2.1.1. Analysis of Jordan's vegetation cover dynamics using MODIS/NDVI from 2000-2009

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Jordan has been affected by frequent droughts in the last few years. A Moderate Resolution Imaging Spectroradiometer (MODIS) - Normalized Difference Vegetation Index (NDVI), time series 2000-2009, 1 km resolution was used to extract the NDVI values of a 10 km buffer area for twelve meteorological stations representing the rainfed cultivated areas of Jordan. The objective of this study was to investigate the vegetation dynamics within seasons, and stations, as an indication of climate change. The average annual NDVI values for the different stations tend to follow a similar pattern through the growing season, which extends from November to May. It reflects that there is decrease of precipitation from west to east and from north to south. Results of Pearson correlation analysis showed a significant response of monthly NDVI to cumulative rainfall. A threshold method was developed to determine the onset and the end of the growing season. Results show that in the past four years, a trend of delay in the start of the growing season is occurring, especially in the south of Jordan.

Keywords: climate change, Jordan, MODIS, NDVI, remote sensing.

2.1.2. Application of the IHACRES rainfall-runoff model in semi-arid areas of Jordan

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With increasing demands on water resources in Jordan, application of rainfall-runoff models can be part of the solution to manage and sustain the water sector. The change of arid climates is considered as one of major factors affecting the rainfall-runoff relationships. This paper presents the preliminary results of applying lumped rainfall runoff models into ephemeral streams in northeastern Jordan where rainfall can exhibit a rapid change in intensity and volume over relatively short distances. The IHACRES model (Identification of unit Hydrographs And Component flows from Rainfall, Evaporation and Stream-flow data) can confidently be applied in semi-arid catchments, and under different hydro-climatic zones and time steps. The major problem with this application is the limitation of long term continuous observations. However, the results of this study showed a good agreement between effective rainfall and stream-flow. Therefore, this model can be used to predict water flow for which there are no existing records. Furthermore, because of the complexity of climate attributes in the region, there are often errors in runoff estimations.

Keywords: effective rainfall, IHACRES, semi-arid areas, Unit Hydrograph.

2.1.3. Generating a high-resolution climate raster dataset for climate change impact assessment in Central Asia and northwest China

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The contiguous dryland region of Central Asia and northwest China is expected to be significantly affected by climate change. In a pivotal and very diverse region, where the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report predicts a precipitation increase or decrease depending on the specific location, the coarse-resolution climate change maps provided by Global Circulation Models (GCM) are unable to

capture the influence of high-intensity relief. The paper describes the steps taken for generating high-resolution (1 km) maps of future climates in the five countries of Central Asia and the Chinese province Xingjiang. Three different time horizons (2010-2040, 2040-2070 and 2070-2100) and four climatic variables (precipitation, minimum, maximum and mean temperature) were downscaled to high-resolution gridded datasets based on 17 out of the 23 GCM outputs under three greenhouse gas emission (SRES) scenarios (A1b, A2 and B1). The downscaling method consisted of overlaying coarse-gridded CGM change fields onto current high-resolution climate grids. By automating the map generating process in a GIS environment, 5184 high-resolution maps of future climatic conditions were generated for this dryland region. These maps confirm agreement of the selected GCMs on a significant warming (from approximately +2°C to +5°C by the end of the 21st century) over the whole area, but major disagreement between models on the direction and extent of precipitation changes. The downscaled maps will be aggregated and used for analyzing climate change impacts through changes in agroclimatic zones, growing periods and crop suitability.

Keywords: Central Asia, China, climate change, precipitation, temperature.

2.1.4. Mapping drought extent, severity and trends using the Standardized Precipitation Index

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The Standardized Precipitation Index (SPI) is a tool for monitoring drought and anomalously wet events, based on a cumulative probability distribution of precipitation time series. Using a time series of monthly precipitation data from Sudan, the annual SPI has been calculated from 1921 to 1993, a period in which the number of meteorological stations in the country expanded from 50 to 120, and declined afterwards to 30. By interpolating station SPI values and using a mask to cover hyper-arid areas, 73 annual SPI maps were created which allow the characterization of historical drought patterns, and the comparison of the extent of drought in the different states of Sudan. The Drought Extent Index, defined as the average percentage area that would be affected by drought each year, varies between states between 5% and 11%. This is a surprisingly narrow range, indicating that drought is a feature of all states, with Southern Darfur and Western Darfur the most vulnerable ones. The SPI trend analysis indicates that droughts became both more extensive and more severe towards the end of the period, and that wetness anomalies have declined. Droughts during the mid-1920s, particularly in southern Sudan, were followed between 1930 and 1960 by a period characterized by normal or even above normal precipitation across the country, interrupted by local and scattered drought events. This period of relative climatic stability was followed by an increase in droughts during the 1960s and 1970s, and culminated in a new climate state characterized by multi-year regional droughts from 1982 onwards. The drought patterns of the period 1921 to 1993 are indicative of the increases in precipitation variability to be expected under global warming. The SPI mapping is in agreement with field and satellite data and can be a useful tool for comparing longer-term vulnerability to drought within countries.

Keywords: Sudan, Standardized Precipitation Index, drought.