CLIMAT CHANGE IMPACT ASSESSMENT ON WATER RESOURCES OF KARKHEH BASIN AND FORMULATION OF ADAPTATION STRATEGIES

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ABSTRACT

Climate, freshwater, ecological and socio-economic systems are inter-connected in complex ways, so a change in any one of these systems in turn triggers impacts in other systems. The major challenges concerning fresh water include: experiencing extremes of too much and/or, too little water, and consequent water issues. Each of these problems may be intensified by climate change in semi-arid areas. Existing research and observational evidences provides strong arguments that future climate may change significantly and, therefore, impact the water resources of the given basin. Thus, the strategies that can be used to mitigate possible negative impacts of climate change on water resources are of great importance. During the past decades, a great deal of research has been devoted to the detection of climate change impact on hydro-climatic components. The intensity and character of the impact, however, can vary significantly from region to region.

This thesis intends to investigate the impacts and adaptation strategies to climate change on water resources, and shall also compare adaptation strategies to cope with climate change impacts using an Integrated Water Resource Management (IWRM) approach for a pilot area in Iran, i.e., the Karkheh River Basin (KRB). Understanding the hydrologic response to climate change for
watersheds of this type is particularly important due to the dependence of major water systems on the contribution made by the stream-flow.

Two available Regional Climate Models (RCMs) under A2, B2, and A1B emission scenarios were used for the climate change impacts assessment on water resources in the study area. The SWAT model was then used to evaluate the sensitivity of annual and seasonal stream-flows from the KRB to possible changes in climate. The change in precipitation had the most significant impact on the magnitude of annual water yield (WYLD). Temperature rise as well as precipitation reduction shall cause a significant reduction in total stream-flow. The outcomes of the projected model have shown that the maximum increase in the WYLD is 8.2 mm under A2 scenario in August whereas the maximum reduction is 78.3 mm under B2 scenario in January in the Upper KRB. Similar trends were also predicted for the Middle and Lower KRB. The pattern of the monthly change in evapotranspiration (ET), WYLD and discharge is largely governed by the combined impact of temperature and precipitation in a very complex manner. Changes were also calculated using the differences between the averages of the future time period (2070–2099) with respect to the average of the baseline time period (1970–1999). While the A1B scenario shows a general reduction in the WYLD and ET across most of the KRB, however, there are variations over the Middle and Lower KRB. For example, a large increase in the WYLD has been projected in the Lower KRB during the autumn months of OND. Moreover, there are also uncertainties in climate change projections which in turn result in uncertainty in both climate and hydrologic projections. The analysis also revealed that the middle KRB is the most stable sub-region within the KRB in response to future climate change impacts mainly due to the prevailing irrigated cultivation. The risk of drought and heat stress is thought to increase in whole of the study area. Overall, the present study shows the
consequences of climate change on the water resources of the KRB and shall be useful in formulating the adaptation options in a sustainable manner.

The final part of this research work focused on formulating adaptation measures as well as research into adaptation strategies to climate change in the study area using the IWRM and prioritization of the same. Enhancing the water use efficiency is the simplest answer to cope with water scarcity. In order to formulate the adaptation scenario, various possible adaptation operations have been recognised first and then the validated application operations have been ranked based on questionnaire response and expert judgment approach. It is required to prioritize the validated adaptation operations, with respect to functionalities/capabilities for hydrological modelling, social-economical, and ecological/technological limitations which were achieved using the Strengths, Weaknesses, Opportunities and Threats analysis (SWOT), and Partial Order Analysis (POA). Thus, four adaptation activities have been suggested, two of these being agricultural and land management system activities (Ac.1 and Ac.2), another one being land-use change activity (Ac.3), and the fourth one being cropping pattern change (Ac.4).

The SWAT model allows for simulation of management practices and therefore it is best used for exploring the impact of adopting a specific adaptation option. In the present study SWAT has been used to assess the impacts of adopting specific cultivation field operations as well as changes in land-use of range and forest lands. The impact of suggested adaptation activities had various effects on hydrology and the same has been depicted through tracking major hydrological components; e.g. surface runoff, groundwater and sediment erosion. Amongst the suggested adaptation scenarios, activities Ac.1 and Ac.2; that include terracing, strip cropping, Grade
Stabilization Structure (GSS), and contouring were found to influence significantly the desired hydrologic components. Both Ac.1 and Ac.2 were also found to sustain crop production against the extreme hydrologic conditions. The effect of Ac.3 is comparatively low on influencing the local hydrology. Moreover, converting rain-fed cultivated land to range and forest lands will result in the loss of income to the farming community.

Agriculture in the KRB if fully integrated with the economic activity of the region by associating with more efficient agriculture activities such as use of new technology to irrigate, using more efficient cultivars, and using proper fertilizers can enhance the yield and compensate for loss of economic income. However, such increase in efficiency is associated with enhanced use of fertilizer. Therefore, reduction in nutrient loading in the watershed needs to be addressed in conjunction. Ac.4 (using the Syrian 4, cultivar of durum wheat) has also resulted in some savings in water. The land-use and cropping pattern changes were successful in bringing about the desired changes to the hydrologic components.