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Appraisal of Devastation by Droughts in Pakistan

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We should not take dry weather for granted, as it has the potential to have huge economic repercussions. In Pakistan, a lack of water negatively influences agriculture and hydropower output. Droughts in the Indus River basin in Pakistan were studied using stream flow data from Pakistan's major rivers. The Indus, Jhelum, and Chenab, Rivers stream flow were investigated to measure the severity of the droughts in the Tarbela, Mangla, Marala, and Warsak hydrological sites. All of Pakistan's stations had a dry spell, which is considered the country's worst drought on record. In the previous 12 years, droughts have become more common, which may be attributable to climate change. While the research was taking place, there were a number of storms of varying severity. Droughts can be mitigated by a variety of methods in the scientific community.

Keywords; Stream flow and other drought indicators show a high frequency of dry periods in the Indus Basin, Droughts Stream flow, Basin, Moisture, Temperature.

Introduction

In terms of economic, social, and environmental impact, floods and droughts are two extreme natural calamities[1][2]. An area experiencing drought is one where the amount of precipitation falls below average over an extended period of time. Defining and tracking drought is particularly challenging due to the large number of variables that have a role in it. Droughts come in four varieties: meteorological, hydrological, agricultural, and socioeconomic [3][4]. A location experiencing a prolonged period of low precipitation is referred to as being in "drought." A hydrological drought occurs when the land phase of the hydrological cycle experiences a considerable decrease in water availability [5][6]. Drought is defined as a decrease in yield due to a decrease in soil moisture content over an acceptable amount of time in agricultural production. Drought-related socioeconomic problems are exacerbated by a lack of water, whether it comes from natural or man-made sources [7][8][9]. Agricultural drought and severe consequences for people's well-being and the country's economic standing happen when precipitation falls below normal levels, causing a drought on land and in groundwater supplies.

Using statistical methods and models, [10][11] investigated the relationship between weather and water shortage characteristics in the United States. They discovered that the two droughts (meteorological and hydrological) were interconnected in terms of duration and severity. Drought management is critical for the economy and for our daily life [12][13]. Drought directly impacts hydraulic power and cooling water availability, river transportation, agricultural productivity, and the public water supply [3][14]. In the event of a future drought, knowledge of previous drought variations could help water resources be better managed[15][16]. A drought event can be defined by its severity, duration, geographic scope, and frequency, all of which are quantifiable metrics [6]. In the literature, drought indexes are used to forecast these aspects [17][18]. These indices employ one or more hydrological cycle factors to input stream flow [19][20][21][22]. Using reservoir storage, streamflow, snowfall, and precipitation as inputs for the surface water supply index [23][19]. Drought monitoring uses precipitation as an input variable. Temperature is included as an additional input component in the (reclamation drought index) [24][20]. Sarmiento (2008)[25] claims to have created a stream flow drought index that relies purely on stream flow data to reduce computation issues and data needs.

Hydrological drought has been measured using the SDI method in a number of studies around the world [7], [26], [27]. River Basin hydrological drought was evaluated using the SDI and the standardized runoff index. Researchers found that mild drought occurred frequently over a twenty-year period. Using data from Sardou and Bahremand [28][6], researchers found that the Halilrud basin suffered a range of mild to severe hydrological droughts. According to Pandey et al., the upper sections of the Betwa river stream were more vulnerable to severe drought [29][23]. Pakistan has seen numerous severe droughts during the last half-century. Drought has been a constant problem throughout the 1960s and early 1970s, the mid-1980s, and the early 2000s. Agricultural output was reduced by 3.1% as a result of a severe drought that ended in 2001. According to researchers.[30][31], the droughts of 2001 produced water shortages of up to 54% of normal supplies, compared to 39% the year before. The drought of 2001 killed 30,000 livestock in Sindh and Baluchistan. other researchers [2], [32] demonstrated that Pakistan's geographic location makes it vulnerable to drought using data. Baluchistan and Sindh, two of Pakistan's most at-risk provinces for drought, rank among the country's driest [33][34]. According to the World Disasters Report, the drought in California from 1993 to 2002 claimed the lives of 6,148 individuals and affected 8,990,741 others[35].

Previous studies have solely examined meteorological and agricultural drought before using long-term streamflow data in this study to focus on hydrological drought [2], [31], [32],

[34], [36]. Hydrological cycles are important because water from streams can be used for irrigation in agriculture, industry, and even the home. Therefore, seasonal assessments of high and low river flow are crucial for water management. There are three important rivers in Pakistan that are used in a study of hydrological droughts in the Indus River basin: Indus, Jhelum, and Chenab [37].

The Indus River Basin System is Pakistan's principal source of surface water. The Indus, Jhelum, Chenab, Kabul, Ravi, and Sutlej are among the system's key rivers. There are 1.12 million square kilometers in the basin of the Indus River, which is shared by Pakistan, India, China, and Afghanistan (5.9 percent). from the Himalayan Mountains to the Arabian Sea, Pakistan's Sindh area is a dry alluvial plain [38]. Water from the northern highlands, where snow and glacier melt, accounts for over half of the water in this basin[39][40]. A quarter of Pakistan's GDP comes from agriculture, which is the country's principal economic sector [29], [41]. Farming relies heavily on irrigation in this corner of the world because of the country's dry environment. According to agricultural data, 76 percent of Pakistan's arable land is irrigated. The Indus Basin Irrigation System (IBIS) is the primary source of irrigation in the region. It is comprised of five major rivers. More than 17.9 million acres of farmland are irrigated with 135 billion cubic meters of the river system's 174 billion cubic meters of runoff[42][43]. The Arabian Sea receives 44 billion cubic meters of water as a result of this procedure. Tarbela (on the Indus), Mangla (on the Jhelum), and Warsak are three of the study's hydrological stations (on the Chenab). Due to their prominent positions, the selected stations are particularly important. Water scarcity at these stations will have a detrimental influence on the country's agriculture and economy. Water managers need to know how prior droughts have behaved in order to plan and manage water resources effectively and take early mitigation actions in the case of a future drought[40].

Methodology

Taking dry weather for granted could have serious economic consequences. Agricultural and hydropower output in Pakistan is negatively affected by a lack of water. It was found that the Indus River basin's major river stream flows were useful in predicting droughts. To gauge the impact of drought on hydrological sites in Tarbela, Mangla, Marala, and Warsak the SDIs of the Indus, Jhelum, and Chenab. It is generally agreed that Pakistan's worst drought ever occurred in 2001 when all of the country's stations were dry. Droughts have become increasingly frequent in the last 12 years, due to climate change. This can be seen in the streamflow data. Numerous storms of various severity occurred during this time period. Scientists have devised a slew of strategies for dealing with droughts. According to stream flow and other drought indicators, dry spells are common in the Indus Basin. Impending dryness can be predicted by monitoring changes in streamflow, soil moisture, and air temperature over time.

Results

Pakistan's primary supply of surface water is the Indus River Basin System. Its major rivers include the Indus, Jhelum, Chenab, Kabul, Ravi, and Sutlej. In the basin of the Indus River, which is shared by Pakistan, India, China, and Afghanistan, there are 1.15 million square kilometers (6 percent). The Sindh region of Pakistan stretches from the Himalayas to the Arabian Sea on a dry alluvial plain[38]. Snow and glacier melt from the northern highlands accounts for more than half of the water in this basin [40]. Farming accounts for a quarter of Pakistan's gross domestic product (GDP)[29], [41]. In this part of the world, farming relies significantly on irrigation because of the country's dry climate. The Indus Basin Irrigation System is the region's principal irrigation source. Five important rivers make up this region. More than 18 million acres of farmland are irrigated with 129 billion cubic meters of the 174 billion cubic meters of runoff from the river system [43]. This process delivers 44 billion cubic meters of water to the Arabian Sea. Tarbela, Mangla, and Warsak are three hydrological stations on the Chenab, which have major positions in the International Biodiversity Information System. The country's agriculture and the economy will suffer if these reservoirs run dry. In order to plan and manage water resources effectively and take early mitigation measures in the event of a future drought, water managers need to know how previous droughts have behaved.

Non-stationary Markov chains can be used to anticipate the occurrence of drought [44]. Markov Chains are commonly used in the water resources area to forecast droughts and their probabilities[12], [24], [28]. To predict drought and wet severity frequency, a non-stationary Markov Chain approach was incorporated.

The SDI values are then determined by applying an Equation to each reference period during the hydrological year. Based on the SDI data. Monthly stream data were used to compute stream flow volumes over time. the hydrological year's SDI values are then calculated for each reference period Drought conditions range from -3 to -3 based on the SDI data.

To estimate the severity of hydrological drought, these results are compared [1]. A negative value suggests that there is no water present, although there is water present. For the months of October through September, Tarbela and Mangla stations were subjected to an exceptional drought

Over the course of the study, the highest and lowest SDI values were reported.

Between 1998 and 2002, the average magnitude of the drought at Mangla Station was -2.11. The mild to moderate drought in Warsaw has lasted longer than any other city in Poland. From 1998 to 2002, all of the stations were hit by a moderate to severe drought. The SDI during the six months. (October-March). October to March is the month with the most seasonal rainfall. Researchers found that the reference era includes this spectrum of droughts during the investigation. In 1970, the drought in Mangla and Marala began. Since 2011, it has demonstrated a cyclical pattern. This was the driest time in Tarbela's history. Tarbela experienced the longest drought during this time period.

From 1970 to 1990, there were many droughts, followed by periods of wet weather. Tarbela and Warsak experienced fewer droughts and more rain in 1990-91, which is considered a watershed year hydrologically. It was observed that the drought, which began in 1998 and ended in 2001, affected every area. According to the study, drought conditions began to improve in 2002 and continued.

There were several dry spells between 1976 and 1990, followed by wet spells All country areas were affected by the drought that began in 1998 and concluded in 2002.

Recommendations and Conclusions

The SDI approach studied drought conditions in Tarbela, Mangla, Marala, and Warsak. Although the drought was mild to severe at some locations, it was consistent across the board. It is possible that water managers could use the findings of this study to develop methods to reduce the risk of drought in their watersheds.

Different levels of wet and dry conditions affected all hydrological locations. Droughts also afflicted Tarbela, Marala, and Warsak.

Drought mitigation approaches include water storage reservoirs, water deficit irrigation, and high-efficiency irrigation systems.

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