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EFFECTS OF GLOBAL WARMING ON FRESH GROUNDWATER RESOURCE IN COASTAL REGIONS

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1. INTRODUCTION

Global warming due to greenhouse effect is expected to cause major changes in climate. The change in climate has a profound effect on hydrological cycle through precipitation, evapotranspiration, soil moisture etc. Studies on global warming and its effect on climatic change are being pursued vigorously as a multi-disciplinary problem especially for global fresh water resources (Arnell, 1999, 2004). When considering the water resource in areas bordering seas, coastal aquifers are very important resource of freshwater, but salinity intrusion is the one of the major problems there. Salinity intrusion leads to replace the freshwater in coastal aquifers by saltwater reduction of available fresh groundwater resource. Change in groundwater recharge directly affects the changes in fresh groundwater resources. Subsequently, the salinisation of coastal aquifers will accelerate due to the reduction of groundwater recharge. This could mean a reduction of fresh groundwater resources. Under such circumstances, it is important to study changes in groundwater recharge due to future climate changes and related loss of fresh groundwater resources in coastal zones.

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) warned that global warming, due to the enhanced greenhouse effect, the hydrological cycle will be intensified, with more evaporation and more precipitation, but the extra precipitation will be unequally distributed around the globe. Some parts of the world may see significant reductions in precipitation, or major alterations in the timing of wet and dry seasons (IPCC, 1999, 2001)

This paper describes an assessment of the implications of climate change for groundwater recharge and the effect of change in groundwater recharge and sea level rise on the on loss of fresh groundwater resource in coastal aquifers. The study concerns a case study on Sri Lankan coastal aquifers.

2. METHODOLOGY

The study uses climate change scenarios developed from Hadley Centre climate simulations (HadCM3-A2). The climate data is available at a spatial resolution of 2.5^0 of latitude by 3.75^0 of longitude, which is equivalent to a surface resolution of about 417 km ×278 km at the equator. According to this resolution, only one cell was selected for the evaluation. Water balance technique has been used to estimate the annual average groundwater recharge. The recharge is estimated as the difference between precipitation and evapotranspiration. Evapotranspiration is calculated using Penman-Monteith formula. The sharp interface model has been utilized to simulate the movement in freshwater saltwater interface due to the change in groundwater recharge as a result of global climate changes. The sea level rise has been estimated as 0.9mm/year for the Indian sub continent area (PSMSL). The hydro-geological properties of the study area have been obtained from Global Groundwater Information System, developed by IGRAC (2004). The model has been simulated over 100 years of annual change in groundwater recharge. The concept of interface between freshwater and saltwater has been used to estimate the amount of fresh groundwater resources in coastal aquifers. The movement of salinity interface due to the changes in climate and sea level rise leads to change in available fresh groundwater resource in the aquifer.

3. RESULTS AND DISCUSSION

The future fluctuations of annual precipitation clearly show long-term increases and decreases in annual precipitation. These variations in precipitation mainly lead to the fluctuations in groundwater recharge. In this study, from the present climate change point of view, the change in recharge allows the estimation of the change of fresh groundwater resource over the future 100 years, providing new insight into temporal succession of dry and humid periods. As shown in Figure 1, the pattern of the change in precipitation is well matched with the changes in loss of fresh groundwater resources and reproduces the relative changes. The long-term precipitation increments in 2000-2030, 2050-2075 and 2075-2100 are followed by a succession of reduction in loss of fresh groundwater resource. A long-term reduction in precipitation is also can be identified between 2030-2050. It leads to increase the loss of fresh groundwater resource in the region.

The average annual variations also highlight the complexity of the hydrological consequences and feedbacks of future climate changes, but indicate a rough decrease of loss of fresh groundwater resources with precipitation increments in the area. The regression coefficients between precipitation and freshwater loss and the temperature and freshwater loss can be expressed as relationships of water and energy for the loss of fresh groundwater resource. The regression between precipitation and loss of fresh groundwater resource suggests that the fresh groundwater loss decreases by approximately 3 % when annual precipitation rises by 1mm/day (figure 2). The opposite correlation can be observed between mean temperature and loss of fresh groundwater resource. It says that 1 ^{0}C increment of mean temperature will causes 1.4 % of increase in loss of fresh groundwater resource in Sri Lankan coastal aquifers (figure 3).

4. SUMMARY

IPCC climate change scenario, HadCM3 climate data has been used to evaluate the changes in fresh groundwater resource in tropical monsoon region, Sri Lanka. Using sharp interface model, the freshwater-saltwater interface and related loss of fresh groundwater resource has been estimated. It shows linear relationships between precipitation, temperature and fresh groundwater loss for long-term climate changes.

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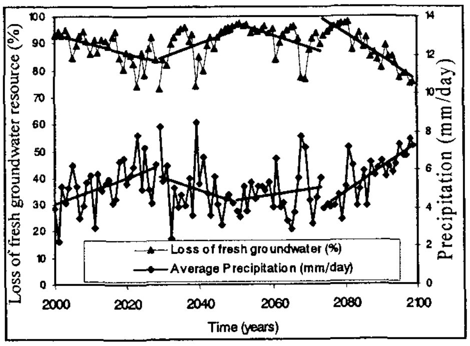

Figure 1. Annual change in Precipitation and loss of fresh groundwater resource over 2000-2100 period

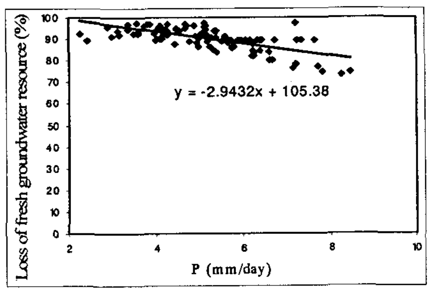

Figure 2. Mean precipitation versus loss of fresh groundwater resource relationship

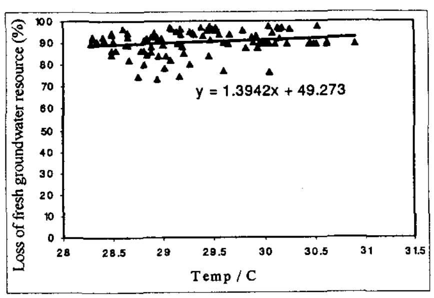

Figure 3. Mean temperature versus loss of fresh groundwater resource relationship