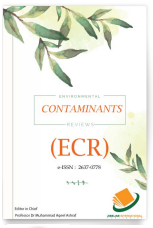
ZIBELINE INTERNATIONAL PUBLISHING

e-ISSN : 2637-0778
CODEN: ECRNAE

Environmental Contaminants Reviews (ECR)

***DOI** : http://doi.org/10.26480/ecr.01.2018.13.17*



REVIEW ARTICLE

IMPACTS OF ENVIRONMENTAL CHANGEABILITY AND HUMAN ACTIVITIES ON HYDROLOGICAL PROCESSES AND RESPONSE

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ARTICLE DETAILS

Article History:

Received 13 April 2018
Accepted 16 May 2018
Available online 01 June 2018

ABSTRACT

The climate change is an important global issue impacting the water resources worldwide. The environmental changeability would lead to rapid melting of glaciers and increased evaporation rates leading to the shortage of available water resources. The climate change would also increase the frequency and intensity of extreme climatic events such as droughts, heat waves and cold epochs etc., and hydrological response such as floods. The human activities significantly impact the water resources availability. The increasing concentrations of CO_2 and other greenhouse gases, for example methane (CH_4), nitrous oxide (N_2O) and Ozone (O_3) significantly contribute to the climate change and influence the water resources. This systematic review is focused on the impacts of climate change and human activities on the water resources. These changes will profoundly impact the development of the different regions of the world economically and socially. The climate change impacts the vegetation with changes in distribution, growing seasons and productions. The physiological and hydrological processes are also being affected by climate change and because of human being.

KEYWORDS

Environmental Changeability, Elevated CO_2, human activities, water resources.

1. INTRODUCTION

The sustainability and characteristics of ecosystem are affected by climate change directly or indirectly. Climate change involves the changes in temperature and precipitation distribution [1]. The climate change can modify the structure and functioning of ecosystem, impact natural processes, increase natural disturbances, and alter the distribution of water resources and vegetation patterns [2].

The climate changes affect the water resources and agriculture. The agricultural crops require favorable temperature ranges and the crop yields can be reduced by the increases in seasonal temperature and more extreme temperature events [3,4]. The global climate system is changing faster than the natural variability patterns and the natural human living conditions range [5]. The main concern about climate change is related with anthropogenic global warming [6]. Nowadays more anthropogenic greenhouse gas emissions have impacted the climate like temperature increase, sea level rise and higher intensity and frequency of floods and droughts [7]. The potential impacts of increased emissions of CO_2 are ecosystems damage, increased droughts and floods, sea level rise, crop productivity reduction, increased malnutrition and more infectious diseases causing deaths [8]. The increasing CO_2 concentration will affect the climate change and hydrological cycle through effects on plant physiology and through its radiative greenhouse effect [9-11].

The understanding of human-climate-environment interactions is important for the assessment of ecosystems vulnerability to the future climate change impacts [12]. The setup of economic incentives is important so that the global and regional actors have more interest in forest protection with its carbon storage than cutting it for agriculture, urban expansion and other usage [13].

Climate Adaptation is what to do for avoiding and recovering from extreme climate events. The five focus areas of adaptation activities typologies are spatial scope (local, regional, national, global) stimulus related timing (reactive, concurrent, anticipatory), necessary change degree (transformational, incremental), form (institutional, financial, behavioral, technological) and intent (planned, autonomous) [14-17]. The three discrete adaptation approaches are social vulnerability approaches focused to tackle social issues, resilience approaches focused to enhance resilience of systems and targeted adaptation approaches focused to actions for dealing with climate change risks [18]. There is relationship between domains of resilience, vulnerability and adaptation within human dimensions of climate change [19].

The vulnerability and risks due to climate change are increasing because globally the rapid population and economic growth are mostly concentrated in areas more exposed to climate change. Various areas of the world are already being affected by climate change such as recent extreme events of droughts in East Africa and USA, wildfires in Canada, Russia, Portugal and USA, and floods in Colombia and Australia are expected [20]. There are uncertainties about the average temperature increase, change in weather patterns, which areas will be hotter, cooler, drier and wetter and the economic impacts. Variability of temperature and precipitation is at shorter scale at regional level is very important for impact assessment studies.

Precipitation is as equally important factor as temperature in climate change [21]. Many research studies on precipitation changes were done at country or regional levels because of the climate changes at regional level [22-24]. Precipitation changes detection is carried out through the analysis of long-term precipitation data and simulated precipitation data by climate models [25,26].

The monitoring, forecasting and warning systems exist in many parts of world for extreme cold and heat events, floods, storms, cyclones,

tornadoes, tsunamis, avalanches and volcanic eruptions [27]. Monitoring, forecasting and warning systems, engineering design standards and building codes, physical protection and barriers, technological control and intervening physical phenomena, relief and insurance mechanisms, and land use changes for reducing exposure and vulnerability are the pathways to respond to disasters and extreme events [28]. All these systems face challenges in indicating the exact location, timing, duration, physical nature, magnitude and impacts. The warning systems can be improved as main efforts for adaptation to climate extremes and for reduction of disaster impacts [29].

Spatial planning has an important role in dealing with climate change because of place-bound nature. Climate change adaptation and mitigation at regional level is considered as a new field of spatial planning research and practice [30-32]. Climate change is impacting the ecological processes and distribution of species and causing the biodiversity loss [33-35].

The world's ecosystems are experiencing changes in climate, land use and CO_2 concentrations. Due to land use change and industrial developments, there has been an increase in atmospheric CO_2 concentrations. These changes are affecting the ecosystems, and hydrological processes. The continuous climate change, land use change, increase in greenhouse gases emissions and higher CO_2 concentrations in the ecosystems needs more assessment, description and explanation of the impacts on the local ecosystem and hydrological processes.

The scope of this study covers the geographical, ecological and scientific studies related to the climate, land use and CO_2 concentrations. This study has wider scope in many study areas such as sustainable development, risk management, ecology, hydrology, environment, health, agriculture, geography, socio-economic studies etc. This study can be used in the assessment of potential risks and threats to ecosystems due to mentioned changes. This review can also be helpful in the formulation and development of climate change adaptation and mitigation strategies and policies.

2. DISCUSSION

2.1 Co_2 Concentration and Environmental Changeability

The increase in CO_2 concentration in atmosphere and the effects of this increase is main problem in climate change studies [36]. The prediction of ecosystem response to the increasing CO_2 levels in atmosphere is very important. The 2008 global emissions of CO_2 by country from fossil fuels and industrial processes are shown in Figure 1.

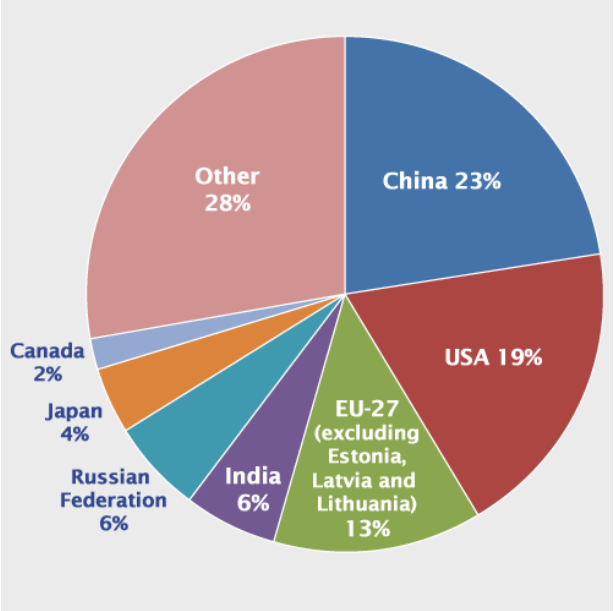

Figure 1: Global CO_2 Emissions by Country 2008

The global emissions of CO_2 for time 1900-2008 from fossil fuels and industrial processes are shown in Figure 2.

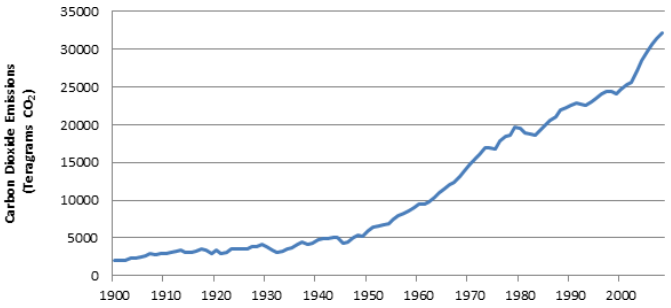

Figure 2: Global CO_2 Emissions 1900-2008

The climate-carbon cycle model of Community Earth System Model (CESM) can be used to describe the ecosystem changes in response to effects of CO_2 and climate changes. This model shows the changes in temperature, precipitation and other climate factors [37,38]. The deductive sequential and parallel approaches can be used for socio-economic and emission scenarios, climate characteristics and projections leading to impacts, vulnerability and adaptation. The inter-relationships between climate change, land use change and CO_2 and their relationship with the ecosystem are as in Figure 3:

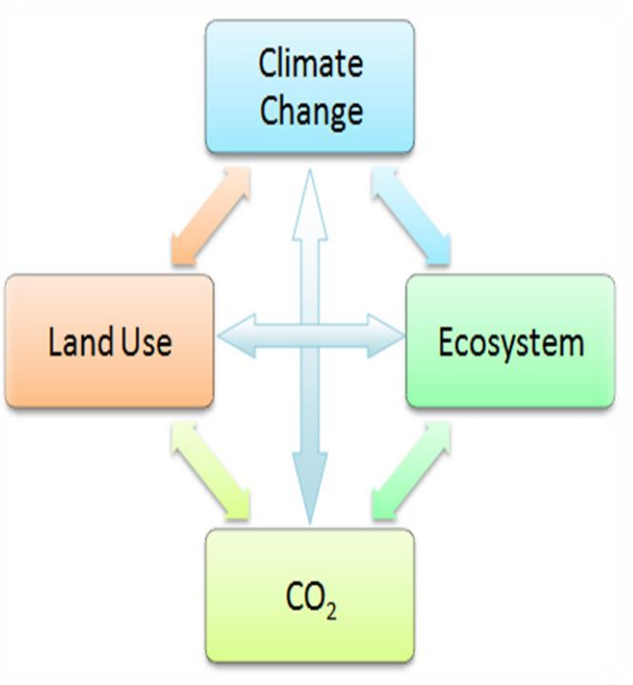

Figure 3: Climate change, land use change, CO2 and ecosystem inter-relationship

Ecosystem and hydrological processes are more sensitive to anthropogenic climate change than to natural climate variability. More research work is needed to clearly describe and explain the ecosystem and hydrological responses under changes due to climate, land use and elevated CO_2 concentration. The structural and physiological dynamics of vegetation play important role in the effects of elevated CO_2 on the water balance and water cycles at the local, regional and global scales. The hydrological responses of ecosystems and physiological responses of vegetation to the higher CO_2 concentrations and climate change are needed to be clearly understood and focused on in ecological and environmental researches. The mechanisms and relationships of hydrological processes of evaporation, transpiration, evapotranspiration, runoff and water storage are important to be clearly understood. Runoff is the difference between precipitation and the sum of evapotranspiration and water storage. These hydrological processes are significantly influenced by the impacts of climate change, land use change and CO_2 concentrations.

Climate change has much larger effects on hydrological processes than CO_2 concentrations. The consideration of direct and indirect interactive impacts of climate change and elevated CO_2 showed the importance of elevated CO_2 which showed more considerable effects on runoff than climate change in the forest ecosystems [39]. The changing atmospheric CO_2 concentration led to runoff increase in humid areas and runoff

decrease in arid areas and these changes were attributed to transpiration changes by vegetation dynamics [40]. Moderate temperature rises with elevated CO_2 concentration increased net photosynthesis but decreased biomass production while higher temperature increase decreased both photosynthesis and biomass production. Precipitation increase leads to increased photosynthesis and biomass production and reduced cloudiness also show increased photosynthesis and biomass production [41]. The evapotranspiration was not affected by elevated CO_2 because the water loss through transpiration was balanced by decrease in soil evaporation. It was indicated that the temperate grasslands can benefit from increased biomass production and maintained water consumption [42].

2.2 Human Activities and Hydrological Response

The impacts of the climate change, human activities and land use change on the hydrological dynamics and relevant hydrological response. The climate change had more contribution to runoff changes as compared to human activities contribution [43]. For example, the impacts of climate change and human activities on the runoff change were quantitatively analyzed in the karst watershed of Yinjiang River in Southwest China. The climate factors had more contribution to runoff change as compared to the human activities contribution in Yinjiang River Watershed [43]. The climate change is profoundly impacting the hydrological processes and water resources. The increasing temperatures would lead to rapid melting of glaciers and increased evaporation rates leading to the shortage of available water resources. The decreasing precipitation would support the water resources availability. The climate change would also increase the frequency and intensity of extreme climatic events such as floods, droughts, heat waves, cold epochs etc. The extreme climatic events inflict significant damages and losses to the humans, ecosystems and environment.

Climate change impacts hydrological processes of basins and watersheds by runoff variations, frequent flooding, disturbed water balance etc. The impacts of the climate change on the hydrologic processes and related management practices in the Ipswich watershed in Massachusetts of USA were evaluated using Hydrological Simulation Program Fortran (HSPF) modeling and different hydrologic fluxes under climate change scenarios. Their results showed the significant impact of climate change on watershed runoff and the Best Management Practices (BMP) were designed for adaptation to and mitigation of climate impacts on watershed such as water runoff variations [44]. The detention effects in flooding mitigation induced by climate change in the Charles River watershed in Massachusetts of USA were assessed using the climate sensitivity test, modeling different climate condition by Soil and Water Assessment Tool (SWAT) and comparison with IPCC scenarios. The results showed that the detention is more effective in flooding mitigation in low emission scenarios and more land area is needed for flood mitigation under climate change scenarios [45]. The hydrological response and the changes in the water balance and related hydrological dynamics due to the climate change, urbanization and land use change were studied in Italy and India. The alterations in watershed hydrology due to climate change and urbanization drivers were analyzed using a modeling framework consisting of hypothetical scenarios of climate and land use change for the hydrological response of basin under different conditions [46,47].

The climate change is profoundly impacting the hydrological processes and water resources. The increasing temperatures would lead to rapid melting of glaciers and increased evaporation rates leading to the shortage of available water resources. The decreasing precipitation would support the water resources availability. The climate change would also increase the frequency and intensity of extreme climatic events such as floods, droughts, heat waves, cold epochs etc [48]. The extreme climatic events inflict significant damages and losses to the humans, ecosystems and environment.

The climate change is profoundly impacting the hydrological processes and water resources. The increasing temperatures would lead to rapid melting of glaciers and increased evaporation rates leading to the shortage of available water resources [49]. The climate change would also increase the frequency and intensity of extreme climatic events such as floods, droughts, heat waves, cold epochs etc. The extreme climatic events inflict significant damages and losses to the humans, ecosystems and environment.

3. CONCLUSION

Environmental impacts have been observed in the study region. The land use change and increasing urbanization are the main reasons of climatic deterioration and for extreme events. Since 1996, the increases in annual mean temperatures and decreases in annual total rainfall are consequently leading to more frequent and intense climatic disasters in many parts of the world, particularly in Asian countries. The climate change would influence the water resources of this region due to changing trends in temperature and rainfall. The development of green infrastructure would support flood risk mitigation and climate extremes alleviation. The complete evaluation of temperature and precipitation, water storage volume and flood risk analysis for different scales and periods would support decision-making on climate change adaptation and mitigation and water resources management. This study can also be used in the exploration of methods and ways for ecosystem balance, ecosystem protection and water management.

ACKNOWLEDGEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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