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Identifying the hill torrents and Groundwater Resources for a remote area of District Jamshoro using Remote Sensing and Geographical Information System

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Abstract: Water resources are the major segments of the sustainable development in any region of the world.The current study identifies the hill torrents and groundwater resourcesin the Kohistan region of district Jamshoro, Sindh province of Pakistan. The study area is a hilly, mountainous range with arid to semi-arid climatic conditions, the high altitude do not allow the source of perennial/canal system, and depending on source of precipitation. Remote sensing data of Alos DEM of 30-meter resolution were obtained throughUSGS earth explorer official website. Shape filewas developed through the Google Earth Pro and ArcGIStechnique. HEC-GeoHMS was used to obtain hill torrents through processing tools and the stream definition was automated fixed to delineate the watershed area covering >= 75 km^2.IdentifiedThe Groundwater resource into two categories of dug well and deep well. The study showed various ranges in the length of hill torrents 0.12 to 43.30 km, the depth of dug well aquifer 08.23-33.50 and deep well 91.50 to 164 meters in the region. Due to some research limitations the number 52 hill torrents, 33 dug wells and 11 deep wells were identified. Hill torrents carry runoff for the least period of rainy days, the torrential beds percolate the runoff and recharge shallow aquifers in the region, while deep aquifers recharges through adjoining watersheds. Water resourcepotential in the study area could be established by efficient heavy machinery to strengthening the torrential beds, and farms periphery bund structures, channelize watercourses, developed different ranges of ponds and reservoirs to capture floodwater, which enhance the recharge capacity of groundwater and introduce a high efficiency irrigation system in the study area. The spatial variation of water resources through modeling assessment has a major importance in the planning and development. Remote Sensing and GIS techniques enable the analysis with accurate results by consuming short time.

Keywords: Hill Torrents, Dug Well, Deep Well, Water Resources, Groundwater, Remote Sensing, GIS, HEC-GeoHMS

1. INTRODUCTION

Most of the World's fresh water comes from hill torrents, rainfall-runoff, and the snow melting process. In Pakistan, 80 percent of the land area could be classified as arid to semi-arid. About 65-70 percent of the area is watershed and rangeland, respectively. Mostly in Pakistan, rain-fed regionsare known as remote and arid regions. Kohistan region of Sindh province of Pakistan is one of the arid regions. Due to high elevation canal irrigation system is not existing in the study area (Ashraf, 1987; Mirjat *et al.* 2012)Livelihood activities depending on rainfall, as well as land use cultivation and groundwater recharge. Climate change is the main threat to the water resources and ecosystem in the region.

1.1 Hill Torrents

Flash floods cause by hill torrent during rainy days. The water coming down through hilly areas and captured to store in reservoirs, ponds or diverted to the dry lands for irrigation purpose is known as 'Nai' in the local term. In Pakistan, the spate irrigation system is knownby different names depending on the region, Viz., 'Nai' in Sindh, 'Rod-Kohi' in Khyber Pakhtunkhwa and Punjab, Sailaba in Baluchistan provinces of Pakistan. The variation of magnitude within hill torrents is the main threat for the stakeholders, particularly for the downstream stakeholders. Less flow leads to droughts (Akhtar, 2008). Subsequently, high flow results more run-off increases the velocity of water due to uneven topography, which causes soil erosion and damages the infrastructure (Mehrai *et al.* 2005). Moreover, the assessment of water resources is vital in the context of a climate change scenario (Akhtar 2008; Ahmed 2000; Ahmad and Choudhry, 2005; FAO 2010). The assessment results will be helpful for policy makers and stakeholders (Archer, 2008).The system can provide valuable assistance by providing an advanced indication of excess or deficit flow in the system (Ali 2008 and Khan 2009).

1.2 Nai/Spate/Rod-Kohi/Ephemeral River irrigation System

It is a unique system of water management, particularly in areas where heavy rainfall on mountains generate floods (Mehrai *et al.* 2005).The old centuries-water rights based on mutually understood rules among the parties using this system. The resource settings and geographic areas are divided into upland and lowland systems. The upland system stands for the distribution mechanisms of the hill torrent water with mountains and lowland means the distribution mechanisms beneath the

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mountains in the region (Kamran and Shamshad, 2014).The irrigation system depicts a model for water distribution on a rotation basis, adopted by the British Government before the independence of Pakistan. Later, the same rules followed by the Pakistan Government for water produced by rainfall in the mountains of the Rod-Kohi areas. The agricultural practices achieved by controlling the flood area to raise the water in periphery bunds (embankment); sometimes water is channeled by already developed watercourse networks within the farming system. The system depends on the three factors of hydrology, geography, and sociology (Ahmed, 2000; Ahmad and Choudhry, 2005; FAO, 2010).

1.3 Groundwater

Precipitation over the land surface develops moisture zones in the soil layer, which increase the percolation and recharging the groundwater(Mehrai*et al*. 2005).Groundwater is the primary source of water supply in many countries around the world. An estimated 1.5 billion people use it for drinking purposes, and about 38 percent of irrigation, land depends on groundwater extraction (Siebert *et al.* 2010). Groundwater is gaining more attention as a significant source for development in the next decades since it is less susceptible and more resilient to the visible effects of global warming (Hetzel *et al.* 2008; Clifton *et al.* 2010). Although, it is indicated by research that groundwater resources are dwindling throughout the world, and it is essential to pay attention to this decline, immediately (Shahid *et al.* 2014). The water requirements are increasing rapidly due to increases in population. Consequently, primary fresh aquifer sources around the world will be stressed to fulfill these demands (Shahid and Hazarika, 2010). Shallow aquifers impact the vast areas of the earth's surface, exceeds about 22 percent cultivated land of Indus basin acquire an aquifer level up to 1½ meter of landsurface and groundwater in the approximately 60 percent area of the Indus basin is brackish (WAPDA, 1979).

The resource availability must be ensured for the sustainability of hilly tracks. The contribution of hill torrents produces significant recharge, which can be utilized by conjunctive systems for drinking and agriculture to promote socioeconomic activities and livelihood, though the groundwater is not held correctly in the mountainous areas, depending on the rainfall.Hydrological information must be ensured with the water column, the quantity of water availability, its relationship to hill torrents, and the number of shallow aquifers along the torrent beds (Murty, 1994).The seepage water by the spate bed and in the runoff area is available underground at shallow depths **(**GOP, 1998); farmers frequently exploit the source to fulfill their irrigation needs (Zuberi and Sufi, 1992) by digging open wells and tube wells (NESPAK, 1991). An estimated 1,700 million m^3 of the derivable quantity of groundwater is present in the Rod-Kohi area (Ashraf *et al.* 2012).

1.4 GIS/Remote sensing

Computer technology is advancing modern technologies during the last few decades. Researchers have developed many spatial modeling techniques to identify the natural streams and assess spatial groundwater resources by combining remote sensing (RS) and the geographical information system (GIS). It is an important task to comprehend the spatial-temporal distribution of hill torrent and groundwater resources according to their need and management (Alcamo *et al.* 2007). Consequently, the spatial variation of groundwater resources through modeling assessment has significant importance in planning and management. It is observed that the traditional procedures to assess the groundwater are time consuming, are more expensive, and provide unreliable results (Al-Abadi and Al-Shamma'a, 2014).

The current studyis aimed to Identify the hill torrents and groundwater resources for a remote area of district Jamshoro using Remote Sensing and Geographical Information System for the future planning and sustainable management for reducing the migration rate and poverty elevation in the study area.

1.5 Study area

The study area covers 9057 km^2, andIt lies between longitudes from 67^0 12' E to 68^0 27' E and latitudes from 25^0 12' N to $26^0$95'Nexistsin Kohistan region district Jamshoro of Sindh province Pakistan **(Fig.1).** Though the selected area consistsofamountainous range with an elevation ranging from 12 to 1115 meters above sea level (A.S.L) **(Fig.2),** which depending on rainfall and groundwater extraction for sustainable agriculture and livelihood practice. The flash floods by hill torrents are the significant source of groundwater recharge. The local community is using deep and shallow aquifers. However, shallow aquifers are developed on the banks of natural streams. The dynamics of groundwater quantity and quality depends on seasonal variation.

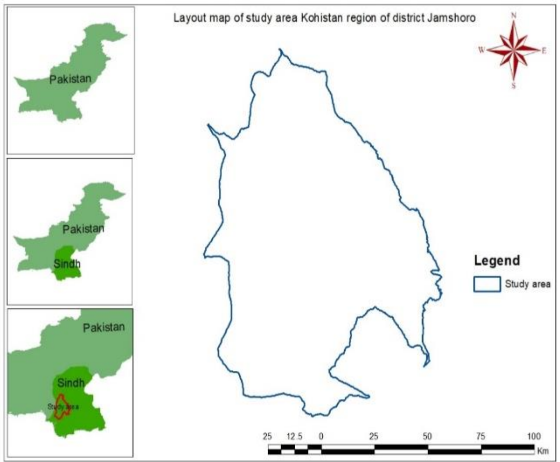

Fig.1: Layout map of study area

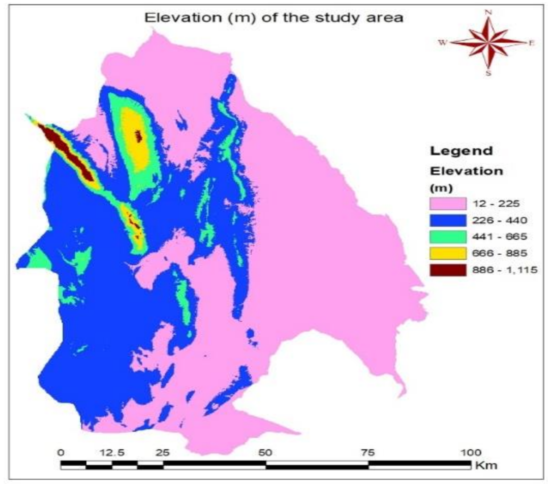

Fig.2 Elevation map of the study area

2. MATERIAL AND METHODS

The Remote sensing data of Alos DEM, 30 meter resolution,were obtained using USGS earth explorer official website (www.earthexplorer.usgs.gov).Google Earth Pro and GIS techniques were used to develop shape files of the study area. Subsequently, acquired DEMwere managed with Geo-Spatial data process techniques by use of ArcGIS 10.3.1.Hill torrents acquired through HEC-GeoHMS processing tool and the stream definition were automated up to the watershed area covering >= 75 km^2. The ground water was classified into two categories, shallow and deep aquifers. However, the location of deep and dug well was identified through field visits and recorded coordinates of latitude and longitude with elevation obtained by the GPS was. Then after; the coordinates incorporated into google earth pro and developed shape file by GIS.

3. RESULTS AND DISCUSSIONS

(Fig. 3) depicts, the location of hill torrents, dug wells, and deep wells in the study area. Most of the dug well located along the hill torrents. While the deep wells located far from the hill torrents.Due to some research limitations, the number 52 hill torrents, 33 dug wells, and 11 deep wells identified.

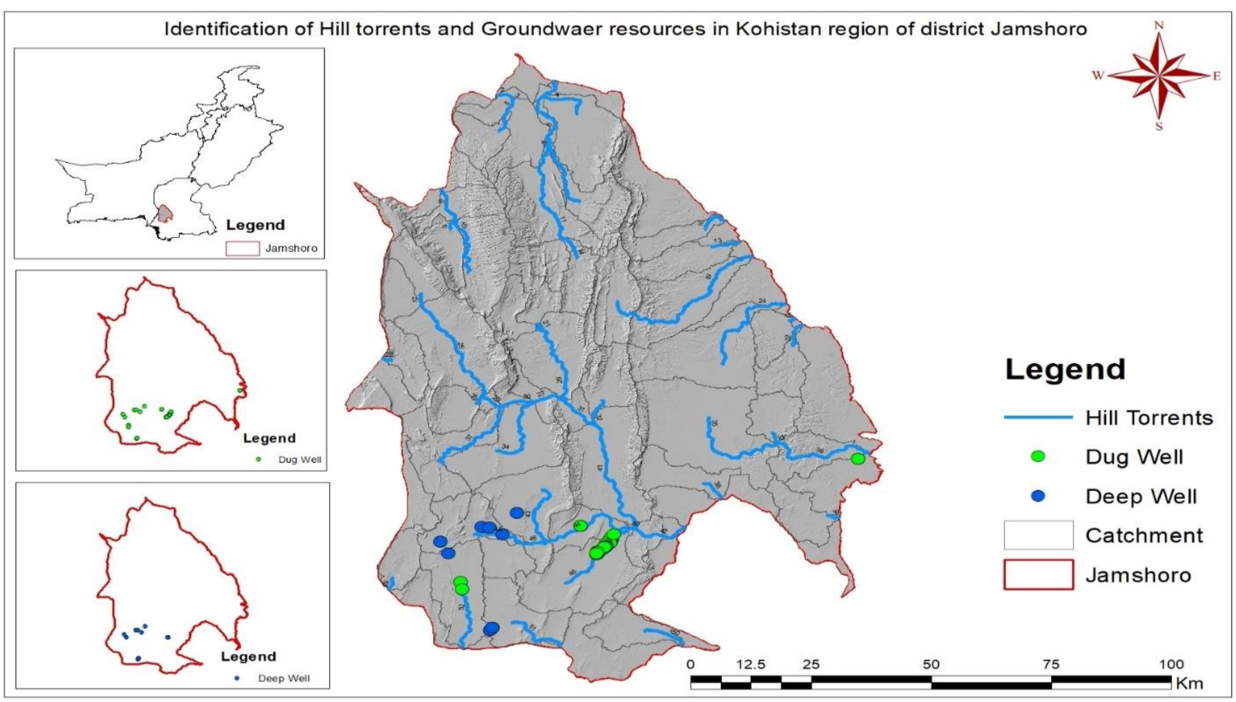

Fig.3 Identification of hill torrents and groundwater resources

(Table.1) showing the region wise location with latitude and longitude coordinates of the dug well along with elevation 99-254 meters above sea level (a.s.l), showing the name of dug well owners in the study area. Furthermore, the table elaborates the aquifer depth ranging from 08.23-33.50 metersconcerningthe surface of the earth. The current range of wells showing the status of shallow aquifers in the study area, which depends on the torrential beds and precipitation. Though, dug wells are the shallow aquifer sources of water and frequently recharged through the torrential beds, the quantity, and quality of shallow aquifers affected by the seasonal precipitation variation

Table.1 Location of dug well, elevation and Name of farmer

Latitude	Longitude	Elevation (m)	Aquifer Depth	Name Farmer	Location
25.39705	67.84707	132	25.90	Muhammad AyoobMemon	Desvi, TBK
25.399356	67.851178	131	28.55	Jan Muhammad Palari	Desvi, TBK
25.3997	67.84708	132	29.87	Haji Nisar-U-ddinPalari	Desvi, TBK
25.401168	67.849916	133	28.00	BahawalPalari	Desvi, TBK
25.403421	67.851936	133	27.33	Jan Muhammad Baplani	Desvi, TBK
25.405435	67.851793	132	28.25	Ghulam Muhammad Baplani	Desvi, TBK
25.405061	67.850423	133	29.75	Amir BuxBaplani	Desvi, TBK
25.396032	67.846109	131	32.00	Ghulam Mustafa Memon	Desvi, TBK
25.39528	67.84538	131	33.50	Abdul Latif Memon	Desvi, TBK
25.369503	67.823572	128	31.12	Abdul HafeezKhaskheli	Desvi, TBK
25.374157	67.824661	127	32.90	Muhammad RafiqueMemon	Desvi, TBK
25.373201	67.825057	129	22.50	Muhammad Khaskheli	Desvi, TBK
25.393332	67.848622	131	33.00	Abdul MajeedMemon	Desvi, TBK
25.389999	67.841388	131	31.28	Muhammad HanifPalari	Desvi, TBK
25.386884	67.841972	131	30.33	Do Do Khan Memon	Desvi, TBK
25.386076	67.840339	131	29.75	Shoukat Ali Memon	Desvi, TBK
25.384825	67.840309	131	29.00	HabibullahMemon	Desvi, TBK
25.385005	67.841093	131	30.26	Ali Murad Memon	Desvi, TBK
25.381113	67.834944	130	30.85	KhamisoBaplani	Desvi, TBK
25.379942	67.835036	130	31.25	MoulaBuxKhaskheli	Desvi, TBK
25.384892	67.838440	127	29.85	KaroKhaskheli	Desvi, TBK
25.383798	67.838783	130	30.64	NabiBuxBaplani	Desvi, TBK
25.367877	67.823321	130	28.32	Karim BuxKhaskheli	Desvi, TBK
25.37330	67.8255	129	21.95	Gul Muhammad Khaskheli	Desvi, TBK
25.3064	67.56941	254	23.00	Muhammad Palari	Desvi, TBK
25.29055	67.57150	245	08.23	Town Committee Saree	Saree
25.43115	67.79294	129	15.00	Pir Bux_1	Seendhiani
25.43054	67.79345	140	14.00	Pir Bux_2	Seendhiani
25.369602	67.823667	129	19.81	SanyalKhaskheli	Desvi, TBK
25.41247222	67.855825	134	13.71	Motio Khan Palari_1	Desvi, TBK
25.41218333	67.85599167	134	19.81	Motio Khan Palari_2	Desvi, TBK
25.57988889	68.31263065	99	24.38	Muhammad Yousif_1	Baz Kando
25.57996111	68.31255833	99	26.82	Muhammad Yousif_2	Baz Kando

Table.2 portrays the location of deep wells by latitude and longitude coordinates and region wise.The elevation of the wells ranges from 128-299 meter above sea level, showing with the name of their owners. The deep well aquifer depth varies from 91.50-164 meters with the reference surface of the earth. The deep well, ranging 91.50 installed in the bed of Desvi Spate by the Town Committee (local government) Thana Boula Khan, the rest of the deep wells installed privately by the local farmers and located far from the torrential beds

Table.2 Location of a deep well, elevation, and name of the farmer

Latitude	Longitude	Elevation (m)	Aquifer Depth	Name Farmer	Location
67.62464	25.19962	209	131.00	Ghulam Ali KheeroBurfat	Habkan, Dada Bhaee
67.62863	25.20493	202	152.00	JumaBaikak-I	Habkan, Dada Bhaee
67.62864	25.20483	202	152.00	JumaBaikak-II	Habkan, Dada Bhaee
67.53168	25.39641	299	107.00	RahooShodo	Habkan, Dada Bhaee
67.54644	25.36981	289	122.00	M.BaratKhaskheli	Near Mole
67.8257	25.36953	128	126.50	Town Committee TBK	Desvi
67.82462	25.36919	129	91.50	TBKTown committee Farm-II	Desvi
67.67444	25.45884	242	122.00	Ali BuxLalani	Morai Nai
67.60877	25.42775	237	125.00	Allah BuxBarejo	UlarNai
67.62331	25.42728	234	122.00	Ali Murad Barejo	UlarNai
67.64762	25.4118	220	164.00	VaryamBurfat (shodo)	Sari

(Table.3) illustrate the overall network of hill torrents in the study area, which carry floods through the higher elevations. The hill torrents covering watershed area > = 75 km^2 have proceeded. The number of 52 hill torrents which contribute floods in the study area. The length of torrents ranges from 0.12- 43.30 km. The shortest length torrents, i.e. 0.12, 0.35, 0.61, 0.79, 1.13, and 1.75 km are playing the connecting part within the torrents, which supports to continue the processing of flow through the longest torrential path. The largest torrents pass through the different potential location of reservoirs which may be built to store for the sustainable development as clear showing the **(Fig.3).**

Table.3 Length of hill torrents

S.No.	Length of hill torrent(km)	S.No.	Length of hill torrent(km)	S.No.	Length of hill torrent(km)
1	4.88	19	43.30	37	24.76
2	3.38	20	1.75	38	6.54
3	0.79	21	2.52	39	2.99
4	11.65	22	7.39	40	1.13
5	10.22	23	2.47	41	32.74
6	14.84	24	27.55	42	13.16
7	20.64	25	29.93	43	17.54
8	9.01	26	22.22	44	23.33
9	3.80	27	7.21	45	12.74
10	6.70	28	2.55	46	5.25
11	30.96	29	4.74	47	0.61
12	0.35	30	6.89	48	21.50
13	6.35	31	8.91	49	3.76
14	6.80	32	7.64	50	10.02
15	17.77	33	3.35	51	15.03
16	0.12	34	20.99	52	20.64
17	3.90	35	26.04		
18	1.74	36	24.58		

4. CONCLUSION

The study area depends on only the source of precipitation; soil layer percolates rainfall, which recharges the groundwater resources. After percolation, the runoff produces and the floods flow through the existing hill torrents.The local farmers divert the flood water for the agricultural activities and extract groundwater resources also used land cultivation and perform livelihood core activities through dug well and deep well. In the study area the number of 52 hill Torrents, 33 dug well, and 11 deep wellswere focused with some limitations. Hill torrents vary from 0.12-43.30 km, dug well aquifer ranges 08.23-33.50 meters, and deep well ranges 91.50 to 164 meter concerningthe surface of the earth.The source of water is available at the surface of the earth through hill torrents and at different depth of beneath the earth's surface that depending on the precipitation pattern. The establishment of a water resource network is a prime segment of sustainable development in the study area by modernizedmachineryof strengthening the torrential beds, channelize watercourses, developed different ranges of ponds and reservoirs and introduceda high efficiency irrigation system in the study area. Remote sensing and GIS are significant tools, which enable the research with accurate results and less time consumption.

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