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**SCHOOL OF APPLIED SCIENCES**

**DEPARTMENT OF METEOROLOGICAL AND ENVIRONMENTAL SCIENCES**

**PG Diploma in Environmental Science and Management**

**ESM 803: Climate Change Impacts and Adaptation in the South Pacific**

**Natabua and Nabua campuses**

**FINAL EXAMINATION: SEMESTER 2, 2020**

**Venue and Time as per Final examination Time-table**

 **INSTRUCTIONS**

Read the following instructions before writing.

1. Time Allowed: 3 hours with additional 10 minutes reading time.
2. All answers should be written in the Answer Booklet provided.
3. Write your ID Number on all the pages in your Answer Booklet and the additional sheets that you use.
4. Requirement: Score a minimum of 40% (20/50) to pass the course.

5. This is a closed book examination.

6. There are six pages to this paper.

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| **Sections**  | **Marks** |
| **Section A- 10 Short Answer Questions @ 2 marks** | 20 Marks |
| **Section B- 10 Longer Answer Questions @ 5 marks** | 50 Marks |
| **Section C- 2 Essay type Questions** **@ 15 marks.** **Question C1 is compulsory. Choose any one out of Questions C2, C3 or C4 to complete Section C.**  Each essay is worth 15 marks.  | 30 Marks |
| ***Total*** | **100 Marks | Weighting 50%** |

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| **Section A: Short Answer Questions** |
| **Answer all the questions. There are 10 questions in this section. Each question is worth 2 marks for a total of 20 marks for this section.** |
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| **A. Explain briefly (2 – 3 sentences) what each of these terms mean. You may use diagrams or examples to clarify your answer.** |
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| A-1 | Carbon sequestrationThe term “carbon sequestration” is used to describe both natural and deliberate processes by which CO2 is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils, and sediments), and geologic formations. | 2 marks |
| A-2 | UNFCCC and COPUnited Nations Framework Convention on Climate Change (UNFCCC). Major outcome of Rio Summit / Earth Summit of 1992. It is an international treaty for reducing greenhouse gas emissions. GHGs. Nearly every country on Earth is a party to the UNFCCC.COP – Conference of the Parties (to a particular Convention, e.g. UNFCCC). The nations, who’ve signed UNFCCC convention, meet every year to discuss climate change strategy. These meetings are called Conference of the Parties (COP). The first COP (COP 1) was held in Berlin in 1995 to outline specific targets on emissionsThird COP (COP 3) held in Kyoto, Japan. It was here the famous Kyoto Protocol came in to existence. 2011: COP held in Durban, S.Africa. 2012: COP held in Doha, Qatar in November 2012 | 2 marks |
| A-3 | Milankovitch cycles Milankovitch Cycles refer to the 3 different cycles which describe how the Earth orbits around the sun. The Earth’s orbit is not fixed – it changes regularly over time. These changes in Earth’s orbit alter the pattern of insolation, which in turn climate swings between hot and cold during the Quaternary period (the period , some 2.6 million years ago).There are 3 principle ways in which Earth’s orbit varies:1. Eccentricity or Orbital shape, meaning the Earth’s orbit is not perfectly circular, but instead it follows an eclipse. This means that the Earth is sometimes closer, and sometimes further away from the Sun. This changes the amount of insolation by a few percent.2. Axial Tilt or Obliquity: This means that the Earth spins at an angle around the Sun. This angle known as ‘axial tilt’ is 23.5 degrees at this point in time. This change causes the different seasons for the northern and southern hemisphere. The larger the tilt, the greater the difference in temperature between summer and winter for the two hemispheres3. Axial Precession: The axis of rotation for the Earth (straight line from North to South Pole) also change direction over a 20,000 year cycle, between pointing towards the star Polaris (as of now) or towards the star Vegas. This impacts the Earth’s climate as it determines when the seasons occur. E.g. Now with the North Pole pointing towards Polaris, the Northern hemisphere summer is in July, while it is winter for the Southern Hemisphere. This situation would change when the North Pole points towards the star Vegas, in 20,000 years! | 2 marks |
| A-4 | Keeling CurveThe concentration of CO2 has been changing over time, as shown by the findings of the scientist Richard Keeling, whose life's work was the observation of CO2 concentrations at the Mauna Loa Observatory in Hawaii. Beginning in the early 1950s, observations of CO2, a well-mixed gas in our atmosphere, have shown a remarkable climb in concentration. (see Figure CO2 Concentrations at the Mauna Loa Observatory, the curve is known as ‘The Keeling Curve’,\_ as it is sometimes called, clearly shows that since the 1950s CO2 concentrations have increased steadily from 315 ppm to 390 ppm. The zigzag nature of this graph is due to life cycle of plants in the NH. The NH has much more land area that the SH, so when spring and summer arrive in the NH, the abundance of new plant life reduces the CO2 concentrations in the atmosphere. When the plants die or become dormant in the fall and winter, CO2 concentrations spike again. | 2 marks |
| A-5 | ‘Urban Heat Island’Urban cities are more likely to suffer heat waves due to ‘Urban Heat Island’ effect (see next slide). Lack of vegetation (and therefore lack of cooling effect of evaporation) in cities produce the ‘Urban Heat Island’ effect | 2 marks |
| A-6 |  Carbon TradingIn real life scenario, each annex B country makes law giving fixed quota to the companies. Suppose steel factory cannot emit more than 1 ton of Green house gas Tire company cannot emit more than 2 tonnes of green house gas. So if tire company owner buys superfine machinaries that produce less gas so he has some spare credit/quota (say 1 ton). While Steel factory emits more than its allowed quota (suppose it was allowed 2 tonnes but emitted 3 tonnes). Then the steel company can pay the tire company and get a certificate that we’ve purchase 1 ton quota from this xyz tire company. This Is the essence of “Carbon Trading.” | 2 marks |
| A-7 | The Koppean Climate Classification System5 main types or categories of climate systems, as developed by the German scientist WLadimnir Koppen. | 2 marks |
| A-8 | DendrochronologyThe study of tree rings is another way of determining historical climate change. The dating and study of annual rings in trees is called dendrochronology.  | 2 marks |
| A-9 | Ocean acidificationOcean acidification is another indicator of climate change, because the increased CO2 concentration in the atmosphere causes more dissolution of CO2 at the atmosphere-ocean interphase (coupling), with the formation of carbonic acid, resulting in more dissolution of the calcium carbonate in the skeletons of corals, shelled organisms etc. in the ocean.Ocean Acidification is the name given to ongoing decrease in pH of the earth’s Oceans. Caused by the Ocean’s uptake of anthropogenic carbon dioxide from the atmosphere. Between 1751 and 1994 the surface ocean pH is estimated to have decreased from 8.25 to 8.14. It is believed the resulting continual decrease in pH will have a negative effect for oceanic calcifying organisms (Projected pH 2100 = 7.82) | 2 marks |
| A-10 | Climate and weatherClimate is the average of weather conditions over a long period of time, while weather is the condition of the atmospheric parameters of temperature, precipitation, humidity etc. in a day. | 2 marks |

**Section B: There are ten (10) questions, all are compulsory. Each question is worth 5 marks, for a total of 50 marks. You may use diagrams and formulae to clarify your answers**

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| B-1 | **Common but differentiated responsibilities****Using examples, explain what the above statement means. Explain the significance of the Kyoto Protocol in this matter.** On 12 December 2015, 196 Parties to the UN Framework Convention on Climate Change (UNFCCC) adopted the Paris Agreement, a new legally-binding framework for an internationally coordinated effort to tackle climate change. The Agreement represents the culmination of six years of international climate change negotiations under the auspices of the UNFCCC, and was reached under intense international pressure to avoid a repeat failure of the Copenhagen conference in 2009.The Paris Agreement recognizes the different starting points and responsibilities of countries, and emphasizes that the Agreement will be implemented in accordance with the ‘principle of common but differentiated responsibilities and respective capabilities’ which applies ‘in the light of different national circumstances’ (Art.2.2). This means that developed countries have to continue to take the lead in mitigating climate change and support the actions taken by developing countries.**Kyoto protocol** came into force only after required number of Annex 1 Countries ratified it. So this was achieved only in 2005. Thus, Kyoto although signed in 1997, came into force in 2005.Under Kyoto Protocol, each Annex-B country is given emission target “quota” (Kyoto Units). For example, for the year 2009, Australia’s allowed quota was 2,957,579,143 Kyoto units. (each unit is equivalent to 1 ton of carbon dioxide). | 5 marks |
| B-2 | **Clean Development Mechanism (CDM) and Joint Implementation (JI)\_**Explain what the two terms mean, their purposes, and discuss with examples how they are implemented. Under the Kyoto Protocol, countries must meet their targets/quota primarily through national measures (Nationally determined contributions NDC). However, the Protocol also offers them an additional means to meet their targets by way of three market-based mechanisms. The Kyoto mechanisms are: •International Emissions Trading;(see Carbon trading above) •Clean Development Mechanism (CDM); Suppose Annex B country Australia is given emission quota of 200 units, but it emits 210 units of green house gas. But Australia can finance a solar power project in some village of India (Non-Annex or developing Country) and get certificate that the solar plant led to reduction of 10 units of green house gas. In this way, Australia will remain in its quota/limit. Similarly, suppose Australian Government has passed a law that a steel production company with output of 200 tons of steel per a day, must not emit more than 10 units of green house gas in a year. But this company wants to produce more steel, then its green house gas emission has increased to 11 units. (1 more unit above the quota). So this company can also do some solar-projects in India, Brazil etc. and get a certificate that it has led to reduction of 1 unit of GHG emission. = problem solved.•Joint implementation (JI) ; In Joint Implementation, Australia can do the good project in another Annex B country e.g. Japan to meet the quota. | 5 marks |
| B-3 | **The Climate system consists of five components**Name these five systems and discuss the interactions among them that have stabilised the global climate over time. You may use diagrams to help explain your answers.The climate system consists of the five components•Atmosphere – reflects some of the incoming solar radiation back to space; the GHGs e.g. CO2 in the atmosphere absorbs some of the the infrared solar radiation that is reflected from the earth, and re-emits back to the earth warming it (greenhouse effect)•Ocean- has a relatively low albedo (5 -10 %), so it absorbs solar radiation, warming it. •Cryosphere (ice) – Has a high albedo (80 – 90 %) so it reflects much of the solar radiation, resulting in further cooling effect, which leads to more ice forming – the ice-albedo positive feedback loop (see Q 1 c above)•Biosphere – the Photosynthesis-Respiration cycle involving exchange of CO2 and Oxygen O2 in the processes of respiration (all living organisms use O2 and release CO2) and photosynthesis (only green plants or producers use CO2 and release O2).•Geosphere –tectonic plate movements, volcanic activities, gases released into the atmosphere affect the climate. | 5 marks |
| B-4 | **Historical evidence of climate change**Discuss any three methods that have helped scientists learn about the global climate change during pre-human times.a) Sea floor sediments - These seafloor sediments are useful recorders of worldwide climate change because the numbers and types of organisms living near the sea surface change with the climate.B) Oxygen-isotope analysis: c) Ice cores: **Others:** **Fossil Pollen****Corals build their hard skeletons from calcium carbonate (CaCO3) extracted from seawater.****•The carbonate contains isotopes of oxygen that can be used to determine the temperature of the water in which the coral grew. The portion of the skeleton that forms in winter has a density that is different from that formed in summer because of variations in growth rates related to temperature and other environmental factors.****•Thus, corals exhibit seasonal growth bands very much like those observed in trees.** | 5 marks |
| B-5 | **Causes of climate change** Discuss the natural and anthropogenic causes of climate change. Explain the main GHGs, and their sources.Natural causes:•Plate tectonics (rearranging Earth’s continents, moving them closer or farther from the equator and the poles)•Volcanic activity (changing the reflectivity and composition of the atmosphere)•Variations in Earth’s orbit (the natural, cyclic change in our planet’s orbit, axial tilt, and wobble)•Solar variability (whether the Sun varies in its radiation output and whether sunspots affect the output).*•Climate change induced by human activity may occur due to changes in the composition of the Earth’s atmosphere from waste gases due to industry, farm animals and land clearing, or changes in the land surface reflectivity caused by land clearing, cropping and irrigation. These gases include several, such as carbon dioxide, methane and oxides of nitrogen, that can absorb heat radiation (long-wave or infra-red radiation) from the Sun or the Earth.* | 5 marks |
| B-7 | **Sea level rise****Sea level rise is a major concern for low islands in the Pacific. Discuss the main causes of sea level rise and the main impacts that are being felt by these islands. Describe some mitigation measures that Pacific islands can implement.** Cause: Melting of polar ice. Impacts: Flooding of low areas. Seawater intrusion and effects on agriculture and biodiversity in coastal and estuaries. Mitigation: Relocation to higher ground. Planting of crops that can resist seawater intrusion. | 5 marks |
| B-8 | **Albedo and ‘positive feedback’** Discuss using diagrams what is meant by the albedo positive feedback mechanism. Explain how this process has helped stabilise the climate over time.***Explanation:*** *If the climate cools (initial change), snow forms and covers more of the land while sea-ice covers more of the oceans. Snow has a higher albedo than bare ground (land) and ice has a higher albedo than the ocean. Due to the higher albedos of the snow on land and sea-ice in the oceans, the effect of the initial cooling will be more cooling (amplification of the initial cooling) as the amount of sunlight reflected back to space is now increased. This is what* ***‘positive albedo effect’*** *means, shown by the loop in the diagram above* | 5 marks |
| B-9 | **Deforestation and climate change**Explain how deforestation can lead to both a warming effect and a cooling effect for global temperatures.*1. Deforestation – explain or define what it is and why man has over historical time, carried out large scale deforestation. To meet food demands and lifestyle changes, man has cleared forests and replaced them with intensive agricultural lands and cities. The net effect of human existence on Earth is to ‘brighten the surface’ and subsequently increase the global albedo. In addition large scale deforestation in South America and Africa have increased the Earth’s albedo! THIS SHOULD HAVE RESULTED IN A COOLING EFFECT ON THE GOBAL CLIMATE.**2. Warming effect? Forests are carbon sinks, i.e. through the process of photosynthesis where green plants capture the carbon dioxide in the atmosphere and convert it to glucose (thus they are termed the ‘producers’ and the starting point in any food chain), forests help to keep the earth cool by removing the greenhouse gas CO2 from the atmosphere. When forests are cleared (deforestation), the carbon sinks are removed, leading to elevated CO2 concentrations in the atmosphere, and with increased atmospheric CO2, the global climate is expected to get warmer THIS IS HOW DEFORASTATION CAN LEAD TO A WARMING EFFECT.* | 5 marks |
| B-10 |  **IPCC Fifth Assessment Report (AR5) and the 4 RCPs****Explain what is the main subject of the IPCC AR5. Write down what RCP stand for. Discuss what the 4 RCPs are.** IPCC AR5 - The Intergovernmental Panel on Climate Change (IPCC). AR5 – Fifth Assessment Report.The IPCC’s Fifth Assessment Report presented nine (9) Key messages on Impacts of CC for Small Island Developing States :1. The climate is already changing and SIDS are already feeling the impacts2. Further climate change is inevitable in the coming decades3. Climate change is affecting SIDS’ growth and development4. Climate change poses an existential threat to some SIDS5. Adaptation can reduce the impacts of climate change, but there are limits and risks involved6. The economic cost of adaptation to climate change is high in SIDSrelative to the size of their economies7. SIDS stand to benefit from further integration of climate adaptation, mitigation and development approaches8. Transformation to a low-carbon economy implies new patterns of investment9. International cooperation is vital to avert dangerous climate change and SIDS governments can promote ambitious global action**Future global climate – 4 scenarios**In assessing future climate change, the Fifth Assessment Report presents four scenarios, known as Representative Concentration Pathways (RCP). The scenarios show the result of different levels of emissions of greenhouse gases, from the present day to 2100, onglobal warming. In all scenarios, carbon dioxide concentrations are higher in 2100 than they are today.The four RCPs: The low-emissions scenario (RCP2.6) assumes substantial and sustained reductions in greenhouse gas emissions. The high-emissions scenario (RCP8.5) assumes continued high rates of emissions. The two intermediate scenarios (RCPs 4.5 and 6.0) assume some stabilisation in emissions. | 5 marks |

**Section C: Essay Questions.**

**Question C-1 is compulsory. Choose and answer any 1 from C-2, C-3 or C-4. Each question is worth 15 marks for a total of 30 marks for this section.**

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| **C-1** | **Climate change is already affecting the small island developing states such as Fiji.** Select a sector (agriculture OR forestry OR fisheries OR human health OR freshwater resource OR food security) and write an essay on how climate change has affected, or will affect the sector of your choice. Structure your essay to include an introduction and conclusion.  | 15 marks |
| **C-2** | **Climate change and equity issues** “The effect of climate change on the marginalized, vulnerable and economically-weak members of society is usually worse, compared to the rich. The women and children are also affected differently from the men”.Discuss these statements, using examples from the world and locally.Discuss some policy measures that are being implemented, or can be implemented to mitigate the effects of climate change on these vulnerable groups. | 15 marks |
| **C-3** | **Calculation of earth temperature**Using mathematical calculations, prove that calculated temperature of the Earth is less than the actual temperature.Discuss the main cause for this phenomenon.Explain what is the overall goal of the Paris Agreement that was adopted in 2015, with regards to global temperatures.  | 15 marks |
| **C-4** | **Adaptation to Climate change – Ecosystem-based Adaptation (EbA)**Explain what EbA means and what it involves. Most nations have adopted the EbA approach because it helps them to achieve their obligations under three international agreements or conventions initiated at the Rio Earth summit in 1992. Name these three conventions and discuss how EbA contributes to meeting the objectives of the three conventions. Discuss three examples of Ecosystem-based adaptation strategies that would assist a small developing nation like Fiji adapt to the impacts of climate change.Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.Effectiveness of ecosystem-based adaptation: Ecosystem-based adaptation refers to increasing the adaptation capacity of societies and ecosystems of an area by preserving and making use of ecosystem services. For example,extreme events that result from climate change can be prevented by storing water in vegetation, soil, and aquifers.Biodiversity preservation is an additional positive side effect.For SIDS, the ecosystems provide the lifeline for the people, and the limited resources including land space make SIDS more vulnerable to climate change effects. Therefore the preservation and restoration of the ecosystems and the services they provide are the preferred approach to adaptation to CC. “Ecosystem-based adaptation contributes to meeting objectives under all three Rio Conventions” i) Write down what these three (3) UN conventions are The Convention on Biological Diversity (CBD),  the United Nations Convention to Combat Desertification (UNCCD), and  the United Nations Framework Convention on Climate Change (UNFCCC).ii) For each convention, explain one way in which EbA helps the nations to meet their obligations under the convention1. UNFCCC: a) Many countries have included EbA or ecosystem-oriented visions in their Nationally Determined Contributions (NDC) under the Paris Agreement. The Paris Agreement was adopted in Paris in December, 2016, at the COP (Conference of the Parties) to the UNFCCC. b) By providing co-benefits such as carbon sequestration, EbA helps countries to meet mitigation targets under the UNFCCC.2. CBD: The EbA emphasis on restoring and maintaining biodiversity and ecosystem services, and increasing habitat connectivity, helps countries meet their obligations under the Convention on Biodiversity (CBD).3. UNCCD: EbA often involves maintaining or restoring the capacity of ecosystems to regulate water cycles, thus aligning with the goals of the UNCCDThere are five (5) goals of EbA. Select one (1) goal and explain how EbA helps to achieve the goal you have selected The five goals:  1.Reduce social and environmental vulnerability to climate change 2.Generate social benefits and support the most vulnerable 3. Restore, maintain or improve ecosystems and biodiversity 4.Be mainstreamed into policies at multiple levels 5.Support equitable governance and enhance capacitiesHow these goals can be achieved by EbA: Goal 1: Reduce social and environmental vulnerability to climate change.EbA uses the best available science on climate change and ecosystems, alongside local and traditional knowledge, to strengthen the social and ecological resilience and adaptive capacity of vulnerable people. 2.Generate social benefits and support the most vulnerable. EbA delivers direct or indirect benefits that increase peoples’ resilience to climate change, including enhanced food security, shelter, risk reduction, provision of fresh water and medicine, and local climate regulation. 3. Restore, maintain or improve ecosystems and biodiversityBecause climate change can force changes in ecosystem composition and structure, it is important that the health and stability of ecosystem services are maintained, improved and monitored. EbA supports the sustainable use of resources and diversification of land and livelihood options such as multi-cropping and agroforestry 4.Be mainstreamed into policies at multiple levelsEbA should be integrated into existing policy frameworks so that interventions can be sustainable and scalable, rather than short term and stand alone, and can help millions of people vulnerable to climate change, beyond project beneficiaries/target areas. 5.Support equitable governance and enhance capacitiesEbA enhances governance of natural resources, biodiversity and ecosystem services, by following a community-centred, participatory and gender-sensitive approach. | 15 marks |

**THE END**