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論文題目	EFFECT OF CLIMATE CHANGE ON PRECIPITATION IN NEPAL AND KANSAI AREA IN JAPAN, AND ON WATER QUALITY OF OSAKA BAY AREA (気候変動がネパールと日本の関西地区における降雨および大阪湾水質へ及ぼす影響)		
<p>(論文内容の要旨)</p> <p>Climate change driven by anthropogenic activities is likely to increase the temperature and alter the amounts, duration, frequency, and intensity of precipitation. Many studies have reported that climate change directly or indirectly influences water quality, especially the release of nutrients in lakes and sea. This research aims to assess the changes in extreme precipitation indices in Nepal and Kansai region in Japan. Also, it assesses the impact of precipitation indices in sea water nutrient concentration in Osaka Bay.</p> <p><b>Chapter 1 Introduction</b></p> <p>Chapter 1 presents the overview of the precipitation indices across globe, Nepal, and Japan and its effect on water quality, specifically on Osaka Bay in the past and present. It also discusses research problem statements, scope and research objectives, and outline of the dissertation.</p> <p><b>Chapter 2 Materials and methodology</b></p> <p>Chapter 2 presents the materials, methodologies, and description of the study area. The extreme precipitation indices in Nepal and Kansai region of Japan were assessed using ETCCDI's indices. The effect of extreme precipitation indices on water quality of the Osaka Bay, Japan was then analyzed. The water quality prediction in the Osaka Bay was also carried out using EFDC water quality model.</p> <p><b>Chapter 3 Extreme precipitation indices in Nepal</b></p> <p>Chapter 3 analyses the extreme precipitation indices in Nepal from 1976-2015. The spatial distributions of changes of mean annual values of different extreme precipitation indices attributed between two periods T1 (1976-1995) and T2 (1996-2015) with respect to the corresponding values during period T1 are analyzed. The rising trend was observed for R20 (Annual count of days when PRCP<math>\geq</math>20mm) and R50 (Annual count of days when PRCP<math>\geq</math>50 mm) during those periods, which leads to a risk of torrential floods in the low elevated regions and landslides in the high elevated regions. The quantitative change analysis of the precipitation indices in the two periods showed a higher shift in CDD (Consecutive Dry Days) values (14.8%) and a lesser shift in R10 (Annual count of days when PRCP<math>\geq</math>10mm) values (0.6%). This variation concludes that T2 is comparatively drier and has a risk of flash floods.</p> <p><b>Chapter 4 Extreme precipitation indices in Kansai, Japan</b></p> <p>Chapter 4 discusses the extreme precipitation indices in Kansai region, Japan. In a longer timescale (1971-2015), CDD, R10, and R20 showed a gentle trend while other indices show upward trend. We observed a noticeable increasing shift of CDD in four prefectures namely, Hyogo, Kyoto, Shiga, and Nara. The higher variability of CDD is observed in 1986, 2000 and 2011. In contrast, CWD (Consecutive wet days) showed increasing trend in T1 and decreasing in T2. The spatial heterogeneity in rainfall indices were observed in the Kansai region showing a higher extremity in the urbanized prefectures like Osaka and Kyoto and lesser variation in rainfall extremes in less urbanized prefectures.</p> <p><b>Chapter 5 Comparison of precipitation indices distribution between Nepal and the Kansai region in Japan</b></p> <p>Chapter 5 assesses the comparison of precipitation indices distribution between Nepal and Kansai region. Both the area lies in the northern latitudes. The annual precipitation in Nepal and Kansai is almost congruent (1700 mm per year). Both the study area behaved similar tendency of PRCP<sub>TOT</sub> (Annual total wet-day precipitation) in time T1 and T2. Higher amount of precipitation is observed in time T2 compared to time T1 which signifies that floods are the main environmental challenges in both the study area. Further, the spatial and temporal trend of CDD showed reduced number of dry days in time T2 compared to time T1 lower being in the urban areas.</p> <p><b>Chapter 6 Water quality in Osaka Bay</b></p>			

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<p>Chapter 6 discusses about the water quality conditions in the Osaka Bay. Fluctuations in the salinity is observed over the temporal period. The temporal distribution of nitrite showed a gentle decreasing trend in 2007 (0.48 mg/L) and reduced drastically beyond. Similarly, the nitrate concentration reduced gradually from 1994 to 2015. The concentration of nutrients is higher near to the shoreline. The observed value of pH in the bay area showed that the water is alkaline (&gt;7) in nature and fluctuate mostly between 8.1 and 8.2. During 2007 and 2009, the alkalinity in all the stations showed increasing nature.</p> <p><b>Chapter 7 Effect of precipitation indices to water quality of Osaka Bay</b></p> <p>Chapter 7 shows the interrelationship between extreme precipitation indices and water quality nutrients in the Osaka Bay. Salinity concentration descends with increase in total precipitation in the bay area. Further reduction in salinity and nitrogen nutrients is attenuated by increase in R95PTOT (Annual total precipitation when Daily Precipitation&gt;95th percentile) and R99PTOT (Annual total precipitation when Daily Precipitation&gt;99th percentile) in land surface. In contrast, the temporal variation of salinity against R95PTOT and R99PTOT did not show increasing or decreasing tendency with increase or decrease in rainfall indices till 2010. The increase in Rx1day (Yearly maximum one-day precipitation ) has resulted in reduced concentration of both salinity and DIN (Dissolved Inorganic Nitrogen) concentration after 2010. But the temporal distribution of salinity and DIN is fluctuating between 1994 and 2009. Higher amount of 1 day precipitation in 2004 and lower amount in 2002 resulted in low and high concentration of salinity and DIN, respectively.</p> <p><b>Chapter 8 Prediction of water quality of Osaka Bay</b></p> <p>Chapter 8 explains the numerical model that was applied to Osaka Bay, Japan for the prediction of water quality. In this study, salinity, temperature, different forms of nitrogen, DO, pH are simulated using 3D hydrodynamic model. Environmental Fluid Dynamics Code (EFDC) is a public domain, open source, surface water modeling system. The model can simulate the vertical stratification of temperature and salinity near the mouth of rivers. It was found that the freshwater plays major role in stratification and net flushing of the Osaka Bay. Although small individually, the ungauged streams and surface runoff can be a significant portion of the total inflow and affect salinity distribution significantly.</p> <p><b>Chapter 9 Conclusions</b></p> <p>Chapter 9 concludes the research from each preceding chapters. The results of this study imply that only rainfall is not the driving factors that control the water quality concentration in the bay area. There exist other controlling factors such as anthropogenic activities, management practices and policies and that fluctuate the nutrient concentration in the bay area.</p>			

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(論文審査の結果の要旨)

本論文は、気候変動がネパールおよび日本の関西地区の降雨状況に及ぼす影響、および大阪湾水質に及ぼす影響について検討したものである。得られた主な成果は以下のとおりである。

- 1) ETCCDI(Expert Team on Climate Change Detection and Indices)による11の降水指標について、ネパールにおいて2つの期間T1(1971-1995)とT2(1996-2015)を比較した。その結果、R20(降水量20mm以上の年間日数)とR50(降水量50mm以上の年間日数)で増加傾向が認められた。これは低高度地帯での激しい洪水の危険性と、高高度地帯での地滑りの危険性の増加につながる。2つの時間区分での降水インデックスの定量的変化は、CDD(Consecutive Dry Days: 降水量1mm未満の最大連続日数)で14.8%と高く、R10(降水量10mm以上の年間日数)では0.6%と小さかった。
- 2) 同様の解析を日本の関西地区について行った結果、京都や大阪において、降水指標の大きな変動が観察された。特にCDDの増加傾向や降水日数の減少傾向が見られ、これは大都市において、降水および乾燥のリスクが大きいことを示している。このことから関西地区においてもネパール同様、洪水と乾燥の振れが大きくなり、洪水、干ばつ、地滑り、山火事といった自然災害のリスクが増加していると考えられる。
- 3) WRTDS(Weighted Regression on Time, Discharge, and Season)モデルを用いて、大阪湾水質変化に及ぼす下水処理場からの排水や土地利用変化などの影響を解析した。その結果、増加した集水域への降水の影響によって、栄養塩濃度や溶存酸素濃度の減少をもたらすが、それだけでなく、人間活動の影響も大きいことが示された。今後、推定精度を上げるためには、より多くの観測地点のデータを用いることが必要である。

以上の結果は、気候変動が集水域や閉鎖性水域に及ぼす影響を解析し、予測する手法を提供するものであり、気候変動下における今後の水環境管理手法の発展に大きく貢献するものであって、学術上、実際上寄与するところが少なくない。よって、本論文は博士(工学)の学位論文として価値あるものと認める。また、令和3年8月10日、論文内容とそれに関連した事項について試問を行って、申請者が博士後期課程学位取得基準を満たしていることを確認し、合格と認めた。

なお、本論文は、京都大学学位規程第14条第2項に該当するものと判断し、公表に際しては、当該論文の全文に代えてその内容を要約したものとすることを認める。