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Global Warming and Biodiversity Conservation Adaptation Technique in Khageri Watershed, Chitwan

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Abstract

This paper analyzes the land use and land suitability analysis of Khageri watershed in Chitwan. Nepal has been experienced water scarcity in dry season and flood inundation in monsoon. Khageri watershed is the source of water for west Chitwan irrigation and it also this area is rich biodiversity area. This area covered 67.2 percent of jungle in 2024 and that was 74.5 percent in 1999. The study utilized secondary map data sources like Google Earth Pro, USGS, FAO, and ARCMAP 10.8., and eight parameters were used to analyze land suitability analysis. There were 219 small locations found suitable for water harvest areas. Out of which, ten majors' locations have been chosen and further analysis with 5-meter earth dams assumed and they were extended. The extended ten locations cover 712 hectors of land, and they can harvest 24,760,930 cubic meters of water.

Keywords: DEM, proximity, interpolation, GPX and reservoir aquifers

Introduction

Global warming is a contemporary issue of the world. Global warming is the long-term heating of Earth's surface observed since pre-industrial period (1850-1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere. Climate change due to human activities has caused about 1^0C of global warming above pre-industrial levels (Ghimire, P, 2019). Though the major contribution of greenhouse gases is developed countries, the consequences of climate change are most felt by developing countries. Nepal shares only around 0.027 percent of total global greenhouse gases emission (NPC Nepal, 2022) and Nepal has been facing a lot of climate induced disaster.

Success in biodiversity conservation is one of the areas that Nepal can showcase to international communities. (GOV, Nepal, 2018). Altitude varies within a short distance in Nepal. Elevation ranges in Nepal is 60 meters to 8,848 meters. (60 meters

in Kechana Kalan, Jhapa and 8.848 meters in Mt. Everest). The North South average width distance of Nepal is 193 Kilometers. Nepal is a mountainous agricultural country. The crop cultivation practice ranges 60 meters from Kechana Kalan to 4700 meters in Khumbu of Solukhumbu district. In high altitude the potato is grown (Op.cit. pp. 7). Khageri watershed ranges 190 meters south to 1344 meters in the North within 18 kilometers. It has rich biodiversity with varies type flora and fauna.

There are several types of vegetations. Sal (Shorea Robusta) is a dominant type of vegetation. And it is known as a moist deciduous vegetation type of the area. The remaining vegetation types are grassland, riverine forest and Sal with Chair pine Pinus roxburghii. And there are several faunas. They are four horned antelope, Pangolin, Golden monitor lizard, Python, wild boar, sambar, muntjac, chital, rhesus and hanuman monkeys found in Chitwan National Park.

Sal (Shorea Robusta) is a dominant moist deciduous vegetation type of the area. including the elephant grass (Saccharam), renowned for its immense height.

The total temperature ranges 47.9^0F to 98.3^0F in Chitwan. The minimum night temperature is 47.9^0F to 75.9^0F at night and day maximum temperature range from 73^0F to 98.3^0F. Nepal's temperature is projected to increase by 0.9^0C between 2016 and 2045 under the medium-range emissions pathway. Winter is projected to be drier and monsoon summers wetter, with up to a threefold increase in rainfall. Climate change has profoundly affected the farmers in Chitwan in terms of cropping pattern, largely due to variability in temperature and rainfall pattern. Farmers are now continuously confronted with climate related risks like drought, floods, erratic rain and hailstone.

Table 1. Climate and Weather of Rampur Station

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp. record ^{0}C	33.46	35.62	43.18	46.42	47.5	47.5	43.18	42.1	39.49	39.94	35.62	33.46
Ave. high Temp. ^{0}C	25.28	29.15	34.84	39.5	41.05	40.2	36.13	36.56	35.29	33.89	30.66	26.64
Daily Mean Temp ^{0}C	20.08	23.89	30.11	35.11	36.42	36.1	32.83	33.23	31.95	29.76	26.22	22.03
Average Low Temp ^{0}C	11.57	14	18.82	23.45	25.55	27.18	26.25	26.05	25.14	22.08	18.38	14.23
Record Low Temp ^{0}C	2.16	6.48	10.79	17.27	**20.51**	22.67	22.67	21.59	19.43	16.19	10.79	6.48
Ave. rain in mm	12.5	19.89	33.16	117.07	229.45	445.09	935.41	752.98	423.73	99.96	12.69	8.8
Ave. Relative Humidity %	58.9	52.68	37.15	34.79	46.53	61.48	80.42	80.25	81.91	72.92	64.98	61.83
Ave. monthly Sunrise hrs.	9.22	10.41	12.44	13.77	14.26	14.4	13.47	13.42	12.78	9.78	9.37	9.31

Source: https://weatherandclimate.com/nepal/narayani/rampur

Climate change has a significant impact on freshwater of wetland ecosystem in Chitwan. Thermal stratification and water level fluctuation impacted wetland ecology and vegetation composition. In addition, that influences food for wildlife, birds, and wetland species. The extreme weather condition can lead to soil erosion, sedimentation and change in water quality. That resulted the habitat degradation. Floods downstream and drought are resulted by extreme weather events. There is some the effect of climate change in Badharjhula of Chitwan district has been facing climate induced disaster of unusual heavy rainfall (23%), floods (18%), drought (17%), firing (15%), lighting (14%) and hailstone (13%) (Chaudhary et all, 2020).

There is high altitude variation within a short distance of 18 kilometers. The sub-tropical type of climate is there. October through February with average temperatures of 25^0C offer an enjoyable climate. In contrast, from March to June temperature can reach as high as 43^0C. The hot and humid days give way to the monsoon season. June until September the River becomes flooded.

The area has many mammal species. The king of the jungle is the Bengal Tiger. Beside the tiger there are one-horned rhinoceros, Leopard, Sloth Bear, Gaur and four Horne antelope are the major animals. Sal, rosewood, axle wood, riverain forest and kans grass are dominant species. Butterflies, moths, insects, and mosquitoes are there.

The increasing temperature of the glove helps to cause more ice melting in the upland Himalayas and reduce the water table in the lowland in Nepal. Himalayan Glaciers are the main permanent source of water of river systems of Nepal and even India and Bangladesh. The increasing temperature around the Himalayas, the ice melting is common and that causes snowline increase and that has been shifted upwards. And that helps to expansion of glacier lakes. The history of Imja glacier lake in Makalu area, it was small ephemeral ponds in the late 1950s calculated the area lake in 1962 as 0.028 sq.km. Imja expanded to 0.64 Sq.Km in 1987, and rapidly increased to 0.69, 0.9, and 1.34 Sq.Km in 1996, 2006 and 2016 respectively.(K. Nitesh, Z. Guoqing and C. Wenfeng, 2019).

The average depletion of groundwater in Kathmandu valley was 0.7249 meter annually. The survey was taken from 25 different points of Kathmandu valley (G. Dipendra and N.P. Raghu, 2014). The rapid growth in water demand of the Kathmandu valley and low possibility of groundwater recharge, every year groundwater table depletion has been made. In Prembasti, Khaireni and Bhimnagar areas of Chitwan district found a 2-meter water table decline during pre-monsoon period (M. Rabin and K. Kabita, 2016).

This has been practiced since ancient times around the world to address water storage for varied uses. Water harvesting is the concentration of rainfall and run-off from

roofs, watersheds, or build-up areas for beneficial use. The collection and management of floodwater, rainwater and run-off water increases water availability for domestic and agriculture use as ecosystem sustenance. Water harvesting is a practice used to harvest or collect water and make it available for crops and other needs. It is an adaptation of water stressed condition. Run-off water harvesting is a group of catchment level activities. That collects or impounds flood waters, run-off water, lakes, or rivers diverts flood water using structures in the rivers to farms and required areas.

Subsurface aquifers or groundwaters can also be recharged by delaying run-off, infiltration ponds, spreading run-off over large areas, and delaying flood propagation. Injection wells and boreholes can also be constructed to store water during excess flows, store water in underground mounds in suitable aquifers, and retrieve them as required using mechanical pump sets. The water is thus injected, stored, and extracted, generally termed artificial recharge or aquifer storage.

Groundwater infiltration has also been suggested to store floodwaters, that can decrease flood problems downstream. And it can address water scarcity in the post -monsoon season. Flood water upstream was directed to infiltration pond and wells, and the ground water was recharged, this could be tapped during the subsequent dry season. This could be proving beneficial in disaster reduction and aiding crop production. Such practices can be feasible in the terai and wider valleys in hilly regions where the soil horizon has good water storage and transmissivity properties. (CARE, 2023). Even in the study area there were two lakes named Raino Lake and Tiger Lake that have been practiced.

Global warming is one of the contemporary global issues for the 21st century. Scholars believe that the global total water resource volume could not been changed but the distribution and its form has been differed since the year of global warming. This changed pattern has influenced ecological balance and it has been inviting new conditions and people need to adapt accordingly. *Nepal's mountains are crying for help and COP28, (28th Conference of the Parties to the Framework convention on Climate Change) must respond,* Said UN Chief Antonio Guterres in Expo City Dubai on November 30, 2023. This is our pleasure, and it is thought that every individual has a responsibility to do something as up their knowledge. Local people should have initiated this regard locally and assisted local authorities to cope with future potential water scarcity. Khageri watershed is situated between two major cities (Bharatpur Metropoliton City and Ratnanagar Municipality) in Chitwan. Khageri cannel is the important cannel system for west Chitwan which produce agriculture commodities that supply to Kathmandu and Pokhara. The water source of the canal is Khageri watershed. That area is partially covered by Barandarbar Jungle. In addition, Barandabhar forest

is a wildlife corridor, that connecting Chitwan National Park of Nepal's inner Terai and Mahabharat foothills (DNPWC, 2022). Animals can pass both terai and hill through this corridor. After the resettlement of Padampur VDC, Sagun tole's land use pattern was highly dynamic and more encroached to the natural resources.

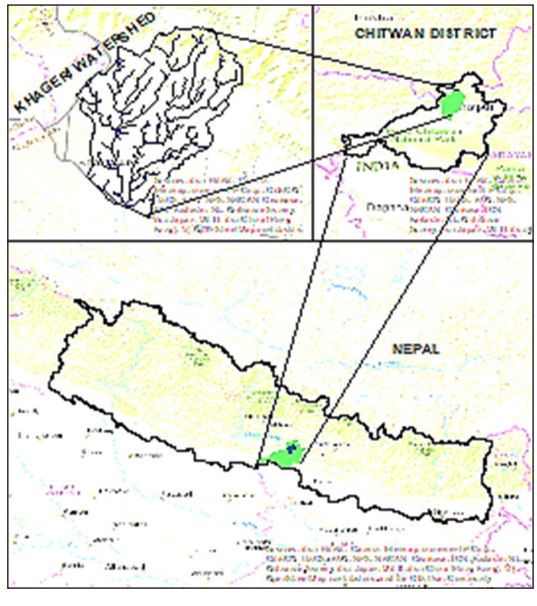
The general objective of the study is to analysis of land use dynamism of the Khageri watershed and identify water harvesting areas through GIS technique to fight future potential water scarcity and assist biodiversity conservation.

Materials and methods

Study Area

Khageri sub-watershed is situated in Chitwan district of Bagmati province which lies upper Siwalik and Inner Terai (Dun Valley) in northern and eastern fringe of the Barandabar forest corridor on the northern side of East west Highway. It lies to the northern and eastern hemisphere extended to $27^0$47'43" north to $27^0$37'46" north and $84^0$26'53" east to and $84^0$35'15" east. It covers 142.84 sq.km. it has an altitude range 191 meter to 1322 meter above the sea level. It lies between Ratnanagar Municipality and Bharatpur metropolitan city. It has several small and seasonal streams inlet like than khola, Khahare Khola, Mani Khola and other small creeks.

The area is influenced by 4 different political entities of Chitwan district. They are Ratnanagar municipality (wards No. ,10,11,12, and 13) in southeast, Bharatpur metropolitan (ward no. 1,11 and 12) in the west, Kalika municipality (1 - 9) in the east and ward number 7 of Ichchha Kamana rural municipality in the north.



Khageri watershed is the main water source area for Khageri cannel system which was initiated in 2017 B.S and completed in 2026 B.S. Khageri cannel irrigated to 3900 hectors of land of west Chitwan (Gautam S., et al. 2077. B.S). In that important area was relocated people from Padampur of east Chitwan where the people were suffering from many severe problems.

Khageri Watershed is a part of Tikauli Forest in East Chitwan. It has a humid subtropical monsoon influenced climate with humidity all through the year. Monsoon starts in June and eases off in late

September. The annual average rainfall recorded to 2200 mm. Winter Temperature falls to 16^0C and summer temperature rise up to 43^0C.

Population

Chitwan district is a highly populated district. The people from several central mountain districts have migrated and it accelerated to population increase. According to the national census 2021, the total population of the district is 719,857. The population growth rate is 2.7 percent in Chitwan that is higher than the national average that is 2.3 percent. Bharatpur Metropolitan city and Ratnanagar municipality are the majors' political entities around the Khageri watershed.

Bharatpur Metropolitan, Ratnanagar Municipality, Kalika Municipality and Icchakamana Rural Municipality are the major entities around and within the watershed. East North part of Bharatpur is highly populated areas. Barandabar jungle area is also kept within the political entities. Ward number 11 and 12 cover a large part of barandabar jungle. Beyond Barandabar jungle, ward number 11 covers 4.60 Square Kilometer and ward number 12 covers 3.23 Square Kilometer. According to the national census 2021 there are 21004 population in ward number 11 and 10939 in ward number 12. The population density calculated to 4080 people per square kilometer.

There are 4 wards of Ratnanagar Municipality which are southeast of the watershed. They are ward numbers 10,11,12 and 13. Altogether they cover 16.33 square kilometers. And they have 8241, 4779, 7439 and 8749 respectively (altogether 29208) population. The population density is calculated to 1789 per square kilometers.

Kalika municipality is located to the east part of the watershed. There are 7 ward (1,2,3,4,5,6 and 7) that lie within the watershed boundary. Those 7 wards have 36,722 population, and they cover to 46.27 square kilometers. Thus, all those political entities have a higher population density than the average density of Chitwan, i.e. 325.

Data source and types

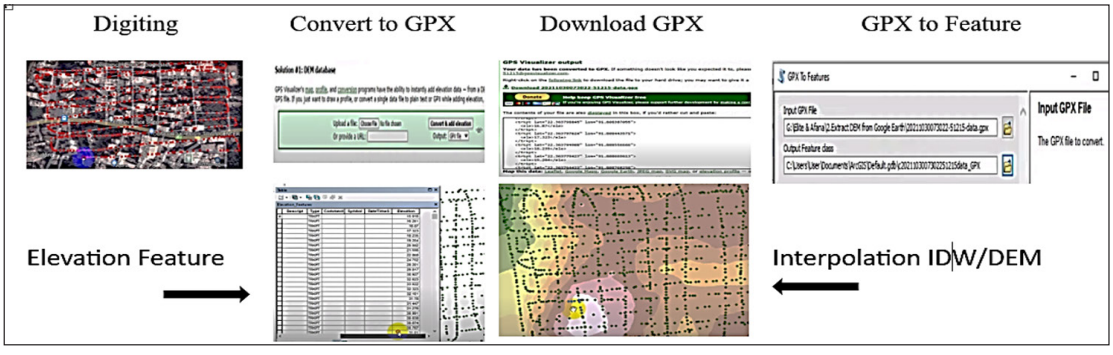
Open data sources were widely used for the study. Google map, USGS (United State Geological Survey) satellite Map, Google earth pro source maps were widely used. Beside those map data, the GIS map developed by the survey department of Nepal, department of road and other agencies were widely used. The rainfall map was developed on the based on numeric data collected from Department of hydrology and metrology of Nepal. Esri produced ArcMap 10.8.2 versions and was used for analysis.

Dem Raster

Most of the data sources are from Google Earth Pro and Arc Google. The Digital

Elevation Model (DEM) was widely used. It had been navigated to the chosen location and created a path via points throughout the study area. It had been taken as many points as needed for accuracy. The number of points in the created paths were large so the accuracy and resolution of the DEM were comparatively high. Taken points were saved into a "KML" type file in the desired directory. Using GPS Visualizer website, populated the elevation points values as convert and added elevation points in the GPX file. After converting them into a GPX file, it had been downloaded and extracted it in the desired path location. To convert the GPX file to feature file, a conversion tool of ARCMAP had been used (Conversion tool -- from GPS -- Gpx to features). And the watershed boundary was delineated using Hydrology tools of Arc Toolbox.

Figure :1. Process to create DEM from Google earth map



Slope raster: The slope map had been developed through a DEM raster file. Spatial analysis tools, surface tools and slope tools of ArcMap were used. Mainly there were 5 slope categories identified as 0 to 15, 16 to 25, 26 to 35, 36 to 45 and 45^{+} degree.

Land use and road network: These types of data had been developed by using google earth pro, digitizing and save them as KML file and later converted into feature class in ArcMap 10.8.2.

Soil map: Soil Map of the study area was extracted from soil and water assessment tools (SWAT) model of south Asia. And it was found single soil type across the study area that was boulder mixed soil (lucidols) which is shallow and rocky soil.

Geological map: Geological map of south Asia downloaded and extracted it into Nepal boundary. The website (https://certmapper.cr.usgs.gov/data/apps/world-maps/) had been used to download the geological map. It had found a single geological cover that was sandstone, siltstone and mudstone type geology.

Rainfall data: The raw tabular data (CSV type) of annual rainfall of different 424 stations had been carried out from environment statistics of Nepal 2019, published by Central Bureau of statistics. The website was (https://cbs.gov.np/environment-statistics-of-nepal-2019). There were 5 different years rainfall data of 424 metrological stations. They were 2013, 2014, 2015, 2016 and 2017 years. Found numerical data had been averaged. The calculated average rainfall data were interpolated with IDW tools in ArcMap and developed raster map.

Water volume: The extended reservoir water volume was calculated using DEM elevation points. Clipped all height points with extended lake boundary. The attribute table of clip DEM elevation points were exported into excel file and calculated the average depth of the extended lakes.

$V = L \times B \times H$

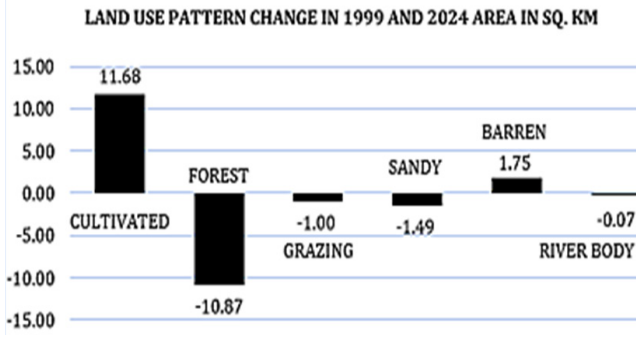
The Geographic Coordination System of all map data were GCS_WGS_184 coordinate system and they all were projected into WGS_1986_UTM_Zone_45N for data analysis.

Land use of Khageri watershed

The land use pattern of 1999 has been carried out from secondary source data that was analyzed based on Topographic map of 1994/1995 published by Topographical Survey Branch and field verification in 1999. Six major categories of land use have been found (Dhakal, K. 2014). The Land use pattern of 2024 has been carried out using an open data base that was of satellite image of 2024 provided by Google earth Pro image Landsat/Copernicus. That image was analyzed through ArcMap 10.8.2.

Table: 2. Land use change of Khageri Watershed between 1978/79 and 2024 (Area in Sq.Km)

Land Use Type	**1978 /79****	**1999****	**2024***
Cultivated	15.04	28.96	40.64
Forest	120.03	110.78	99.91
Grazing	12.51	3.57	2.57
Sandy Area	1.07	3.9	2.41
Barren Land	N/A	0.94	2.69
Water Body	N/A	0.47	0.40
Total	**148.62**	**148.62**	**148.62**



Source:1.**Dhakal Keshav, 2014 Land Use Change in Khageri Watershed in Chitwan
2.*GIS analysis of Satellite Image 2024

In 1978/79 the table shows that the forest land has covered by 80.7 percent (120.03sq.km) area of the watershed. Forest type land use was the most dominant land use type. It is further classified into protected forest, forest with 40-70 crown density forest and more than 70 percent crown density forest. The proportion of those forests were 15.53 sq.km, 103.0 sq.km and 1.5 sq.km respectively.

Agriculture is the second most dominant land use type in this watershed. It covers 15.04 sq.km 10.12 percent) area. It has further reclassified as valley agriculture and slopping terrace cultivation. In agriculture land use, valley cultivation occupies 14.74 sq.km (14.74 percent) and sloping terrace agriculture occupies only 0.3 sq.km. (0.2 percent) of the watershed. Grazing land type land use is the third dominant land use type. It covers 12.51 sq.km (8.4 percent) area. And less than one percent land cover by the water body that is 1.07 sq.km of the area.

Table 2 shows both respective years forestland is the dominant land use type. It has covered 74.52 percent (110.78 sq.km) area of the watershed in 1999 and it has reduced to 67.23 percent (99.91 sq.km) in 2024. Mainly The forest land, grass land and sandy area were decreased. Padampur shifted project was conducted there and it reduced those areas.

Padampur VDC was situated on the lap of Rapti River which was surrounded by Chitwan National Park. The people of Padampur VDC had several types of problems like Rapti river yearly flood, jungle animals' encroachment to the settlement, lack of road connectivity to district headquarter, health and education. After the new dawn of democracy in 1991, New government was asked to shift this village for people's safety and conservation of the forest and wild animals. The late Sailaja Acharya (First Female Deputy Prime minister of Nepal) visited the Padampur area and understood their people's griefs and purposed to shift it next to Saguntole near Jutpani VDC around 14 Kilometers north from previous Padampur. So Padampur VDC shifted, and it had been completed in 2006.

There were two types of land use that were increased. They are cultivated land and Barren Land. The cultivated land was remarkably increased in the middle east part of the watershed. That was 11.68 sq.km. The barren/fallow land had increased in north high land. And fallow land increased south low land along the Khageri riverbank.
The forest, sandy and grazing land had decreased in 2024. Forest land decreased by 10.87 sq.km, sandy area decreased by 1.49 sq.km and grazing land decreased by 1 sq.km. And the water cover area seems look similar.

Land Suitability Analysis

There are several factors that affected suitable land for water harvest area. Elevation

is an important factor in determining the best location of a dam, as it influences water accumulation and flow. Low elevation values are the most suitable areas.

High slope areas are considered unsuitable for water storage structures, as a large structure (in term of height) is needed for the storage of a significant amount of water. Medium and or low slope areas are more convenient as large storage capacity can easily be contained in smaller structures. As lower the slope, there is higher possibilities of water accumulation. The slope areas are closely linked to the flood plain and riparian materials (Njiru FM and Siriba DN, 2018).

Stream order is dependent on tributaries connection. Stream density is the total length of runoff in the drainage basin and shows the proximity of the gaps of the water channels. Higher tributaries calculate higher drainage density that indicates high groundwater probability and increase suitability for locating a water harvest area.

Table. 3 Components, weighted values and influence percent

Para meter	Sub. Criteria	Value	Para meter	Sub. Criteria	Value	Para meter	Sub. Criteria	Value	Para meter	Sub. Criteria	Value
Elevation	191-280	5	Slope (Degree)	0.0-3.5	5	Lineament density	0-71	5	Stream Density	1-2	5
	281-413	4		3.6-10.2	4		72-142	4		3-4	4
	414-617	3		10.3-19.4	3		143-213	3		5-6	3
	618-892	2		19.5-30.5	2		214-284	2		7-8	2
	893-1322	1		30.6-53.2	1		285-355	1		9-10	1
Influence	**15%**		**20%**			**10%**			**15%**		
Para meter	**Sub. Criteria**	**Value**	**Para meter**	**Sub. Criteria**	**Value**	**Para meter**	**Sub. Criteria**	**Value**	**Para meter**	**Sub. Criteria**	**Value**
Land Use	Barren/sand	5	Sett. Distance (m)	0-100	5	Road Distance (m)	0-100	5	Rainfall (mm)	2000-2100	5
	Settlement	1		100-200	4		100-200	4		2000-2100	5
	River Body	4		200-300	3		200-300	3		2000-2100	5
	Grass	3		300-400	2		300-400	2		2000-2100	5
	Agriculture	2		400-500	1		400-500	1		2000-2100	5
Influence	**15%**		**10%**			**10%**			**5%**		

Rainfall is the primary source of runoff water discharge. Rainfall density and distribution are some of the prerequisites for designing a water collection system. Rainfall density significantly affects the pick discharge of water. In this study, due to the small study area, rainfall density was not considered.

The distance criteria, the road network, and settlements proximity play an important role in the selection of the dam site. The proximity of roads and settlements

to the purposed areas for the dam site will reduce the transportation cost during construction and its uses as well.

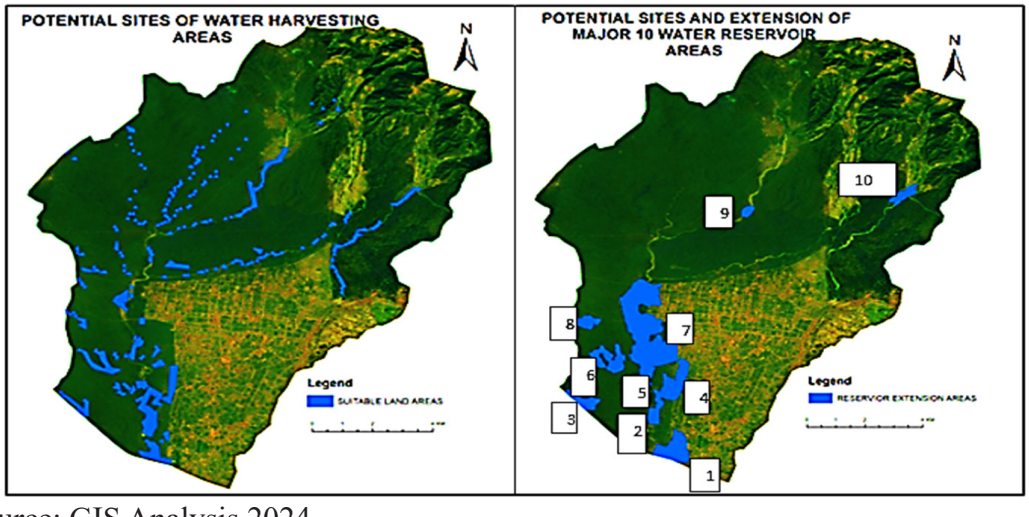
Another topographical feature of lineament density is considered an important factor for water collection. The higher linearity density areas are not suitable for sufficient water collection. Lesser lineament density areas have higher potential for the dam.

Soil type is an important factor in selecting RWH site. Different soils have different rates of swelling that affect the amount of runoff. Different soil textures have different infiltration rates that affect the amount of flow. Medium to fine textured soil is typically more suitable. And clay type sites have been proven to be the best soil group for water storage.

Suitable land and extended Areas

In this study, the total potential areas identified to 2.85 Square kilometers (2 percent of land) in 219 small locations. The southwest part of the watershed and west side of Khageri river and the middle upper part found more areas. Most of the potential areas are along the riverbank, fellow land, wetland, and grass land cover areas. And southeast part there are dense settlement and cultivated areas found nothing potential areas.

Figure:2. Distribution of suitable land and extended of reservoir



Source: GIS Analysis 2024

The major 10 potential areas have been identified based on area coverage and they were extended as water reservoirs. The lowest height points of each major potential

site were assumed as a water pour point of major sites. Between the water pour point contour line and five meters height contour line from the water pour point line were worked as boundary of extended reservoir. The above map shows its distribution and extension.

Extended areas, land balance and biodiversity

There are 10 extended reservoir sites covering 712.49 hector of land and they can hold 24760930 (24,760,930,000 liters) cubic meters of water. This collection water can irrigate to west Chitwan for 36 days in dry season. The water discharge capacity of Khageri irrigation system was designed to 8 m3/s (Gautam S., Shrestha, S, Acharya, U and Bhatta. U, 2077 B.S).

Table 4: Land Balance after extended reservoir (in Hector)

Sites	Cultivation Land	Forest Land	Grass Land	Fallow Land	Water Body	Sandy Land	Total	Water vol. m^3	Pour* Hight
1	53.46	4.78	2.61	15.07	2.49	0.68	79.09	2373071	191 m
2	0.00	13.97	5.08	7.10	2.91	3.28	32.34	1117545	194 m
3	0.00	30.44	1.01	6.10	0.00	0.00	37.55	1318879	210 m
4	38.73	11.98	20.83	0.00	0.23	0.13	71.90	1761413	204 m
5	0.00	11.87	7.40	5.73	2.06	5.54	32.60	1000507	201 m
6	0.00	43.07	13.53	0.00	7.57	0.00	64.17	2041114	112 m
7	20.34	231.25	13.87	53.28	5.62	4.74	329.10	12670762	211 m
8	0.00	24.39	0.00	0.00	3.57	0.00	27.96	791404	225 m
9	0.00	8.36	0.00	0.00	0.00	3.36	11.72	528663	262 m
10	6.38	0.00	15.03	0.00	0.00	4.65	26.06	1157572	312 m
Total	**118.91**	**380.11**	**79.36**	**87.28**	**24.45**	**22.38**	**712.49**	**24760930**	

Source: GIS analysis 2024, * Pour height is the deepest point where water drops.

There were 10 potential areas that have been elaborated to extend as water reservoirs. Site one lies just above Khageri bridge along the east west highway just above the Khageri dam. It has extended to 79.09 hector of land. It ranges 191-meter height to 196-meter height. It covers 53.46 hector cultivated land and dense settlements of Ratnanagar Municipality. This extended area can collect 2373071 cubic meters of water. Site three is located between ward no 9 and 12 of Bharatpur Metropoliton. That is more densely populated areas and industrial areas. Site six overlaps to Rhino Lake. Site six extended reservoir makes an island with 7.35 hector (29 Bigha) between the

extended reservoirs. Site 5 and 7 overlapped with each other. Site seven is the biggest area coverage. The site eight overlaps to Tiger Lake that is close to Nawa Jagriti eco park of ward no 11 of Bharatpur metropolitan. Sites nine and ten are located upstream of the watershed.

Conclusion

The watershed is a topographically delineated area by the river system. The DEM (Digital Elevation Model) was used for the watershed boundary delineation. Esri product ArcMap 10.8.2 was used for all kinds of analysis. Google Earth Pro provided open data source were widely used. Some previous works were considered for analysis. The population growth accelerates the pressure on the natural resources. While forest land is the first dominant land use since last 40 years (1978/79 to 2024) type, it is decreased rapidly. The proportion of forest land was 80.7 percent, and it came down to 67 percent in 2024. In return cultivated land dramatically increased to 15 sq.km to 40.64 sq.km (10 percent to 27 percent. The Padampur resettlement program was seen as the prime factor to increase cultivated land. The grazing land use covered to 12.57 sq.km in 1978/79 and it rapidly decreased to 2.57 sq.km. in 2024.

Along the river line and low altitude plain areas, there were several locations that were identified as suitable zones for water harvest area. This area is located to southern low land areas. 10 majors' locations were extended. And they can store 24760930 cubic meters of water covering 712.5 hector areas.

Consequences

Water harvesting in Khageri watershed can influence two-way irrigation. The slow water flow can help water recharge to aquifer downward and it can supply water to upward dry air in dry season. Khageri watershed areas is a corridor of wild animals passing through Siwalik Mountain, away to terai plain and lower Mahabharat mountain. The wild animals and birds can get sufficient water on the way. The harvested water can help to develop into new aquatic animals. And around the water new flora and fauna will be generated and it will help rich biodiversity. If the reservoirs are managed well, it can collect water in high intensity rainfall time and it recharge later that can control flood disaster to the downstream. As flood management, the riparian flora and fauna can preserve from the flood. There are several methods to biodiversity conservation. In addition, water reservoir is not only the method to biodiversity conservation rather it has more influences on conserve biodiversity.

The water reservoir is natural beauty as a lake. It is one of the important methods to preserve biodiversity in the Khageri Watershed. People have been using the lake

to reduce stress and enjoy themselves. Boating activities can provide employment generation and it enhances internal tourism. The running water lake is a good source of valued fisheries. The harvested water can irrigate to west Chitwan in dry season and that can have increased self-employment and can increase cash crop and vegetable. Water harvesting alone cannot conserve all entire biodiversity, but it can help to preserve the existing flora and fauna.

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