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Research Article

Groundwater And Surface Water Interactions In The Hailiutu River Basin, Erdos Plateau, China: A Quantitative Assessment

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ABSTRACT

As for the Erdos Plateau, its "Since surface water and groundwater are so intricately connected, hydrological processes are notoriously difficult to understand. The more we learn about hydrology, the better we can manage the water sources that are accessible at the same time. Long-term economic growth and poverty reduction depend on a thriving ecosystem and the responsible use of water supplies. There haven't been many studies done here to determine if groundwater withdrawal affects stream flow, and that's likely because of how intricate the water systems here are. To maintain the long-term viability of water resources management, researcher need a more in-depth knowledge of how surface water and groundwater are connected. The purpose of this research is to provide a better understanding of the groundwater-surface water exchange on the Erdos Plateau by studying the interactions of the two water sources.

KEYWORD: Plateau, Groundwater, Water Resource Management.

INTRODUCTION

When attempting to get a thorough knowledge of the geographical and temporal interactions between surface water and groundwater, it is necessary to take into consideration both components that occur naturally and those that are created purposely. Previous studies have shown that in order to evaluate the impact that people have on the interactions that take place between groundwater and surface water, it is required to use a variety of methodologies. This thesis makes an attempt to discover and quantify the processes that are involved in surface water and groundwater "interactions" (Wang J., 2019). It does so by synthesising the academic literature that deals with the subject of surface water and groundwater encounters.

China has implemented integrated water resources management in order to ensure the organization's continued viability over the long term. On the other hand, when there is a lack of water, people face "both institutional and technological challenges." This is especially true in arid and semi-arid areas, where groundwater plays a crucial role in supplying the water requirements of both humans and the environment. Because of the considerable interaction between surface water and groundwater in these places, ecosystems that are located in semi-arid and dry regions are more vulnerable to changes in the water supply during times of drought. Several studies have shown that the northwest region of China is experiencing economic and social difficulties as a result of a severe dearth of water resources. Since the beginning of China's water management history, groundwater and surface water have always been handled in a distinctly different manner. The mayor and council of Erdos City have lately shown a stronger dedication to environmentally friendly policies, river basin management, and sustainable development. When it comes to water management, however, surface water and groundwater have traditionally been regarded to be two separate entities within the same category. Despite the fact that groundwater is very important to ecosystems, it is often disregarded or poorly managed because of a lack of awareness about it. As stated by (Borde et al., 2014), these interactions have the potential to greatly impact both the amount and quality of the water that is being made accessible. This is why, in order to manage water quantity and quality properly, it is crucial to comprehend the connection between Erdos plateau surface water and groundwater.

BACKGROUND OF THE STUDY

It was formerly thought that the hydrological cycle consisted of two separate parts: surface water and groundwater. However, "these two kinds of water can interact in a number of different ways depending on the topography". In order for society and the economy to progress, surface and groundwater water supplies must be accessible. Because of the challenges in monitoring and measuring their interactions, surface water and groundwater have often been treated independently in water resource management and policy making. Surface and groundwater interactions are very important for stream ecosystems. For rivers, this has significant ecological, conservational, and restorative implications. Additionally, groundwater-dependent ecosystems must be protected (Bertrand et al., 2014). Most people still don't realize how groundwater relates to other types of surface water, such as lakes, rivers, wetlands, and reservoirs. Distinguishing the impacts of climate change from those of people in specific cases is a challenging and controversial issue for hydrogeologists and hydrologists (Xu, 2011).

Present methods for studying surface-groundwater interactions include temperature studies, chemical and isotope tracers, and direct field research to find hydraulic head changes. Methods for upscaling have been widely used in the field of hydrology. These methods integrate observations made on the ground with data collected by a number of satellites. Numerical modeling has been used to look into the water flow in a mesoscale rural river basin. Their study focused on the hydrologic dynamics at small scales in the transition zone (Zhou et al., 2013).

THE PURPOSE OF THE RESEARCH

The Erdos Plateau is a semi-arid area in northwest China. The goal of this study was to learn more about how surface water and groundwater interact in that area. A method from many fields was used to measure how groundwater and surface water interact in the Hailiutu River area. Temperature, isotopes, hydraulics, and hydrochemistry are all part of the set of tools. Approaches include computer models at sub- or watershed sizes, readings taken in real time and in the past, and outdoor studies for chemical and isotopic patterns along a river that flows into the main river. Many conclusions can be drawn from this work.

LITERATURE REVIEW

Recent studies on the interaction between surface water and groundwater have included measurements and direct field investigations to identify variations in hydraulic head, chemical markers, and isotopes. Important for aquatic and riverine ecosystems, the river flow regime explains the pattern of river flow over extended periods of time. When an ecosystem suddenly changes from a stable state to an unstable one, this is called a regime shift.

Hydrological variability is linked to both climate change and human activity (Xu, 2011). A significant issue in hydrology, however, is identifying the sources of changes in flow regimes. Human actions such as soil and water conservation efforts, changes in river limitations, altered climatic conditions, and changes in land use and cover all have an impact on river basin flow regimes. Depending on the study, one may infer the effects of climate change on stream flow or discover that long-term changes in river discharge are mostly caused by climatic factors (Masih et al., 2011). Changes in land cover and usage may affect runoff and infiltration, which in turn affects river flow (Masih et al., 2011). Dams may mitigate flood damage by decreasing peak flows and raising base flows (Love et al., 2010), there are a number of elements that influence the hydrological response. These encompass discharge originating from headwater the catchments, water stored in small dams, or augmented extractions for the purpose of irrigating agricultural produce. Permeability, basin steepness, transpiration, evaporation, and precipitation are other variables that impact the hydrological response. By comparing predicted and measured discharges or running statistical tests on signs of hydrological changes, these studies primarily sought to link the pertinent components to the mean yearly stream flow.

According to this study, which examined the river's discharge on annual, monthly, and daily intervals, A shift has occurred in the flow pattern in the middle section in the Yellow River Basin's sandy zone. Changes in land use, climate, or the development of water resources are also linked to it. The findings shed light on how hydrology in dry regions reacts to natural and anthropogenic climate change (Schilling K, 2016).

RESEARCH QUESTION

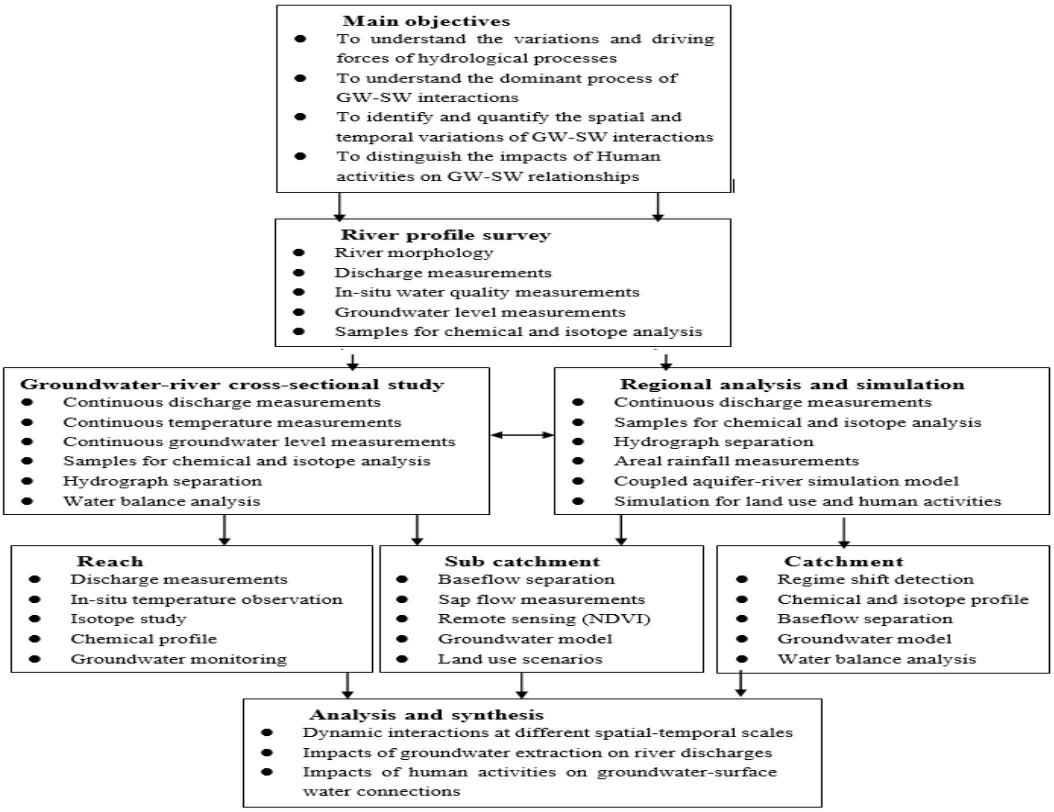
1. What are "the variation and driving forces of hydrological" processes?
2. How "GW-SW domninate the proess of" interaction?

RESEARCH METHODOLOGY

One of the most common ways to spot regime shifts or turning moments is to look for changes in the means, according to Rodionov (2005). This study employed a number of techniques to track changes in the averages of meteorological and hydrological variables, agricultural land use, and the regime shift index (RSI). Among these techniques were the sequential algorithm of the partial CUSUM method (Rodionov, 2018), the cumulative sum chart (CUSUM) with bootstrap analysis (Pettitt, 1979), and the Pettitt test.

The Pettitt test is a popular tool for hydrologists searching for abrupt changes in their series. It is a non-parametric trend test that might potentially pinpoint a single data point where the series changes (Love, et al., 2019). After running the tests using the Datascreen tool, the p-value was determined to be 0.8. We were able to locate the change points across different time periods by dividing the time series data into sub-series. Using CUSUM and bootstrap analysis, Abu-Taleb et al. (2007) looked at how relative humidity changed in Jordan across the year and by season. After making a CUSUM chart with all of the datasets, the authors ran a bootstrap analysis on the apparent changes to find the confidence level. If the CUSUM's direction changes abruptly, it means the average has changed. Rodionov (2004) suggests that a sequential approach might be used to detect regime transitions in their early stages and track their evolving significance. To calculate the regime shift, the RSI technique uses a predetermined cut-off length to divide the data, and then it uses statistical analysis to determine the means for the subsets or the following data sets. The technique iteratively increases the number of data sets or recalculates the means until a statistically significant difference is reached. At the first hint of a statistically significant difference in means, the regime transition may be pinpointed. Many see this spot as a potential springboard for the new regime. Although the CUSUM and RSI methods may find several change points in a time series, the Pettitt test is often used to assess the recurrence of a single change point. These three approaches were used to identify regime changes in this research. A change point cannot be legitimately identified without using at least two different approaches. The change point was further confirmed by showing that the subgroups means before and following the modification point are statistically distinct using the student's t test in differences in two means. According to Zhou (1996), harmonic series may be used to examine the periodic nature of hydrological variables. Initial assessments of the change in the flow regime informed the application of harmonic analysis to monthly discharges and discharge standard deviations across varying time intervals. In order to identify changes in the periodic properties, the harmonic components' periodicity, amplitude, and phase shift were examined. Lastly, in order to examine the variations in the daily discharge characteristics, flow duration curves (FDC) of various periods were created.

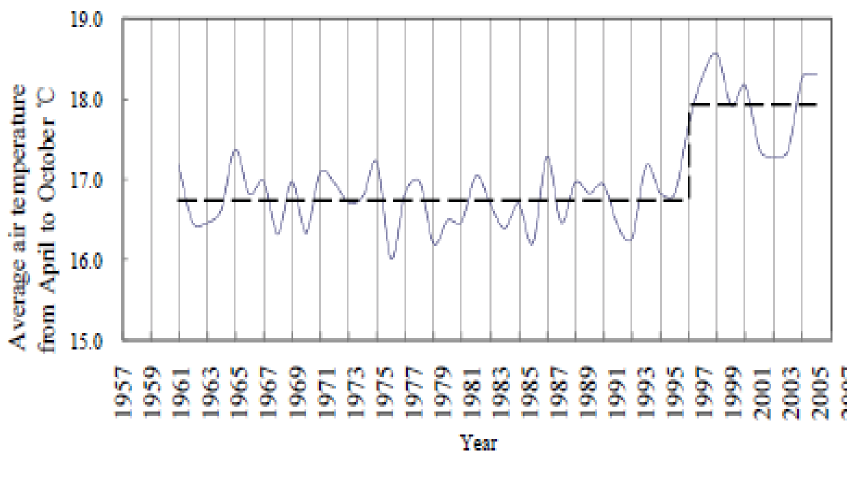
CONCEPTUAL FRAMEWORK



RESULTS

The change point detection analysis reveals the presence of five distinct periods in the annual mean flow pattern at Hanjiamao station from 1957 to 2007. The flow regime in the first period (1957-1967) demonstrates quasi-natural oscillations, with a mean discharge value of 3.49 m3/s, a 6-month periodicity, and correspondingly large daily discharges. The monthly mean discharge series features two peaks: a smaller one in the winter when the baseflow is greatest owing to groundwater release, and a bigger one in the summer due to seasonal rainfall. The flow regime features from the second time period, 1968-1985, include a lower mean discharge value of 2.72 m3/s, 12- and 6-month periodicities, and lower daily flows. The average discharge declined to 2.3 m3/s during the third time period, 1986-1991. The peak summer discharge eventually decreased until it was less than the peak winter flow. For the fourth time between 1992 and 2000, daily flows declined steadily. In addition to the lowest amplitude of harmonic components and the lowest daily flows, the discharge reached its lowest mean value of 1.92 m3/s. With a mean value of 2.41 m3/s, 12-month periodicity, and proportionally larger daily flows, the discharge recovered to reach pre-drought levels in the fifth period of 2001-2007, while it remained below average. It was believed that rising temperatures would cause an increase in actual evaporation. Quite the reverse, "river levels have increased since 2001. The fundamental reason was the substantial loss in agricultural area caused by the effort to turn farmland back into forest and grassland, which began in 1999. Large swathes of arable land in the study catchment have returned to their natural desert shrub cover. When temperatures rise, real evaporation from desert bushes is far lower than from irrigated crops. A projected increase in actual evaporation from desert shrubs at higher temperatures had significantly less impact on river flow than a fall in net water demand caused by a significant decline in agricultural land. This is why, despite rising temperatures, river flows have risen. As a consequence, the fluctuations in the flow regime of the Hailiutu River are unlikely to be caused by climatic warming.

Figure 2 shows how changes in crop area and oscillations in the Hailiutu River's flow regime are connected to local and regional land policy. Crop area fluctuations in Yuyang district may be viewed as an indicator of the amount of water withdrawn from rivers and aquifers for agricultural purposes. Figure 2 shows how cultivation and agricultural policy have affected crop area over the last 51 years. When there was a balance between the development and deterioration of agricultural land from 1957 to 1970, the crop area stayed relatively steady. The total area allotted to crops has been steadily shrinking since the early 1970s, when terraces were constructed for farming on previously farmed land in an effort to mimic Dazhai's agricultural strategy. The 1980s saw the implementation of a plan to distribute farmed land among farmers, who were incentivized to increase their crop area (Zhang et al. 20019). The expansion of crop area for the cultivation of vegetables occurred between 1990 and 1998 as a result of the non-staple food supply plan that was put into place in metropolitan areas in 1988. Substantial diversion of water works or wells to draw groundwater were built to guarantee irrigation of crops. In 1999, the Chinese government launched a campaign (Li, 2018) to turn farmland back into woodland or grassland as part of an attempt to restore the country's environment. Between 2000 and 2007, the amount of China's cropland decreased as a result of this campaign. There is a link between agricultural strategy and changes in land cover in the examined area. The river valley is transitioning from corn production to tree nursery. Additional trees may result in water scarcity (especially if they are young, fast expanding trees). It marks the transition from grain to desert vegetation in the "upper" catchment. Desert shrubs need far less water to grow than irrigated corn. Real evaporation has decreased, resulting in increased river discharge. Although temperatures climbed during this period, the increase in real evaporation was significantly less than the decrease in actual evaporation caused by the crop area reduction.



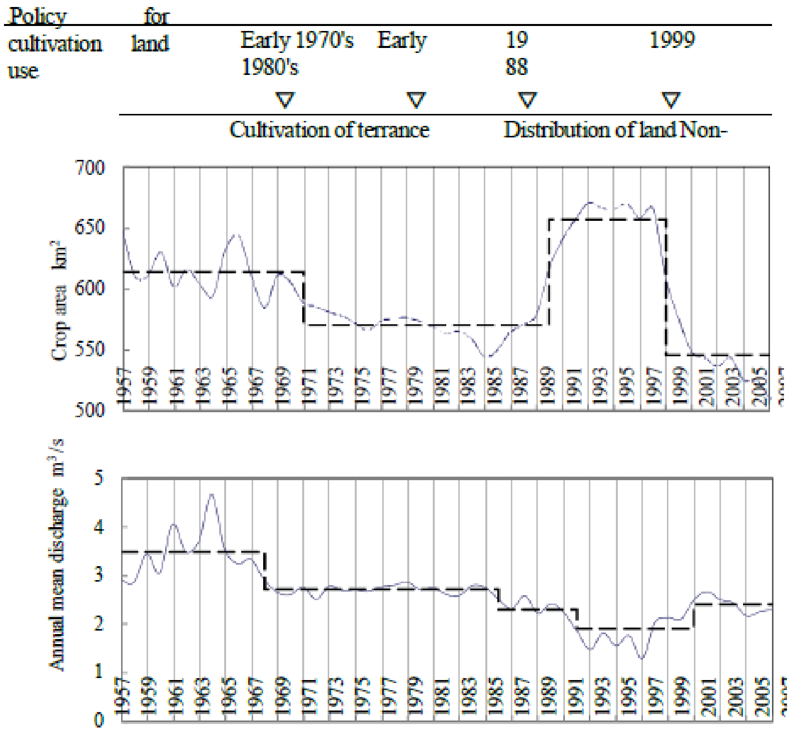


Figure 2: The Yulin meteorological station's yearly discharge, temperature, crop area, and cultivation strategy from April to October as a cause of regime changes

DISCUSSION

The Hailiutu River's flow regime has changed significantly during the last 51 years, according to harmonic analysis and flow regime shift detection. Since 1968, the flow regime has undergone four revisions: in 1986, 1992, 2001, and 2001 again. The river's daily flow variability was considerable, it had two yearly peaks (winter and summer), its standard deviation of mean monthly discharges was bigger than usual, its annual maximum discharge was larger than average, and from 1957 to 1967, there was a 6-month periodicity of the two peaks. The second phase, from 1968 to 1985, saw a shift in the flow regime as a result of reservoir and diversion works building. The results of this were lower monthly discharge standard deviations, lower summer flow peaks, lower annual mean discharges, and lower daily flows. The discharge decreased consistently from 1986 to 1991, the third era, as a result of both the increased use of groundwater resources and the diversion of water from rivers. The flow peak, which was created by groundwater release in the winter, is the only one remaining after summertime river water diversion destroyed it. This month's earlier-than-usual winter flow peak can be due to irrigation return flow in the river valley. Yearly mean discharge, maximum discharge, and average standard deviation of mean monthly flow all hit rock bottom in the fourth phase, which ran from 1992 to 2000. A number of causes came together to produce this, such as the extensive diversion of water, the use of groundwater for irrigation, and the dramatic expansion of agricultural land. A program to convert crops to forests and grasslands was launched in the watershed from 2001 to 2007, which resulted in a restoration of albeit not at their typical levels, the velocity and fluctuation. The plan to "return farmland to forest and grassland" in the research area aims to transform farmland into xeric bushland. Because bushland loses less water to evaporation than irrigated crops, streamflow gains since 2001 are primarily due to this phenomenon. No significant climatic changes have been seen in the drainage basin of the Hailiutu River, according to the findings. During the growth season (April–October), the average air temperature is enough on its own.

October had an uptick, although overall, the flow regime hasn't altered much since 1997. Contrary to common assumption, changes to river regimes have persistently impacted land use policy shifts. The summer flow peaks are diminished or eliminated due to the diversion of river water and reservoirs. The use of groundwater for agricultural purposes reduces both the annual mean discharge and river base flow. River discharges were shown to be most affected by crop area, with temperature and precipitation playing significantly lower roles, according to a simple regression research that compared annual mean discharge vs precipitation, average growing-season air temperature, and crop area. The expansion of farming areas between 1989 and 1999 could explain the decline in river flow. As a result of decreasing regional groundwater levels, desert plants are now facing extinction. Since 1999, as desert plant ecology began to degrade, the local administration has been enforcing a program in order to reduce the use of groundwater for irrigation. This has led to the return of desert vegetation to formerly arable terrain. In the watershed under study, this is the only instance when a change in the hydrological regime has an impact on human policy. Ever since 2001, people have seen the favorable effects: the river flow is normal again, and the vegetation is in better condition. Ecosystems at rivers' borders and water use downstream might be affected by changes to river flow patterns. The effects of groundwater and river flow interactions on downstream water consumption and vegetation must be considered in order to manage and enhance the water resources of the Hailiutu river watershed in a sustainable manner. Future research should focus on understanding how pumping out groundwater affects river flows and plants that rely on it in the catchment area.

CONCLUSION

As a result, "The Erdos Plateau in northwest China will be the focus of study on the relationship between water above and below ground." To identify the mixing mechanism of surface and groundwater in the Hailiutu River basin, we will use a broad approach. It is possible to investigate the water cycle, the chemical composition (including stable isotopes), the weather, and models. Fieldwork will be employed to collect chemical and isotopic samples from a river branch. To derive conclusions from these methodologies, in-situ data from the past and present will be employed, as well as sub- and watershed-scale computer simulations. The evidence from this investigation supports a wide range of beliefs.

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