

Hydrological Modeling of Pashin-Lora Basin Balochistan, and Evaluation of Internally Generated Water Potential of it's Built Check Dams

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Abstract— In recent years, Balochistan, Pakistan's largest province, has experienced droughts and floods, resulting in substantial infrastructural damage and loss of life. This study used geospatial and hydrological modeling to analyze the domestically produced water potential of the province's most water-scarce Pishin Lora Basin (PLB). The basin's hydrological characteristics were retrieved from the Digital Elevation Model (DEM), Landsat-8 images, and the Food Agriculture Organization's (FAO) soil databases. Rainfall data from the Quetta and Kalat stations were collected for the years 1990 to 2021 and used to simulate runoff in HEC-HMS software. Peak discharges for the wet and dry years were 5102.2 and 1095.8 cumecs, respectively, with annual runoff volumes of 5.82 and 1.25 billion cubic meters (BCM).

The water potential during wet years can address water shortage issues if managed well and it will also help to develop appropriate strategic options during dry years to minimize the drought impacts in the region through watershed management. This study has further identified micro-watersheds of the constructed small/check dams for their annual runoff potential. Runoff volumes in wet years often exceeded their dam's holding capacities. That implied that small dams and other development schemes are not designed to incorporate seasonal variations. This notion was further confirmed when flood water topped over these dams during high runoff periods of the recent 2022 rainfalls. This study emphasizes proper planning of water resource development schemes. It highlights the repercussions of inadequately planned interventions. If the safety and sustainability of these structures throughout their design lives are to be warranted, they must be evaluated scientifically and modified accordingly.

Keywords— Droughts and Floods; Land use and land cover (LULC); Micro-watershed; Rainfall-runoff; Small dams; Water resources management.

I. INTRODUCTION

The Balochistan province of Pakistan is currently facing severe water scarcity crises due to prolonged dry seasons, which escalated the community's dependence on groundwater resources, consequently, the water table is declining [1]. The increasing water scarcity in the province contributes to multidimensional issues related to socioeconomic well-being and the sustenance of the ecosystem. The province is experiencing droughts, water shortages, and poor water quality problems, which have harmed the livelihood and health of the local communities. Around 85% population of the province relies on agriculture for their livelihood [2], [3]. Approximately 72% rural population gets its drinking water from dug wells and streams. According to [4], the province's water resources have been depleted by over 90% in the last 50 years. However, the current decline and depletion rates are more rapid. The province's rural parts are currently experiencing short and rare rainfalls, as well as lengthy periods of drought, posing a danger to the livelihoods of locals who rely on agriculture and cattle rearing. Water consumption in urban areas like Quetta city is constantly increasing as a result of fast population increase[1].

Balochistan contains eighteen river basins. The Nari, Kaha, and Gaj Rivers, that are part of the Indus River system and run along the province's northeastern border, are one of two principal drainage systems that contain the rivers and streams. The coastal drainage system is distinguished by tiny, intermittent streams and high torrents. The seasonal rivers in the northeastern section serve as the primary source of groundwater recharge. Balochistan's surface water resources have steadily reduced since the 1980s owing to shifting rainfall patterns[5]. The available water is insufficient to meet the competing demands for irrigation, domestic, and commercial uses. During the previous few decades, more than 40% of apples, peaches, and apricot trees have been dried in different sections of the basin,

approximately 75% of livestock has died, and two million people have been relocated [6].

Aside from droughts, Balochistan saw tremendous rainfall during the monsoon of 2022. Rainfall and floods in the province have brought daily life to a standstill. According to a major news outlet, ARY News, practically everything was damaged. The rains destroyed thousands of houses, toppled seven dams in Balochistan, and put many more at peril. All districts in the Pishin Lora Basin were badly damaged, including Quetta, Pishin, Qilla Abdullah, and Kalat [7]. Extreme floods occur in broad watersheds in mountainous locations, particularly in rough topography with limited vegetation or barren areas, directing massive quantities of water into a few main downstream pathways [8]. Nevertheless, during rainy seasons, extra surface runoffs can be retained in reservoirs to be used in dry years, to recharge the groundwater table, and to avoid devastating floods [9].

Water scarcity difficulties exist in the PLB as a result of decreased precipitation, global climate change, unsustainable groundwater usage, and ineffective water management techniques. There is an urgent need to understand how all available water resources in the region are effectively managed in order to mitigate the negative effects of water shortages during drought seasons. A bottom-up, comprehensive planning strategy for constructing and managing watersheds is an effective way to achieve integrated water resource management and sustainable development. Check/small dams can be built to retain rainwater and supply water needs. The most important regional and global resource management problem is effective water management, which improves the quantity of water available for agriculture while conserving it for other purposes [10]. Efficient use of domestically produced water is required for successful integrated water resource assessment and planning to increase water availability in a basin. However, dam capacity and sediment deposition in reservoirs are two significant offsite consequences of watershed responses that jeopardize dam viability in the long run. As a result, before establishing any water resources project, it is critical to determine the water potential of the region.

The purpose of this study is to determine the internally generated water potential of Balochistan's Pishin Lora Basin (PLB). This study investigated three scenarios: rainy, dry, and average rainfall years. Check dams throughout the basin were chosen, and their micro-watersheds were defined. The potential storage capacity of check dams were calculated using the HEC-HMS rainfall-runoff model and compared to their designed capacities. Hydrological models may help with planning and decision-making processes to enhance water productivity for long-term agricultural production, control flood and drought risks, and ensure future water supply in the basin. HEC-GeoHMS was used to better define sub-basins draining to minor dams and identify high potential locations with their yearly surface water output.

II. MATERIALS AND METHODS

A. Study Area

The Pishin Lora Basin (PLB) is located in the Balochistan highlands of Pakistan, near the Afghan province of Kandahar. As seen in Figure 1, the basin is split

into three sub-basins that include Quetta as well as parts of the Qillah Abdullah, Pishin, Mastung, and Kalat districts. The whole accessible basin for surface water resources is made up of non-perennial rivers and springs. The water supply of these rivers changes dramatically throughout the year based on rainfall. The rainiest months are January through April, and rain falls largely outside of the monsoonal zone.

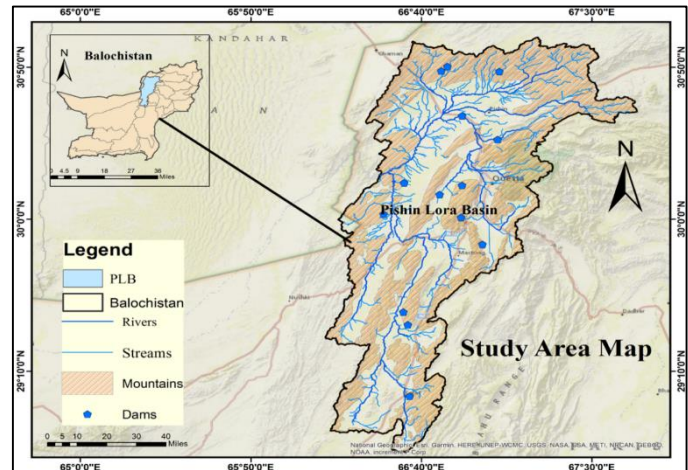


Figure 1. Study Area – Pishin Lora Basin

B. Hydrogeology of Pishin Lora Basin

The Triassic layers beneath Balochistan are divided into several groups by numerous tectonic, metallic, and sedimentary basins [11]. Pishin, Kuchlugh, Quetta, Kolpur, Sardar Khel, Mangocher, Mastung, Shirinab, Patki Shah Nawaz, Kalat, and Kapot are the eight hydrological sub-basins that make up PLB [12]. The majority of water kept in fine-grained rocks is typically not accessible. The geologic layers of the basin are typically categorised as aquitards and are primarily formed of huge impermeable limestone [13]. With good groundwater recharge capacity, the alluvial fan deposits in the piedmonts are made of permeable silty sand, gravel, and boulders [14]. Alluvial fan deposits in the mountain foothills are suitable groundwater recharging sites. The Urak Conglomerate in east Quetta and Kuchlugh sub-basins occupy about 350 sq km of highlands with excellent outflow from the Urak River. Hanna-Urak River flows from the northeastern side to Quetta valley, dissecting this formation with abundant runoff water.

C. Water Scarcity and its Socioeconomic Impact

The economy of PLB mainly depends on agriculture, livestock, and fruit production, with surface and groundwater as primary sources for domestic and non-domestic needs [15]. However, groundwater depletion has increased in recent decades due to unsustainable abstraction causing an annual decline of 3 m to 5 m in alluvial aquifers and up to 20 mm in hard rock aquifers [14]. Most farmers use tube wells to irrigate their agricultural crops and orchards, rather of traditional sources including Karezes, streams, and precipitation. This has exacerbated water

shortages, prompting farmers to abandon their original regions, suffer from health issues, reduce their schooling costs, and face disputes among themselves [16]. Groundwater over and prolonged pumpings have also caused drying up of tube wells. Decrease in land cultivation, damages to orchards, reduction in livestock, unemployment, and other related issues are some of the major socioeconomic factors impacting farmer revenues in the basin due to water shortages [17].

D. Research Data and Processing

This study was carried out using in situ and satellite-based data. The daily rainfall data from 1990 to 2021 from two meteorological stations (Quetta and Kalat) were obtained from the Regional Meteorological Department of Quetta. The Hydrologic Soil Group was determined by using the Harmonized World Soil Database (HWSD) (HSG). To classify Land Use and Land Cover (LULC), identify streams, and define watershed borders, USGS Earth Explorer (<https://earthexplorer.usgs.gov>) obtained the Landsat-8 images from September 2020 and the 30m Digital Elevation Model of Shuttle Radar Topographic Mission (SRTM). The ground surveys were conducted to collect ground truthing points for the accuracy assessment of LULC. LULC, DEM, and soil data were used to calculate the watershed's curve numbers (CNs), empirical parameters used to predict the runoff initial abstraction.

32 years (1990-2021) of rainfall data were used to identify the wettest, driest, and average rainfall years as well as their return period. Climate change is anticipated to affect the nature of precipitation (i.e., intensity, duration, and frequency). As indicated in Table 1, the return times for low and high water availability based on rainfall were simulated and identified using the precipitation data of extreme occurrences.

Season	Station	Year	Annual rainfall (mm)	Max Rainfall Month (mm)	Return period (years)
Wet	Quetta	1992	423.6	March (148.24)	33
Wet	Kalat	1992	274.7	Jan (76.6)	33
Dry	Quetta	2000	112.26	Jan (43.04)	1.5
Dry	Kalat	2000	91	Feb (45.9)	1.5
Average	Quetta	2009	188	Jan (54.0)	2
Average	Kalat	2009	172.7	Jan (71.9)	2

TABLE I: WET, DRY, AND AVERAGE RAINFALLS DATA FOR QUETTA AND KALAT STATIONS (1990-2021)

E. LULC Delineation

Land use is human-driven management actions, whereas land cover is the biophysical land surface [18]. LULC affects the hydrological processes, including interception, evapotranspiration, infiltration, and runoff [19]. Supervised classification with the maximum likelihood approach was used to classify LULCs. Supervised classification uses the spectral signatures obtained from training samples to

classify images. The area has six distinct LULC classes used to classify the basin. For the accuracy assessment of classified LULC, an Error Matrix was developed. For the verification of LULC classes, 300 samples (Figure 2) were collected using GPS, along with Google Earth images.

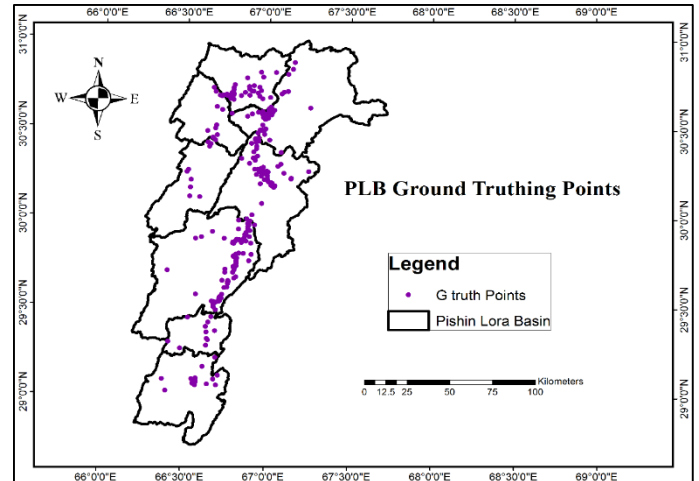


Figure 2. Ground-truthing points in Pishin Lora Basin

F. Soil Data

The entire basin has a type "C" hydrologic soil group (HSG) as per Harmonized World Soil Database (HWSD) (Figure. 3).

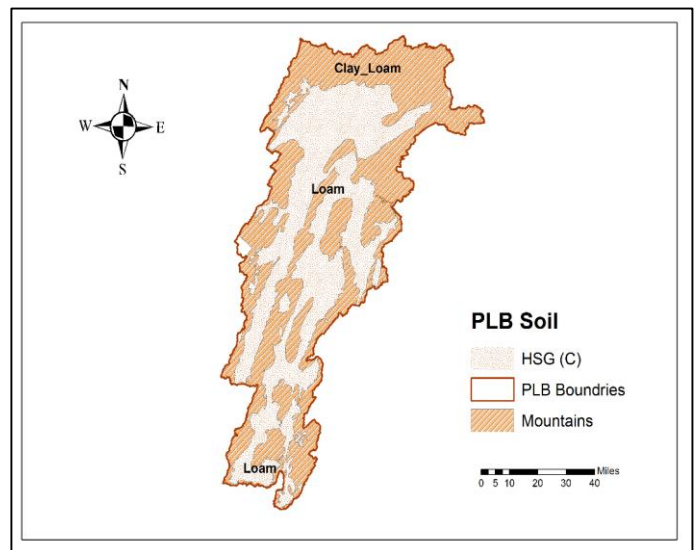


Figure 3. HWSD Soil map of Pishin Lora Basin

G. Delineation of Stream Networks and Watershed Boundaries

Using DEM and HEC-GeoHMS, watershed boundaries and stream networks were identified. The study area's mosaic consisted of five DEM tiles. Figure. 4 displays the primary preprocessing procedures for watershed modelling.

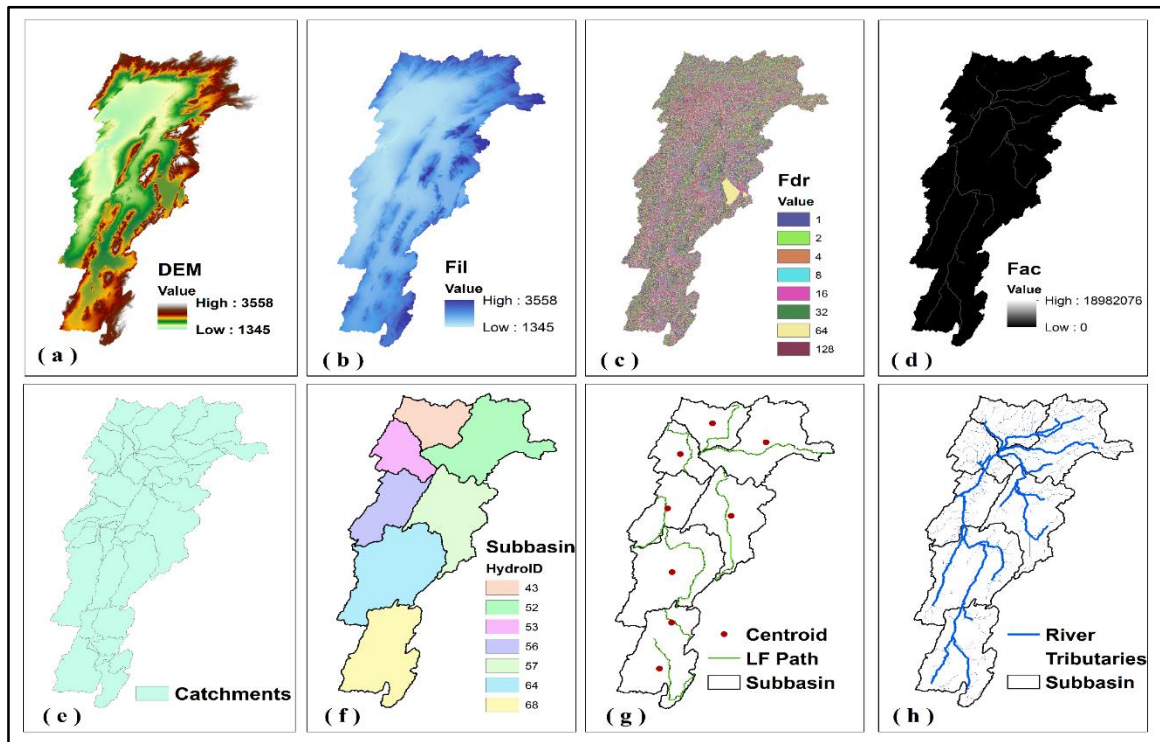


Figure. 4 Digital Elevation Model (DEM), Fill Sinks, Flow Direction, Flow Accumulation, Catchments, and Subbasins are all examples of terrain preprocessing (g) longest flow path, the centroid of the basin, the basin's boundaries and the stream network (h)

Based on the main streams, PLB was divided into eight sub-basins. Kalat, Mogachar, Mastung, East Quetta, West Quetta, Pishin, West Qillah Abdullah, and North Qillah Abdullah are among these basins (Figure 5).

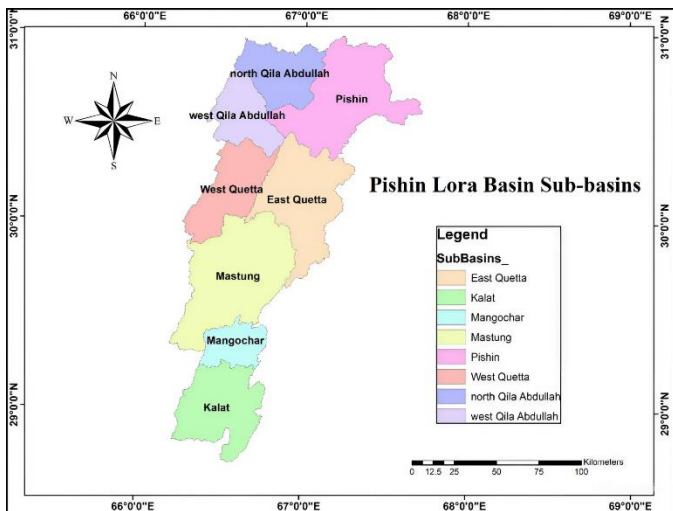


Figure. 5 Pishin Lora Sub-basins

The study area's watershed boundary and drainage network, including the main river and its tributaries, are illustrated in Figure 6. After watershed delineation, the

model was exported to HEC-HMS for rainfall-runoff modeling.

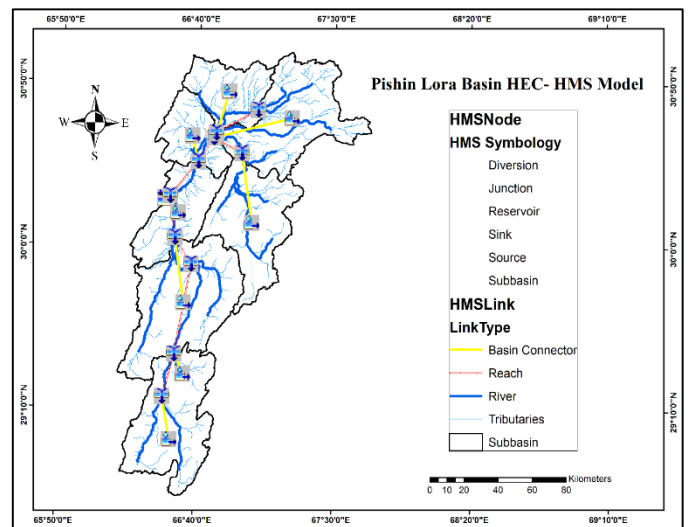


Figure. 6 HEC-GeoHMS Model for Pishin Lora Basin

H. Hydrological modeling

After delineating the watershed, the basin, river names, and other characteristics were assigned to define the simulation

method from the HEC-GeoHMS and prepare input files for Hydrologic Modeling System (HEC-HMS).

The HEC-HMS is a frequently used software that simulates precipitation-runoff dynamics. The software converts the rainfall data into the direct flow. The parameters to run the model are listed in Table 2 .

TABLE II: PARAMETERS SELECTED FOR THE HYDROLOGICAL MODEL

Character	Loss Analysis	Selected Methods
Sub-Basins	Loss approach	SCS curve number method
Sub-Basins	Transform approach	SCS unit hydrograph method
Sub-basins	Base Flow approach	None
Reach/River	Rout approach	Muskingum method

I. Loss Model - The Soil Conservation Service (SCS) Method

The interaction of infiltration, surface runoff, and subsurface processes is represented by the sub-basin element. After deducting the volume of water that was intercepted, penetrated, stored, evaporated, or transpired, the loss model calculates the amount of water from the rainfall [20]. Taking into account the land cover and soil type, it determines how much water infiltrates after rainfall. There are a total of twelve possible loss calculation methods in HEC-HMS. The Soil Conservation Service (SCS) Method was chosen for this investigation (Equation 1). The CN, which measures the effect of soil and LULC on rainfall-runoff generation, is the foundation of the SCS runoff strategy.

$$Q = \left(P - \frac{I_a}{P-I_a} \right) \quad (1)$$

Where Q is the direct runoff depth, P is the total rainfall depth and I_a is Initial Abstraction, and ($I_a = \lambda S$), S is the potential maximum retention calculated by equation (2).

$$S = \frac{1000}{CN} - 10 \quad (2)$$

Where CN shows the curve number, which varies from 0-100.

J. CN GRID preparation

Using Equation (3), the composite CNs for each sub-basin were determined [21]. Where CN_i is the matching curve number and A_i is the area of the sub-basin I The CN Lookup table allocated curve numbers for the study area's land cover (Table 35 in 2C-5- NRCS TR-55 Methodology).

$$CN = \frac{\sum A_i CN_i}{\sum A_i} \quad (3)$$

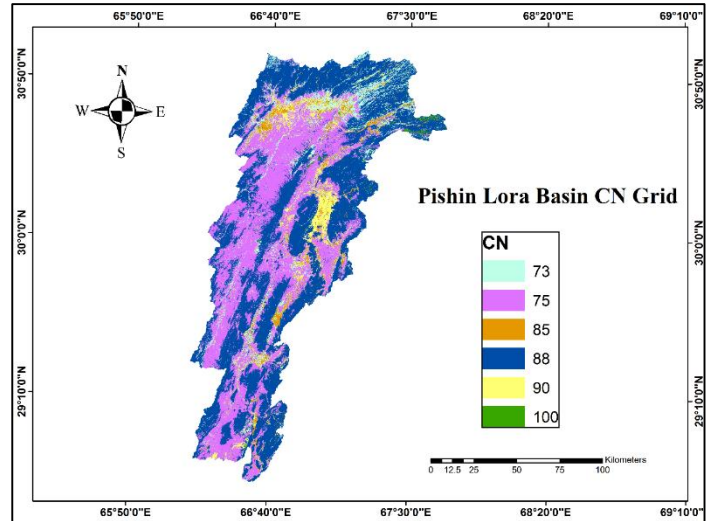


Figure. 7 CN Grid Generated for Pishin Lora Basin

K. Transform Model- SCS Unit Hydrograph Method

The transform approach was used in the surface runoff computations to change the rainfall into a runoff after losses. The SCS unit hydrograph method was chosen from a total of nine available transform methods in HEC-HMS. By setting the unit runoff % before the peak flow, the SCS unit hydrograph approach describes a curvilinear unit hydrograph. Lag time defined by maximum retention, ground slope, and flow length was calculated using Equation (4) [22].

$$L = \frac{l^{0.8}(s+1)^{0.7}}{1900Y^{0.5}} \quad (4)$$

Where (L) is Lag-time ($L=0.6Tc$), the time from the centroid of an excess rainfall hyetograph to the corresponding peak discharge, (S) is the maximum retention, (Y) is the basin slope in percentage, (l) is the longest flow path, and (S) is the maximum retention. The time it takes for runoff to travel from the farthest point in the watershed to the outlet, $T_c =$ time of concentration ($T_c = l^{0.8} (S+1)^{0.7} / 1140Y^{0.5}$), is defined as the interval between the highest rainfall and the peak discharge produced following rainfall. The watershed's slope, type, and flow channel all affect the concentration time.

L. Hydrologic Routing-Muskingum Method

Flood routing forecasts the time and spatial distribution of flood waves in streams. Using the runoff information from upstream sections, flood routing determines the flood hydrograph at a particular stretch of the river. Because of its acceptable level of precision and the dependability of its parameters, the Muskingum approach is regularly used and well-liked in flood routing.

An inflow hydrograph is routed using the Muskingum routing method using a conservation of mass strategy. In the Muskingum model, there are two variables: the storage coefficient (K) and the weighting component (X). For proper channel flood routing, these two parameters must be calculated.

The time it takes to traverse the reach is represented by the Muskingum K parameter. A dimensionless coefficient without a clear physical meaning, the Muskingum X parameter. Maximum attenuation must not be less than 0.0, and this parameter must not exceed 0.5. (no attenuation). For the majority of applications, a first estimate of 0.25 is further refined by model calibration.

M. Micro-watershed Delineation and surface water calculations of small/ check dams

One method for resolving the impact of water shortage crises in arid and semi-arid environments is rainfall-runoff modeling [23] [24]. This study uses a rainfall-runoff model created in HEC-HMS 4.7 to assess the hydrological potential of these check dams by delineating their micro-watersheds. The maximum storage potentials of these dams were then compared with their designed capacities. For this study, dams were chosen in various basins, as shown in Figure.8.

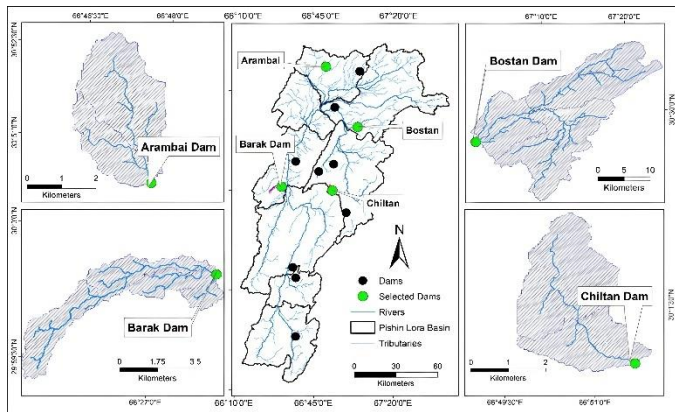


Figure. 8 The selected PLB small/Check Dams (micro-watersheds)

III. RESULTS AND DISCUSSIONS

A. Land Use Land Cover of PLB

The land use and land cover (LULC) affect the hydrological parameters of an area, including infiltration, runoff, and evapotranspiration. The predominant six LULC classes of PLB are shown in Figure. 9, and the area under each land class is provided in Table 3.

TABLE III: PISHIN LORA BASIN LAND USE LAND COVER CLASSES

S/N	Classes	Merged classes	Percent Area
1	Agricultural Land	Crops irrigated, Different fruits orchards	3.3%
2	Hills	Mountains	46.2%
3	Bare Land	Dry plains /no greenery	34.5%
4	Built up Areas	Built-up areas /urbanization/road	5%
5	Water	Water bodies	0.6%
6	Dry streams bed	non-perennial rivers path	10.5%

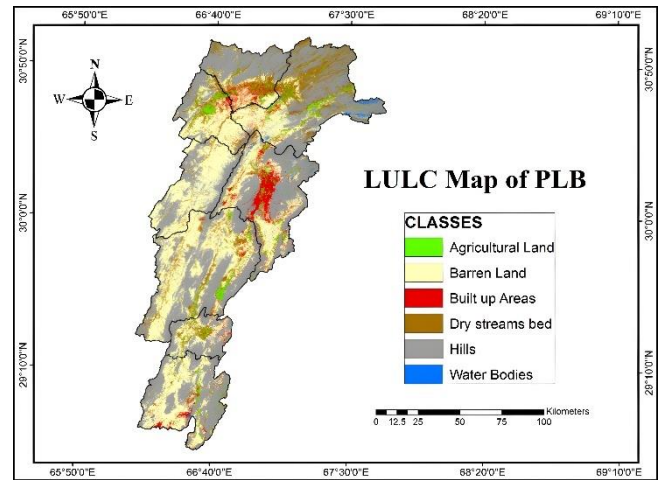


Figure. 9 Land cover of Pishin Lora Basin

The accuracy of the user for each LULC ranged from 82% to 96%, and the accuracy of the producer ranged from 21% to 86%, according to the error matrix obtained from the analysis of LULCs of PLB. The error matrix has a Kappa coefficient value of 89.88% overall, which was regarded as a good agreement.

B. Hydrological modeling of Pishin Lora Basin

By taking into account the response of the model for wet, dry, and average years in terms of precipitation, the temporal fluctuation of the flows at the catchment's outlet was evaluated. Using the major streams and river networks as a guide, the basin was divided into eight sub-basins. For loss, transformation, and routing estimates, respectively, the SCS-CN, SCS Unit Hydrograph, and Muskingum methods were used to estimate runoff from the sub-basins. For all sub-basins, the composite Curve Number (CN) was calculated to be 86. Figures 10, 11, and 12 show the hydrographs for the wet, dry, and average seasons. The key variables influencing runoff volumes were the curve number and the initial abstraction.

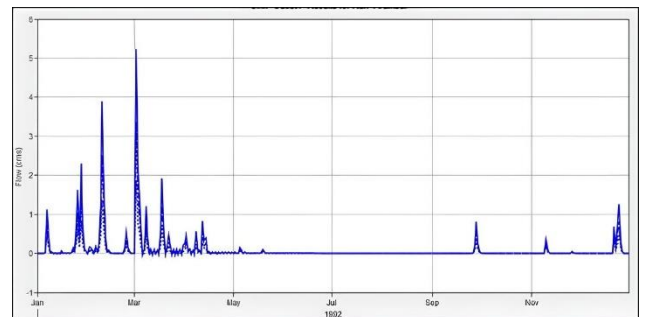


Figure. 10 Hydrograph for the wet year (1992)

The hydrograph of 1992 (Figure. 10) shows the peak discharge values of 5102.23 (m³/s) and the annual volume of 5825946.8(1000m³) corresponding to maximum rainfall values of 423.6 and 274.7 mm, respectively. The maximum of the anticipated discharges for the hydrological year 1992 occurred

between January and December, which was the time when flooding could occur in the area. The hydrograph of the wet year reveals that runoff depth and volume rose from January to March. According to a frequency analysis, flooding is most likely to occur again in 32 years.

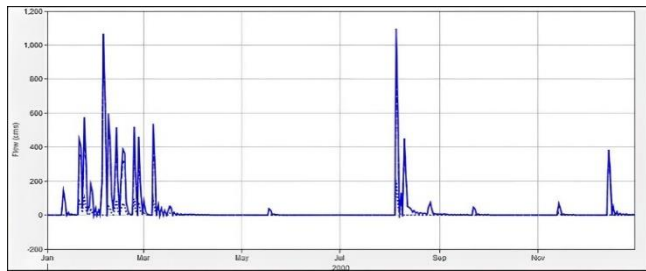


Figure. 11 Hydrograph for Dry year 2000 for PLB

In 2000 (dry year), January-February and August were the rainy months. Figure. 11 shows that, during this period, runoffs reached a peak discharge of 1095.8 (m³/s) and an annual volume of 1247116.7 (1000m³). The maximum rain value for dry year (2000) was 112.26mm. Frequency analysis shows that a drought year is expected after every five years.

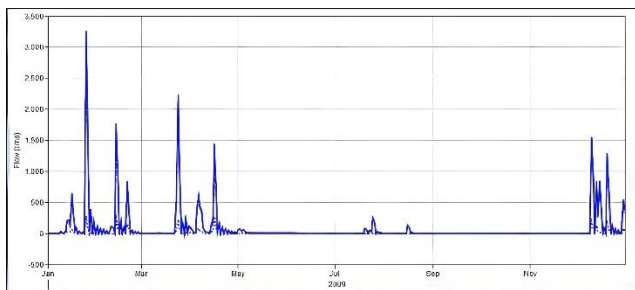


Figure. 12 Hydrograph for the Average year 2009 for PLB

In 2009 (average year), maximum rains were recorded from January-May. During this period, runoffs reached peak inflow values of 3256.8 (m³/s) and 2737410.6(1000 m³). The maximum rainfall in the average year was 188mm. The average year hydrograph illustrates the peak discharge in January-May and December. The average year had no flooding and no drought.

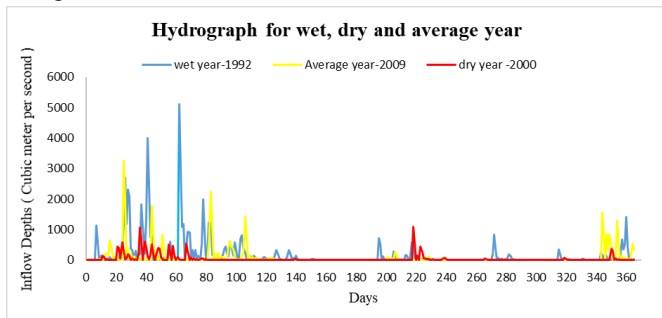


Figure. 13 Combine Hydrograph for Wet, Dry, and Average years PLB.

Figure.23 and Table.4 present the difference in peak discharges and annual volume generation for wet, dry, and average years.

This graph is also showing the difference in the time of peak as well.

TABLE IV: : PEAK DISCHARGES AND ANNUAL VOLUME FOR WET, DRY, AND AVERAGE YEARS

Season	Year	Stations Max Daily Annual Rainfall (mm)		Return Period (Years)	Model Simulated	
		Quetta	Kalat		Peak Discharge (m ³ /s)	Volume (1000m ³)
Dry	2000	112.3	91.0	1.5	1095.8	1247116.7
Average	2009	188.0	172.7	2.0	3256.8	2737410.6
Wet	1992	423.6	274.7	33.0	5102.23	5825946.8

C. Watershed delineation and runoff water estimation of small/ check

Figure. 14, Figure. 15, Figure. 16, and Figure. 17 illustrate the modeling of the micro-watersheds draining to the Arambai, Barak, Bostan, and Chiltan dams, respectively. These are constructed water storage dams in the PLB selected for this study. The hydrologic potentials of these constructed check dams were simulated and compared against their designed capacities.

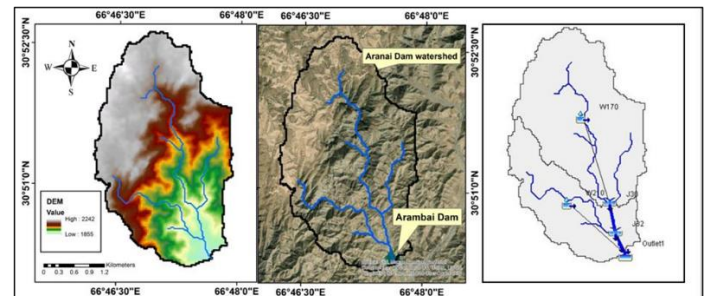


Figure. 14 Arambai Dam (a) Elevation, (b) micro watershed and location of the dam, (c) Hydrological model

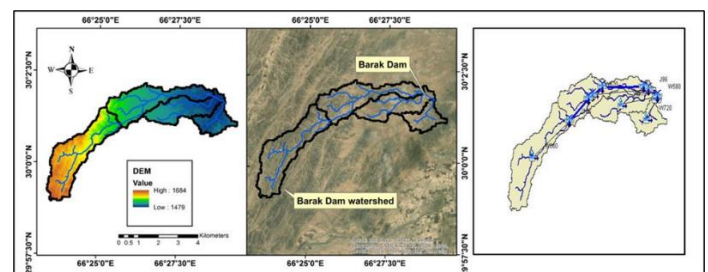


Figure. 15 Barak Dam (a) Elevation, (b) micro watershed and location of the dam, (c) Hydrological model

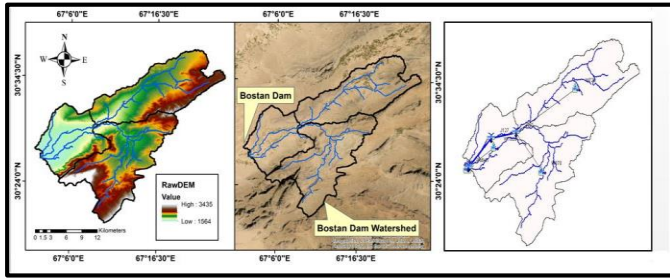


Figure. 16 Bostan Dam (a) Elevation, (b) micro watershed and location of the dam, (c) Hydrological model

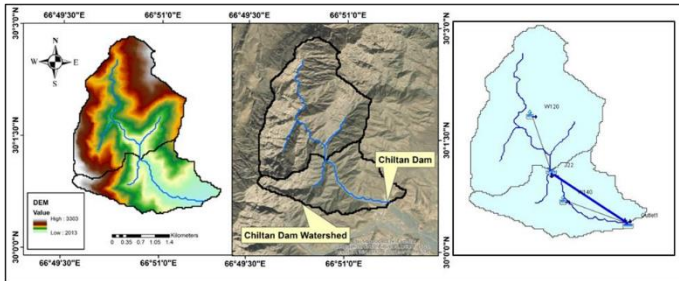


Figure. 17 Chiltan Dam (a) Elevation, (b) micro watershed and location of the dam, (c) Hydrological model

Direct surface runoffs for micro-watersheds of all selected small/check dams were calculated using the SCS Curve number using rainfall data from 1990 to 2021. While the Barak and Bostan dams were built across valleys, the Arambai and Chiltan dams were built at the foot of the mountains. These dams are built with the goal of reducing runoff, enhancing agricultural output, recharging the groundwater table, preserving the local ecosystem, and ultimately lessening the effects of disasters.

The Bostan dam has the highest water potential of all the

examined dams, whereas the Barak dam has the lowest water potential, as indicated in Table 5.

According to the micro-watershed delineation and their hydrological models, the design capacities are adequate for average and dry years but insufficient for wet years, which could lead to the dams being overwhelmed. The suggested method takes into account the built-in storage capacities of the Arambai, Bostan, Barak, and Chiltan dams. The peak discharges, annual volumes, and storage capacities of all the chosen dams are shown in Table 6. Bostan Dam was ranked first based on peak discharges and volumes. However among other dams, its design capacity placed it fourth. This difference calls for thorough consideration while designing such dams. Barak dam has maximum storage capacity, but the estimated results of the model show less water potential. The study results reveal that the design capabilities are enough for average and dry years but not enough for the wet year. The recent 2022 flooding proved this scenario. PDMA said that seven dams in the province were destroyed. Several dams reached their full capacities and overtopped. This comparison recommends thorough water potential analyses before deciding on a dam's size, among other things.

Assessing the internally generated water potential in the Pishin-Lora Basin may help to plan for an improved, efficient, and sustainable water resources management of the basins. The efficient management of water resources in water-stressed regions will ultimately help improve agricultural productivity and ultimately the community of the region will be better off by extending their agricultural activities. This model may provide information related to sediment accumulation in the dams and ultimately assess the life of the dams. Strategies and mitigation measures may also be identified to minimize and address the disaster-related risk.

TABLE V: PEAK DISCHARGES, ANNUAL VOLUMES, AND DESIGN STORAGE CAPACITIES

Name of Dams	Districts	(The wet Year 1992)		(Dry Year 2000)		(The average Year is 2009)		Storage Capacity (1000m ³)
		Peak discharge (m ³ /s)	Annual Volume (1000m ³)	Peak discharge (m ³ /s)	Annual Volume (1000m ³)	Peak Discharge (m ³ /s)	Annual Volume (1000m ³)	
Arambai	Qillah Abdullah	5.224	37169.7	1.16	811.6	1.53	1476.5	772.2
Boston	Pishin	239.99	202925.0	51.61	40040.0	65.65	78963.8	720.4
Barak	Quetta	3.05	1984.7	0.65	382.4	0.83	754.8	1023.7
Chiltan	Mastung	5.47	3855.8	1.22	870.8	1.66	1556.6	370.0

TABLE VI: DAMS' RANKING ACCORDING TO THEIR DESIGN STORAGE CAPACITIES AND ESTIMATED ANNUAL WATER POTENTIAL

Name of Dams	Districts	Storage Capacity (1000m ³)	(The average Year is 2009)			
			Rank Storage Capacity	Peak Discharge (m ³ /s)	Annual Volume (1000m ³)	Rank (Discharge, volume)
Arambai	Qillah Abdullah	772.2	2	1.53	1476.5	3
Bostan	Pishin	720.4	3	65.65	78963.8	1
Barak	Quetta	1023.7	1	0.83	754.8	4
Chiltan	Mastung	370.0	4	1.66	1556.6	2

CONCLUSIONS

This work effectively used geospatial and hydrological modeling to analyze the domestically generated water potential of the water-scarce Pishin Lora Basin (PLB) in Balochistan, Pakistan. The study evaluated runoff quantities for wet, dry, and average rainfall years by examining rainfall data, hydrological parameters, and land use patterns, indicating considerable seasonal fluctuations in water availability. The research found that during rainy years, the water potential is significant enough to alleviate water scarcity concerns if properly managed. However, the study also revealed an important weakness in the design and planning of existing minor dams and water resource development programs, since their storage capabilities are frequently surpassed during peak runoff seasons, resulting in dam overtopping and probable collapses, as shown during the 2022 floods.

The findings highlight the critical need for a paradigm change toward effective planning and scientific assessment of water resource development projects in the PLB. Incorporating seasonal changes and constructing infrastructure that can safely accept peak flows is critical to guaranteeing the long-term safety and sustainability of these initiatives. Furthermore, the study underlines the relevance of integrated water resource management and watershed management measures in mitigating drought effects and increasing water availability in the region. This research, which provides valuable insights into the water potential of micro-watersheds and the performance of existing check dams, can inform decision-making processes and support the development of effective strategies for increasing water productivity, managing flood and drought risks, and ensuring future water availability in the Pishin Lora Basin.

CONFLICT OF INTEREST

The authors declare no competing interest in this study.

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