IMPACT OF CLIMATE CHANGE ON WATER RESOURCES IN CENTRAL HILLS OF SRI LANKA AND POSSIBLE ADAPTATION MEASURES

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INTRODUCTION

Lack of water and occurrence of drought are causing lower yield and less work for the community in the tea lands of the central hill country. The Estate Sector is still confronted with an inadequate supply of safe drinking water, proper housing and toilet facilities, and a lack of resources for education (Ariyabandu, 1999). Therefore they are less aware of the minimum requirement for good health. A safe water supply has not only been recognized as a basic need of people, but is also essential for healthy life. Unsafe water has becomes a significant vehicle for water borne diseases, and is the major cause of illness among the communities in the central hills. Although about 65 percent of estate communities fulfill their water requirement from pipe borne water supply, a scarcity of water resources requires them to travel long distances to fetch water. In many instances such water sources are polluted are a cause for major water related problems.

A further water related problem is the damage caused as a result of floods. This is almost an annual feature during the major rainy seasons. For instance, the city of Ratnapura, situated in the wet lowlands of Sri Lanka and located beside the Kalu Ganga is famous for its annual inundation. The rise in the water level of the Kalu Ganga River contributes to much damage to the city dwellers. Additionally, during high rainfall periods, more than 20% of the urban area is inundated by flood water around the city caused by the accumulation of rainfall within 270 square kilometers covering the upper part of the drainage basin. The city's urban area spreads over 20 square kilometers with a population of 46,300. These inhabitants not only face the natural hazards associated with periodic flooding, but also slope instability associated with mass movement and a number of other environmental problems created by their own activities (Pallawala, 2004). The damage incurred due to the floods which occurred in 2003, is estimated as being around 1.140 million rupees, with a death toll of around 122. Furthermore, the lowlands of Nuwara Eliya and Kandy also experience heavy floods and landslides during the southwest monsoon resulting in much damage to life and property. It is expected that with climate change impacts the situation will be further intensified in the future. Therefore to this issue appropriate development planning is an urgent need.

RATIONALE AND OBJECTIVE

Climatic changes have severely affected the Sri Lankan economic, social, and agricultural sectors due to the high dependency on rainfall for power generation, irrigation, agriculture, domestic and industrial usage and human consumption. The frequency of floods, landslides and droughts have increased drastically in the Central Hills of the country (Ariyabandu, 1999 and Rajapaksha, 2003), and there is an urgent need to study the impacts of climate change on future water resources in the Central Hills of the country.Therefore this paper intends to analyses the climate change impacts on water resources based on HadCM3 model prediction for 2050 in Central Hills of Sri Lanka and possible adaptation measures.

METHODOLOGY

There are few Global Circulation Models (GCMs) developed by various countries (Gordon *et al*,2000) and these models predict the future climate change in climatic variables such as

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rainfall, temperature, wind speed, relative humidity based on the greenhouse gases, sea level rise and other related parameters for the whole world except Antarctic regions for 2020s, 2050s and 2080s (Hulme*et al*, 1998). Therefore the results are in larger pixel points such as 300km x 300km to cover the whole world. It creates problems for small countries such as Sri Lanka which can only use two or three pixels points to extract the results of the global circulation models. It does not mean that the GCM results cannot be used for Sri Lanka or not reliable for Sri Lanka. There are scientifically and internationally accepted downscaling procedures available to downscale original 300km x 300km pixel results as predicted by GCM to the 10km x 10km pixel as used by Sri Lanka (New et al, 2002). Therefore, downscaleof GCM results on climate change predicted for in 2020's, 2050's and 2080s could be scientifically used to predict the rainfall and temperature changes in the study areas using baseline data from 1961-1990.

The climate change predictions for 2050s have been studied for Sri Lanka using climate change projections of HadCM3- a GCM of Hadley Centre for Climate Prediction and Research, UK. These numerical models representing physical processes in the atmosphere, ocean, cryosphere and land surface are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations. HadCM3 is a coupled atmosphere- ocean general circulation model (AOGCM) which has previously been used (Gordon et al., 2000). These predictions were then applied to the Inter-governmental panel of climate change (IPCC) Emission Scenario A2 which is the scenario for highest sea level rise, carbon dioxide concentration, temperature rise and population rise and therefore demarcated as worst impact case (IPCC,2007). Simple water balance methods and runoff co efficient were used to estimate the potential soil moisture deficit, runoff and potential groundwater recharge. For this study three locations in Central Hills were used namely NuwaraEliya, Ratnapura and Kandy. Results of HadCM3 for 2050s - A2 scenario were compared with 1961-1990 data as baseline and past decade data (1999-2008) of the Meteorology Department.

RESULTS AND DISCUSSION

The annual average rainfall is predicted to increase in Ratnapura, NuwaraEliya and Kandy by 12% in 2050 (A2) scenario compared to the baseline (1961-1990). This is mainly due to the increase predicted during the southwest monsoon rainfall across the country by 38% (A2) and 16% (B2) in 2050s. The predicted increase in rainfall during the southwest monsoon period (May to September) in Ratnapura, NuwaraEliya and Kandy are 43%, 57% and 20% respectively in 2050 (A2) compared to the base line (1961-1990). The prediction results agree with the past decade (1999-2008) data collected by the Meteorological Department on the southwest monsoon rainfall which show an increase of 10% in NuwaraEliya (Figure 01).Further, among the wet zone areas the annual runoff in Ratnapura, NuwaraEliya and Kandy are predicted to increase and the predicted increase in Kandy is almost 100% compared to the baseline (1961-1990). Due to the increase in the surface runoff, floods also increase significantly in the Central Hills, resulting in increased landslides. Further, the Central Hills are predicted to receive an excessive amount of rainfall which causes excessive runoff floods and landslides in these areas during the 5 months of the southwest monsoon season (May to September) (De Silva et al, 2007).

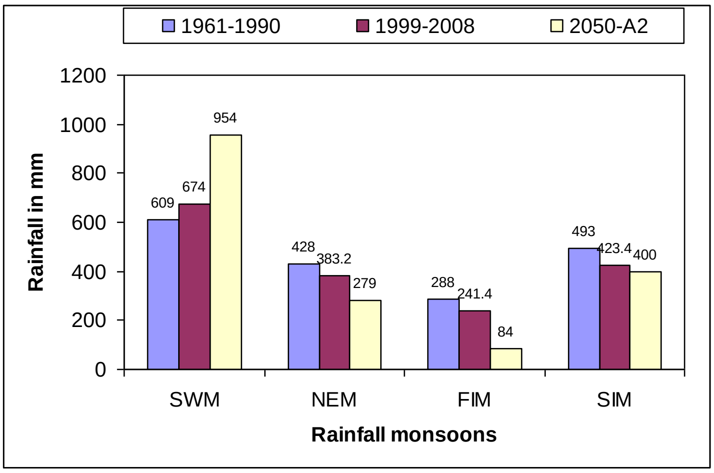

Figure 1: Rainfall in NuwaraEliya during Southwest- monsoon (SWM), Northeast-monsoon (NEM), first inter-monsoon (FIM) and second inter-monsoon (SIM) in mm for periods from 1961-1990, 1999-2008 and HadCM3 prediction for 2050.

Table 1: Predicted increase in runoff in percentage compared to the base line (1961-1990) in Kandy/Katugastota

Year	Kandy/Katugastota
2010	33.2
2020	49.8
2030	66.4
2040	83.0
2050	100

In contrast, during the northeast monsoon rains, in December to February, the annual average rainfall is predicted to decrease by 31%, 32% and 29% respectively in Ratnapura, NuwaraEliya and Kandy in 2050 compared to the base line (1961-1990). Further, during the second intermonsoon (October to November) too decrease in rainfall is predicted. Therefore the rainfall during October to February (northeast monsoon) is predicted to decrease in Ratnapura, NuwaraEliya and Kandy by 6%, 10% and 5% respectively in 2050(A2) scenario compared to the baseline (1961-1990).This agrees with the recent past decade (1999-2008). For example in NuwaraEliya the average annual rainfall has already decreased by 6%, 8% and 16% during the northeast monsoon, first and second intermonsoon respectively (Figure 01). It shows that the decreasing trend in northeast and first and second inter monsoon rainfall are proportionally high compared to the HadCM3 prediction in 2050s.Therefore for 7 months from October to May decrease in rainfall is predicted. Further the annual average temperature is predicted to increase in Ratnapura, NuwaraEliya and Kandy by 1.7ºC, 1.1ºC and 1.5 ºC respectively in 2050 (A2) compared to the baseline. Because of this temperature increase, the maximum soil moisture deficit is predicted to increase by almost 100% in all these stations in the central hills. This will severe impact on the up-country vegetable cultivation which may need additional irrigation water for sustainability. On the other hand, the potential groundwater recharge is predicted to increase by 74%, 23% and 33% in Kandy, NuwaraEliya and Ratnapura respectively in 2050 (A2) scenario compared to the baseline.

CONCLUSIONS

According to the HadCM3 and the results obtained for 1999-2008, there is an increase in rainfall for 5 months during the southwest monsoon period. This will cause excessive runoff leading to floods and landslides. But for 7 months during the first, second inter monsoon and northeast monsoon the rainfall is predictedto decrease in the Central Hills which will severely impact up-country vegetable cultivation due to a shortage of water. Further it will affect the availability of water for drinking and domestic purposes.

Adaptation Measures

Adaptation measures should be designed to store the excess water when the demand for water is low in the Central Hills during the southwest monsoon for the months when there is no rainfall and the demand for water is high.

During the southwest monsoon period the excess water must be retained in surface ponds or small reservoirs or surface tanks wherever possible in the direction of water flow. Further, a series of water retention dams and structures could be erected in the downstream of each reservoir so that the spillway water could be retained rather than go waste. In the dry zone of Sri Lanka there is a cascade system where the excess water flows downstream and is collected in tanks placed one after another one after one thus ensuring minimum water loss. In the present system, there is no mechanism to store the spillway water inthe downstream of the reservoirs, which have serious problems in water retention. Therefore; the system similar to the dry zone should be developed in the central hills wherever possible. When the slope is steep there should be mechanical structures constructed to reduce the velocity of the water and divert it to the surface ponds and surface tanks. By the careful planning of water retention and water management techniques the excess water during southwest monsoon period could be retained for future use.

In contrast, during the northeast monsoon, first and second inter monsoon period there will be decrease in rainfall as shown in the results. Therefore, the available rain water during the southwest monsoon must be used efficiently for sustainable agricultural activities. Drip and Sprinkler irrigation systems will increase the efficiency of the use of water. Further, cultivation in protected house/poly tunnels and green houses will reduce the impact of adverse climate. But the farmers involved in small scale farming can practice mulching and water retention methods such as ridge and furrows.Further, the farmers could consider crops which need less water. However, for drinking purposes the groundwater could be used as the potential groundwater recharge is predicted to increase based on HadCM3 data. But the use of groundwater should be done very carefully to make sure that there is no over exploitation of groundwater resources and sustainability should be ensured.

REFERENCES

Ariyabandu, R. de S. (1999). *Water security through rainwater harvesting*. 25th WEDC Conference on Integrated development for water supply and sanitation. Addis Abba, Ethiopia.166-168.

De Silva, C.S., E.K.Weatherhead, J.W. Knox, J.A.Rodrihuez-Diaz. (2007). Predicting the impacts of climate change-A case study of paddy irrigation water requirements in Sri Lanka. *Journal of Agricultural Water Management* 93(2007)19-29. Elsevier Publishers, Amsterdam, Netherlands.

Gordon, C., Cooper, C., Senior, C.A., Banks, H., Gregory, J.M., Johns, T.C., Mitchell, J.F.B., Wood, R.A., (2000). The simulation of sea surface temperature, sea ice extents and ocean heat transports in a version of the Hadley Centre coupled model without flux adjustments. *Climate Dynamics*.16,147-168.

Hulme, M. and G.J.Jenkins. (1998). Climate change scenarios for the UK: Scientific Report. UKCIP Technical Report No.1. Climate Research Unit, Norwich, UK.

Intergovernmental Panel of Climate Change. (2007). Climate Change. The Physical Science Basis. IPCC Working Group I Fourth Assessment Report : Summary for Policymakers. IPCC, Geneva.

New, M., Lister, D., Hulme, M., Makin, I.. (2002). A high resolution data set of surface climate over global land areas. Climate Research 21, 1-25.

Pallawala, P.M.D.W.D,Pitawala, H.M.T.G.A &A.A.J.K.Gunathileke (2004). Urban geological problems in Ratnapura city, Sri Lanka. *Proceedings of the Peradeniya University Research Sessions*, Sri Lanka. Department of Geology, Faculty of Science, University of Peradeniya, Vol. 9. pp.193.