Fiji National University

PG Diploma in Environmental Science and Management
ESM 803: Climate Change Impacts and Adaptation in the South Pacific
Final Examination, Semester 2, 2021: ANSWERS

Section A: Short Answer Questions

1) Carbon Sequestration
   a) Carbon Sequestration is the long-term removal, capture or sequestration of carbon dioxide from the atmosphere to slow or reverse atmospheric carbon dioxide [CO2] pollution and to mitigate or reverse climate change.

   b) Carbon dioxide is naturally captured from the atmosphere through biological, chemical and physical processes which includes changes in land use and agricultural practices such as converting crop and livestock grazing land into non-crop fast growing plants. Artificial methods have been devised to produce similar effects, including large scale, artificial capture and sequestration of industrially produced CO2 using subsurface saline aquifers, reservoirs, ocean water and other carbon sinks, bio-energy with carbon capture and storage, ocean fertilization, enhanced weathering and direct air capture when combined with storage.

2) UNFCCC
   United Nations Framework Convention on Climate Change.
   a) This convention established an international environmental treaty to combat "dangerous human interference with the climate system", in part by stabilizing greenhouse gas concentrations in the atmosphere.

   b) Almost every country on Earth is a party to the UNFCCC. This treaty called for ongoing scientific research and regular meetings, negotiations and future policy agreements designed to allow ecosystems to adapt naturally to climate change and to also ensure that food production is not threatened and to enable economic development to proceed in sustainable manner. Nations who are signatories to this treaty meets annually discussing climate change strategy. These meetings are called Conference of Parties (COP) and it assess the progress in dealing with climate change.

3) Milankovitch Cycles
   a) The Milankovitch Cycles describes the collective effects of changes in the Earth's movements over thousands of years. These cycles describe how relatively slight changes in the Earth's movement affect the planet's climate. It is names after a Serbian astrophysicist, Milutin Milankovitch who was investigating the cause of Earth's ancient ice age in early 1900s.

   b) The Milankovitch cycles takes into account three variations in the orbit of the earth around the sun. These cycles influence the length of the seasons and the amount of solar radiation received by the earth.

4) Keeling Curve
   a) The Keeling Curve is a graph that represents the concentration of carbon dioxide (CO2) in Earth's atmosphere since 1958.

   b) The Keeling Curve is named after its creator, Dr. Charles David Keeling who began studying atmospheric carbon dioxide in 1956 by taking air sample and measuring the amount of carbon dioxide they contained.

5) 'Urban Heat Island'
    a) Urban heat island occurs when a city experiences much warmer temperature than nearby rural areas.

    b) The difference between urban and less developed rural areas had to do with how well the surfaces in each environment absorb and hold heat.

6) Carbon Trading
    a) Carbon Trading is the buying and selling of carbon quota that permits a party or company to emit a certain amount of carbon dioxide.

    b) For example, two Annex B parties are Japan and Australia who have been given quota of 100 units and 200 units respectively. However, Australia government is unable to maintain its limit and emits 210 units of greenhouse gas in the given year. Japanese government on the other hand takes very strong steps to control emissions and only emits 90units of greenhouse gas with 10 units remaining. Under the carbon trading, Australia can purchase the 10 spare Kyoto units from Japan, thus, remains within its limit.

7) The Koppean Climate Classification System
    a) The Koppen climate classification uses precipitation and temperature to describe a region's climate and has been widely used in various fields such as hydrology and ecology.

    b) Climate classification is an important variable when studying health-related effects as climate determines many facets of season. For example, some climates only experience two principle seasons (e.g., wet vs dry season) while others experience the more traditional 'four seasons' climate. The Koppen climate classification system is selected which models various facets of climate that also affect season intensities

8) Dendrochronology
    a) Is the scientific method of dating tree rings (also called growth rings) to the exact year they were formed.

    b) It also gives data on the timing of events and rates of change in the environment (most prominently climate) and also used as a check in radiocarbon dating to calibrate radiocarbon ages.

9) Ocean Acidification
    a) It is the ongoing decrease in pH value of the Earth's oceans caused by the uptake of carbon dioxide from the atmosphere.
    b) It reduces the availability of carbonate ions in ocean water which provide building blocks the organisms need to make their shells and skeletons, significantly reducing the chances for their offspring to survive.

10) Climate and Weather
    a) Climate is the average daily weather for an extended period of time at a certain location. Climate if the average of weather over time and space.

    b) Weather is the short-term conditions of the atmosphere and can change from minute-to-minute, hour-to-hour, day-to-day and season-to-season.

Section B: Long Answer Questions

B-1 Common but Differentiated Responsibilities

It is when developed countries like United Stated [US] and United Kingdom [UK] have already polluted the atmosphere with greenhouse gases through industrialization and are the ones who started global warming all its associated mess. On the other hand, developing countries like India and Brazil have just begun the polluting the world recently. Therefore, the burden of lowering the overall emissions should be less on the developing countries [India and Brazil] compared to developed countries [US and UK].

While, it is "common responsibility" for every nation in the world to reduce greenhouse gas emission, there should be some difference between the responsibility given to developing countries and developed countries. This principle is the basis of the Kyoto Protocol which assigns separate responsibilities to the countries.

B-2 IPCC AR6 – Weather and Climate Extremes

The world is extremely likely to exceed 2ºC during the 21st century if greenhouse gas emission do not start to decline before 2050. It is very likely that the Pacific will continue to warm in the coming decades at a level slightly lower that the global average because the ocean warms more slowly than land.

The land and ocean CO_2 sinks have a reduced capacity to remove further emissions. To limit warming to 1.5ºC to 2ºC rapid emissions reduction (mitigation) assisted by carbon dioxide removal (sequestration) is needed.

Land and Marine heatwave events will continue to increase in frequency, duration and intensity. The Pacific will face increase heat stress with an increased number of days where combines heat and humidity are harmful to human health.

B-3 The Climate system consists of five components

The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations and anthropogenic forcings such as the changing composition of the atmosphere and land use change."

- Atmosphere:

The gaseous envelope surrounding the Earth.

- Hydrosphere:

The component of the climate system comprising liquid surface and subterranean water, such as oceans, seas, rivers, lakes, underground water, etc.

- Biosphere (terrestrial and marine):

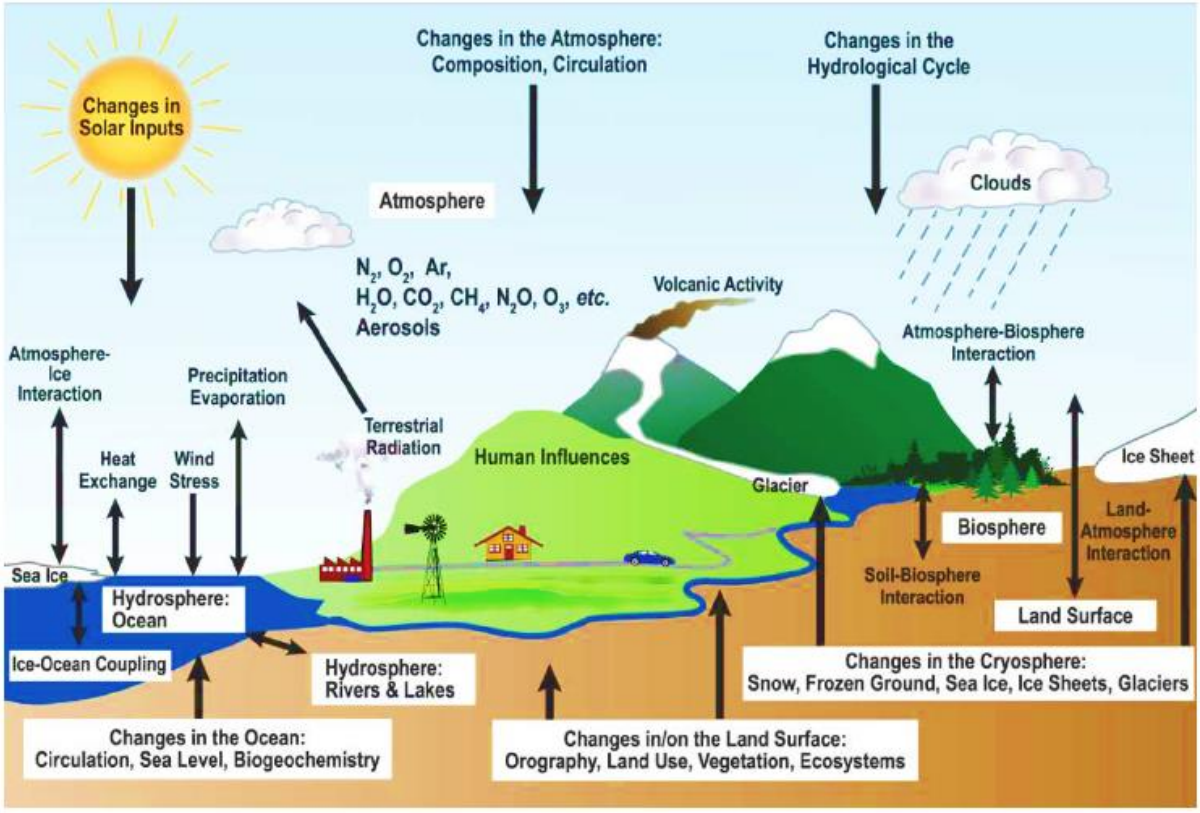
The part of the Earth system comprising all ecosystems and living organisms… including derived dead organic matter, such as litter, soil organic matter and oceanic detritus.

- Cryosphere:

All regions on and beneath the surface of the Earth and ocean where water is in solid form, including sea ice, lake ice, river ice, snow cover, glaciers and ice sheets, and frozen ground (which includes permafrost).

- Lithosphere:

The upper layer of the solid Earth, both continental and oceanic, which comprises all crustal rocks and the cold, mainly elastic part of the uppermost mantle



B-5 Causes of Climate Change

Natural Causes of Climate Change would be the orbital changes explained through the Milankovitch cycles that 3 cyclical changes in the Earth's orbit and tilt that cause climate fluctuations to occur over thousands of years. Also, the volcanic eruptions that discharges carbon dioxide and also emit aerosols. Variation in Solar radiation and El Nino Southern Oscillation (ENSO) are also natural causes of climate change.

Climate Change not only occurs naturally but also through human influence on the climate system. This is anthropogenic causes which is created through burning of fossil fuels, deforestation, increasing in livestock farming, fertilizers containing nitrogen and fluorinated gases.

Main GHGs:

i. Carbon dioxide – the consumption of energy from burning fossil fuels and deforestation
ii. Methane CH_4 - from agricultural activities, energy production and waste
iii. Nitrous Oxide N_2O – mainly from agricultural activities
iv. Hydrofluorocarbons (HFCs) – used as replacements for ozone depleting substances
v. Sulfur hexafluoride (SF_6) – used in some industrial processes and in electric equipment.

B-7 Sea Level Rise

Sea level rise is mainly caused through ice melting from land into ocean and this has caused two thirds of the global sea level rise. Rise in sea level is also caused by thermal expansion which is the scientific term for expanding water whereby as the ocean gets warmer, it expands thus raising the sea level. A lowing gulf stream and sinking land are also small contributors to sea level rise.

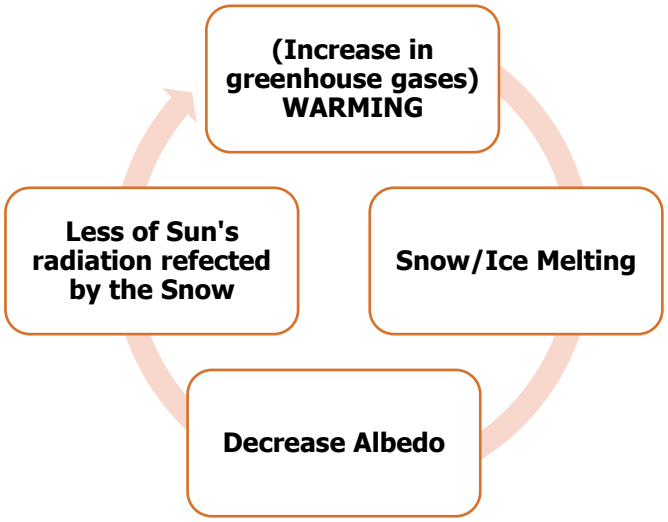
The impacts sea level rise has on our pacific islands are mostly coastal erosion, destruction of root crops, increased inundation and salt water intrusion into rivers and underground aquifers.

Some mitigating measures to the impacts of sea level rise are relocation due to inundation, refilling areas that are frequently flooded by water and replanting mangroves. Considering alternative food

source. Extreme measure such as relocation is one that will actually give hope to the people rather than thoughts that sea level will be reversible when it actually is irreversible.

B-8 Albedo Positive Feedback

Albedo is generally understood to be the fraction of the radiation reflected by an object with respect to the radiation incident upon it. The global albedo depends on the percentage cover of highly reflective surfaces and clouds. Of the total amount of solar energy reaching the Earth's atmosphere, an average 31% is reflected back to space by the upper surface of clouds, the particles in the atmosphere or the surface of the earth. Incoming energy that is not reflected (69%) is absorbed by the troposphere and the Earth's surface. Positive feedbacks are elements that can significantly enhance the rate and magnitude of climate change by increasing the initial global warming. One of the most important current feedback that contributes to climate change is the snow albedo feedback

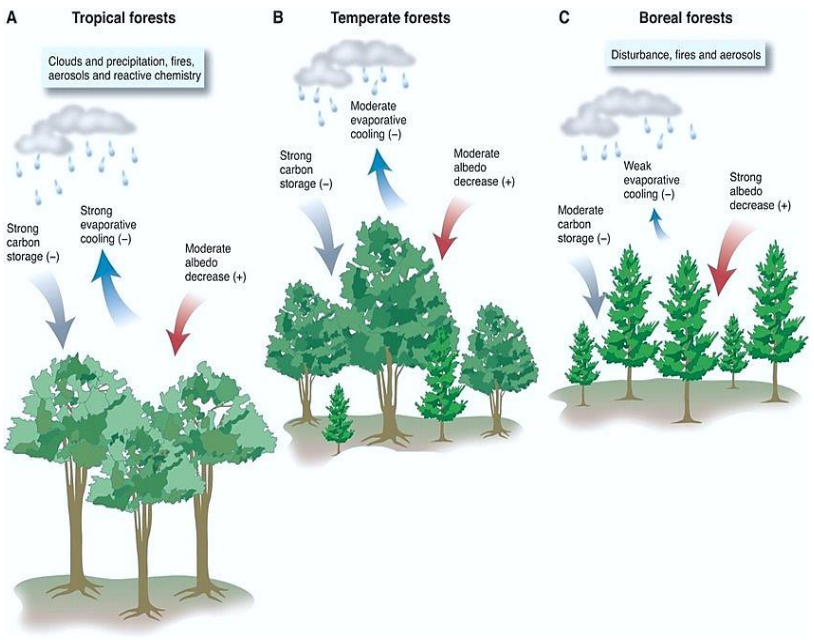


When the greenhouse gases such as carbon dioxide increases, global warming increases which leads to melting of snow/ice covers, thus, exposing more oceans. The dark colored earth surfaces tend to absorb most of the incoming solar radiations. This increases the temperature hence leading to more warming. This is also a positive feedback.

B-9 Deforestation and Climate Change

When forests are destroyed through activities such as logging, commercial development, agricultural purposes, it produces large quantities of Carbon Dioxide and other greenhouse gases which increase global temperature, hence, warming effect on the Earth and further contributing to climate change.

On the contrary, deforestation also contributes to the cooling effect of the global temperature. This is made possible through reactive gasses that is also emitted by trees and vegetation. As deforestation is usually associated with the amount of carbon dioxide emitted or changes in land-surface energy and water exchanges with the atmosphere, it is vital to note that trees also emit other gases that takes part in the complicated chemical reactions in the atmosphere.



Upon emission of gases by the forests in the air, it reacts with other atmospheric chemicals to form tine particles. These particles will then have the ability to reflect sunlight back into space, hence, cooling effect on the global temperature

B-10 IPCC Fifth Assessment Report (AR5) and the 4 RCPs

Inter-governmental Panel on Climate Change Fifth Assessment Report

The report provides and update of knowledge on the scientific, technical and socio-economic aspects of climate change and consists of three Working Group [WG] with WG1 report "Focusing on the physical science basis", WG2 report "Assessing the impacts, adaptation strategies and vulnerability related to climate change" and WG3 report "Covering mitigation response strategies in an integrated risk and uncertainty framework".

IPCC AR5 also offers key messages for Small Island Developing States (SIDS) about the impacts of climate change and some of its general findings on climate change adaptation and mitigation to SIDS.

The Representative Concentration Pathway (RCP) makes predictions of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities. The fours RCPs very from very high (RCP8.5) to very low (RCP2.6). The numerical values of the RCPs are 2.6, 4.5, 6.0 and 8.5.

Section C: Essay Questions

C-1 Impacts of Climate Change on Fiji's Freshwater Resources

Water is the most fundamental component of climate change and main medium through which it exerts its impacts. According to the World Water Assessment Special Report, 2012 the dynamics of water resources are influenced by a number of external factors, one of which is climate change. For Pacific Island countries, it is quite contradictory to say that water is becoming scarce when the Pacific Ocean is considered the largest single body of water in the world

Freshwater-related impacts, vulnerabilities and risks induced by climate change are better projected by comparing historical conditions. Such projections help to understand the impacts that human activities have on nature and providing a platform for adaptation to climate change. Nevertheless, comparing different hydrological changes projected as per various future GHG emissions scenarios or the differing rise in mean global temperature can be more helpful in aiding decision of mitigating climate change.

In such projections, two objectives that can be laid out is to quantify the current management practice and what may happen to it and the other is to highlight what actions can be put in place to evade undesirable results. Although mitigating measures such as reduction of greenhouse gas emission, transferring clean technologies and protecting forests may be crucial when dealing with climate change, it may slow it down but they will not stop nor reverse its impacts in the unpredictable future.

Scenarios of emissions are quite parallel until the 2050s providing more clarity on its impacts and benefits of mitigation by the end of the 21st century. For instance, those part of the world population that were exposed to the 20th century 100-year flood is projected to be three times more per year for RCP8.5 than RCP2.6 at the end of the 21st century. For every degree of global warming, it is projected to decrease renewable freshwater sources by 20% together with an additional increase of world population by 7%. Therefore, access to renewable groundwater sources will ultimately decrease, projecting to be about 50% higher under RCP8.5 as oppose to RCP2.6. Those living around river basins will face scarcity projected to increase simultaneously to global warming from 8% at 2ºC to 13% at 5ºC.

Surface air temperature for the South Pacific has risen by 0.3-0.8ºC during the 20th Century with the southwest zone of the Southern Pacific Convergence Zone having the greatest increase. For the 21st Century, IPPC in its Third Assessment Report, projects that in the Pacific, temperature will approximately increase 2ºC by 2050 and 3ºC by 2080. Sea level is also projected to increase in the region as much as 5ml in the 21st century and continue to do so in the 22nd century.

Freshwater Resources are impacted by Climate Change through Sea level rise that is projected to rise by 50cm over the next century, the Pacific islands will be greatly affected by its impacts. Salt water intrusion into freshwater lenses will mostly affect population that solely relies on groundwater for water supply. Islands may face a shrink in their width due to inundation or erosion. However, increase of 40-50cm sea level would not have any effect on groundwater but will raise the top of the freshwater lens leaving its base unaffected. Either way, it will still be an issue because raising the water tables to the surface would potentially result in full evapotranspiration of the resource and lead to many islands human habitation impossible.

In addition to Sea level rise, precipitation also affects freshwater resources as the pattern on many pacific islands will be affected with increased rainfall in some regions and decrease in others. Increased rainfall most likely will lead to increase flooding, intrusion of sea water into the islands recharge zones, hence, reducing water supply. Should increase in precipitation occur on shorter scales, recharging of freshwater lenses will drop due to water runoffs into the sea.

Also, an impact would be an increase in El Nino Southern Oscillation (ENSO) events that has proved in the past to greatly reduce rainfall in the western part of the Pacific. With reduction in rainfall, freshwater supplies especially or islands that rely in rainwater will be mostly affected. Decrease rainfall will also diminish groundwater supply which in turn contributes to drought in the Pacific

With respect to the evolving climate change, freshwater resources need to be managed wisely through proactive adaptation strategies. it will need policy conditions at all levels, national, regional and international. For national level, water governance must incorporate non-water sectors, having access to technology and information should be improved for thorough planning. At regional levels, water management collaboration in terms of shared surface and groundwater should be highlighted. And finally for international level, need for increased finances for water-related investments, entailing infrastructure and technology.

C-4 Adaptation to Climate Change – Ecosystem based Adaptation (EbA)

Ecosystem-based adaptation is a strategy for adapting to climate change that harnesses nature-based solutions and ecosystem services. For instance, protecting coastal habitats like mangroves provides natural flood defences; reforestation can hold back desertification and recharge groundwater supplies in times of drought; and water bodies like rivers and lakes provide natural drainage to reduce flooding.

Ecosystem-based adaptation uses the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. EbA is a means of adaptation that is readily available to the rural poor, can generate social, economic and cultural co-benefits, contribute to the conservation of biodiversity, and build on the traditional knowledge of indigenous peoples and local communities. In addition, healthy, well managed ecosystems have climate change mitigation potential. For example, through the sequestration and storage of carbon in healthy forests, wetlands, and coastal ecosystems

In promoting the sustainable use of natural resources, ecosystem-based adaptation strategies provide policy coherence with other national and international commitments. For maximum effectiveness, these strategies should be aligned with ongoing action under the Convention on Biological Diversity, the UN Convention to Combat Desertification and the Ramsar Convention on Wetlands.

The Convention on Biological Diversity has three main objectives: conservation, sustainable use, and fair and equitable sharing of the benefits derived from natural resources.2 Examples of ecosystem-based approaches include the conservation and restoration of forests, wetlands, and peatlands; marine conservation; improved grassland management; and environmentally friendly agricultural practices.

The Ramsar Convention focuses on wetland conservation as ecosystems that are extremely important to biodiversity conservation as it involves the protection of shores from wave actions, reduction on the impact of floods, absorbs pollutants and improve water quality. These are example of EbA adaptation approaches.

Many countries use ecosystem-based adaptation to deal with a broad range of climatic hazards and impacts. Some examples od adaptation strategies that may assist small developing nations like Fiji are:

i. Mangrove reforestation and conservation to protect against storms and help control erosion.
ii. Mixed farming techniques to maintain soil fertility and conserve water.
iii. Slow-forming terrace farming systems to increase soil moisture and reduce run off.

Positive results from these and many other interventions are being documented using several effectiveness measures including biophysical monitoring, cost–benefit analysis, community perception, and multicriteria scoring