state parties.

Market-based measures provide mechanisms to monetize the GHG emissions from shipping. Under this, Emissions Trading Scheme (ETS) and Carbon Tax / Levies on Fuel have been introduced which impose emission charges on vessels calling at port states, based on the fuel consumption on voyages to respective ports.This approach encourages the vessel owners to invest on energy efficient equipment and generates funds for adaptations, mitigations, and research and development related to GHG emissions.

By introducing EEDI and SEEMP alone, the IMO targets CO_2 reductions of 200 million tons by year 2020 and 420 million tons by year 2030. Gradually, the international maritime business leans towards “Green shipping”, which involves clean energy and reduced emissions. However, there are still significant developments that the developing maritime nations should achieve in order to meet the global GHG reduction targets.

Optimising energy use in buildingsto reduce GHG emissions

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We spend most of our lives inside buildings. May it be our home, office or the occasional vacation spot, buildings provide shelter, security and comfort. To provide our daily amenities buildings consume a lot of electrical energy. In fact, buildings globally consume more than 40% of the electricity produced in power plants. Hence, buildings contribute to large amount of CO_2 emissions in the atmosphere causing global warming that has led to Climate change. Therefore, considerations in to reducing our energy consumption in buildings or supplying with a renewable energy resource can result in mitigating climate change.

Once built, a building will continue to function for at least 50 years. During its lifetime it will consume more and more energy as the building gets old and the systems become less energy efficient. In Sri Lanka, due to the hot humid climate, most of the energy consumed by buildings is to cool the indoor environment. The effort to cut down on the cooling load sometimes results in completely covering windows cutting off daylight as well. This further increases the energy burden as artificial lighting is used during day-time.

If careful consideration is given to optimising energy use, buildings can operate with a minimal financial burden on the building owner as well as contribute to a cleaner environment in the long term, adding value to the building beyond aesthetics and function.

Reducing energy use during operation of a building has two primary stages as depicted in fig.1. The goal of energy saving measures in a building is to achieve a Zero Energy Building (ZEBs), or at least a Nearly Zero Energy Building (NZEBs). Zero Energy Buildings demand less energy to operate while the remaining electricity demand is supplied through renewable energy source such as hydro or solar power. Zero energy buildings therefore do not contribute to CO_2 emissions during operation and hence do not contribute to climate change during their life time. Nearly Zero Energy Buildings use less energy than an average building but are dependent on the national electricity grid. Therefore, they still contribute to CO_2 emissions.

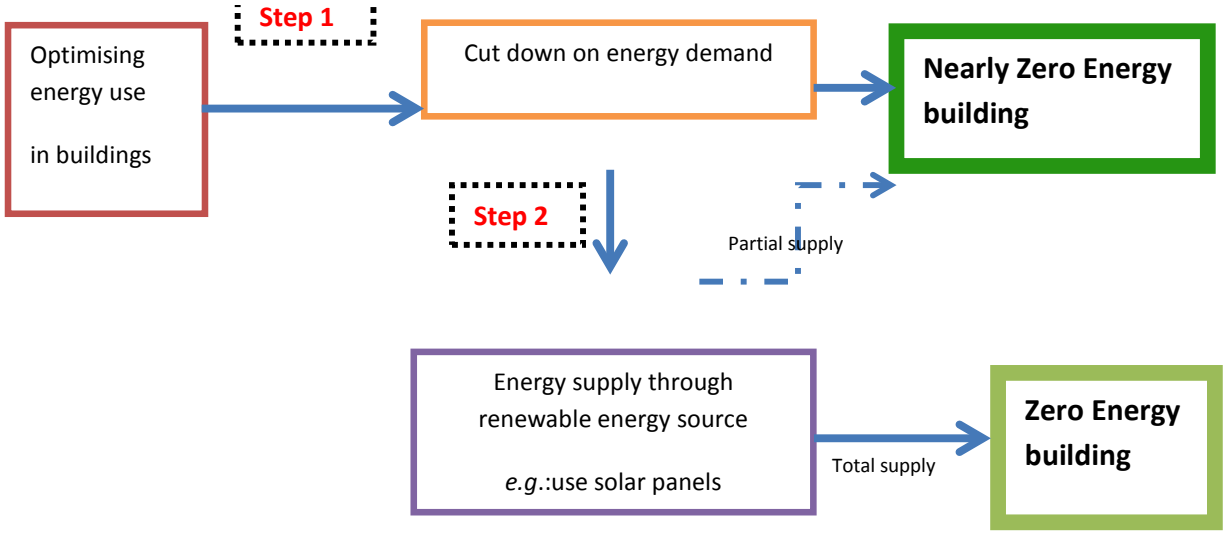

Fig.1 - Energy use optimisation in buildings

Cutting down on energy demand is the first step into energy optimisation. It is important to follow *step 1before* going in to step 2, in order to minimise the high capital costs for renewable energy generation. However, cutting down the energy demand requires the collaboration of all the stakeholders in the building process.

Step 1

Reducing energy use can be done at two levels: firstly, at the building design stage, secondly, during the operational stage. At the onset of building design, the owner can convey his desire to operate a zero-energy building to his building team. At the design stage, the architect could design the building by reducing the internal cooling load while maximising natural light in to the building. Further, the mechanical and electrical engineers could design energy efficient systems for lighting and cooling.

When the building reaches the operational stage, the owner can install energy use monitoring systems such as BMS (Building Management Systems) to keep check on energy use. As buildings last a long time, new energy efficient technologies for lighting and ventilation can be adopted periodically. In addition, occupant behaviour is also crucial for improving building energy efficiency. Building users have to be educated on energy conservation practices.

Step 2

When the demand for energy is optimally reduced, then renewable energy sources can be introduced to supply the remaining energy need. Renewable energies such as solar power, hydro-power, and wind power can be considered for onsite generation, depending on the availability of the infrastructure and the location of the building.

In Sri Lanka, new building constructions should strive to become Zero-Energy Buildings by reducing energy use and switching in to renewable energy supply to meet the remaining energy need. For

existing buildings, it is difficult to be fully independent of the national electricity grid, therefore, they can be retrofitted with energy efficient strategies to become Nearly Zero Energy Buildings and reduce their impact on the environment.

If building energy consumption can be reduced by building design, operation and occupant behaviour, then the burden on the national electricity grid will be lessened, reducing national CO_2 emissions that contribute to Climate change.

Climate change and soil: As a carbon sink

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Climate change is considered as the biggest threat to our environment, with significant impacts across the world. While most of the current discussions on impacts of climate change on agriculture are focused on plants and crop production, less is relatively discussed on the impact of climate change on soils and soil management strategies to reducethe negative effects. There is a need to have farming systems that emit reduced amounts of greenhouse gases (GHGs) and help reversing or slowing-down the cause of climate change. Soil management is a crucial aspect of these farming systems proposed to mitigate the effects of climate change. The relationship between the soil and climate change can be viewed from two perspectives, i.e. the impact on the soil and the soil management strategies for carbon sequestration towards the mitigation of global warming and climate change.

Impact of climate change on soil

Soils are highly variable and therefore, the impact of climate change on a soil would be location specific and predicting the impact of climate change on soils in general is a difficult task. The impact of climate change on soil can vary according to specific conditions such as: water availability; existing vegetative cover; and the biophysical and mechanical features of soil such as friability, compactness, water permeability, nutrient content and the number of soil biota.

Climate change could produce heavy rains, floods and prolonged droughts in tropical countries like Sri Lanka and could directly affect soils or vital functions associated with it. Increased intensity of rainfall may erode valuable topsoil and remove nutrients, which will end up in water bodies and accelerate siltation and lower the capacity of water reservoirs. Lack of rainfall will increase the drought risk, affecting soil stability and structure and the resulting low soil moisture will lead to failures in plant growth.In general, as the temperatures rise, soil moisture decreases if rain or irrigation water is not available.

However, under the moderate temperature increases associated with climate change, different scenarios may be experienced. Due to the increased levels of CO_2 in the atmosphere; enhanced vegetative growth may occur (increased photosynthesis) thus facilitating increased soil organic matter (SOM). An increase in SOM is highly beneficial as it improves soil physical, chemical and biological properties resulting improved plant growth and vegetation.

However, it is highly unlikely that this type of a scenario would occur under tropical conditions like in Sri Lanka since the rising temperatures brought about by climate change will cause microorganisms in the soils to decompose organic matter more rapidly, releasing extra CO_2 and accelerating climate change. Therefore, the net effect of climate change will be to decrease stocks of organic carbon in soils, and

releasing additional CO_2 into the atmosphere and acting as a net source, further accelerating climate change.

Soil management towards carbon sequestration

Good soil management can help to regulate emissions of three key GHGs (CO_2, CH_4 and N_2O) from agriculture, which contribute to climate change. Soil has the potential to be an effective regulator of climate change by storing carbon and therefore reducing losses of carbon as CO_2 to the atmosphere. Soils are the largest sink of the global terrestrial carbon cycle holding 1,500 Gigatonnes (Gt), three times the amount of carbon in vegetation (~560 Gt) and twice as much as the carbon in the atmosphere (~770 Gt) (Lal *et al*., 1995; Kimble *et al.*, 1995).

Carbon sequestration in plants/trees and soils is seen as a primary means to rapidly reduce current CO_2 levels. Soil carbon sequestration is the removal of atmospheric CO_2 through photosynthesis to form organic matter, which is ultimately stored in the soil as long-lived, stable forms of carbon. Soil carbon sequestration is an important and immediate sink for removing atmospheric CO_2 and mitigating global warming and climate change. An increase in soil carbon could make a significant impact on the amount CO_2 in the atmosphere. For instance, a 1% increase in organic carbon in the top 20 cm of one hectare of a soil with a bulk density of 1.3 g/cm^3 represents a 26 t/ha increase in soil carbon which is equal to 95 t/ha of CO_2 sequestered.

Carbon sequestration options in soils under most forms of agricultural management is limited, however, farmers can potentially improve and maintain SOM levels by regular addition of crop residues and manures or organic materials such as compost. In Sri Lanka, efforts are currently being taken to promote the use of organic manure and fertilizers due to high financial cost and serious environmental and human health issues associated with the continued use of inorganic chemical fertilizer. Use of organic fertilizer and manure would provide the dual benefit of supplying nutrients to crops and the carbon sequestration through the buildup of organic matter in soils. Conservation and maintenance of uncultivated areas within arable landscapes as soil carbon sinks, conservation tillage and reducing or prevention of soil erosion will significantly contribute to keeping carbon stocks in soils. The significant relationship of land and soil to climate change should be recognized and there should be concerted efforts towards carbon sequestration in soil.

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Agro-well Irrigation Systems in Mahaweli Regionto Reduce Vulnerability of Farmers to Agricultural Drought

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Every year natural disasters, such as floods, drought and fires challenge the global agricultural production, as a result of climate change. Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time. Climate change may refer to a change in average weather conditions or in the time variation of weather around longer-term average conditions. Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics and volcanic eruptions. Certain human activities have also been significant causes of recent climate change, often referred to as global warming.

Since agriculture relies on the weather, climate, and water availability to thrive, it is easily impacted by natural events and disasters which have been amplified due to the unpredictability of the climate. Agricultural impacts of disasters most commonly include: drought, contamination of water bodies, loss of harvest or livestock, increased susceptibility to disease, and destruction of irrigation systems and other agricultural infrastructure. Even though natural events and disasters can be devastating to agricultural production, disaster does not offer an excuse according to environmental laws.

Mahaweli region and climate change

Mahaweli project was the largest multipurpose development program undertaken in Sri Lanka. It was started in 1970 and has settled 130,000 farmer families and developed 90,000 ha of land for irrigated agriculture under the downstream development. The goals of the development program were increased agricultural production providing assured irrigation facilities and opening new employment opportunities in the agricultural sector with assurance of high standard of living condition and the hydro-power generation. Prime task of the agriculture extension in the Mahaweli area is to enhance rice production and productivity while promoting crop diversification in the irrigable lands aiming for maximum utilization of water, land, and labor and the food security of the country to uplift living standard of people in Mahaweli areas.

Agriculture in Mahaweli areas also has to encounter natural events. Currently, major issue of the dry zonal agriculture is the drought in yala season. Drought is a chronic, potential natural disaster, which is challenging human survival by affecting the social stability, agricultural production and sustainable development of resources and environments. Agricultural drought occurs due to climate change. Afterwards all crops will be damaged due to the water shortage at plant root zone. At these times, agricultural drought mitigation technologies benefit Mahaweli farmers to achieve their objectives. Cultivation under agro-wells was initiated as a technological change to overcome the effect of climate change on agriculture.

Agrowells to overcome agricultural droughts

Agro-wells are large dug-wells, which allow larger quantities of water to be extracted at a time, used mostly for irrigation of crops. The depth depends on ground water table. It helps to continue the cultivation even at drought condition. Cultivation under agro-wells was the major project conducted in Mahaweli area to overcome agricultural drought in *yala.*

Drip-irrigation is a highly efficient way of watering,by saving time and water. Well-designed drip systems use 30 percent less water than other methods of watering. Drip system provides direct water to the root zone of plant, where it seeps slowly into the soil. There is almost no water loss through surface run-off or evaporation, and soil particles have plenty of opportunity to absorb and hold water for plants. It also means very few nutrients leach down beyond the reach of plant roots. Furthermore, since drip irrigation delivers water directly to the plants, less is wasted on weeds. The soil surface between the plants remains drier, which discourages weed seeds. Hence, water pumps with drip irrigation systems have been attached to agro-wells to obtain water efficiently.

Improved irrigation during *yala*, enable the production of high-value crops, such as big-onion, red-onion, chilies, tomatoes and vegetables, without fallowing. Agro-wells can be used to continue healthy vegetable cultivation without water deficit in *yala.* Abandoned dry areas have been turned into productive land. New varieties of crops have opened up continuous marketing opportunities for these foods. The production of off-season vegetables has improved the linkages of small and medium scale producers in the market as well as strengthened their bargaining power. The productive land has enabled households to enrich their diet and supply diverse plants to the local market. Increased income has enabled farmers to spend more money on children's education, clothing and food. Sanitation of settlers has also improved due to the assurance of water availability. Therefore, the construction of agro-wells is a capital investment that adds value to property because of its use for irrigation and its low maintenance costs and as a solution for water shortage due to climate change.

Food safety and income of farmers in Mahaweli area have been ensured by these drought mitigation technologies. All Mahaweli farmers who use agro-wells have positive ideas on facing drought hazards, occurring due to climate change. Some improvements should be included to introduce such projects in the future. Quality and quantity of yield have been affected by quality of irrigated water. There are several water quality parameters such as pH, salinity, temperature and amount of heavy metals which have to be checked before irrigating. So, there should be manual or automatic methods integrated with drip systems to check and adjust those parameters. These methods will help to keep high quality agricultural fields through the water deficit period.

VULNERABILITY TO ADVERSE IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES IN SRI LANKA:

A REVIEW

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Introduction

Sri Lanka, a tropical nation, is highly vulnerable to impacts of climate change (Climate Change Secretariat, 2015). These impacts can be vulnerable in all the natural resources. In general, more than any other natural resources, water resources are more sensitive and vulnerable to climate change. Mostly, climate change adds pressure to existing threats on freshwater resources and water management systems. According to the Fourth Assessment Report of the IPCC (2007), the South Asia region is highly vulnerable to the adverse effects of global warming and climate change on water resources. In this respect, it is important to understand the impacts of climate change on water resources in Sri Lanka. Therefore, this paper has focused on discussing the adverse impacts of climate change on water resources in Sri Lanka.

Identified changes in climate of Sri Lanka

It was found that there is no significant trend in Sri Lanka's mean annual rainfall (MAR) during the last century. However, during 1961-1990, the country's MAR decreased by 144 mm (7%) compared to the period 1931-1960 (Eriyagama *et al*., 2010). In addition, variability of both annual and seasonal rainfall has increased during recent decades (Punyawardena, B.V.R., 2012).Although, no significant changes in rainfall amount have been observed in the South-West Monsoon (SWM) and the Second Inter-monsoon (IM2), rainfall in the North-East Monsoon (NEM) and the First Inter-monsoon (IM1) has reduced with the NEM showing increased variability (Eriyagama *et al*., 2010). However, the intensity of the two monsoon seasons has increased dramatically over the past several decades. Further to this, the frequency of heavy rainfall events has also increased.

In addition to the above, recent observations also indicated that there are significant changes in rainfall patterns in both the Dry and Wet Zones of Sri Lanka. Considering the period of 1961-2002, it is evident that all most of the areas in the Dry Zone show a decreasing trend in the total rainfall (Senalankadhikara, S. and Manawadu, L., 2009). Further, the highest decrease of rainfall is observed in the Mahaweli catchment areas (Manthrithilake, H., 2012).According to the Department of Meteorology of Sri Lanka, the NEM rainfall in Anuradhapura has decreased by 6 percent during the ten-year period of 1999-2008 (De Silva, C.S., 2012). It shows that climate change effects on NEM rains in North, Central and Eastern regions and is taking place at an accelerated pace. The decreasing trend is especially manifest in the Wet Zone (Senalankadhikara, S. and Manawadu, L., 2009). For Example, rainfall on the Western slopes of the

Central Highlands has declined significantly from 1900 to 2002 due to the reduction in the SWM rainfall in this region.

This region has the highest mean annual rainfall in the country, often exceeding 5,000 mm (Eriyagama et al., 2010). Therefore, in the country as a whole, the number of consecutive dry days has increased while the number of consecutive wet days has reduced. According to the recent analysis of the spatial pattern of rainfall indicates an expansion of the Dry Zone (Eriyagama *et al*., 2010).

The frequency and intensity of extreme rainfall events (especially droughts and floods) have increased in recent decades, triggering an increase in natural disasters in Sri Lanka (Punyawardena, B.V.R., 2012; Wickramasinghe, K., 2013). The country has already experienced 2 years of serious drought and one major flood event within the first 5 years of the twenty-first century and the districts of Ratnapura and Kalutara, which are generally flooded once or twice a year, experienced floods four times in 2008 including one severe event (Eriyagama et al., 2010). Just in the first half of 2016, Sri Lanka experienced both abnormally high temperatures and record levels of rainfall. This follows a disturbing trend of anomaly over the past decade or so, applying to observable changes in both monsoon behavior and extreme events (Munasinghe, M., 2016).

The average rate of increase in temperature from 1961 to 1990 is 0.016 °C per year. Sri Lanka's 100-year warming trend from 1896 to 1996 is 0.003 °C per year, while it is 0.025 °C per year for the 10-year period 1987-1996, indicating a faster warming trend in more recent years (Eriyagama *et al*., 2010).

Impacts of climate change on water resources in Sri Lanka

Water is one of the most vulnerable sectors to the impacts of climate change in Sri Lanka (Climate Change Secretariat, 2015). Specially, monsoonal weather patterns have a major influence on the spatial and temporal variation of water availability within the country (Amarasinghe, A., 2010). Among the four main rainfall seasons, the highest quantity of water is supplied by the NEM. However, an increase in variability of monsoon rainfall is expected to increase water shortages in the Dry Zone.Therefore, the variations in rainfall patterns due to climate change directly affect the water resources of the country.
Moreover, the availability of water resources is strongly related to the amount and timing of runoff and precipitation. Sri Lanka is blessed with 103 small and medium rivers, collecting about 52 billion cubic meters of annual surface runoff. In per capita terms, the annual runoff in 2001 was 2,799 m^3, which will decrease to about 2,232 m^3 by 2050 due to climate change. Thus, Sri Lanka is well within the generally accepted national water scarcity threshold of 1,700 m^3 per person (Amarasinghe, A., 2010). Specially, low runoff is affected to reduce the amount of water infiltration into the soil and changes the groundwater table. Therefore, affecting a 2 percent change in the air temperature would result in a change of runoff by 4-12 percent (Wijesekara *et al*., 2006). In addition, decreased in rainfall leads to reduce the water level of surface water resources. In general, surface water in Sri Lanka is estimated to vary from 4 to 5.13 million cubic meters annually (GFDRR, 2011).

Natural disasters have also negatively affected to the water resources in Sri Lanka. For example, recurrent floods and droughts in the last 5-6 years have directly affected on drinking water in all the districts (www.adaptation-undp.org, 18.08.2016). In South-eastern and North-western areas, climate change may extend the dry season and droughts of no or very low flows, which particularly affect water users unable to rely on groundwater wells in the North-west and tube wells in the South-east of the country. Dry Zone is also representative of water stressed areas experiencing erratic seasonal water availability. This area is highly vulnerable due to a prolonged drought season, increasing evaporation and diminishing precipitation driven by climate change. For example, 80 percent of Dry Zone's 12,500 small tanks are highly vulnerable to rapid drying up (Perera, M.P., 2010). It causes to reduce drinking water supplies since village irrigation reservoirs are a key source of drinking water in the Dry Zone. Further, water demand and water scarcity are more increased in the Dry Zone. With demand for water increasing, supplies of surface water and ground water are already stressed. However, certain districts of the Wet Zone are at risk of recurrent floods. Floods cause to reduce water quality as well as increase water recharge in these areas.

The current rate of sea level rise in coastal areas of Asia is reported to be 1-3 mm/year (Eriyagama et al., 2010). Hence, freshwater resources along the coastal zone of Sri Lanka are vulnerable to sea level rise. Saltwater moves into freshwater and it reduces in freshwater quality and availability of the country. This may force water managers to seek other sources of freshwater or increase the need for desalination for some coastal freshwater aquifers used as drinking water supply. In addition, saltwater will move farther upstream. Also, drought and dry seasons can cause coastal water resources to become more saline as freshwater supplies from rivers and reduced. This may affect urban water supply in future.

Impacts of changing in water resources on other sectors

Water is essential for many sectors including energy production, infrastructure, human health, agriculture and ecosystems while climate change has important implications on these sectors, especially through the hydrological changes, water availability and quality. Specially, water-dependent sectors are mostly affected by the impact of climate change on the watersector. In fact, Sri Lanka depends primarily on its surface water resources for agricultural, domestic and industrial uses (Eriyagama, N. and Smakhtin, V., 2010). Therefore, the impacts of climate change on water resources in Sri Lanka will mainly affect these sectors as follows:

Impacts on Agriculture and food supply

Changes in climate may also influence the water availability and water needs for agriculture (Watts *et al*., 2015). Agriculture is largely sustained by direct rainfall (rain-fed) and irrigation water extractions from rivers and cascade systems in Sri Lanka (Eriyagama, N. and Smakhtin, V., 2010). The two principal crops of Sri Lankan agriculture, rice and tea are both highly influenced by variations in temperature and rainfall. Specially, Sri Lanka's main subsistence agriculture is paddy cultivation. Paddy cultivation is highly susceptible to variations in air temperature, rainfall, soil moisture and increases in the intensity and frequency of extreme events. During the past few decades, paddy production has been destroyed either

by severe rainfall or the lack of timely rain (Senalankadhikara, S. and Manawadu, L., 2009). For Example, the rainfall during *Yala* season (May- August) has been decreased during the past ten years (1999-2008) when compared with the base line of 1961-1990 (De Silva, C.S., 2012).

Irrigation is by far the highest water use sector in Sri Lanka, accounting for 92 percent of the water withdrawals in 1991 and still is high at 90 percent in 2000. At the present rate of growth, Sri Lanka's population will peak in the early 2040s, with an addition of 15 percent to the population. If the present self-sufficiency levels of different crops are to be maintained and the present level of crop productivity persists, the irrigation demand for meeting food demand for this maximum population could increase by at most 15 percent (Amarasinghe, A., 2010). In addition, the average paddy irrigation water requirement during the *Maha* season will increase by 13 percent to 23 percent by 2050 compared to that of 1961-1990. Irrigation water requirements for other field crops cultivated in the Dry and Intermediate Zones during the dry (*Yala*) season will also significantly increase (Eriyagama, N. and Smakhtin, V., 2010).

Moreover, as results of floods and droughts, both extremes, i.e., water scarcity and excess water have become a recurrent problem faced by crop production in Sri Lanka. Under such situations, crop losses due to decreased soil moisture and excess water, both in terms of quality and quantity are inevitable (Punyawardena, B.V.R., 2012). In fact, Sri Lanka's mean temperature may increase by approximately 0.9 - 4 ^{0}C by the year 2100 (Eriyagama *et al.*, 2010). Therefore, evaporation will also increase. Increased evaporation is affected to reduce soil moisture and decline water quantity in the Dry and Intermediate Zones. In addition, affects to the freshwater availability in all climatic zones further reduce water supplies for agriculture and it may reduce food supply.

Impacts on Energy Production

Climate-induced water scarcity has implications on energy security of the country as well. During 2000-08, hydroelectricity is estimated to have contributed 43 percent on average to the national electricity supply. However, a lack of adequate water in the country's major reservoirs, thus leads to a reduction in hydropower generation (Wickramasinghe, K., 2012). For Example, 34 out of 58 major reservoirs were below 25 percent of their full capacity due to drought in 2003 (Dhanapala, A.H., 2011). According to that, climate change may lead to reduce energy production of country.

Addition to agricultural and energy sectors, many other sectors such as infrastructure, ecosystems, tourism etc. put pressure on water resources, stresses that are likely to be exacerbated by climate change in future.

Conclusions

Sri Lanka is one of the most vulnerable countries in the world to adverse impacts of climate change on water resources. Climate change affects to the water resources in several forms. In many areas, climate change will be likely to increase water demand while shrinking water supplies. In some areas, it can reduce the quality of water and damage to the deliver water. Specially, Intermediate and Dry Zones are

mainly affected to the impacts of climate change on freshwater. Climate change also affects groundwater recharge and discharge rates, as well as groundwater quality. Therefore, dealing with water is an important part of adaptation to climate change. In addition, there a need for good practices for adaptation to climate change into sustainable development planning in the country.

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දේශගුණ විපර්යාසයන් කෘමි සතුන් කෙරෙහි කෙසේ බලපායි ද?

චින්තක විදානපතිරණ

කීට විද්‍යා අංශය, අපනයන කෘෂිකර්ම දෙපාර්තමේන්තුව chinthakauw@gmail.com

දේශගුණික විපර්යාසයන් විවිධ පරිසර පද්ධතීන් තුල ජීවත් වන ජීවීන් හා ඔවුන් එකිනෙකා අතර ඇති අන්තර්ක්‍රියා කෙරෙහි විවිධ ආකාරයෙන් බලපායි. මෙතෙක් හඳුනාගෙන ඇති සමස්ත සජීවී ප්‍රජාවෙන් 80%කටත් වඩා සමන්විත වනුයේ කෘමි සතුන්ගෙනි. එසේම ඔවුන් පරිසර පද්ධතියේ මූලික ව්‍යුහය හා ක්‍රියාකාරීත්වය නියෝජනය කරන නිසා මෙකී දේශගුණික විපර්යාසයන්ගේ සෘජු හා වක්‍ර බලපෑමට අන් කිසිදු ජීවී කොටසකටත් වඩා ඔවුන් ලක් වේ. ශාක භක්ෂකයන්, පරාගනය කරන්නන්, විලෝපිකයන්, ලෙස පරිසර පද්ධතීන් තුල ඉතා වැදගත් කාර්ය භාරයන් කෘමි සතුන් විසින් ඉටුකෙරෙයි. මේ නිසා කෘමි සතුන්ගේ සෘජු බලපෑම් සහිත බීජ ව්‍යාප්තිය හා පරාගණය ආදී ක්‍රියාවලීන් කෙරෙහි දේශගුණික විපර්යාසයන් තදින් බලපානු ඇත.

දේශගුණ විපර්යාසයේ ස්වරූපයන් වන, වෙනස් උෂ්ණත්ව කළාපයන් නිර්මාණය වීම, වායුගෝලීය සංයුතියේ, සාමාන්‍ය වායුගෝල උෂ්ණත්වය හා වර්ෂාපතන රටාවේ වෙනස් වීම්වලට ප්‍රතිතිචාර ලෙස කෘමීන් විවිධ අනුවර්තනයන් මඟින් උචිත පරිදි හැඩ ගැසීම හෝ පරිසරයෙන් ඉවත්වී යාම සිදු විය හැක. කෘමීන් ගේ කෙටි ජීවන චක්‍ර, ඉහළ ප්‍රජනන හැකියාව හා වේගයෙන් පැතිරී යාමේ හැකියාව හේතුවෙන්, ඉහළ යන පරිසර උෂ්ණත්වය නිසා ඇතිවන කායික විද්‍යාත්මක වෙනස්වීම් නිසා කෘමීන්ගේ ගහණය ඉක්මනින් වෙනස් වෙයි. සර්ම කළාපීය රට වල සිටින කෘමි විශේෂයන් ඔවුනගේ ඉහළ පරිවෘත්තීය ක්‍රියාකාරීත්වය හා වඩා වේගයෙන් බෝ වීමේ හැකියාව නිසා වඩා තීව්‍ර ලෙස මේ තත්ත්වයට මුහුණ දෙයි.

බේල් (2002) දී සඳහන් කර ඇති පරිදි, උෂ්ණත්වය ඉහළ යාම කෘමීන් කෙරෙහි ධනාත්මක ලෙස හෝ ඍණාත්මක ලෙස බල පෑ හැකිය. කෘමීන්ගේ ජීවන චක්‍රය සම්පූර්ණ කිරීමට ගතවන කාලය, ගහණ ඝණත්වය, ප්‍රමාණය, ජානමය සංයුතිය, ධාරක ශාක සොයා ගැනීමේ හැකියාව, කායික විද්‍යාව හෝ හැසිරීම මත හෝ, වක්‍රාකාරව ඔවුනගේ ධාරක ශාක හා ස්වාභාවික සතුරන් හා ව්‍යාප්තිය ආදී සාධක මත උෂ්ණත්වය බලපායි. කෘමීන් මෙම පරිසර වෙනසට ඉක්මනින් ප්‍රතිචාර දක්වමින් අන්තර් හා අන්තං විශේෂ අන්තර්ක්‍රියා සැලකිය යුතුලෙස වෙනස් කර ගනු ඇත.

පාමිසන් (1999) පෙන්වා දෙන පරිදි, ගෝලීය උණුසුම ඉහල යාම නිසා, දැනටමත් ඇතැම් සමනල, කුරුමිණි, බත් කුරු හා තණ කොළ පෙති විශේෂ ඉහළ උන්නතාංශ වලට සංක්‍රමණය වී ඇත. සමහර යුරෝපීය සමනල විශේෂ උණුසුම අඩු උතුරු කළාපයට ව්‍යාප්ත වී ඇත. කොල්වෙල් 2008 දී කළ අධ්‍යයනයකට අනුව මේ ආකාරයේ සංක්‍රමණය වීම් සර්මකළාපීය රටවල් සඳහා ද අදාලය. මේ ආකාරයෙන් දේශගුණයේ වෙනස් වීම් සමඟ තම ව්‍යාප්තිය වෙනස් කර ගැනීමට අපහසු කෘමි විශේෂ වඳ වී යාමේ තර්ජනයට මුහුණ දෙනු ඇති බවද ප්‍රකාශ වී ඇත.

ගෝලීය උණුසුම වැඩි වීම හේතුවෙන් ශාක වල මල් හට ගැනීම ආදී ක්‍රියාවලීන් ප්‍රමාද වීම හෝ ඉක්මන් වීම හේතුවෙන්, ශාක සහ කෘමි සතුන් අතර ඇති අන්තර්ක්‍රියාවන් වෙනස් වීම සිදු වේ. ඇතැම් කෘමීන්ගේ ජීවන චක්‍රය සම්පූර්ණ වීමට, මෙකී අන්තර්ක්‍රියාවන් නිවැරදි කාල වකවානුවේදී සිදු වීම අත්‍යාවශ්‍යය. එසේ සිදු නොවීමෙන් මෙම ශාක සත්ව සම්බන්ධතා සහ පරිණාමික ක්‍රියාවලීන් බිඳ වැටෙනු ඇත. කෘමීන් යනු බොහෝ පරිසර පද්ධතීන් වල ඉතාම වැදගත් සංරචකයක් නිසා පරිසර පද්ධතියේ අනෙක් ජීවීන්ගේ ජීවන රටාවන් කෘමි විශේෂ වල ජීවන චක්‍රය සමඟ ගැලපෙන ලෙස ස්වභාවයෙන්ම සකස් වී ඇත. උදාහරණයක් ලෙස, යම් පරිසර පද්ධතියක දළඹු ගහණය ඉහල යන කාලය, එම දළඹුවන් මත යැපෙන කුරුල්ලන් බිජු වලින් එළියට එන කාලය හා ගැලපෙන ලෙස සකස් වී ඇත. මේ නිසා මේ කුරුල්ලන්ට ආහාර හිඟයක් ඇති නොවන අතරම දළඹු ගහණයද අනවශ්‍ය පරිදි ඉහළ නොයනු ඇත. නමුත් පරිසර උෂ්ණත්වය ඉහළ යාම හේතුවෙන් මෙකී දළඹුවන් ඉක්මනින් ජීවන චක්‍රය සම්පූර්ණ කළ හැක. මෙහිදී ඉහත කුරුල්ලනට සාගතයකට මුහුණ දීමට සිදු වන අතර, අනවශ්‍ය ලෙස ඉහළ යන දළඹුවන් විසින් ඔවුනගේ ධාරක ශාකය ද නැවත ප්‍රතිස්ථාපනය කළ නොහැකි වන තරමට කා දමා විනාශ කෙරෙණු ඇත. එහි අවසන් ප්‍රතිඵලය ලෙස පරිසර පද්ධතීන් අඩාල වීම පවා සිදු විය හැක.

ආර්ථික විද්‍යාඥයන් සාමාන්‍යයෙන් පවසන පරිදි දියුණු රටවල කෘෂි නිෂ්පාදනයෙන් 10% පමණ හා දියුණු වෙමින් පවතින රටවල එකී නිෂ්පාදනයෙන් 25% පමණ ප්‍රමාණයක් වාර්ෂිකව කෘමීන් විසින් හානිකර විනාශකර දමනු ලැබේ.

මෙම හානිය, දේශගුණ තත්ත්ව වෙනස් වීම සමඟ තව දුරටත් වැඩි වනු ඇතැයි කෘෂි විද්‍යාඥයෝ අනතුරු හඟවා සිටිති. මෙයට හේතුව නම්, පාරිසරික වෙනස් වීම් හේතුවෙන් ස්වාභාවික සතුරන්ට වඩා වාසිදායක තත්ත්වයක් කෘමි පළිබෝධකයනට ඇති වීමයි. ඉහළ යන පාරිසරික උෂ්ණත්වය හා ඒ හේතුවෙන් වැඩි වන ආර්ද්‍රතාවය නිසා කෘමීන්ගේ වර්ධනය හා පැතිරීම වේගවත් කෙරේ. කෘමීන් නව ප්‍රදේශ කරා ව්‍යාප්ත වීම ඔවුන්ගේ සංඛ්‍යාවේ වර්ධනය හා එක් වූ කළ එය කෘමි "ආක්‍රමණයක්" ලෙස සැලකිය හැක. කෘමි පළිබෝධකයින්ගේ හානිය හා රෝග වාහක කෘමි ගහණය වැඩිවත්ම පළිබෝධනාශක භාවිතයද ඒ අනුව වැඩි කිරීමට සිදු වීමෙන්, එහි අහිතකර බලපෑම් වක්‍ර ආකාරයෙන් මිනිසාට ද පරිසර පද්ධතීන්ටද වැඩි වැඩියෙන් එල්ල වනු ඇත.

පිටි මකුණා Paracoccus marginatus (Papaya mealy bug) යනු 2008 සහ ආසන්න වර්ෂ වල ඉතා දරුණු ලෙස ශ්‍රී ලංකාවේ පලතුරු භෝග ඇතුලු වෙනත් වගාවන් රැසකට හානි පැමිණ වීමට සමත් වූ කෘමි පළිබෝධකයෙකි. මෙම පළිබෝධකයාගේ ගහණයද උෂ්ණත්වය ආදී පරිසර සාධක මත රඳා පවතින බැව් පෙනී ගොස් තිබේ. එසේම මෙකී කෘමියාගේ ගහණය ඉතා අධික ලෙස එක වරම ඉහළ යාමටත්, පාරිසරික සාධකවල බලපෑමක් තිබිය හැකිය. සාමාන්‍යයෙන් පරිසරයේ සමතුලිත තත්ත්ව යටතේ ජීවත්වන කෘමි සතකු විවිධ පරිසර තත්ත්ව වෙනස් වීම් හමුවේ තම ගහණය අධික ලෙස ඉහළ නංවමින්, පළිබෝධකයකු ලෙස හැසිරීම සාමාන්‍ය සංසිද්ධියකි.

ඉහත හේතූන් නිසා දේශගුණික වෙනස් වීමේ බලපෑම කෘමි ප්‍රජාව මත ඇති කරන පීඩනය සමස්ත ලෝකයේ පරිසර පද්ධතීන් මත හා මානවයා මත නොයෙක් ආකාරයේ සෘජු හා වක්‍ර බලපෑම් එල්ල කරන බව පෙනී යයි.

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Potential use of native fig trees in reducing the risk of wildlife food scarcity under changing climate

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Figs are botanically grouped as *Ficus* plant species belonging to Moraceae family. In Sri Lanka, there are 23 *Ficus* species distributed almost all over the country: hill country, dry lowlands, wet lowlands and coastal areas. *Ficus* shows diverse life forms ranging from massive trees to small climbing plants. Sacred Bo tree (*Ficus religiosa*) and Mahanuga (*Ficus benghalensis*) are well known and familiar fig trees found in villages as well as in urban areas.Both trees are sacred trees in India and Sri Lanka and represent two of Atavisisi Bodhi trees (28 scared Bodhi trees) worshiped by people. Legends says that *Ficus benghalensis* is the 27th Bodhi tree under which the Kassapa Buddha (27th Buddha) attained enlightenment and *Ficus religiosa* is the 28th Bodhi tree under which the Gauthama Buddha (28th Buddha) attained enlightenment. Extracting of natural dye from bark of *Ficus benghalensis* is an old cultural practice in Sri Lanka. The dye is exclusively used for giving a brownish-red color to robes of Buddhist monks.

Tropical fig trees are considered as keystone species on account of its exceptional role in providing wildlife feeding resources and habitat requirements for a number of wild animals. Studies have shown that an array of wild animals are sustained by fig trees, which include from tiny wasps, ants and butterflies to many kinds of fruit eating birds, squirrels, bats, civet cat, sloth bear and elephant. In Sri Lanka, apparently, there is no other kind of tree providing that much silent services for the well-being of wild life as far as the diversity of resource seeking animals flocking around figs is considered .

The changing climate over the years is depriving wild life feeding resources in many direct and indirect ways. Observations on chain reaction of climate change clearly show that wildlife is facing the risk of scarcity of feeding resources due to several factors. Among them, drought, forest fires, industrial agriculture and forestry that replace lands with wildlife resource, poor vegetation, spread of alien invasive plants, expansion of urban landscape with no suitable plants having quality wild life feeding resources and man induced forest degradation are prime factors that affect wildlife in slow-onset manner but with serious impacts on our native biodiversity. Therefore, it is high time to think of climate change adaption avenues to manage the risk of wildlife food scarcity, using low cost and indigenous solutions. In this regard, native fig trees are ideal candidates to put into service in mitigating climate change impacts on wildlife food supply. Several of our native fig trees have superb plus characters in terms of resource value for wild life affected by climate change. They are briefly,

(a). ability to grow in almost all climatic zones of Sri Lanka, including in extreme dry areas,

(b). ample supply of nutritious fruits, especially during periods when no other fruits are available for dependent wild life (It is predicted that a decline of series of wildlife populations can take place if such keystone resources were removed),

(c). massive size of fig trees which makes it a massive store house of wild life feeding resources,

(d). ability to be used in urban planting as well as in restoring forests for enhanced biodiversity, and

(e). ability to last longer, often several hundred years, supporting wildlife even in urban areas.

Considering the usefulness to native wildlife and practical ground realities of our country, the following native fig species are suggested for widespread introduction to localities where wildlife feeding resources are in short supply, both in urban and natural landscape.

Ficus benghalensis (Mahanuga or Banyan) - The tree can thrive well both in dry and wet localities except in the hills. This massive fruit bearing tree is capable of developing the world largest canopy cover by a single tree. More fruiting observed in August-September period.

Ficus drupacea (Boonuga) - A large fig tree, with good wild life food supply preferring wet zone and intermediate zone of Sri Lanka. Fruiting can be seen both in dry periods (August-September) as well as wet periods (January-February).

Ficus microcarpa (Laurel fig) - Another large fig tree that is well adapted to coastal areas and dry country. Fruiting can be seen both in dry and wet seasons, August-December period.

Ficus fergusoni (Kosgonna) - A wildlife resource fig tree endemic to Sri Lanka found in hill country; often seen in association with tea plantations. Fruits are available many months of the year with no apparent seasonality.

Moreover, *Ficus virens, Ficus caulocarpa* and *Ficus costata* are also useful figs found in both wet and dry areas. *Ficus mollis* (Wal Aralu) provides good wildlife feeding resources in dry and rocky areas where few plants can grow.

It is well known that wildlife food supply is highly exposed to disruption from increasing extreme weather events driven by climate change. Wild animals are already struggling to cope with more frequent and intense droughts and changing weather patterns. Drought is the most catastrophic natural event that causes widespread periodic wildlife food shortages in Sri Lanka, but it is by no means the only natural hazard facing animals. Periodically, floods afflict localized parts of even the driest areas. Drought diminishes dietary diversity and reduces overall food consumption of wild animals. In the wake of such crises, *Ficus* can play a bigger role as food safety nets, helping more vulnerable biodiversity. *Ficus* fruits are available both during dry and wet seasons in several species, hence a natural insurance system against wildlife food insecurity. *Ficus* being a keystone resource on account of its significant role in sustaining diverse groups of animals interconnected through a well-functioning food web, the plant itself form a mini ecosystem. Add to that, the massive *Ficus* trees can withstand extreme climate events such as droughts and floods.

Figure: *Ficus benghalensis (Mahanuga or Banyan) with its characteristic root system.*

Fig trees can be propagated easily using stem cuttings or seeds. Possible applications of figs in climate response interventions in wild life sector may involve a variety of ways such as improve wildlife carrying capacity of degraded forests, connect fragmented forests through 'habitat stepping stones' and sustain urban biodiversity. In this regard, promotion of figs needs to be a component of climate smart management plans under Department of wildlife conservation, Forest Department, Urban Development Authority and Road Development Authority. Considering the ecological role of fig trees as a safety net to climate affected wildlife, legal refinements can be considered for giving some protection to selected keystone fig species. Meanwhile, an enhanced understanding of the role of figs through appropriate research could be accelerated. Awareness on useful native figs needs to be an important activity touching upon policy arena as well as down to earth community. Furthermore, given the deteriorating situation of wildlife feeding resources under changing climate, it is suggested that necessary actions are put in place, not only by state agencies but also by non-government organizations and wildlife enthusiasts in order to sustain a healthy population of wildlife both in human landscape and natural landscape.

Palaeoecological reconstruction of the Pleistocene climate of Sri Lanka

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Introduction

The Pleistocene epoch lasted from 2- 1.67million to 12,000- 10,000 years BP. The evolution of modern man in Africa and his dispersal / migration to other countries; the extinction of certain animals due to hunting or natural catastrophe; the production of stone tools (evolution of technology); the development of human settlements and domestication of both flora and fauna occurred during the Pleistocene. Of the flora and fauna that existed during the Pleistocene whilst some became extinct others exist upto the present time.

The glacial and inter glacial periods brought in changes of sea levels. Until 15,000BP land bridges existed connecting Sri Lanka, India and East Asia. Thereby, fauna could disperse from one land to another. For example, the Spotted deer (*Axis axis*) thrives in both India and Sri Lanka.

The survival in some countries of animals that are extinct in others raises much doubt as to whether any geological epoch ever affected the entire earth simultaneously to an equal degree since animals that are known only from their fossilised remains in the temperate countries are found as living species towards the equator and *vice versa*. It can be assumed that climatic changes producing their extinction and characteristic geological deposits, could only affect one part of the earth at a time. Hence, when another new change commences, it influences one part and its climate spreads into some other region which thereupon supports similar fauna and flora and produces similar deposits.

Faunal and floral remains in excavations done in caves in the Wet Zone and from open air settlements in the Dry Zone facilitate in reconstructing palaeoecological environments.

Reconstruction of Pleistocene climate in Sri Lanka

The island has been subjected to at least four major uplifts during Jurassic, Miocene, Pliocene and Pleistocene times which broke up its sedimentary beds and altered its topography (Cooray, 1984). As a result, the earlier sedimentary deposits have disappeared from the greater part of Sri Lanka while the youngest, the Pleistocene ones, have survived these changes better and are best in evidence in the strike valleys of the province of Sabaragamuwa.

Dr.P.E.P.Deraniyagala studied the faunal remains in the sedimentary beds and identified both extinct and extant fauna. A majority of the extinct mega fauna was found in the excavations of gem pits, whilst other fauna was found in the excavations of caves which was inhabited by man.

Sri Lanka's extinct fossil fauna, which is termed the 'Ratnapura Fauna' is a branch of the Indian Shivalik which has accumulated in troughs. These are the youngest fossil deposits in the Island the oldest being the Jurassic and Miocene ones (Deraniyagala, 1958).

The chief index animals for the Pleistocene in Asia are the six incisored hippopotamus (*Hexaprotodon*), the ridge-browed elephants (*Hypselephas hysudricus* and *Palaeoloxodon namadicus*), the Asian elephant (*Elephas maximus*), the cervid genera (*Axis, Rusa*), the bovine genera (*Bos*, *Bubalus*, *Bibos*) and the various species of man (*Pithencanthropus, Homo*).

The following Table 1 contains a list of species found in the gem pits in the Ratnapura area. Most of these species or their evolved species are to be found existing today. But, some of these fauna are extinct from Sri Lanka. In comparison with the environment of the extant species, the palaeoenvironment can be surmised.

Table: 1 List of some key fossil fauna found in the gem pits at Ratnapura and their surmised biogeographical condition

Some key fossil faunal Species	**Extant species**	**Environment/ biogeographical condition**
Callianassa sp, *Scylla serrata, Macropthalmus latreillei*	Marine crabs	Inhabits burrows in muddy estuarine shores.
Paludomus sp. *(*Freshwater snails)	*Paludomus* sp.	Streams, moist mid-hills
Acavus sp. (Tree snail)	*Acavus* sp.	Forests, moist mid-hills
Melanochelys trijuga sinhaleyus (Black turtle)	*Melanochelys trijuga*	Swamps and lakes
*Trionyx punctatus sinhaleyus (*soft shelledterrapin*)*	*Lissemys ceylonensis*	Swamps and lakes
Crocodylus sinhaleyus (Crocodile)	*Crocodylus porosus* *Crocodylus palustris*	Swamps and lakes
Hystrix sivalensis sinhaleyus (Porcupine)	*Hystrix indica*	Savannah with rocks and forest
Cuon javanicus sinhaleyus (wild dog)	*Cuon alpinus*(in India)	Savannah with rocks and forest
Palaeoloxodon namadicus sinhaleyus (Elephant)	*Elephas*	Savannah with rocks, ancient marshes, streams and forest (semi arid)

Hypselephas hysudricus sinhaleyus (Elephant)	*Elephas*	Savannah with rocks, ancient marshes, streams and forest (semi arid)
Elephas maximus sinhaleyus (Elephant)	*Elephas maximus maximus*	Savannah with rocks, ancient marshes, streams and forest (moist)
Rhinoceros sinhaleyus (Rhinoceros)	*Rhinoceros* sp. (no longer in Sri Lanka)	Savannah with rocks, streams and forest (moist)
Rhinoceros kangavena (Rhinoceros)	*Rhinoceros* sp. (no longer in Sri Lanka)	Savannah with rocks, streams and forest (moist)
Sus sinhaleyus (Wild boar)	*Sus scrofa*	Savannah with rocks, streams and forest (moist)
Hexaprotodon sinhaleyus (Hippopotamus)	*Hippopotamus* sp + *Choeropsis* sp. . (no longer in Sri Lanka)	Savannah with rocks, streams and forest (moist)
Muva sinhaleya (Deer)	Extinct	Savannah and scrub forest (semi arid)
*Rusa (*Sambur)	*Rusa sp.*	Mountains and forest (moist), lowland dry zone (semi-arid)
Bibos sinhaleyus (Gaur)	*Bibos* sp. (no longer in Sri Lanka)	Mountains with savannah tracts and forest (moist)
Gona sinhaleya (Buffalo)	Extinct	Savannah and forest with streams and lakes (moist)
Panthera leo (Lion)	*Panthera leo* (India, Africa)	Savannah with streams and forests
Panthera tigris (Tiger)	*Panthera tigris* (no longer in Sri Lanka, widely distributed in Asia)	Savannah with streams and forests
Homo sinhaleyus (Human) Not valid species		Savannah with rocks, streams and forest (moist)
Homopithecus sinhaleyus(Human) Not valid species		Savannah with rocks, streams and forest (moist)
**Homo sapiens balangodensis* (Human)	*Homo sapiens*	Savannah with rocks, streams and forest (moist)

*Has been later identified as *Homo sapiens* by Kennedy.

The flora of the Pleistocene is known from 10 species (Table 2). This indicates that it was not very different to the existing one although, probably different in the manner of zonal distribution and relative abundance since the palaeofauna suggest the prevalence of savannah conditions with rocks, streams and areas of rain forest, for a considerable period.

Table 2. The species of the fossil Ratnapura flora known from the gem sands (from Deraniyagala, 1940, 1958, Puri, 1941)

Scientific name	**Common name (Sinhala)**
Alsophila zeylanica	Pini Baru
Bambusa vulgaris	Bambu
Ochlandra stridula	Bata
Onchiosperma fasciculata	Katu Kitul
Elaeocarpus subvillosus	Gal Veralu
Myristica dactyloides	Malaboda
Canarium zeylanicum	Kakuna
Coscinium fenestrum	Veni Val
Caryota urens	Kitul
Wrightia flavodorosea	

By these fossils and their palaeoenvironment, P.E.P.Deraniyagala (1958) surmised that the Pleistocene climate consisted of three distinct phases termed Ratnapura Phase, Palagaha Turai Phase and Colombo Phase (Early Holocene).

The Ratnapura Phase was characterised by wet and cool climatic conditions. The fossil beds from this stage contain lake dwelling animals such as the hippopotamus (*Hexaprotodon)* and aquatic vegetation suggestive of large lakes and swamps. The Palugaha Turai Phase is represented by highly oxidised red earth and wind blown sands suggesting a dry and arid period, overlying the beds of the Ratnapura Phase. The Colombo Phase is essentially of the Early Holocene Age, during which conditions became wetter and stabilized themselves in the climatic conditions experienced today.

In a palaeoecological reconstruction of climates and biota by S.U. Deraniyagala (1992) 6 ecological zones were identified. A study of the Tree Snail *Acavus* sp which is a predominantly Wet Zone species in caves such as Kuruvita Batadombalena and Belilena Kitulgala followed by Alulena at Attanagoda and Pothgul lena at Alawala indicate that moisture conditions during this time-span of Late Upper Pleistocene to early Holocene was scarcely drier than those climatic conditions of today. Fossils of spotted deer, lion

and water buffalo (who are mainly dry zone species) in the Ratnapura Beds suggests that during certain episodes in the Pleistocene, the lowland wet zone of Sri Lanka showed relative aridity resulting in a biome that was 'dry' (Perera,2010).

Climatic stability is implied in the continuity of *Acavus* molluscs in excavation layers, which suggests that the climate of Sri Lanka's Wet Zone remained fairly stable during the final millennia of the Pleistocene. It further suggests that the temperatures were not significantly different from that of today and would have been averaging no more than 5^{o}C below present conditions. (Kennedy *et al*., 1989)

Prematilleke and Risberg (2003) conducted a pollen and spore study of peat in Horton Plains National Park.Siliceous microfossils such as phytoliths, diatoms and chrysophyte stomatocyst were also separated from the material. These assist to identify specific groups of plants which existed during that time. Further, by carbon dating this material, time ranges can be determined.

Taxa such as *Chenopodium* sp.and *Gomphrena* sp which are xerophytic vegetation and represent semi arid climates, and *Syzygium* sp which thrive in high moisture conditions, represent a humid environment.

Further, this study revealed that the climate of Horton Plains (Central Highlands) indicates the presence of an arid climate in the Late Pleistocene. They identified an increase in precipitation by the presence of a predominantly montane environment between 12,000-11,000 BP. A further change was depicted during the Holocene. It indicates an increase in precipitation in the intervals during 8000 -7000 and 4000-3000 BP and an arid phase from 6000-5000BP and also another short wet phase around 600BP.

Conclusion

From work on palaeoecological done by researchers (figure 1), it can be concluded that the climate of Sri Lanka fluctuated between wet and dry phases. This correlated with similar evidence of climate change in South India. Further, the temperatures for the past millennium were 5^{o}C less than today'

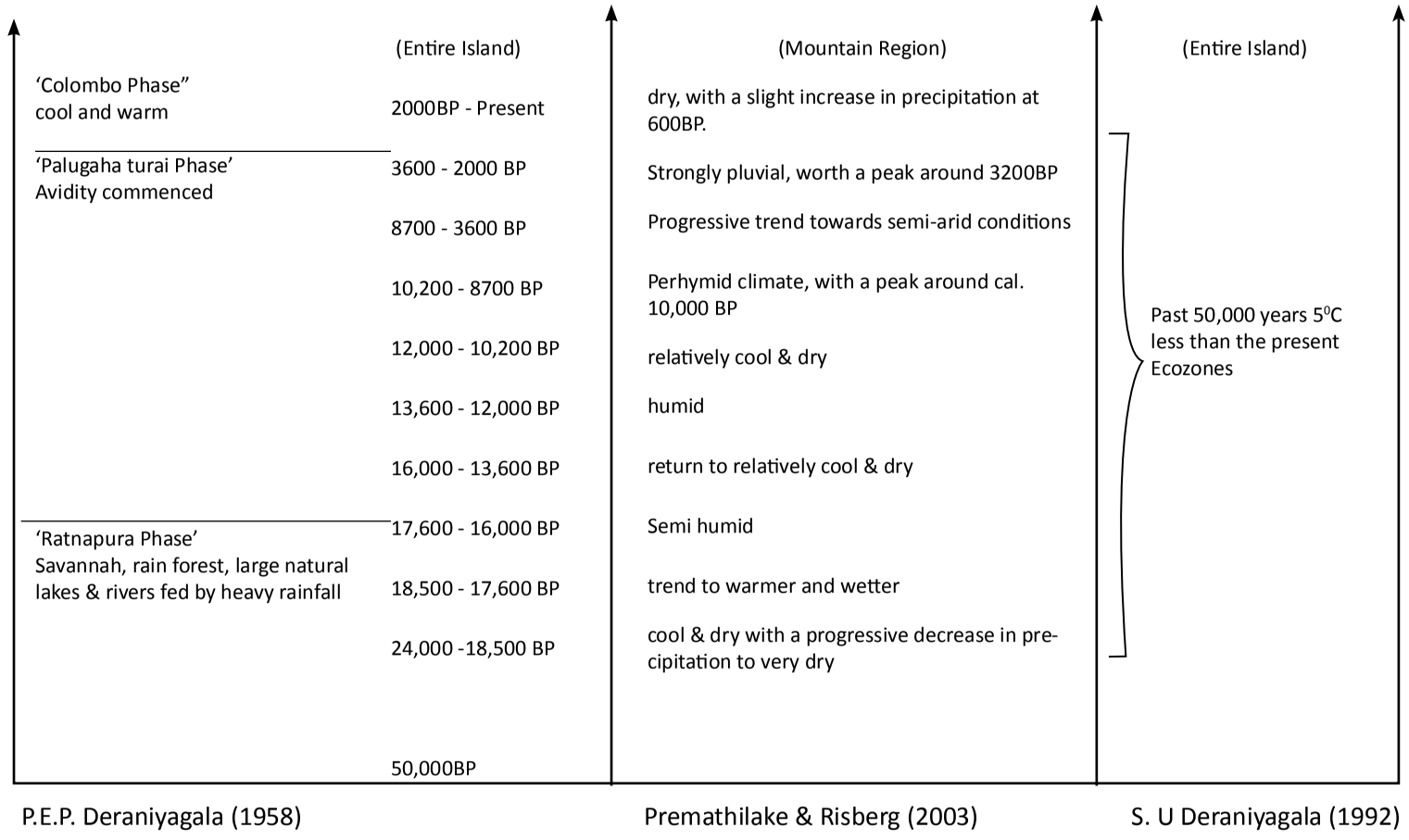
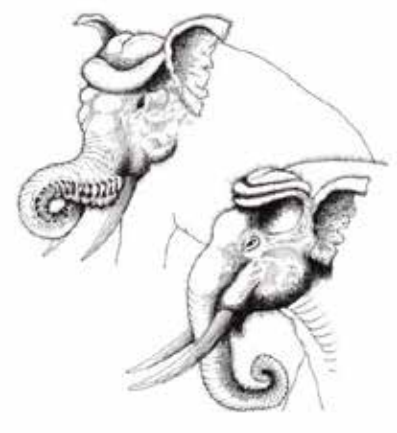


Fig 1: Concept of Climate change during the pleistocene in Sri Lanka



Palaeoloxodon namadicus

Hexaprotodon sinhaleyus (Hippopotamus)
© Kelum Manamendra-arachchi

*Rhinoceros sinhaleyus (*RHINOCEROS) ©
Kelum Manamendraarachchi

Reference:

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දේශගුණ විපර්යාස බලපෑම්වලට අනුහුරුවීම උදෙසා වූ උතුරුමැද වියළි කලාපීය එල්ලංගා පද්ධතිය ආශ්‍රිත දේශීය දැනුම

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තුල්‍ය කාල පරිච්ඡේදයක් තුල හටගන්නා ස්වභාවික දේශගුණික විචල්‍යතාවය සහ ඍතුවිය වටා පිහිටි වායුගෝලීය සංයුතිය වෙනස්කරන මානව ක්‍රියාකාරකම්වල ස්වභාවයට ඍජුවම හා වක්‍රව බලපාන දේශගුණික වෙනස්වීම දේශගුණ විපර්යාස ලෙස පොදුවේ හඳුන්වා දිය හැකිය. එමෙන්ම දේශගුණික ඉසව් (Events) වල ප්‍රථිපල වල වාසිය ලබා ගැනීම පිණිස වැඩි දියුණු කිරීම, සංවර්ධනය කිරීම හා ක්‍රියාත්මක කිරීම මගින් ඉහත ප්‍රථිපල වල ඇති අහිතකර ස්වභාවය බල කිරීමට හෝ අඩු කිරීමට හා මැඩලීමට අවශ්‍ය උපායමාර්ග සහිත ක්‍රියාවලිය දේශගුණික බලපෑම්වලට අනුහුරුවීම ලෙස හැඳින්විය හැකිය.

දිගු කාලයක් තිස්සේ ස්ථාපනය වූ සංස්කෘතියක් සහිත රටක හෝ ජන සමාජයක කාලාන්තරයක් තිස්සේ ලිඛිතව හෝ බස් වහරින් පරම්පරාවෙන් පරම්පරාවට සම්ප්‍රේෂණය වූ දැනුම් සම්භාරය දේශීය හෝ පාරම්පරික දැනුම ලෙස පොදුවේ හඳුන්ව දිය හැකිය. අතීතයේදී ඉන්දියාව, චීනය ඇතුළු පෙරදිග කලාපය තුල බොහොමයක් දැනුම මුලින්ම ගොඩනැගුණු අතර ඒවා බටහිරට සංක්‍රමණය වී යම්තාක් දුරට බටහිරකරණය තුලින් තුන්වන ලෝකයට නැවතත් ඉදිරිපත්වී ඇත. මෙලෙස සංක්‍රමණය නොවූ දැනුම් සම්භාරය තම කලාපයට අදාල සුවිශේෂී දේශීය දැනුම ලෙස තවදුරටත් පවතිනු ඇත.

දිවයිනක් වශයෙන් පිහිටා තිබීම හා ප්‍රධාන භාෂාව එම දිවයිනට පමණක් සීමාවීම නිසාද, දේශීය දැනුම භාෂාව තුල ගැබ්වී ඇති නිසාද ශ්‍රී ලංකාව සතු දේශීය දැනුම ලෝකයේ අද පවතින සුවිශේෂී දේශීය දැනුම් සම්භාරයක් වේ. පුරාණ කාලයේ දේශීය දැනුම ලේඛනගත කිරීමක් නොතිබූ නිසාද, ලේඛන ගත කල දේශීය දැනුම වුවද විවිධ ගැටපද හා පද්‍ය තුලින් පිටස්තරයන්ට තේරුම් ගැනීමට නොහැකි වීම නිසාද තම දේශීය දැනුම තව දුරටත් ශ්‍රී ලංකාව හා අදාල ජන සමාජයට හෝ ප්‍රවීණයන්ට පමණක් සීමා වී ඇත.

වියළි කලාපීය රැලි බිම් සහිත භූ විෂමතාව උපයෝගී කර නිම්නයක ජල බැසීම එකවරම ඍජුව සිදුවන ආකාරයට එහි ඉහල කෙලවරේ පිහිටි වැවකින් හෝ වැව් 2-3 කින් පටන් ගෙන ජල නිම්නයේ පහල කෙලවර දක්වා වැවකින් වැවකට (කුඹුරුබිම් හරහා) ගලා යන ආකාරයට පිහිටි නිම්නයක් එල්ලංගාව ලෙස හැඳින්විය හැකිය. මෙම එල්ලංගාවන් වැඩිපුරම පිහිටා ඇත්තේ වියළි කලාපීය රජරට ප්‍රදේශයේය. උතුරුමැද පළාතේ ඇති ප්‍රධාන ගංගා නිම්න 9 ශාඛා ගංගා ද්‍රෝණි 50කින් සමන්විතය. ඒ සියල්ල යලි එල්ලංගා 457 කට බෙදා දැක්විය හැකිය(පානබොක්කේ 1990)

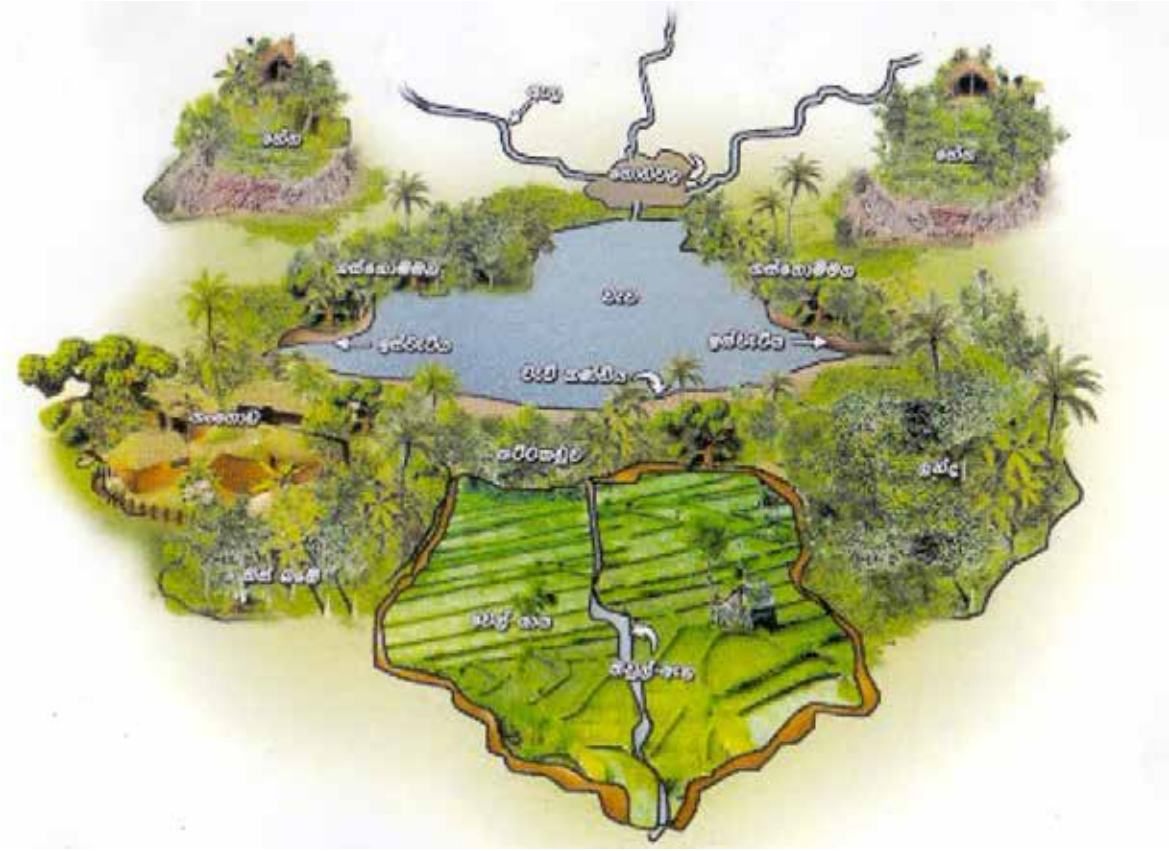
එල්ලංගා පද්ධතිය ආශ්‍රිත දේශීය දැනුම, අතීතයේදී නිර්මාණ බිහි කිරීම සඳහා යොදාගෙන ඇති දේශීය දැනුම, දේශගුණය පුරෝකථනය කිරීම සඳහා ජන සමාජය සතු දේශීය දැනුම සහ අනුහුරු වීමේ ක්‍රියාවන් ක්‍රියාත්මක කිරීමේදී යොදාගන්නා දේශීය දැනුම යන ආකාරයට කොටස් තුනකට බෙදා දැක්විය හැකිය.

එල්ලංගා පද්ධතිය සහිත මෙම ප්‍රදේශවල ප්‍රධාන ජීවනෝපාය වන්නේ කෘෂිකර්මයයි. දේශගුණ විපර්යාසවල ප්‍රධාන බලපෑම් වශයෙන් නියඟය හා ගංවතුර ඉදිරිපත් කළහැකි අතර මෙම බලපෑම් වලට හේතුවන ආන්තික තත්වයන් දක්වා වර්ෂාව අඩුවීම හෝ වැඩිවීම, අක්‍රමවත් ව්‍යාප්තිය ආදියද සුළඟ වැනි කාලගුණ සාධකවල අහිතකර තත්වයන් යන ආදිය මග හැරීම සඳහා ද දේශීය දැනුම යොදාගෙන ඇත.

එල්ලංගා පද්ධතිය තුල වූ ප්‍රධාන අංග ලෙස කුළුවැව්, මුදුන් ඇල, උඩත්තාවේ වැව්, යටත්තාවේ වැව්, ශාඛා මුදුන් ඇල, හින්න, ඇලවක, ගොඩවල වැව් යනාදිය හඳුන්වා දිය හැකිය.

එල්ලංකා පද්ධතිය තුල ගොඩනැගුන උත්කෘෂ්ට භූමි පරිහරණ රටාවක් ලෙස ශ්‍රී ලංකාවේ පුරාණ කාලීන වැව් ගම් සංකල්පය ඉදිරිපත් කල හැකිය. වැව් ගමක ප්‍රධාන අංගයන් වන්නේ ගස්ගොම්මන, පෙරහන, ඉස්වැටිය/පෝටාවැටිය කිවුල් ඇල, කට්ටකාණුව, මහවෙල, කුරුළුපාලුව, ගම්ගොඩ, විහාරස්ථානය යන ඒවාය. මෙයට අමතරව එල්ලංගා පද්ධතිය තුල පිහිටි වැව්වල දක්නට ලැබෙන බිසෝකොටුව සහ පද්ධති එකිනෙකට යාකරන යෝධ ඇළද දේශීය දැනුම භාවිතයෙන් ගොඩනැගුණු සුවිශේෂී නිර්මාණ වේ.

කුඩා වැවක් සහිත පරිසර පද්ධතියක අංග



අතීතයේ සිදුකර ඇති නිර්මාණ සඳහා භාවිතාකර ඇති එක් එක් දේශීය දැණුම පිළිබඳ සලකා බැලීමේදී එල්ලංගාවේ ඇති එක් එක් අංග වලට යොදාගෙන ඇති දේශීය දැණුම එමගින් සිදුකර ඇති අනුහුරු වීමේ ක්‍රියාවලිය පිළිබඳ පැහැදිලි කිරීම් පහත සඳහන් කර ඇත.

කුළුවැව් යනු අදාල මහවැවට ඉහලින් පිහිටි සොරොව්, වාන් ආදි ව්‍යුහයන් රහිත කුඩා ජල තටාකයන්ය. මෙම කුළුවැව්වලට පහලින් පිහිටි මහ වැවේ ජල මට්ටම අඩුවන විට භූගතව ජලය සැපයීම මගින් නියගයේ ආදීනව අඩුකර ගැනීමද, නියන් කාලවලදී සතුනට ජලය ලබා දීමේ ප්‍රභවයක් ලෙසද ක්‍රියා කර ඇත. අධික වර්ෂාවකදී ගලන ජලයට එකතුවන රොන් මඩ කුළුවැව් වල නවතාගෙන මහවැවේ ධාරිතාව අඩුවීම වැලැක්වීමටද මෙම කුළුවැව් ක්‍රියා කරනු ඇත.

වැව තුල වැවේ ජලමට්ටම හා ගොඩබිම අතර කොටසේ ස්ථාන ගත වී ඇති ගස් ගොම්මන නම්වූ වෘක්ෂ ගොනුව මගින් උඩාවතේ සිට වැවට ගලා එන අධික සුළඟ වෙනත් අතකට හරවා යවා වැවේ වාෂ්පීකරණය අඩුකර වර්ෂාව රහිත කාලවලට වැව මගින් වැඩි ජල සම්පාදනයක් සිදු කිරීමට අවශ්‍ය දැනුම පැරැන්නන් සතුව තිබී ඇත.

අධික වර්ෂාවකදී වැවට ගලා එන රොන්මඩ හා කුණු රොඩු අඩිය වැවට ඉහලින් පිහිටි තෘණපිටියක් ලෙස පවතින පෙරහන් මගින්ද ඉතා කුඩා අඩි 11 Xක ගොඩැල්ලක් ලෙස වැව්පිටියට ඉහලින් වැව් බැම්මට සමපාත වන ආකාරයට පිහිටි ඉස්වැටිය/පෝටාවැටිය මගින්ද රොන්මඩ වැවට ගලා ඒම වලක්වා අධික වර්ෂාවේ බලපෑම් මගින් වැව ගොඩවී ධාරිතාව අඩුවීම අවමකරයි.

වැවට ඉහලින් පිහිටි කැලය "තහනම් කැලය" ලෙස නම්කර එයට ඇතුල්වීම, සතුන් දඩයම් කිරීම තහනම් කර තිබූ අතර එම කැලයෙන් පිටතදී තෝරාගත් සතුන් සමහරක් (උදාහරණ: වල් ඌරා) දඩයම් කිරීමට අවසර දී තිබුණි. වියළි කාලගුණ ප්‍රවාහය (Dry Weather Flow) ඇතුළු වැවට ජලය ලබා ගැනීමට පෝෂක ප්‍රදේශයක් තිබිය යුතු බවත් සත්ව කොට්ඨාශයක් සඳහා තහනම් කැලයේ ධාරිතාව ඉක්මවීමෙන් පසු සතුන් කැලයෙන් එලියට ගමන් කරන බවත්, එම සතුන් ඉවත්කිරීම අදාල සත්ව කොට්ඨාශයේ පැවැත්මට හානියක් නොවන බවත් පැරැන්නන් අවබෝධ කර සිටි බව පැහැදිලිය.

දකුණු වියළි කලාපයේ වලවේ නිම්නයේ සොරොව්වක් රහිත අත්හැර දමන ලද වැව් වර්ගයක් හමුවූ අතර 1960 දශකයේ වලවේ නිම්නයේ සිදුකරන ලද සමීක්ෂණයකින් හෙළිවී ඇත්තේ මෙම වැව් බැමි සියල්ලේම කෙලවර පහල දිශාවට වක්‍රවන පරිදි සකස් කොට ඇති බවය. මෙම වැව් ඉටුකළ කාර්යය වූයේ නිසි කාලයේ දිය සීරාව අධික නිම්න දෙපස උස්බිම් කරා ජලය එසවීම බව අනාවරණය වී තිබේ. (ඉංජිනේරු පී. ඒ. ජි පරනමාන)

හේන් වගාව හැමවිටම වැව දෙපැත්තෙන් වැවට ජලය ගලා එන ප්‍රදේශ මග හැර සිදු කල අතර පාංශු හායනය සිදුවීම අවම කිරීම සඳහා වාර 2-3 කට වරක් එකම හේන වගා නොකර වල් වැදීමට අතහැර දැමීම, එක් වරක් වගා කරන ලද හේනක් වල් වැදීම සඳහා අවම වශයෙන් වසර 810ක් යොදා ගැනීමත් මගින් පස සරු කිරීමේ ක්ෂුද්‍ර ජීවී මෙහෙය පිළිබඳ දැනුම පැරැන්නන් යොදාගෙන ඇත.

හේන්වල පොදුවේ හා විශේෂයෙන් යල කන්නයේ වගාවන් සඳහා නියන් වැටකොළු, ගොඩ කැකිරි ආදී නියන් ප්‍රතිරෝධී බෝග වර්ග, වර්ෂාව රහිතව පින්නටත් කිරිවදින නියන් ප්‍රතිරෝධී වී වර්ග (පච්චපෙරුමාල්) යන ආදිය පිළිබඳ දැනුමද, ජීවන කාලය අඩු බෝග, මතුපිට පස වියලීම අඩු කරන ක්‍රමවේද ආදිය පිළිබඳ දැනුමද භාවිතාකල පැරැන්නන් අබණ්ඩ බෝග වගාව සිදු කරන ලදී. වියලි කාලවලදී සිටුවන පැල වලට ජල සම්පාදනය අපහසු වන අවස්ථා වලදී කෙසෙල්කැන කපාගත් කෙසෙල් ගසක අල කැලිවලට කපා පැල සිටුවන වලේ පැලයේ මුල් සහිත ප්‍රදේශය ආසන්නව තැම්පත් කිරීම මගින් සති 23ක් ජලය රහිතව පැලය මුල් ඇද්දවීම සිදුකිරීම දේශීය දැනුම තුලින් කෘෂිකාර්මික නියගයේ බලපෑම් අවම කිරීම සඳහාවූ එක් උදාහරණයකි.

කුඹුරු හා අනෙකුත් පහත්බිම් වල ජල වහනය අඩු තත්වයන්ට ඔරොත්තු දෙන බෝග වර්ග (වී, කොහිල ආදිය) සහ ගංවතුර නිසා වැඩිකාලයක් ජලයෙන් යටවීමට ඔරොත්තුදෙන වී වර්ග (දෙවැරද්දිලි) තේරීම පිළිබඳ දැනුම පැරන්නන් සතුවිය.

වැවේ බැම්මට වහාම පහලින් කට්ටකාණුව නමැති ජලය රඳන වගුරු බිම් සහිත ප්‍රදේශය මගින් වැව් බැම්මේ ජලය කාන්දුවීම නිසා ඇතිවන නාලාකාර ව්‍යුහ වලට බාධා ඇතිකර යම්කිසි ආකාරයකට බැම්මට දිගු කාලීනව සිදුවන හානිය වැලක්වීමට හැකි බව පැරැන්නන්ගේ ඉංජිනේරු දැනුම තුල ගැබ් වී ඇත.

අධික වර්ෂාව සහිත කාලවලදී වැව් ජලයෙන් පිරීම නිසා වැව් බැම්මට ඇතිවන පීඩනය අඩු කිරීම සඳහා පිටවාන සහ සොරොව්ව සකස් කර ඇත. සෘජුවම සොරොව්වෙන් ජලය පිට කිරීමට යාමේදී සොරොව්ව ප්‍රදේශයට වැවේ මුළු ජල පීඩනයට බලපානු ඇත. මෙම තත්ත්වය මග හැරීම සඳහා පැරැන්නන්ගේ දේශීය දැනුම යොදාගත් විශිෂ්ඨ නිර්මාණයක් වන බිසෝකොටුව යෙදාගෙන ඇත.

අඩි 30-40ක් උස් වූ වැව් බැම් සහිත වැව්වලින් වැකන්ද හරහා සොරොව්වට එමගින් ජලය පිටතට ගැනීමට මෙම නිර්මාණය (බිසෝකොටුව) උපකාරී වේ. බිසෝකොටුව යනු වැවේ ජලය ඇති පැත්තේ ඇති සෘජුකෝණාශ්‍රාකාර ළිඳකි. ප්‍රථමයෙන් වැව් ජලය එයට ඇතුලුවේ. අනතුරුව එහි අනෙක් පස ඇති සොරොව් දොරටුවෙන් ජලය වැකන්ද හරහා පිටවී යයි. බිසෝකොටුව නොතිබුණේ නම් සොරොව්කට ප්‍රදේශයට වැවේ මුළු ජල පීඩනයම බලපානු ඇත. එසේම සොරොව්ව ඔස්සේ එම අධික පීඩනයට අනුරූප වූ ජල ප්‍රමාණයක් වේගයෙන් ගලනු ඇත. මෙම අධික පීඩනය හා ජල වේගයද සොරොව්වට සහ වැකන්දට හානිකරය. අධික ජල පීඩනය නිසා වැකන්දට සොරොව්වේ බිත්ති හරහා ජලය කාන්දුවිය හැකි අතර එමගින් වැකන්ද තුල ජල පීඩනය ඉහළ ගොස් වැකන්දට හානි සිදුවිය හැකිය. අධික ජලවේගය නිසා සොරොව්ව හා එහි විවර ඛාදනය විය හැකිය. බිසෝකොටුව නිසා මෙම හානිකර තත්ත්වයන් දෙකම සමනය කෙරේ.

බිසෝකොටුව නිසා වැවෙන් පිටවන ජල ප්‍රවාහ රේඛා (Stream lines) දිග වැඩිවේ. මේ නිසා දුස්ස්‍රාවිතාවය හේතුකොටගෙන සොරොව්වකට අදාල ජල පීඩනය අඩුවේ. මේ නිසාම සොරොව්ව හරහා ගලන ජල පරිමා

සීඝ්‍රතාවයද අඩුවේ. මේ ජල පීඩනය අඩුවීම නිසා බිසෝකොටුව තුල ජල මට්ටම වැවේ ජල මට්ටමට වඩා අඩුවෙන් පවතී.

බිසෝකොටුව හා ඒ අවට අනුකූල ජල ප්‍රවාහයක් ඇති වුවහොත් දුස්ස්‍රාවිතා බලවලට අමතරව ජලයේ ගැටුම්කාරී ස්වභාවය නිසාද පෙර සඳහන් පීඩන සමනය වීම සිදුවේ. එය ජලය ජලයේම ගැටී සිදුවන පීඩන සමනයක් ලෙස හැඳින්විය හැකිය. මේ සියලු ආවරණයන් සිදුවීම සඳහා බිසෝකොටුව තරමක් විශාල විය යුතුයි. එසේම බොහෝ පැරණි බිසෝකොටුවල දැකිය හැකි පරිදි බිසෝකොටුවට ජලය ඇතුල්වන විවරයේ ප්‍රමාණයට වඩා පිටවන විවරයේ ප්‍රමාණය විශාලවීමද ඉහත ආවරණවලට අනුබල දෙන්නකි. ද්‍රෝනියක අධික වර්ෂාවකදී ගංවතුර තත්වයන්ට සහ නියන් කාලවලදී ජලසම්පාදනයටද අනුහුරුවීම සඳහා බිසෝකොටුව නිර්මාණයට අදාල දේශීය දැනුම පැරැන්නන් සතුවිය.

යෝධ ඇල පද්ධතිය පැරැන්නන්ගේ සුවිශේෂී දේශීය දැනුම යොදා නියඟය, ගංවතුර ආදී ව්‍යසනයන්ට අනුහුරුවීම සඳහා නිර්මාණය කර ඇත. අතීතයේ විවිධ ජල ද්‍රෝණිවල ජලය ගබඩා කිරීම, ද්‍රෝණි හරහා ජලය ගෙනයාම, භූගත ජල මට්ටම පවත්වාගෙන යාම හා මානව හා සත්ත්ව අවශ්‍යතා සඳහා ජලය සැපයීම වැනි ජල කළමනාකරණ කාර්යයන් සඳහා යෝධ ඇලවල් රාශියක් නිර්මාණය කර තිබුණි. වැව් ද්‍රෝණියේ සිට ජලය අඩු ද්‍රෝණියට ජලය ගෙනයෑම, වැවකින් වැවකට ජලය ගෙනයෑම, අතිරික්ත ජලය ගබඩා කිරීම සඳහා වැවකට ගෙනයෑම වැනි දියවර හුවමාරු අවශ්‍යතා යෝධ ඇල පද්ධතිය මගින් අතීතයේදී සිදුකරගෙන ඇත. මෙය ස්වභාව ධර්මය මගින් ඉටුකර නොදුන් දෙයක් මිනිසා විසින් නිර්මාණය කිරීමක් ලෙස හඳුන්වාදිය හැකිය.

යෝධ ඇලේ බැම්ම වැව් බැම්මකට සමානය. මෙහි බැම්ම සාදා ඇත්තේ යටි පැත්තට පමණි. ඇලේ උඩුපැත්ත බොහෝවිට සුළු බෑවුම් සහිත බිමකි. යෝධ ඇලේ උඩාවතේ පිහිටි එල්ලංගා වලින් ගංගා ජලය යෝධ ඇලට එකතු වේ. මෙලෙස එල්ලංගා වලින් ගලා එන ජලය වැසි ජලය හා එක් රැස්වූ විට එය නිතර වැවක් සේ වතුර පිරී පවතී. යෝධ ඇලෙන් පහළ පැවති කෙත්වතුවලට පමණක් නොව විශේෂ තත්ත්ව යටතේ යෝධ ඇලේ ඉහළ පැවති කෙත්වතු වලට හා එල්ලංගා වලටද ජලය සපයා ඇත.

යෝධ ඇල නිසා පරිසර සංරක්ෂණයද සිදුවේ. වැව්වලට උඩහින් (උඩාවතේ) යෝධ ඇල ගමන් කිරීම නිසා වැව්වලට රොන්මඩ ගලා ඒම වැළකී තිබුණි. වැව්වල වතුර පාලනය කරමින් වැඩි වතුර ඒම වළක්වා තිබුණි. මහ කන්නයේදී වර්ෂාවෙන් යෝධ ඇලට එකතු වන ජලය අවශ්‍ය වැව් කරා ගෙන ගොස් ජලය බෙදා දී ඇත.

යෝධ ඇලේ කැපී පෙනෙන ලක්ෂණ වන්නේ අඩු ගැඹුරය. මෙමගින් වියළි කාලවලදී ඇලේ ජල මට්ටම පොළව මට්ටමින් පහළ බැසීම හා එම කාලවලදී අවට ප්‍රදේශයෙන් ජලය ඇලට කාන්දුවීම වළක්වා භූ ජල මට්ටමක පවත්වා ගැනීමට සිදුවේ. තවද යෝධ ඇලේ ජලය පහළට ගලන්නේ ඉතා හෙමින්ය. මෙමගින් වේගයෙන් ගලායන ජලය සමග පැමිණෙන රොන් මඩ ප්‍රමාණය අවම කර ඇත.

යෝධ ඇලේ ඇලවංගු තුල පිහිටා ඇති දියකලි ලෙසින් හැඳින්වෙන දියකඩිත්ත මගින් අවුරුද්දේ හැමදාටම වනගත සතා සිවුපාවන් සහ අලි ඇතුන්ගේ ජල අවශ්‍යතාවය සපුරාලයිය. මෙම "දියකලි" සදාකාලික දිය උල්පත්ය.

යෝධ ඇල ගලා ගිය ප්‍රදේශය පුරාවට භූගත ජලය උස් මට්ටමකින් පවත්වාගෙන යාමට අවශ්‍ය දැනුම් සංභාරයක් පැරැන්නන් සතුවිය. මේ නිසා යෝධ ඇල ආශ්‍රිත සශ්‍රික වැව් ගම්මාන රැසක් බිහිවිය. භූ ගත ජලයෙන් පෝෂණය වූ පාරිසරික පද්ධතියක් නිර්මාණය විය. වාෂ්පීකරණය පාලනය කිරීම සඳහා ඇල දොල ගහකොළ වලින් බරිත විය.

එල්ලංගා පද්ධතිය තුල ගොඩනැගී ඇති සුවිශේෂී නිර්මාණවලට පාදකවූ දේශීය දැනුමට අමතරව එහි ජනසමාජය තුල කෘෂිකර්මයට හා ජනජීවිතයට අදාල කාලගුණය හා දේශගුණය පිළිබඳ පුරෝකතනය කිරීම සඳහා වූ දේශීය දැනුම් සම්භාරයක් අද දවසේ පවා දක්නට ඇත. මෙම පුරෝකතනය කිරීම් විශේෂයෙන්ම වායුගෝලයේ හැසිරීම, සත්ව චර්යා හා ශාඛවල විශේෂ ලක්ෂණ ආදිය මත පදනම්වී ඇති අතර වැඩි දැනුම් සම්භාරයක් වර්ෂාවට හා නියඟයට අදාලව පැරණි පුස්කොළ පොතක්වූ "වැහි ලකුනු ශාස්ත්‍රය" චන්ද්‍ර හා සූර්යග්‍රහ මන්ඩල ලකුනු, ග්‍රහ පිහිටීම්, වාළාකුළුවල ස්වභාවය, හැඩය, ප්‍රමාණය, විසිරී ඇති රටාව, පාට, පිහිටන දිශාව, දේදුනු ලකුනු, දවස, දවසේ කාලය, නැකත ආදී ලක්ෂණ අනුව දවසක, සතියක, මාසයක හා මාස හයක පමණ ඉදිරි කාලයේදී වර්ෂාව පැවතීම හෝ වර්ෂාව නොමැතිවීම පිළිබඳ පුරෝකතනයන් 85 ක් පමණ ලිඛිත දේශීය දැනුම ලෙස ඉදිරිපත්කර

ඇත. උදාහරණ ලෙස "කැළැ මල් ගිනෙර මල් රත් නෙළුම් මල් ඇත් ගිජුලිහිණියන් වැනි වළා හිරුට පෙර පෙනේනම් සත් දවසකින් වසී කියනු. ඉන්ද්‍ර කොන ඊසාන කොන දෙව්දුනු (දේදුනු) පෑව වැසි බොහොම වසී කියනු. මා නැකතින් දෙව්දුනු පෑව වැසි මඳ කියනු. ඇසළ නිකිනි පුර පෑලවිය මැදින් දින පෝය දවස්වල ඉඳුරු දෙසින් විදුලිය පෙනුනොත් සතියෙන් වසී. ඉන්ද්‍ර දිගින් රාහු ගත වැසි බොවේ. කුජ ශ්‍රාවධිපති වූ විට වැසි නෙවැටේ. වප් උදුවප් සංක්‍රාන්තිවල මධ්‍යම වැසි ඇතිවේ. කුජ රවිට පසුව හා ඉදිරියෙන් ගමන් කරනවිට පිළිවෙලින් බිඳුනු කලයක් මෙන් වැසි වැටීම හා අහම්බෙන් ලැබෙන වැසි ද වියලීම සිදුවේ."

ක්ෂීරපායී, උරග, උභයජීවී, පක්ෂී හා කෘමි යන ජීවී කාන්ඩවල සත්ව චර්යා මගින් වර්ෂාව හා නියගය පිළිබඳ පුරෝකතනයන් ලබාගත හැකි අතර එවායින් කිහිපයක් පහත දක්වා ඇත. වඩු කුරුල්ලන් ගස්වල (විශේෂයෙන් වැව් ඉස්මත්තේ) ඉතා ඉහල හෝ ඉතා පහල අතුවල කැදලි සෑදුවහොත් පිළිවෙලින් එලඹෙන වැසි සමය අධික හෝ ඉතා අඩු(නියග) වැසි සහිතය. උලලේනා වර්ෂා හෝ නියත් කාලවල කෑගැසීම පිළිවෙලින් නියත් හෝ වර්ෂා කාලයක් පැමිණෙන සලකුණකි. කෑදැත්තා දහවල් කාලයේ කෑගැසීම හා උකුස්සා ඉතා ඉහල අහසේ පියෑඹීම වර්ෂාව ලඟ ලඟම පැමිණෙන නිමිති වේ. හිඳුන වැවක වැව් පිටියේ වැව් බැම්මට ආසන්නව. වැව් පිටිය මැද හා ඉහත්තාවේ කිරළා බිත්තර දැමීම පිළිවෙලින් ඉදිරි කන්නය වර්ෂාව රහිතය. තරමක වර්ෂාවක් සහිත හා අධික වර්ෂාවක් සහිත කන්නයකි. කාක් කුඩුවක සිටින පැටවුන් ගණනින් එනම් පැටවුන් 1 හෝ 3 නම් ඉදිරි මහ කන්නයේ හොඳ වර්ෂාවක්ද, පැටව් දෙදෙනෙකු නම් තරමක අඩු වර්ෂාවක්ද ලැබේ. ග්‍රීෂ්ම සමයේ කටුස්සන් එක දිගට කෑගැසීම (සිවුරුවම්බෑම) ඉදිරි සතියේදී වර්ෂාවක් ඇතිවන නිමිත්තකි. කුඹුරේ/තණ පිටියේ බැදි ගවයින් වැසි සමයේ උදේ වරුවේ ඉතා උවමනාවෙන් තණ බුදිනම් සවස් වරුවේ වැසි ඇතිවිය හැකි අතර උදේ වරුවේ ඉතා කුසීතව උලා නොකා සිටියි නම් සවස් වරුවේ වැසි රහිත කාලගුණයක් පවතී. ඩුගුලුමා (නීලගොයා) උදය වරුවේ දිගින් දිගටම කෑගැසීම සිදුකරයි නම් හවස හෝ රාත්‍රී කාලයේ වර්ෂාව ලැබිය හැකිය. බළලා කලබලයෙන් ඔබ මොබ දුවමින් කොට්ට මෙට්ට දොර ජනෙල් පහුරුගෑම වැසි කුනාටුවක පෙර නිමිත්තකි.

සමහර ශාඛ වල මල් පිපීම, ඵල හටගැනීම යන ආදී ලක්ෂණ මගින් වර්ෂාව හා නියගය පිළිබඳ පුරෝකතනයන් ලබාගත හැකි අතර එවායින් කිහිපයක් පහත දක්වා ඇත. ගඩාගෙඩි (කරඹ, දඹ, හිඹුටු) අවාරේ හටගත්තොත් එළබෙන සමයේ වැසිඵල ඉතා අඩුය. වනාන්තරයේ පලු හා වීර ගස්වල ඉතා හොඳින් ඵල දැරීම ඉදිරි මාස්කන්නයේදී අධික වර්ෂාපතනයක පෙරනිමිත්තකි. කරඹ මල් අදික ලෙස පිපීම ඉදිරි මාස්කන්නයේදී අඩු වර්ෂාපතනයක පෙරනිමිත්තකි.

නියගයේ ආදිනව සමනය කිරීම සඳහා භූගත ජලය සම්පාදනයේදී ජලය පවතින ගැඹුර, ජල ප්‍රමාණය, ජලයේ ගුණාත්මය යන ආදිය පුරෝකතනය කිරීමේ හැකියාව පිළිබඳ දැනුම අද දවසේ පවා එල්ලංකාවේ වැසියන් අතර පවතියි. යම් ස්ථානයක ස්වාභාවිකව වැවී ඇති ශාඛ, පස මතුපිට පවතින වැනි ව්‍යුහ, පස් තට්ටු වල පාට යන ආදී සාධක අනුව භූජල මට්ටම පොලව මතුපිටට ඇති දුර, ජලය ගලාඑන දිශාව, ලබාගතහැකි ජලයේ ප්‍රමාණය හා ගුණාත්මය ආදිය පිළිබඳ දැනුම දගාර්ගලය (වරහාමිහිර - ක්‍රි.ව. 5 වන සියවස) නම් ග්‍රන්ථයෙන් ඉදිරිපත් කර ඇත. මෙම ග්‍රන්ථයේ දැනුම් ඒකක 100කට වැඩි ප්‍රමාණයක් සඳහන් කර ඇති අතර එයින් කිහිපයක් පහත සඳහන් කර ඇත.

ස්වාභාවිකව වැඩුනු කොටදිඹුලා ගසක් සමීපයෙහි තුඹසක්වේද එයට බටහිර පැත්තෙන් තුන් රියනකට ඈතින් අඩි19 1/2 කට යටින් ජල නහරයක් ඇත. ස්වාභාවිකව වැඩුනු බුළු ගසකට දකුනු පැත්තෙන් තුඹසක් වේද, ඒ තුඹසට නැගෙනහිර පැත්තෙන් අඩි 9ක් දුරින් දිය සීරාවක් ඇත. ජලය අඩු යම් පෙදෙසක ඉගුරු, බෙරු තණ, හා ඊ තණ පඳුරු දක්නට ලැබේද, එහි අඩි 6ක් යට කැපුකල වතුර ලැබේ, යම් තැනෙක කටුවැල්බටු පඳුරක කටු රහිතව සුදු මල් පමණක් දක්නට ලැබේද, එයට යට අඩි 21 ක් කැපූකල ජලය ලැබේ.

ආශ්‍රිත ලේඛන

කපිල පීරිස්, (2007). කළිඟුල සැකැස්ම, කළිගු බැමි සහ කාලිංග ඇළ (පුවත්පත් ලිපිය), විදුසර විද්‍යා සඟරාව

කපිල පීරිස්, (2008). රජරට වැව්වල වැදගත්කම (පුවත්පත් ලිපිය), විදුසර විද්‍යා සඟරාව

කපිල පීරිස්, හේරත්, එච්.එම්.එල්.යු (2008.12.17). යෝද ඇළ නිසා ජය ගඟ අනා ගැනීම (පුවත්පත් ලිපිය), විදුසර විද්‍යාව සඟරාව

කපිල පීරිස්, සහ අන් අය (2013.07.17). ශ්‍රී ලංකාවේ ජාතික ඉංජිනේරු තාක්ෂණ උරුමයන් (පුවත්පත් ලිපිය) කොටස බිසෝකොටුව, විදුසර විද්‍යා සඟරාව

ජෛවවිවිධත්වය හා බැඳුනු පාරම්පරික දැනුම් සංග්‍රහය (පළමුවන වෙළුම) (2005) ISBN 9559120379 ජෛවවිවිධත්වය හා සම්බන්ධ ආනාවැකි පල කිරීම, සංනිවේදනය පිළිබඳ පාරම්පරික දැනුම කොටස, ජෛවවිවිධත්ව ලේකම් කාර්යාලය පරිසර හා ස්වාභාවික සම්පත් අමාත්‍යාංශය. පිටු 57 - 61

ජෛවවිවිධත්වය හා බැඳුනු පරම්පරික දැනුම් සංග්‍රහය (දෙවන වෙළුම) (2006) ISBN 9559120751 ජෛවවිවිධත්වය හා සම්බන්ධ ආනාවැකි පල කිරීම, සංනිවේදනය පිළිබඳ පාරම්පරික දැනුම කොටස, ජෛවවිවිධත්ව ලේකම් කාර්යාලය පරිසර හා ස්වාභාවික සම්පත් අමාත්‍යාංශය. පිටු 53 - 63

ජෛවවිවිධත්වය හා බැඳුනු පාරම්පරික දැනුම් සංග්‍රහය (තෙවන වෙළුම) (2009) ISBN 97895500330304 අනාවැකි පල කිරීම් කොටස, ජෛවවිවිධත්ව ලේකම් කාර්යාලය පරිසර හා ස්වාභාවික සම්පත් අමාත්‍යාංශය. පිටු 51 - 55

තෙන්නකෝන්, එම්.යු.ඒ (2005). ISBN 955206872X, වියළි කලාපීය පරිසරානුගත සංවර්ධනයක් සඳහා එල්ලංගාව (ග්‍රන්ථයෙහි) කොටස් අංක 01 සිට 05, ඇස්. ගොඩගේ සහ සහෝදරයෝ. පිටු 21 - 28

මතුගම සෙනවිරුවන් (2005). යලට මහට කලට ගොවිතැන (ග්‍රන්ථයෙහි) වැසි ලකුණු ශාස්ත්‍රය, සරුකෙත ව්‍යාපාරය. පිටු 01 06.

වරාමිහිර (ක්‍රී.ව. 5 සියවස) බෘහත් සංහිතාවය පරිච්ඡේදය දගාර්ගලය. සංශෝධනය හා පරිවර්තනය සේනානායක ජී.එස්.බී (1986). ඇස්. ගොඩගේ සහ සහෝදරයෝ. පිටු 13 – 28

Climate change and infectious diseases

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Introduction

United Nations Framework Convention on Climate Change (UNFCCC) defines that climate change is the change that can be attributed "directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". This is a crucial threat to the world environment, caused by the human activities and their mishandling of resources. Mankind always alters and renews the natural resources in terms of development, without considering its environment. Continuous process in this nature will widely affect the entire eco-system of the globe and consequently meteorological conditions (wind, rain, snow, sunshine, temperature, *etc*.). This will adversely affect the socio-economic condition of a nation, generating multifarious infectious diseases.

Each of the last 3 decades has been continuously warmer than any preceding decade since 1850. Over the last five decades, human activities, particularly burning of fossil fuels and clearing of forest, have released more carbon dioxide and other greenhouse gases to the atmosphere, which trap additional heat in the lower atmosphere and affect the global climate adversely (UNFCCC, 2010). Increases in average global air and ocean temperatures, widespread melting of snow and ice, rising average global sea levels and changing of precipitation patterns are a few major adverse effects caused by the climate change. Moreover, this situation generates eligibility for emerging infectious diseases to new places and new hosts. Researchers have found that there is a close link between local climate and the occurrence or severity of diseases and other human health related threats.

Correlation between climate change and infectious diseases

Climate change accelerates the spread of diseases, primarily because warmer global temperatures enlarge the geographic range in which disease carrying animals, insects and microorganisms as well as the germs and viruses can survive. In addition, changing weather patterns and climatic conditions affect the diseases shift *via* vectors such as mosquitoes (vector-borne disease) or through rodents (rodent-borne disease). The malaria and dengue fever are transmitted by mosquitoes, which cannot survive if temperatures are too low. Further, climate restricts infections, limiting the distribution of other species that are required for disease transmission. More predictable as climate change unfolds is the spread of so-called waterborne infections.

These infections most often cause diarrheal illness and flourish in the wake of heavy rainfalls as runoff from land enters into and may contaminate water supplies. Many pathogens that cause diarrheal disease reproduce more quickly in warmer conditions as well.

World Health Organization (2012) states that the average atmospheric temperature rose by about one degree Fahrenheit in the last quarter of the 20th century. This increase was responsible for the

annual loss of about 160,000 lives and the loss of 5.5 million years of healthy life of nature. Further, it estimates that the climate change contributes to 150,000 deaths and 5 million illnesses each year, due to the contamination of air, water, soil and food. Climate-sensitive diseases are among the largest global killers. Diarrhea, malaria and protein-energy malnutrition alone caused more than 3.3 million deaths globally in 2002, with 29% of these deaths occurring in the region of Africa. Deadly diseases often associated with hot weather, like the West Nile virus, Cholera and Lyme disease, are spreading rapidly throughout North America and Europe because increased temperatures in these areas allow disease carriers like mosquitoes, ticks, and mice to thrive ((UNFCCC, 2010). Further, it records approximately 2.4% of worldwide diarrhea and 6% of malaria in some middle-income countries (WHO, 2010).

Types of infectious disease

The Inter-governmental Panel on Climate Change noted in its 2007 report that climate change may contribute to expanding risk areas for infectious diseases. Types of such diseases are elaborated below.

Water-borne diseases

A warmer climate could cause water-borne diseases to become more frequent, including cholera and diarrhoeal diseases; such as giardiasis, salmonellosis and cryptosporidiosis. Diarrhoeal diseases are already a major cause of morbidity and mortality in South Asia, particularly among children. It is estimated that one-quarter of childhood deaths in South Asia are due to diarrhoeal diseases. As rising ambient temperatures increase bacterial survival time and proliferation, the incidence of diarrhoeal diseases might further increase (WHO, 2012).

Cholera is a well-known water-borne disease that has afflicted humankind since ancient times. Outbreaks of cholera have occurred in India, Bangladesh, and more recently, Latin America and Africa. Molecular techniques have shown that bacteria are now recognized as naturally occurring in aquatic environments, with bacterial population peaks in spring and fall in association with plankton blooms. The discovery of *Vibrio cholerae* in the natural environment, with a dormant state between epidemics, changed the understanding that this disease had only a human reservoir. A relationship has been observed between increase in sea-surface temperature and the onset of cholera epidemics, with the cholera outbreaks following the seasonal rise and fall in sea-surface height and temperature (UN, 2008).

Vector-borne diseases

The incidence of mosquito-borne diseases, including malaria, dengue, and viral encephalitides, are among those diseases most sensitive to climate. Climate change would directly affect disease transmission by shifting the vector's geographic range and increasing reproductive and biting rates and by shortening the pathogen incubation period. Climate-related increases in sea surface temperature and sea level can lead to higher incidence of water-borne infectious and toxin-related illnesses, such as cholera and shellfish poisoning. Human migration and damage to health infrastructures from the projected increase in climate variability could indirectly contribute to disease transmission. Human

susceptibility to infections might be further compounded by malnutrition due to climate stress on agriculture and potential alterations in the human immune system caused by increased flux of ultraviolet radiation (UN, 2008).

Other diseases

Climate change might affect other diseases endemic to an area. These include mosquito-borne diseases such as chikungunya fever and dengue, parasitic diseases such as leishmaniasis, lymphatic filariasis and onchocerciasis, and tick-borne diseases, which may exhibit changes in transmission intensity or shifts in their geographical ranges, due to the impact of climate on the relevant vector populations. Climatic factors might also influence human plague, a bacterial disease carried by rodents and transmitted by fleas. Temperature and rainfall are important determinants of rodent population abundance and distribution. Combined with the influence of temperature and humidity on flea survival and development, changes in any of these climatic components may result in changes in plague incidence. Murine typhus, a rickettsial disease, is also transmitted by fleas and thus may exhibit similar climate sensitivity (UN, 2008).

Conclusion

Changes in infectious disease transmission patterns are a likely major consequence of climate change. General practitioners as well as specialists can play a role in anticipating the health effects of climate change and improving the health, through discussing effective preventive health care with their patients. Measures include curriculum development for schools, supply of information to community groups and women's networks, radio and television programmes, public poster campaigns, and leadership by national figures and celebrities. Healthy ecosystems provide significant benefits for resilience, livelihoods, health care and adaptive capacity. Measures include strengthening of environmental management in areas of greatest risk from weather hazards and protecting ecosystems

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Will Climate change refugees become the world largest humanitarian crisis?

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The term "Climate change refugees" refers to people who are forced to migrate from or flee their home region due to sudden or long-term changes to their local environment which compromise their wellbeing or secure livelihood. Increasing extreme weather events such as droughts, floods and cyclones, disasters such as landslides, desertification, sea level rise, and disruption of seasonal weather patterns such as monsoons are the main climate change impacts forces to displace and migrate the people. Climate change refugees may flee to or migrate to another country or they may migrate internally within their own country. More than two decades ago, the Intergovernmental Panel on Climate Change (IPCC) warned that one of the gravest effects of climate change may be those on human migration (McTegart *et al*., 1990). Climate refugees belong to a larger group of immigrants known as environmental refugees. Environmental refugees include immigrants forced to flee not only because of climate change but also natural disasters, such as volcanoes and tsunamis (Myers, 2001).

Over the last 50 years, human activities, particularly the burning of fossil fuels, have released sufficient quantities of carbon dioxide and other greenhouse gases to trap additional heat in the lower atmosphere and affect the global climate. Rising temperatures associated with global warming cause glaciers and ice caps to melt. This can cause flooding and make sea levels rise. Rising temperatures also lead to droughts and desertification - the transformation of arable land to desert. Some of these effects, such as sea level rise, can put land completely underwater, making it uninhabitable. Others effects, such as drought, make it impossible for people in the region to support themselves.

Statistics

The International Red Cross estimates that there are more environmental refugees than political refugees fleeing from wars and other conflicts. The United Nations High Commissioner for Refugees says 36 million people were displaced by natural disasters in 2009, of whom more than 20 million were forced on the move by climate change-related factors (UNHCR, 2009). Scientists predict this number will be raised up to at least 150 million by 2050 (Singer, 2012). 55.7 million People were displaced in Asia by Sudden-Onset Climate-Related and Extreme Weather Events in 2009–2011 and 3,400,000 people displaced in South Asia due to Climate-Related and Extreme Weather Events in 2009 (ADB, 2012).

Sea Level Rise

Sea Level Rising is a major force of migration and will have increasingly serious consequences for human health and life quality, with coastal populations at risk for dislocation due to flooding.

The Intergovernmental Panel on Climate Change predicts that sea levels will rise a total of 0.18 to 0.6 meters (7 inches to 2 feet) between 1990 and 2100.

Rising sea levels already cause problems in low-lying coastal areas of the world (National Geographic, 2011). It is not only Small Island states that need to worry about sea level rise. Sea level rise increases the risk of both temporary and permanent flooding of coastal lands. Around 23% of the world population lives in the near coastal zone with population densities about three times higher than the global average (Greenpeace, 2012).

Increased storm damage to coastal infrastructure, more rapid coastal erosion, shoreline change including the possibility for total loss of protective natural barriers, saltwater intrusion into aquifers and surface waters, rising water tables, and changes in tidal prism are the major impacts of sea level rise and those factors force the coastal populations to migrate elsewhere for searching residential areas.

Bangladesh is a common example for impact of sea level rise where about half of the population lives less than 5 meters (16.5 feet) above sea level. Scientists predict Bangladesh will lose 17 percent of its land by 2050 due to flooding caused by climate change. The loss of land could lead to as many as 20 million climate refugees from Bangladesh. The U.S. state of Louisiana loses about 65 square kilometers (25 square miles) to the sea every year. More lands are eroding near the Mississippi delta. Sea level rise puts the productive fisheries around the delta at risk as wetlands are submerged. Maldives, an island nation in the Indian Ocean, is perhaps the country most threatened by sea level rise. Maldives rises only 2.4 meters (8 feet) above sea level at its highest point. Sea level rise will likely create climate refugees because of changes in both economy and habitat. Sea level rise may sink all 1,200 islands of Maldives. This would force all Maldivians to find new places to live. Maldives leaders have worked with leaders in Australia, India, and Sri Lanka to plan an evacuation program should Maldives become uninhabitable.

Natural Disasters

The world already is nearly five times as dangerous and disaster-prone as it was in the 1970s because of the increasing risks brought by climate change, according to a new report from the World Meteorological Organization. The first decade of the 21st century saw 3,496 natural disasters from floods, storms, droughts and heat waves. That was nearly five times as many disasters as the 743 catastrophes reported during the 1970s, and all of those weather events are influenced by climate change (Goldenberg, 2014). An increase of greenhouse gases in the atmosphere will probably boost temperatures over most land surfaces, though the exact change will vary regionally. More uncertain-but possible-outcomes of an increase in global temperatures include increased risk of drought and increased intensity of storms, including tropical cyclones with higher wind speeds, a wetter Asian monsoon, and, possibly, more intense mid-latitude storms (NASA, 2001). As a result of these changes of the atmosphere high intensity rainfall will be more common and ultimate outcome is flash floods and landslides. People who are living in low-lying areas and hilly areas are forced to migrate to protect themselves from the floods and landslides.

Desertification

While rising seas threaten coastal regions, drought can create climate refugees inland. When people cannot grow crops on the land where they live, they have to move somewhere else in order to survive. For example, the Gobi Desert in China expands more than 3,600 square kilometers (1,390 square miles) every year. Farmers and merchants in the area surrounding the Gobi migrate to China's crowded urban areas as grasslands are overtaken by desert. Morocco, Tunisia, and Libya each lose more than 1,000 square kilometers (386 square miles) of productive land every year to desertification. These residents on the edge of the Sahara Desert may move to cities in the Maghreb, a region of northwest Africa. They may also choose to move to the more developed countries of Europe.

Residents near the Horn of Africa are especially vulnerable to drought and desertification. Most rural residents in Somalia, Ethiopia, and Eritrea engage in subsistence agriculture. Subsistence agriculture means that the farmers produce enough crops for themselves, their families, and communities. They do not sell their produce on the national or international market. Many subsistence farmers depend on their crops to feed their livestock. Years of severe drought prevents crops from growing, which also prevents livestock from being raised. Thousands of Somalis and Ethiopians, threatened by starvation and poverty, have already fled to refugee camps in Kenya. Camps that were designed to provide temporary shelter for 90,000 people are now home to twice that number.

The Calamity

Climate change refugees are not protected by international laws. Currently, a central problem with the term 'climate refugee' is that it is not an officially recognized category under existing international law. There are no frameworks, no conventions, no protocols and no specific guidelines that can provide protection and assistance for people crossing international borders because of climate change, and while existing international humanitarian law may apply in some cases of environmental displacement, the existing rights guaranteed to refugees – specifically those of international humanitarian assistance and the right of return – do not apply. They face greater political risks than refugees who flee their homes due to conflict or political oppression. Unlike conventionalrefugees (people fleeing political oppression, religious persecution and ethnic troubles), climate refugees may be sent back to their devastated homeland or forced into a refugee camp (National Geographic, 2011).

Even the United Nations cannot help to protect people seeking safety abroad if their homes and jobs are destroyed by prolonged drought, rising sea levels or other climate change-related phenomena in the same way as if they were displaced by war or human rights abuses (UN News Center, 2014).

Most climate refugees are internal migrants. Internal migration is the process of people moving elsewhere in their own country. Often, climate refugees are rural and coastal residents who are forced to migrate to urban areas. These climate refugees face numerous problems. Skills such as herding and farming are not relevant in urban areas. Rural farmers are often more self-sufficient than many urban dwellers; they may not be familiar with depending on a corporation or other people for employment.

Climate refugees who migrate outside their home countries face other difficulties. They must adjust to different laws, languages, and cultures. Climate refugees may encounter conflict with indigenous residents. Educational and health care systems must adjust to a sudden, new population. This population may speak a different language or have different customs than the native population. Climate change may also increase the number of traditional refugees. Climate change can enhance the competition for resources like water, food, grazing lands for livestock, *etc.* and that competition can trigger conflict (Terminski, 2011).

Is the notion of labeling people climate change refugees ethical? Will climate change refugees be treated differently to political or economic refugees? What rights would climate change refugees have? Who should be responsible for their well-being and re-settlement? These are serious and yet answerless questions.

Status of Sri Lanka

Being a developing island nation subject to tropical climate patterns, Sri Lanka is highly vulnerable to climate change impacts. Extreme weather events such as high intensity rainfall followed by flash floods and landslides, and extended dry periods resulting in water scarcity are now becoming common occurrences in Sri Lanka (Climate Change Secretariat of Sri Lanka, 2011). One third of the country population, 24% of the country's land area, more than 80% of the country's fish production, rich mineral resources and tourism, along with concentration of 80% of industries are situated in the coastal region of Sri Lanka. The coastal contribution to the gross domestic production (GDP) increasing gradually to 40% by 1989.Loss of income from tourism in Sri Lanka will jeopardize the present rate of development and will also affect the attainment of human development goals (WHO SEARO, 2012).

Conclusion

Climate change which is the ultimate outcome of global warming is now universally recognized as the fundamental human development challenge of the 21st century and climate refugees are a main part of the challenge. Climate-induced Sea level rising force the communities living in coastal regions to migrate towards high land and at the same time people in the central high land to more secure places free from natural disasters. Meanwhile the farming communities in the dry zone, who are affected by the extreme weather events, are forced to migrate elsewhere for better living conditions. The climate change refugees of Maldives are another concern which affects the local socio-economic and cultural stability. Therefore, Urgent action is necessary to take adaptive measures to build resilience of the country to face the adverse impacts of climate change and address the climate refugees' problems. While taking adaptive measures as the priority, Sri Lanka should be actively involved in the global efforts to minimize the greenhouse gas emissions within the framework of sustainable development and principles enshrined in the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol.

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People's perceptions and its role in climate change actions

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Perception is a process by which people translate sensory impressions into a coherent and unified view of the world around them. Although necessarily based on incomplete and unverified information, perception is equated with reality for most practical purposes. Direct experience on climate change - inarguably a greater individual and societal threat, constrained by the individuals difficulties in detecting its effects amid the normal variation of daily weather. However, the range of increasing impacts of climate change offers the possibility that individuals may recognize other signals less subject to everyday variability, such as shifts in precipitation seasons, and trend in weather parameters. One of the reasons that people may not take action to mitigate climate change is that they lackfirst -hand experience of its potential consequences. Most studies address the potential impact of climate change based on the modelling technologies integrating available observed climatic data. However, it is important to understand the people's perception of climate change and its impact when planning and implementing the adaptation measures for the climate change impacts. This is because people's perception greatly influences the decision on whether or not and how people respond to climate change.The local perception reflects local issues/concerns and reveals that the actual impacts of climate change on people's lives, which are mainly related to local factors and may not be estimated through models only.

People's perceptions-emperical evidence

According to the people's perception obtained by household survey at Kalu and Walawe river basins in Sri Lanka, about 58% and 70% of households have perceived climate change mainly through personal experience. In addition, most of the others have comprehended climate change from various sources, (*e.g.* mass media or communication with neighbors, governmental officers and schools. Mass media are the most potential medium for the dissemination of climate related information according to the both river basins' households. Local people have perceived remarkable changes in rainfall, mainly decreasing amount of rainfall and number of rainy days in Walawe river basin and short term heavy rainfall increase in Kalu river basin during last two decades. More than 98% of households in both river basins have perceived that the timing of rainfall is irregular compared to the past. Peoples' perception obtained by household survey and climate data analyses are very similar and complementary, which demonstrates a good level of knowledge and understanding of climate change by people.

Exposure to climate change also means exposure to its various impacts such as drought, flood and *etc*. About 86% households have experienced drought and majority believed in an increase in drought frequency in the last decades in Walawe river basin. The drought events which respondents could recall that had major impacts on their livelihoods were those of the 2004 and 2013.

Respondents reported of major flood experiences in 2003 and 2008 in Kalu river basin, and majority have perceived decreasing or no any trend in increasing flood during last decades. Most disastrous impacts experienced and remembered by locals were from the past fifteen years in both basins. The flood and drought record on Disaster Information System in Sri Lanka and modeled river flow data analysis also confirmed the respondents' perception about the past hydrological disasters in the basins.

Suggestions

It provides evidence that information from household survey on local climate change, unaddressed by global climate change models is an important basis for tailoring adaptation policies. Advancing robust and resilient development policies that promote adaptation based on both local people's perception and modeling technology is needed today, as the research has provided evidence that changes in the climate will increase even in the short term at local level.

Climate Finance: Trends and Challenges

Athula Senaratne[25]

Negotiating parties from all over the world are set to gather in Paris this December to adopt the all-important legally binding global agreement on climate change, among others[26]. Though not an easy task, there is widespread optimism that the global climate change agreement will serve as a landmark in the global effort to address climate change. However, the agreement, if signed in Paris, will not magically dispel the imminent threat of climate change. Any effective response to climate change will undoubtedly require concerted efforts of all signatories. Regrettably, any effort to address climate change issues is associated with financial burdens, which particularly put developing and least-developed countries in a more difficult position as climate change tops the long list of priorities competing for limited fiscal budget. As a result, global climate finance mechanisms have captured the attention of those policy makers and interest groups who are concerned with the implementation of mitigation and adaptation efforts in poor countries.

The scale and nature of risk involved are among the most important salient factors associated with all forms of climate finance mechanisms. While the factor of risk originates from the fundamental issue that climate change is a public externality of global scale with impacts that may extend over generations, the scale of risk and uncertainties generated as a result of these spatial and temporal dimensions, along with the limited knowledge about complex atmospheric mechanisms poses significant challenges for any global or national financial mechanism. Even the global financial mechanisms that deal with long-term development challenges are not fully attuned to the disproportionate scale of risk and uncertainties presented by the phenomenon. In spite of this challenge, the governments of developed and developing nations, multilateral agencies and national institutions are striving to develop a viable system of climate finance to address the rising threat of climate change.

Architecture of global climate finance

Global climate finance architecture includes both public and private actors. Private channels of climate finance are engaged by project developers, mainly utilities and independent power producers, as well as corporate actors/manufacturers, households, commercial financial institutions, institutional investors, private equity, venture capital, and infrastructure funds. Largely concentrated in developed and emerging economies, 90 percent of funds generated through private climate finance mechanism continue to remain with source countries (Buchner *et al* 2014). Thus far the flow of private funds to developing and least-developed nations as foreign direct investments (FDI), and private investments by developing country businesses in their own countries are very low. Owing to limited inflow of FDI coupled with national financial constraints, the growing demand for renewable energy and energy efficient technologies in developing countries are largely met through increased imports from the developed countries in the North and emerging economies in Asia, in turn leading to the reverse flow of currency rather than inflow of capital. Against this backdrop, it is imperative for developing and least-developed countries to explore and seek public sources of climate finance to support climate change adaptation and mitigation efforts. In the present architecture of global climate finance, the public channel is consisted of following major components:

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26This article was first published few months prior to the historical Paris Climate Agreement in Dec. 2015

Contributors: As in the case of other forms of development assistance, the major source of public climate finance is the contributions from developed nations. Many of these countries are the Organisation for Economic Co-operation and Development (OECD) member countries. Among the key contributor nations are the United States, United Kingdom, Japan, France, Germany, Canada, European Union (EU) and Norway. Funds from contributors flow through different channels.

Bilateral aid agencies: Bilateral institutions like the Agency for International Development (USAID), Norwegian Agency for Development Cooperation (NORAD), Department of International Development (DFID) and Japan International Cooperation Agency (JICA), among others, that administer donor assistance of respective contributor countries are another important channel of climate finance.

Specialized bilateral climate funds: A part of the flow of climate finance is also channelled through specialized climate funds established by contributor countries. Global Climate Change Initiative (GCCI) of US, International Climate Fund of UK, International Climate Forest Initiative (ICFI) of Norway, International Climate Initiative of Germany and the Nationally Appropriate Mitigation Actions (NAMA) Facility offered by UK and Germany are some of the key specialized funds currently available.

Multilateral institutions: Multinational banks such as the World Bank (WB) and other Regional Development Banks, namely Asian Development Bank (ADB), Inter-American Development Bank (IADB) and African Development Bank (AfDB), as well as United Nation (UN) agencies are also a source of climate finance. Major funding facilities operated by multilateral agencies include Climate Investment Funds (CIFs) handled by regional banks and globally administered by the WB. Moreover, climate change has been identified as a priority area for funding by many multilateral institutions, and consequently several special climate focused facilities have been made available by respective institutions.

Multilateral climate funds: Besides, global funding made available by multilateral financial institutions, various UN agencies are striving to build a system of global funding facilities to assist the mitigation and adaptation efforts of member nations. The Global Environmental Facility (GEF) and Adaptation Fund are two main UN based funding facilities. Among the key agencies working to facilitate funding for climate change are United Nations Framework Convention on Climate Change (UNFCCC), United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP). In addition, specialized agencies such as the World Health Organizaiton (WHO) and Food and Agriculture Organization (FAO) have also identified climate change as a major focus area and diverted significant resources to provide technical assistance to member nations in respective areas of interest.

National climate funds: Many developing nations have also set up line ministries/agencies and specialized institutions to deal with climate change. Some countries have even established specialized climate funds for addressing national climate change issues. Major examples include China Clean Development Mechanism Fund (CCDMF), Bangladesh Climate Change Resilience Fund (BCCRF) and Indonesia Climate Change Trust Fund (ICCTF).

Global flow of climate finance

The widely quoted report on *Global Landscape of Global Climate Finance2014* published by the Climate Policy Initiative (CPI) provides some estimates about current flows of climate finance. According to the

Report, the flow of global climate finance decreased by US$30 billion in 2013 to US$331 billion. However, the number is likely a conservative estimate since capturing accurate data on government and private spending in developing and least-developed countries is a widespread issue owing to poor data availability and management. But on a positive note, the drop in global climate finance in 2013 is partly a result of the decreased cost of renewable energy technologies. As a result, the installed capacity of these technologies was higher in 2013 even under low volume of investment.

More importantly, majority of the funds (58 percent) of the total funds for climate finance was handled by private sector and approximately two-third of the total funds remained within countries of origin.[i] Sadly, this implies that only about US$80 billion of the total fund for climate finance was invested in the form of FDI in other countries, of which, a smaller portion was invested in developing and least-developed nations.[ii] Hence, public channels continue to be the major source of climate finance available to developing and least-developed countries.

In addition, a closer look at the composition of climate finance reveal that the lion's share of climate finance is used for climate change mitigation. In 2013, investment in mitigation efforts was a whopping 91 percent of total global climate finance, equivalent to US$302 billion, of which a large share (78 percent) was spent on renewable energy followed by energy efficiency (10 percent) and sustainable transport (6 percent).[iii] On the other hand, of the limited funds available for adaptation, 58 percent was allocated for water supply and management followed by climate resilient infrastructure (14 percent), disaster risk management (9 percent), and agriculture and forestry (8 percent).[iv] Notably, funds for climate change adaptation were financed through public sources and low-cost debt, including concessional loans (52 percent), grants (16 percent) and market-rate debt (30 percent).[v] Funded largely by development finance institutes (DFIs), East Asia is the major destination of climate finance, followed by Sub-Saharan Africa, Latin America and South Asia.[vi]

Climate finance in Asia

Information on national sources of climate finance (from both public and private) is rare in Asia and the Pacific. However, 22 dedicated climate funds and initiatives are currently active in the region (Bernard et al. 2014; Carroza 2015). According to the Climate Funds Update[vii]—an initiative run by Overseas Development Institute (ODI)—32 countries in Asia-Pacific have received over a quarter of public climate finance made available from dedicated climate funds and have approved nearly US$3.5 billion projects (Bernard et al. 2014). A majority of finding are on mitigation projects and India, China and Indonesia are among the major recipients. In addition, multi-national banks such as the World Bank and ADB had disbursed over US$2 billion for investments on climate change, specifically US$1.07 billion in East Asia and US$1.01 billion in South Asia by 2013 (Carroza 2015). Major recipient countries of such disbursements are India, Indonesia and China. Moreover, relatively high share of funds was spent on adaptation in South Asia compared with the average situation in Asia-Pacific region.

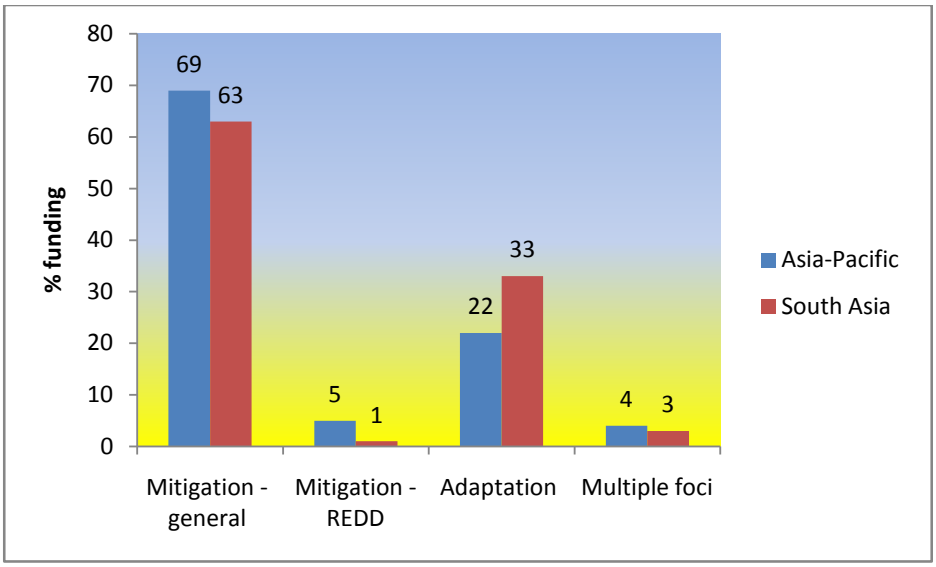

Figure 1: Comparative use of climate finance by purpose

Source: Carroza (2015) based on http://www.climatefundsupdate.org/regions/asia-pacific

Conclusion

Available information suggests that global architecture of climate finance is becoming increasingly more complex. At present, the global climate finance mechanism channels over US$330 billion, over 90 percent of which is spent on mitigation. And while private investment does have a dominant share in climate finance, the funds are largely invested in countries of their origin, specifically developed nations in the North and emerging economies. There are no significant FDI flows to developing nations for investments on mitigation or adaptation from private sources. Hence, vulnerable developing nations for which adaptation becomes the main priority have to depend on public sources of climate finance from bi-lateral and multi-lateral donors or dedicated climate funds and initiatives. Few developing countries have established their own climate funds too. Despite these developments, however, scarcity of climate finance act as a major barrier against undertaking effective actions to face the risk of climate change. It appears that the gap between level of finance needed and finance actually delivered is ever widening with growing incidence of negative impacts of climate change on economies. Mobilizing domestic private sector for investments on mitigation and adaptation, rationalizing the use of limited public finance to address the growing risk of climate change impacts and global and regional cooperation for mutual benefits are the main alternatives available for vulnerable developing nations to fill this gap.

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State of the art climate change assessments for Sri Lanka from CMIP5

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The characterization of future climate change for Sri Lanka is critical for assessment of impacts on various sectors, regions, systems, and for formulation of policies and practices to adapt to climate change. Such attribution requires detailed understanding of historical and ongoing climate variability, extreme events, and decadal change. The work in Sri Lanka should be contextualized in terms of South Asia and Indian Ocean climate variability and its change. In Sri Lanka, the issues of fine-spatial scale are critical given the rapid variation in climate over relatively small distances. Projections of climate change should include indications of confidence levels and assessment of uncertainty.

Climate change assessments in the near-term can be based on understanding long-term decadal change from observations and proxies of climate such as the size of tree rings. Climate systems could also be projected by developing computer models through understanding the physics and incorporating the consequences of recent human action. But, there are major limitations in the computer modeling approach primarily due to the complexity of the atmospheric system, the limitations of the historical observations, and the characterization of the processes such as cloud physics. Understanding the climate system and projecting into the future considering the impact of human action is the methodology that is still commonly used to project future climate under the UN framework to undertake projections. Under this framework, global climate models from many science centers in advanced countries produce global projections based on common baselines. These models have much in common, but also have similar weaknesses. The long-term projections unfortunately cannot be verified on an ongoing basis. In any case, some of the uncertainty can be captured by examining the outputs from all the models, and some of the skills of the models can be evaluated for different regions and seasons by investigating the ability of these models to reproduce past climate.

Current Problems in Climate Change Assessments

Climate Change assessments for Sri Lanka have been undertaken from time to time, but not in a systematic and sustained way. The methodologies have been only based on downscaling the results from global scale models, where the general skill of these models over the region is not being investigated. Indeed, the past projections and the current projections from these models are for a wetter and warmer future. However, these projections have not been borne out in the last 15 years – thus, calling into question the skill of the Global Climate Models (GCMs) for this region. In addition, the various projections have been inconsistent when it comes to rainfall projections. Therefore, it is imperative that these issues are addressed rather than simply just downscaling from global climate models without further investigation.

Climate Change Projection Methodologies using GCMs

Currently, the climate models use underlying physics of the atmosphere along with anticipated changes (in forcing such as of Greenhouse gas emissions, changes in human activity) into the future, as the main tool to project climate change. At present, Global Climate Models (GCMs) are run, typically for a resolution of about 100- 250 km for the entire globe due to the limitations in computing power and availability of data. At such course resolution, these models do not capture critical climate factors such as cloud formation or details of the high-mountain topography which can have profound influences. The methodology by which results that are produced at such large scale are interpreted for finer scale are referred to as downscaling. The two broad classes of downscaling methodologies are statistical and dynamical, which have their limitations. Such downscaling is critical for Sri Lanka, given its quite varied climate and topography.

As part of the global climate change assessment process, the Coordinated Model Inter-Comparison Program (CMIP) has produced archives of simulations, using leading General Circulation Models, and common input data and standardized domains referred to as CMIP5. Outputs of CMIP5 GCMs were assessed in the latest report by the IPCC- AR5.

Past Projection Studies for Sri Lanka

Previous studies had been conducted to project the future climate based on Carbon Dioxide emission scenarios developed by the IPCC in their Special Report on Emission Scenarios (IPCC-SRES) (IPCC, 2000). Climate predictions for Sri Lanka have been done only for SRES scenarios A1F1, A2, B1 and B2. A study done using GCMs by HadCM3, CSIRO and CGCM predict an increase in temperature by 2 – 3 ^{0}C under A1F1 scenario, 0.9 – 1.4 ^{0}C increase under B1 scenario and 1.7 – 2.5 ^{0}C increase under A2 scenario at the end of the 21st century (Basnayake, *et al*., 2004). Another study using the HadCM3 model has predicted 1.6 ^{0}C and 1.2 ^{0}C increase in temperature by 2050, under A2 and B2 scenarios respectively (De Silva, 2006).

Prior assessments have shown consistency across global climate models for temperature projections. There is greater variability among the projections with regard to precipitation (Eriyagama, *et al*., 2010); (Mahanama & Zubair, 2011).HadCM3 and CSIRO models have predicted higher southwest and northeast monsoon precipitation under A1F1, A2 and B1 scenarios, but CGCM model has predicted lower rainfall in these two monsoon seasons for the future (Basnayake & Vithanage, 2003, Eriyagama, *et al*., 2010). Another study has predicted higher southwest monsoon rainfall and lower northeast monsoon rainfall using HadCM3 GCM and A2 scenario (De Silva, 2006). Similar prediction has also been made using the same GCM but with A1 and B1 scenarios (Basnayake & Vithanage, 2004). The effect of changing the planting date of rice as an adaptation strategy to climate change under A2 and B2 scenarios has also been studied previously (Dharmarathna, *et al*., 2014).

Recent Work at FECT

FECT has tried to bring best practices into generating climate change projections. The work that has been undertaken is not completed but it does a good job of addressing the quality and uncertainty of the assessments.

Climate change projections for Sri Lanka for the 21st century has been produced using 20 CMIP5 GCMs, and latest CO_2 concentration pathways adopted by the IPCC for AR5 called Representative Concentration Pathways (RCP). Out of 4 possible concentration pathways categorized based on possible range of radiative forcing by year 2100 relative to pre-industrial values (van Vuuren, *et al.*, 2011) 2 were used (RCP4.5 and RCP8.5). Here RCP8.5 is the worst case CO_2 emission scenario. Projections for the 21st century were done for three 30-year periods, 2010- 2040, 2040- 2070 and 2070- 2100. Here, only results obtained for Batalagoda is presented, located in south-western Sri Lanka under the worst case CO_2 emission scenario in 2040- 2070 period which wasdefined as the Mid-Century.

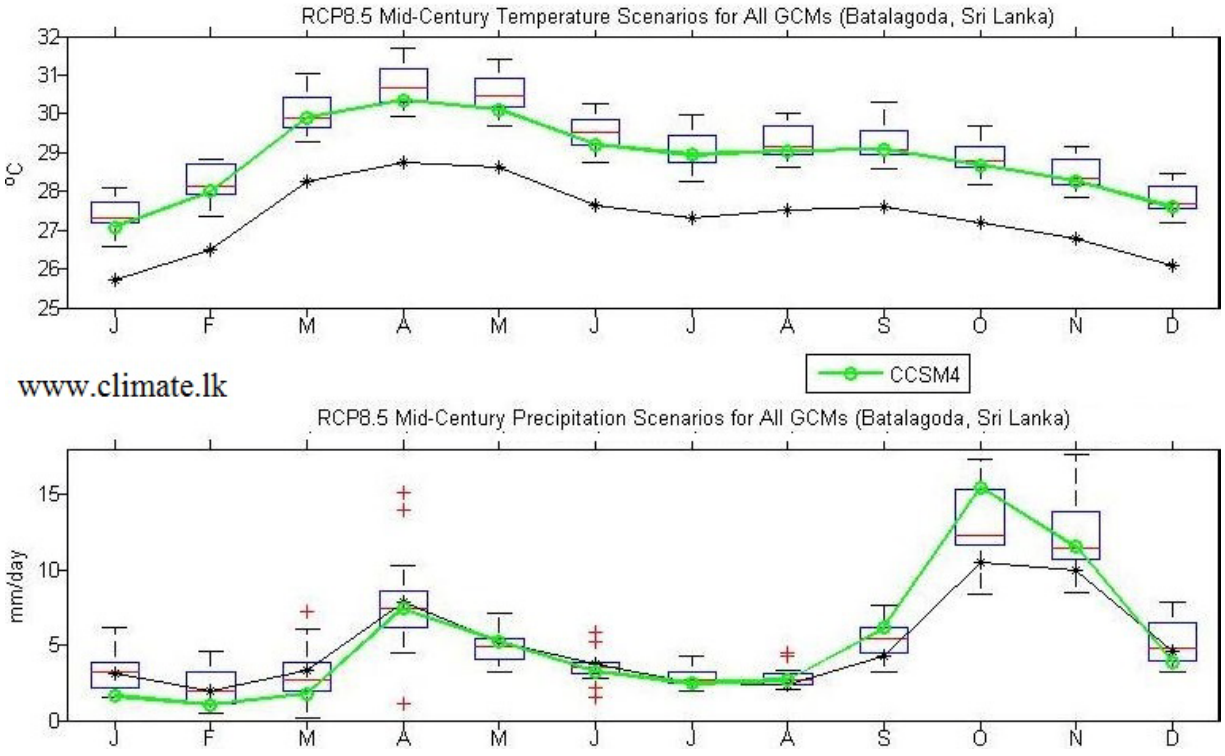

Figure 3: Projected Temperature (top) and Rainfall (bottom) Climatologies for 2040- 2070 of all GCMs under RCP8.5 for Batalagoda. Black line with stars shows the climatology of the baseline (1980- 2010) period while the green line shows CCSM4 GCM.

Figure 3 shows temperature and rainfall climatologies in Batalagoda during 1980- 2010 by the black solid line and future projections of 20 selected GCMs of each month by box and whisker plots. Box and whisker plots provide information about the variability of 20 future projections for each month and thus, the uncertainty. In the temperature prediction, the variability of 20 predictions by 20 GCMs are similar throughout the year which ranges from 1- 2.5 ^{0}C above the historical mean temperature each month. Contrary to the temperature prediction, the rainfall prediction shows variability of different

magnitudes among 20 predictions in different months of the year. June to August has the lowest variability and also the lowest expected change of rainfall magnitude while September to December has the highest variability and the highest change in rainfall.

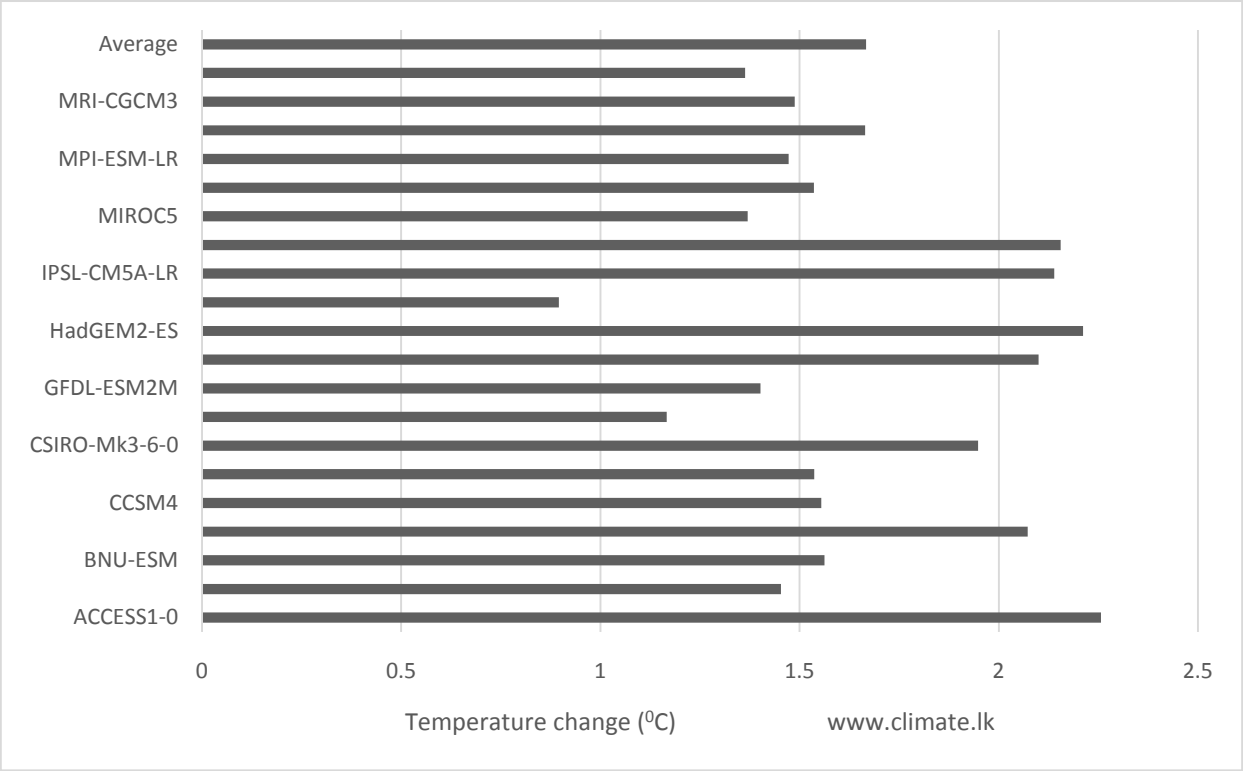

Figure 4: Projected annual Maximum Temperature departures of 20 GCMs from the historical average during the Mid-Century under RCP8.5 in Batalagoda, Sri Lanka.

Figure 4 shows projected maximum temperature changes by 20 GCMs in the Mid-Century. While some models predict an increase as low as 0.9 ^{0}C, some predict more than 2^{0}C increase in maximum temperature. This is a good example for the uncertainty associated with predictions using GCMs.

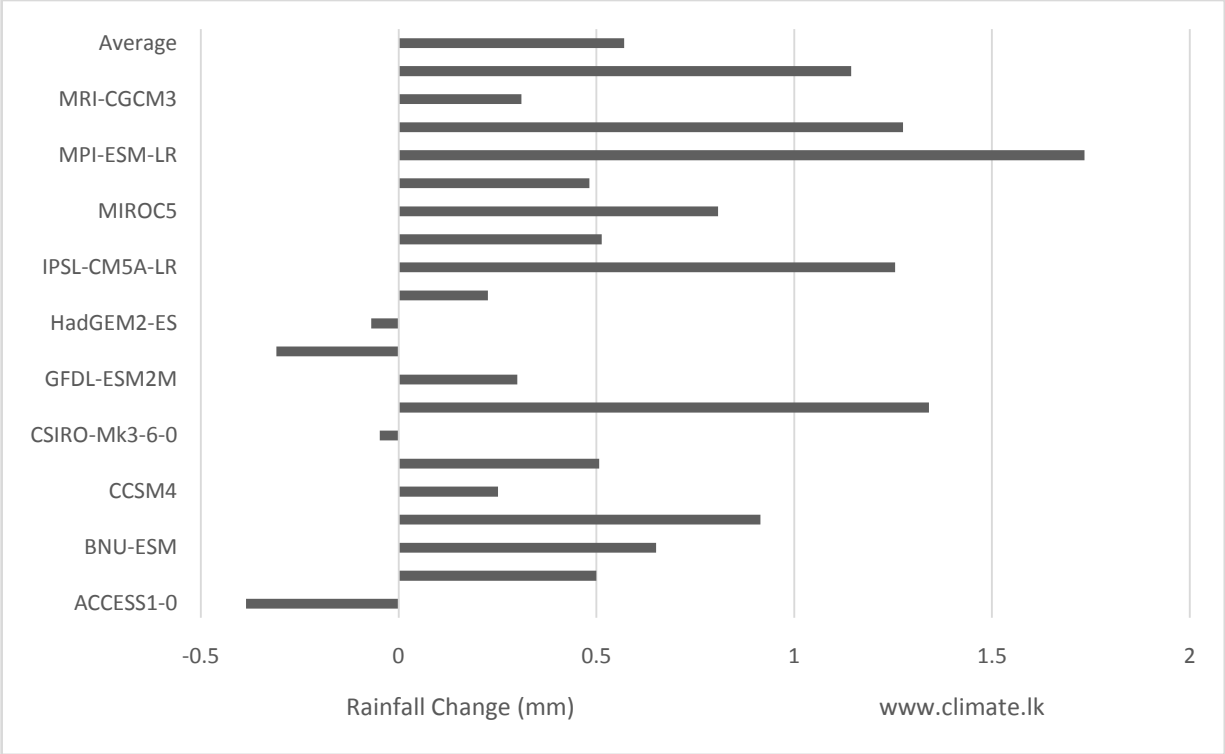

Figure 5: Projected annual Rainfall departures of 20 GCMs from the historical average during the Mid-Century under RCP8.5 in Batalagoda, Sri Lanka.

According to Figure 5, some models predict that the rainfall will decrease in the future, while the majority of models predict that rainfall will increase.

There is a very high uncertainty regarding the magnitude in which the rainfall shall change in the future. About half of the models predicting an increase in rainfall expect that the change will be below 0.5 mm while one fourth of models predict an increase excess of 1 mm in the Mid-Century.

Following a study by (Zubair, *et al*., 2015) 5 GCMS (CCSM4, GFDL-ESM2M, HadGEM2-ES, MIROC5, MPI-ESM-MR) were selected for further analysis, and the summary statistics for RCP8.5 scenario in Batalagoda are tabulated as follows (Table 1). The standard deviations of projected means of 5 GCMs were found to be higher than that of the historical mean.

Table 1: Daily mean, standard deviation and the confidence interval of mean, of maximum and minimum temperatures and rainfall in Batalagoda. Historical calculations are done using data from 1980- 2010 and calculations for other 5 GCMs are done using projected future values during 2040- 2070.

Scenario	T_{MAX} (^{o}C)			T_{MIN} (^{o}C)			Precipitation (mm)		
	Mean	SD	CI	Mean	SD	CI	Mean	SD	CI
Historical	31.3	1.9	± 0.03	23.4	1.8	± 0.03	5.0	13.2	± 0.24
CCSM4	32.8	1.9	± 0.03	24.9	1.8	± 0.03	5.2	14.6	± 0.27
GFDL-ESM2M	32.7	2.1	± 0.04	25.0	2.0	± 0.04	5.3	15.0	± 0.28
HadGEM2-ES	33.5	2.0	± 0.04	25.9	1.9	± 0.03	4.9	13.6	± 0.25
MIROC5	32.7	1.8	± 0.03	24.9	1.8	± 0.03	5.8	15.5	± 0.29
MPI-ESM-MR	32.9	2.0	± 0.04	25.3	1.8	± 0.03	6.3	17.2	± 0.32

Results under both RCPs show that both minimum and maximum temperature shall increase in the future. Temperature increase under higher CO_2 emission scenario (RCP8.5) is about 0.5 ^{0}C higher than RCP4.5 in the Mid-Century and is about 1.5 ^{0}C higher by the end of the 21st century. Majority of prediction models expect an increase in rainfall, but there is high uncertainty about the magnitude which it will increase. When comparing the results for rainfall predictions under RCP4.5 and RCP8.5, by it is evident that the expected magnitude of change is the same but the variability of the prediction is higher under the high emission scenario.

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OBSERVATIONS

Sri Lanka's rich biodiversity is primarily due to its topography and climate. Many sub-species occur due to climatic isolations. Further, behavioral changes also occur due to climate differentiations.

Despite the fact that people know there are many changes occurring in the world of plants and animals due to climate change, in Sri Lanka we have very few published articles. Therefore, together with the articles on climate change, some pages on 'Observations'have been included.

These observations were contributed by researchers in the field. They are merely 'observations' and are not scientifically linked to climate change but, it could be an eventuality.

You are left with some 'food for thought', to open your eyes and observe and relate the changes in your environment. You are encouraged to scientifically document climate change with biodiversity and assist us to conserve those species and habitats that are most sensitive to climate change.

Hasula Wickremasinghe
Methmali Rajaguru

Climate Change Secretariat
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Declining populations of some threatened plants associated with rocky seepages in Knuckles area.

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Rocky seepages are special micro- environments where open rocky areas, with or without thin layer of soil, are constantly washed by slowly escaped natural spring water. The low growing vegetation on bare rock is often patchy and variable depending on soil depth, moisture regimes, physical properties of the rock formation and light conditions. Lichens, mosses, Bryophytes, ferns and few species of flowering plants occupy such specific habitats. Also, the rocky seepages are safe havens for several specially adapted small animals.

Frequent visits to the northern part of Knuckles area, during the last 25 plus years, enabled the observation of the decline of populations of several threated plants populations adapted to seepage environment. Among them, *Brachystelma lankana* (Patan Ala) *Dipcadi montanum* (Wal loonu) and *Didymocarpus humboldtianus* are noteworthy threatened herbaceous species. There is a strong possibility that climate change is badly affecting populations of those plants by way of making unfavorable moisture regimes, temperature extremes and spread of bush fire in dry season. Some recent studies on climate change in Sri Lanka have proven that, over the years, the country is experiencing gradual increase of mean air temperature, increase of number of consecutive dry days and decrease of consecutive wet days. Hence, at habitat level, the end results turn out to be heated rocks, dried springs and weak mist formation in the environment – a massive climatic blow to the moist loving sensitive flora through a desiccation effect.

Brachystelma lankana is a small herb with a globose edible tuber that grows in shallow soil carpeting the wet rocky surface at Pitawala Patana grassland. This plant is a critically endangered point endemic species and so far, it has no occurrence records from any other part of Sri Lanka. *Dipcadi montanum* is also a critically endangered native herb growing in the same area. Essentially, its subterranean bulbs are squeezed between horizontal rock crevices in moist habitats in grassland edges. *Didymocarpus humboldtianus* is thriving on moist vertical rocky surfaces with some shade, and located at higher elevations, especially, around Riverstern area. The plants are more visible with well developed shoots in wet season (November-February). However, over the years, encounters with those species have become less frequent even in wet season; especially, those plants at Pitawala Patana.

Many sites formerly occupied by *Didymocarpus humboldtianus* have overgrown with invasive *Ageratina riparia* herb. Trampling due to over visitation of Pitawala Patana area is an added pressure on *Brachystelma lankana* and *Dipcadi montanum*. The situation probably calls for appropriate actions for the safety of those kinds of habitat specialists. At present, the set of conditions necessary for those species is poorly understood, and such small scale sensitive habitats often escape the eye of conservationists.

Figure 1: Pitawala Patana turf grass community on thin soil layer of rocky expanse where *Brachystelma lankana* and *Dipcadi montanum* are found occasionally.

Figure 2: *Didymocarpus humboldtianus* attached to moist vertical rock surface.

Thoughts on the possible effects of climate change on the Odonata of Sri Lanka

Nancy van der Poorten

Since Odonates rely almost entirely on water throughout their life, changes to rainfall patterns and to their water environment would be expected to affect them significantly. One study showed that the higher elevations have experienced a loss of rainfall whereas the lowlands of the southwest have experienced enhanced rainfall with changes in rainfall patterns (Malmgren *et al*. 2003). Rainfall has tended to be more intense with longer periods of drought. Many of Sri Lanka's endemic odonates are found in the lowlands of the southwest and in the higher elevations and many are stream-dwellers in the larval stages. Each species, however, is adapted to a particular type of stream: some require slow-moving or still water; others fast running water. We might expect that species that are adapted to stiller waters would be affected by intense rainfall that would cause flooding, whereas those species adapted to fast-flowing streams might be most affected by the longer periods of drought which would reduce stream flow and volume. It would be the larval stages that would suffer since the adults are free flying in the air.

Libellago corbeti female ovipositing onto a leaf floating on a stream

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Climate Change: How will it impact on Mollusca?

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The Phylum Mollusca includes many life forms that inhabit marine, brackish water and freshwater habitats - as well as terrestrial ones. For the purpose of this article I shall deal only with the shelled molluscs of marine and brackish waters—the snails and bivalved clams. As a matter of interest other marine mollusca include the octopus, cuttlefish, squid and small deep-water forms such as tusk shells and spirula.

The expression 'Climate change' is a term that would mean different things in different contexts; e.g. changes in rainfall pattern, seasonal temperatures, wind patterns, oceanic currents and so on, mostly inter-related. What is relevant to this article is rise in atmospheric and sea temperature and the secondary effect of rising sea levels as a result of shrinkage of the polar ice caps.

A majority of the shelled molluscs live sub-tidally, *i.e.* below the level of the lowest tides, where they are always covered by water. In these habitats they would experience rising water temperatures, but would probably not be much affected by changes in sea level. On the other hand, those specialised forms that live in the inter-tidal zone probably would be affected by sea level changes earlier rather than later. These animals, and the algae (seaweeds) amongst which they live, are periodically submerged or exposed to sunlight for varying periods; many of them requiring specific periods of wet and dry sunny conditions.

Clypidina notate

Umbonium vestiarum

Cerithium obeliscus

Inter-tidal habitats exist in a variety of forms: rocky shores, sandy beaches, mudflats, estuaries and mangroves. Each type of habitat has its own diversity of species. If we look at shelled molluscs we would find snails and clams adapted to withstand breaking surf on exposed rocky shores; or able to burrow into sand at the water edge on sandy beaches; or on mudflats, the clams burrowing into and the snails living on the mud surface; or in estuaries and mangroves adapted to varying degrees of salinity, from near seawater to near freshwater, living on the muddy bottom or on the surrounding vegetation. In each of these habitats a suitable environment includes shelter and sufficient prey species. Shelter would be provided by plants, such as seaweeds or riverine/mangrove vegetation, or other, larger animals

(shells) on which they could attach themselves. Prey species would be plants or animals of various types, including plankton and organic detritus.

Changing temperature is likely to deplete populations that are unable to adapt to such change; or to shift populations to other areas that are within the tolerable temperature range. In a tropical country like ours, if the sea gets too hot, where can they go? Research along the Pacific coast of North America has shown subtropical species extending their range north together with the spread of warmer

water. We have been seeing a temperature-related event in recent years in our off shore reefs by the bleachingof coral. Periods of increased seawater temperature kills minute, single-celled algae that live in the tissues of corals. The coral responds by expelling them, turning white in the process, as the zooxanthellae, as they are called, are responsible for the colour of the coral. They also contribute nutrients by way of photosynthetic products and the loss of this source of energy eventually leads to the death of the coral.

Impact of climate change for sea turtles

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Genetic sex determination (GSD) predominates among vertebrate species. Nevertheless, in many reptiles and in some other taxa, sex is determined by environmental factors, such as temperature (Temperature-dependent Sex Determination- TSD), that act after conception. In many species of reptiles, the incubation of eggs at some temperatures yields 100% phenotypic males, whereas 100% phenotypic females are produced at other temperatures. Both sexes may be produced only in a range of temperatures, often narrow, between these male and female producing temperatures. This range of incubation temperature is called the transitional range of temperature or TRT and it is usually at a range of 2-3ºC. Within this range, is centered the "pivotal temperature" defined as the temperature during incubation at constant temperature, which gives 50% individuals of each sexual phenotype. The pivotal temperature cannot be determined for a single egg, but for single clutch.

Of the seven species of sea turtles in the world, five come ashore to nest in Sri Lanka while their feeding habitats & migratory routes arelocated around the island (Green turtle, Hawksbill, Leatherback, Loggerhead and Olive ridley turtle). Sea turtles also haveTSD and the lower temperature produces more males while the temperature higher than the pivotal temperature produces more females. Naturally, green turtles have 30:70 male female ratio in most populations in the world and the pivotal temperature is estimatedat 29°C. But, due to the increase of environmental temperature the female ratio could reach 90 or more. The temperature increase will highly impact the sex ratio and it could lead to unbalanced wild population. Further, it was observed that in many sea turtle hatcheries in Sri Lanka the reburied nests were shallower than the natural nests. Climate change and temperature increase will impact those nests and almost all the hatchlings could be females. The emerging hatchlings are staying in the upper part of the nest until the environmental temperature gets lower in the evening or night. We have observed that some dehydrated turtle hatchlings dead in the top layer of the nest due to the higher temperature in the daytime.

Sea turtles represent an ancient and distinctive component of the world's biological diversity. They first appeared more than 100 million years ago. They are highly adaptive species for the environmental changes, climate change and temperature rise. However, it has taken millions of years for those environmental changes to occur. But, due to human activities the global temperature is changing rapidly within a short period of time. Therefore, it is highly unlikely that sea turtles could adopt and tolerate this rapid change and hence, they are at risk.

Green Turtle *(Chelonia mydas)*

Landsnails are susceptible to climate change

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Sri Lanka has a rich diversity of land snails. Two hundred and fifty three species of land snails have been recorded so far, of which 205 (81%) are endemic to the country. According to the 2012 National Red List, 179 species have been listed in a threatened category. (Ranawana & Priyadarshana, 2012).

Five land snail genera, namely *Ravana*, *Ratnadvipia*, *Acavus*, *Oligospira* and *Aulopoma* are restricted to Sri Lanka. Their specific habitat lies in the wet and southwestern region of the island. This genera requires shade and constant moist conditions and is sensitive to high temperatures. Micro snails such as *Oligospira* and *Leptopom*a envelop themselves in a bag of mucous to prevent dehydration when temperature increases.

Species such as *Cryptozona chenui*, *Ratnadvipia irradians*, *Acavus phoenix*, *Corilla adamsi*, *Beddomea albizonatus* and *Leptopoma semiclausum*are considered as indicator species of the lowland rainforests (Raheem *et al*., 2000).

With the recent prevailing dry conditions in the lowland wet zone, in certain areas, live specimens of the above land snails could not be observed. Only shells and operculum were found. The rainforest conditions seem to be fast disappearing. Therefore, it could be surmised that temperature increase would be detrimental to the survival of moisture loving species, driving them closer to extinction.

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Acavus sp

Ratnadvipia irradiens

Tortulosa colletti

Possible impact of drought on Nannophrys ceylonensis

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Nannophrys ceylonensis commonly known as Sri Lanka Rock Frog is endemic to the central, western and southern region of Sri Lanka and listed as Endangered according to the National Red List (2012). It is mainly an aquatic species and inhabits rocky cascades, wet rock surfaces and under boulders where conditions are moist. Since its colouration is yellowish-brown with mottled brown patches it is well camouflaged when sitting on rocks.

The female frog lays clusters of eggs in rock crevices in the spray zone or on rocks which are constantly moist. The tadpoles hatch on the rock surface and feed on algae and micro-organisms untill they become adults.

Nannophrys ceylonensis and its tadpoles thrived on a rock which was adjacent to a narrow steam in a forested home garden at Warakapola for many years. Due to a prolonged drought which prevailed in that area for a couple of months, the rock surface which was its habitat dried up. Thereafter, sightings of *N. ceylonensis* was not prevalent.

There are only four species of *Nannophrys* listed in Sri Lanka of which one species, *N.guentheri* is already listed as Extinct, and the extant three species are restricted to moist conditions and listed in a threatened category according to the National Red List (2012). Besides desiccation of habitats due to droughts, they are also susceptible to high concentrations of agrochemicals in water bodies. Other climate change factors such as increase in atmospheric temperature, may also cause biological changes in the species resulting in a population decline.

Nannophrys ceylonensis
(Source: Internet)

Fish in jeopardy

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A recent hike through the Baddegana Wetland found a marsh that was drying up. Instead of a water bogged land, there were only small pools of water here and there. A large number of *Puntius vittatus* (silver barb) was congregated in a small pool of shallow water with their mouths gaping.

It is possible that the temperature increase in the water would have depleted the oxygen percentage, thereby inhibiting respiration. These fish were an easy prey to a group of egrets.

Similar observations have been made at Malabe, Attidiya and Bandaragama wetlands. Further, it was interesting to note, at Attidiya, while the native species were finding it difficult to adjust to the dry conditions, exotic species were thriving. This was especially seen of the three spot gourami and Snake skin gourami. This may also be due to the fact that these gouramis can breathe air directly, as well as absorb oxygen from water through gills.

Snake skin gourami

Three spot gourami

Silver barb

අධික උණුසුම කුරුළු පැටවුන්ගේ පැවැත්මට තර්ජනයක්ද?

සුසන්ත උඩගෙදර

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පිටිසුම

නිතඹ දම් සූටික්කා ලෙස සිංහලෙන් හඳුන්වන කුරුළු විශේෂය, ඉංග්‍රීසි භාෂාවෙන් Purple-rumph Sunbird ලෙසද, *Nectarinia zeylonica* (Linnaeus, 1766) යන විද්‍යාත්මක නාමයෙන්ද හඳුන්වනු ලැබේ. 2012 වසරේ ප්‍රකාශයට පත් කරනු ලැබූ ජාතික රතු දත්ත පොතට අනුව මෙම කුරුළු විශේෂයේ සුලභතායව නිසා අඩු අවධානම් (Least Concern- LC) පක්ෂියෙකු ලෙස නම්කර ඇත.

සූටික්කන් අතර කෙටිම හොටක් ඇති මෙම පක්ෂියාගේ හොටය යටට නැවී ඇත. පිරිමි පක්ෂීන් ලොහවත්, සිලුටු පිල්කලඹ හා නිල්වන් දම් නිතඹ සහිත වන අතර කිරුල තද නිල් පැහැතිය. ගැහැනු පක්ෂීන්ගේ උඩුකය ඔලිව් දුඹුරු පැහැය ගන්නා අතර පියාපත් තද දුඹුරු පැහැති වේ. මෙම පක්ෂියා සෑම විටම යුවලක් ලෙසින් හැසිරෙන අතර මල්වල පැණි උරා බීමට ප්‍රිය කරයි. සුවදි සමය (බිත්තර දමන කාලය) පෙබරවාරි මස සිට ජූනි මස දක්වා දිවෙන අතර දෙවන සමය අගෝස්තු සැප්තැම්බර් අතර වාර්තා වේ. මොවුන් ගේ කූඩුව සාදනු ලබන්නේ වැසුනු ආකාරයේ බුබුලක් ලෙසය. විශාලත්වයෙන් මී. මී. 17×11 පමණ වූ කොළ පැහැති දුඹුරු තිත් සහිත බිත්තර 2 ක් පමණ දමන බව තහවුරු කොට ඇත.

නිරීක්ෂණය:

තෙත් මධ්‍ය කඳුකර 2බී පස් කාණ්ඩය සහිත කෘෂි පාරිසරික කලාපයට අයත් මාගේ නිවස අසල තිබෙන දෙහි ගසක (*Citrus aurantifolia*) නිවස පවතින දිශාවට මුහුණලා මෙම මස මාර්තු මස තුලදී ගැහැණු සහ පිරිමි පක්ෂියාගේ සහභාගිත්වයෙන් අලංකාරවත් බුබුලක් වැනි කූඩුවක් තැනීම ආරම්භ කරන ලදී (ඡායාරූපය1). මෙය සකස් කිරීමෙන් අනතුරුව ගැහැණු පක්ෂියා කූඩුව තුලම රැඳී සිටිනු දක්නට ලැබිණි. මේනිසා අප විසින් මෙම පක්ෂියා බිත්තර රකින බවට නිගමනය කරන ලදී. මෙලෙස කූඩුව තුල බිත්තර රැකීමට ආසන්න වශයෙන් දින 10ක් පමණ ගතකරන ලදී. පසුව මොවුන් හොටය තුල ආහාර තබාගෙන කූඩුවට යන ආකාරය සහ පැටවුන්ගේ ශබ්දය මගින් බිත්තර පිපිරී පැටව් සිටින බවට තහවුරු කෙරිණි. මෙලෙස ආසන්න වශයෙන් දින 20ක් පමණ කෑම කැවීම සිදුවූ අතරම (ඡායාරූපය 1 සහ 2) අවසාන දින වලදී කූඩුවේ සිදුර මව්පිය පක්ෂීන් විසින් ක්‍රමානුකූලව විශාල කරන ලදී. මෙමගින් අප නිගමනය කරනු ලැබුවේ පැටවුන්ට ඉගිලීමට ක්‍රමානුකූලව සිදුර විශාල කරන බවය.

මෙම කාලය මුළුල්ලේම ලංකාවටම අධික උෂ්ණත්වයක් (32^0C අංශක වඩා) වාර්තා වූ අතරම එම කාලය තුලදී කිසිදු වර්ෂාපතනයක් වාර්තා නොවුණි. මෙයට හේතුව ඉන්දු පැසිපික් කලාපයට බලපා තිබූ එල්නිනෝ (El-nino) තත්වයක් බව තහවුරු කොට තිබුණි. එබැවින් එම කාලය තුල විවිධ පාරිසරික වෙනස් වීම් රාශියක් වාර්තා විය. එහි ප්‍රතිපලයක් ලෙස මහ ඔයේ ජල මට්ටම අධික ලෙස පහල ගොස් පැවතුණි.

කූඩුව සදා ඇති ස්ථානය පැය 5 කට වැඩි කාලයක් හිරු එලියට නිරාවරණය වී පවතී. මේ කාලය තුල සවස් කාලයේ කූඩුවට ලම්භකව සූර්යාලෝකය පතිතවන අතරම එක් කුරුළු පැටවකු බිම වැටී මිය යාම නිරීක්ෂණය කිරීමට හැකිවිය. තවද පසුදින සවස් කාලය වනවිට අනෙක් පැටවාද බිම වැටී මිය යන ලදි.

නිගමනය

මෙයට හේතුව ලෙස අප විසින් නිගමනය කරන ලද්දේ සවස් කාලය තුල අධික උණුසුම දරා ගත නොහැකි වීම නිසා මොවුන් පිහාටු නිසි ලෙස වර්ධනය වීමට පෙර අධික උණුසුමෙන් බේරීමට කුඩුවෙන් එළියට ඒමට උත්සාහ කිරීමේදී බිමට පතිත වීම නිසා මිය ගිය බවය. පර්යේෂකයන් පෙන්වාදෙන ආකාරයට අද පවතින පරිසරය විවිධාකාර දේශගුණ විපර්යාස වලට භාජනය වෙමින් පවතී. තවද එම තත්වයන් අනාගත කාලය තුලදී තවදුරටත් වර්ධනය විය හැකි බව පුරෝකථනය කොට ඇත. උදාහරණ ලෙස අධික වැසි, ගංවතුර, අධික නියඟය සහ වෙනත් අනපේක්ෂිත ආපදා තත්වයන් සැලකිය හැකිය.

එමෙන්ම කුරුළු පර්යේෂකයන් පෙන්වාදෙන ආකාරයට සරු ජනිතයන් ඇතිවීමේ හැකියාව මෙම පාරිසරික උණුසුම ඉහල යාම නිසා අඩුවෙමන් පවතී. මෙයට අමතරව අධික උෂ්ණත්වය නිසා ගැහැනු පක්ෂීන් කුඩුවලට ආහාර ගෙන ඒමේදී කුඩුව තුල ගත කරන කාලය වැඩිවේ. එබැවින් පැටවුන්ට ආහාර හිඟයක් මතුවීමට ඉඩකඩ පවතින අතරම ඔවුන්ගේ වර්ධනය අවම වේ. මෙහිදී අපහට කුඩා පැටවුන්ගේ මියයාම සහ අධික උෂ්ණත්වය සහිත පරිසරය අතර සෘජු සම්බන්ධතාවක් පවතීද යන්න තහවුරු කර ගැනීමට තරම් ගැඹුරට මෙම නිරීක්ෂණය කර නොමැත. එබැවින් දේශගුණ විපර්යාස නිසා පක්ෂීන්ට සිදුවන මෙවන් හානි පිළිබඳව පර්යේෂණවලට යොමුවීම තුලින් විවිධ සම්බන්ධතා සොයාගත හැකිය. අවසන් වශයෙන්, අනාගතයේදී සංරක්ෂණ වැඩපිළිවෙලවල් සකස් කිරීමේදී මෙවන් අධ්‍යයනයන් සිදුකිරීම තුළින් දේශගුණ විපර්යාස වලට අනුහුරු කිරීමට මනා පිටුවහලක් වනු නොඅනුමානය.

ඡායාරූපය - 1: ගැහැණු සතා විසින් පැටවුන්ට කෑම ලබා දීම (උපුටා ගැනීම - Dr. Hemachandra Kularatne)

ඡායාරූපය - 2: පිරිමි සතා විසින් පැටවුන්ට කෑම ලබා දීම (උපුටා ගැනීම - Dr. Hemachandra Kularatne)

Distribution range changes of White browed fantail: An impact of climate change?

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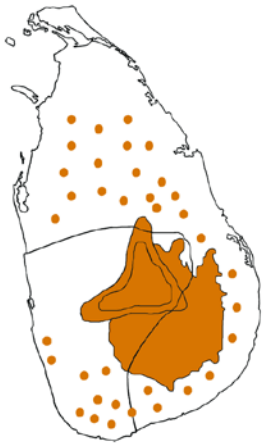
Based on the distribution patterns of the residential bird species, Sri Lanka has been divided into six Avifaunal Zones (Kotagama, 1993). They are the Northern zone, Low country wet zone, mid country wet zone, Hill country wet zone, Dry zone and Uva zone. The Dry zone and Uva zone contain mainly common bird species and a few rare species that are restricted to these zones.

White browed fantail (*Rhipidura aureola* –බැමසුදු පවන්පෙන්දා) is more prominent in the Uva avifaunal zone. It is a bird favouring the climate of the intermediate zone (Kotagama & Ratnavira, 2010).



There are scattered distribution sightings of the White browed fantail in the Minneriya, Polonnaruwa and Maduru Oya areas which are mainly dry. Most recently, this bird has been observed at Heerassagala (Hantane) in the Central Hills and at Sinharaja and Kanneliya which are Low country wet zone rainforests. Its wide spread dispersal into the wet zone may likely be due to the change in the climate or habitat conditions.

Dispersal range change may affect other bird species indirectly by building up competition for food and nesting places. Therefore, temperature changes may affect species by altering their life cycles resulting in a possible decline of populations.

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Is the Peacock invading the Wet Zone?

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The Peacock has been considered as an introduced species which has established itself in the Dry Zone. With its high numbers, it is considered a pest by farmers to chili cultivations and other crops of the dry zone.

In the excavation of Pothana Prehistoric cave site which is situated near Sigiriya in the Intermediate zone, the skeletal remains of a Peacock was identified (Premarathna, 2011). This faunal material was dated to 6,000 YBP which may mean that the Peacock was a resident bird (Premaratne *et al* 2012). So far, no Peacock remains have been found from prehistoric sites in the Wet Zone, which that the Peacock was a Dry Zone bird. But, recently, the Peacock was seen in Matara which is in the Wet Zone. What needs to be looked into is whether temperature ranges have increased in the Wet emphasizes Zone.

Reference:

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ප්‍රේමරත්න, කේ.එච්.එස්.ආර්., කේ.එන්. මනමේන්ද්‍රආරච්චි, ජී. අදිකාරි, 2012. සීගිරිය ආශ්‍රිත පොතාන ප්‍රාග් ඓතිහාසික ගුහාවෙන් හමුවූ (අදින් වසර 6000 ක් පැරණි) මොණර (*Pavo cristatus*) අස්ථි අවශේෂ. *ආචාර්ය පී.ඊ.පී. දැරණියගල 39 වන ගුණානුස්මරණය වෙනුවෙන් පැවැත්වූ පුරාජෛව විවිධත්ව සමුළුව, 2012, පර්යේෂණ ලිපි සහ නොරතුරු පත්‍රිකා එකතුව*. ජෛවවිවිධත්ව ලේකම් කාර්යාලය, පරිසර අමාත්‍යාංශය, මධ්‍යම සංස්කෘතික අරමුදල, සංස්කෘතික අමාත්‍යාංශය සහ පුරාවිද්‍යා පශ්චාත් උපාධි ආයතනය, කැලණිය විශ්වවිද්‍යාලය: පිටු 261-269.

Peacock *(Pavo cristasus)©Vimukthi Weeratunga*

Tarso-metatarsus of peacock from Pothana prehistoric cave site © S. Madanayake

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