Hydrol. Earth Syst. Sci. Discuss., 8, C4453–C4455, 2011
www.hydrol-earth-syst-sci-discuss.net/8/C4453/2011/

Hydrology and Earth System Sciences Discussions

Interactive comment on "The causes of flow regime shifts in the semi-arid Hailiutu River, Northwest China" *by* Z. Yang et al.

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Received and published: 14 October 2011

We appreciate the encouraging comments and helpful suggestions to clearly bring out the message of interactions between human policy changes and hydrological regime changes.

Fig. 7 illustrates that every large policy change in history always had a significant impact on river flow regime changes. Direct river water diversion for irrigation in the river valley, groundwater abstraction for irrigation in the upper part of the catchment, and land cover changes are results of policy changes and, concurrently, are causes of flow regime changes. Relevant climatic variables are precipitation, temperature, net radiation, wind speed, air pressure, and humidity. Since there are no data on net radi-

ation to calculate potential evapotranspiration, pan water evaporation was used as an indicator of potential evapotranspiration. No significant changes (shifts) were found in annual precipitation and pan evaporation, only an increase of average air temperature in the growing season (April-October) was detected since 1997. Therefore, flow regime shifts in 1968, 1986, 1992 are not likely caused by climatic changes since no climatic changes could be detected. The average growing-season temperature increase since 1997 could have an impact on the decrease of river flows as the actual evaporation is expected to increase with a higher temperature. On the contrary, river flow increased since 2001. The main cause was the large decrease of crop area with the implementation of the policy to return farmland to forest and grassland started in 1999. In the study catchment, crop area in steeper slopes was often not cultivated anymore and a succession of desert bushes became dominant. Evaporation from desert bushes is much smaller than from irrigated crops under a higher temperature. This explains why river flow increased in spite of the recorded temperature increase.

The expansion of crop area in 1990-1998 not only caused lowest river flow, but also a decrease of regional groundwater levels and it threatened the health of desert vegetation. The degradation of the desert vegetation ecosystem forced the local government to implement the policy of returning farmland to desert vegetation and, consequently, reduce groundwater abstraction for irrigation in 1999. This is the only time in the study catchment that the human policy was changed in response to the hydrological regime change. The positive effects have been observed since 2001: river flow has recovered and vegetation health has improved.

The lack of historical data on river water diversions, groundwater abstractions, detailed land cover changes and actual evaporation prevent a full quantitative cause-effect analysis. Nevertheless, the simple regression analysis of annual mean discharge against annual precipitation, crop area and annual average air temperature indicates that the largest contribution to the variation in river discharges comes from crop area. The combined effects of temperature and precipitation on flow variation is smaller than the impact of crop area.

We will revise the manuscript to reflect above explanations accordingly.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 5999, 2011.