Suitability and Prominent Analysis on Proposal for Constructing a Dam on Wakal River Basin, North Gujarat-Rajasthan

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Abstract

Dam is an important way of water-resources utilization in large rivers. Dam construction has played significant roles in flood control, irrigation, navigation, and energy supply; however, the enormous negative effects, such as landslides, ecological problems, and water quality decline, could surpass positive gains. In these days, the water has become the most important need of everyone. In the monsoon season, there is over amount of water. Because of no facility of storage of water, this amount of water is being wasted. On the other side, in the summer season, there is no water for daily use only. So, our main concept for this project is to give better storage system of water to all villagers and to keep water in storage & use it in every season. The present study motives to design a dam proposed on Wakal river basin. The suitable dam site & its healthy catchment is very helpful in putting the reservoir. Extensive experiments of rock fragments and soil practical's have been done, major survey's on seven possible dam sites were carried out, testing have been followed by laboratory analysis. It was observed that the dam site has rocky foundation which is suitable & gravity dam may be constructed. To control flood, Gravity dam may be preferred. Various other observation will be carried out in future in addition the perform tests. Analysis of flood magnitude has been done using rational method, Empirical formulas, and Geological surveys & by software various analysis has been done. Proposal of constructing dam on Wakal river basin has been checked and it has been found that gravity concrete dam may be proposed to construct at the basin.
Keyword- Dam, Wakal River Basin, Flood Control, Structural Measures

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I. INTRODUCTION

Water resources are one of the most important and best natural resources without which the nature and scenic beauties are in complete and not marvelous. Water, which is required for each and every human being's life must be easily available and should not be wasted through the natural hazards such as floods etc. Natural resources of water are the creations of god which the almighty has made for the recreation and used purposes. Hydraulic structures are the creations of Civil engineers which not only fulfill the God's dream of availing water to each individual but also it is useful in various needs and requirements of humans. God has made man and man as a Civil Engineer has responsibilities of building and developing recreating and useful structures for the nation and world by designing and redesigning the world's natural resources without wasting and disturbing the natural climate and hazards. By uplifting this thought and after getting motivation from the nature the proposal of building a dam is checked for the Wakal basin on Sabarmati River.

Following are the main points under the development of this study:

- Assessment of surface water resources of Wakal river basin.
- Flood routing by RWHs.
- Possibility of improvement of existing drainage system.
- Collection and analysis of data.
- Development of methodology to propose a dam.
- Identifying the type of dam based on laboratory testing and soil profile.
- Soil stratification, geological surveys and other soil testing comments.

A. Problem and Proposal Statement

The demand of water is increasing day by day. In construction of dam, many problems are found. The main problems are listed below:

- Irrigation benefits were less than expected and always late
- Other benefits, even when achieved, were difficult to quantify, including flood control.
- Lack of water in nearby areas.
- Ground water level depletion.

The main purpose of this study are listed below:

- To propose construction of a dam which may be served to utilize water for drinking and industrial supply.
- To protect flood of Magnitute having return period of 25 years.
- To provide safe source of drinking water and naturally free from bacteria and harmful chemicals.
- To improve the Ground water level.
- To fulfill the water supply and irrigation requirement.
- To check the proposal of dam designing.

When it is thought that a dam will be build and on a non-perennial river then there is a wide and major scope of work to be done. Following works have been carried out such as Study of rainfall and pattern, Available water capacity of the Wakal basin, Flood Analysis, Water demand and possible supply after harvesting.

II. LITERATURE REVIEWS

V.S.Pawar et. al. (2013) Suggested That Water is scarce natural resource, even though 71% of land is covered by water. Out of total water on the earth near about 2.5% are fresh which is being utilized for various purposes viz. domestic, irrigation and industrial are common. Ankit Patel et. al. (2006) suggested that often, as a frantic response to problems of water scarcity and consequent hardships faced by both urban and communities, India has invested heavily in rainwater harvesting. Unlike investment in large water resource systems, these efforts, by and large, lack hydrological planning and sound economic analysis: research on the impact of local water harvesting/groundwater recharge activities in India is very sparse. They identified critical issues in rainwater harvesting efforts in water-scarce regions of India. First: there is no emphasis on potential local supplies and the demand they have to cater for: local supply potential is low in most water scarce regions, a fact compounded by poor reliability, and demand far exceeds the supply potential. Second: there are complexities in the economic evaluation of RWH, due to lack of scientific data on inflows, runoff collection and storage efficiency, beneficiaries, value of the incremental benefits generated and scale considerations.

Jai Krishna et al. model Tests on Ram Ganda Saddle tests were performed. It was found that the section with inclined clay core exhibited greater resistance to horizontal shocks. Broke McDonald et al studied an analytical overview of the cumulative effects of years of dam development. A lack of commitment or capacity to cope with displacement or to consider the civil rights of, or risks to, displaced people led to the impoverishment and suffering of tens of millions and growing opposition to dams by affected communities worldwide. Proposal on "Building Check-Dams for Drinking Water: A Teaching and Research Initiative". Studied problems identified in Karjat taluka of Raigad district, the home to Matheran, Bhimashankar and many other spots, is a popular destination with tourists. Though it receives in excess of 3000mm of rainfall, many villages in the taluka run dry by January. In the summer months, drinking water has to be fetched from as far as 3-4 km. Two such villages are Belachiwadi and Gudwan. Belachiwadi and surrounding hamlets house about 800 people and an equal number of cattle/sheep. For Gudwan, the number is roughly 600. Drinking water is an acute problem in both villages. Jhimli Bhattacharjee proposed to understand the nature of movements against the construction of dams. It tries to explore the causes of movements against dams in the region in particular and in India and the world in general. Moreover, since the region is the abode of a number of ethnic groups with their distinct set of culture and values, the paper also keeps a scope to inquire if the region has a 'special variety of environmentalism' in so far as the movements against dams is concerned.

Liqa-Sally Raschid et al summarized from the ToR were to: review the Bui Hydropower Project Environmental and Social Impact Assessment (ESIA) for weaknesses and identify potential research areas for further studies. Identify institutions and other agencies that have a role to play in dam development - examine their mandates, the types of data collected, and how they can be strengthened.

Ms. Patil Swapnal V studied, the effect on gravity dam has been examined using finite element analysis software ANSYS 14. The gravity damis completely resting on soil media and surrounded by soil media. The relevant amount of soil around and bottom of the gravity dam has been modeled to simulate the in-situ conditions. The gravity dam has been analyzed using dynamic loading in transient analysis using Imperial Valley (1940) earthquake record are included.

III. STUDY AREA, DATA COLLECTION AND SAMPLING OF SOIL AND STONES

Wakal river is a non-perennial river but its catchment area is very large. The culturable command area of Wakal basin is very water demanded due to humidity and high temperature climate. For checking the proposal of dam Wakal river has been selected as a study area and out of four locations one location has been selected as the proposed site for the dam. Wakal basin yields a considerable water during rainy season.

A. Wakal River Basin

The wakal river originates north-west of Udaipur near Sran village. The river flows in a generally south direction up to Manpur vilaage in Udaipur district, where it turns Northest & after a distance of about 90km leaves Rajasthan near the Gaupipli village & joins Sabarmati River near Eitarwar village in Gujarat. The catchments in Rajasthan is situated in Udaipur district between latitudes 24°0' and 24°52' & longitude 73°4' and 73°36' & covers 1688.82km2. The main tributaries of Wakal are Mansi & Parvi rivers.

The total length of the basin is 71.77km, whereas the maximum width is 44.67km. The Wakal river basin is most water-stressed regions with diverse water related problem; & as search there is an urgent need of implement the IWRM strategy in this basin.

B. Data Collection

For carrying out project work a lots of data and visits have been made to various places and governments bodies such as State Water Data centre Gandhinagar, Central Water Commision, Gandhinagar, Geological Department, Jaipur and Study area as well. Following is a list of collected data.

1. Rainfall data, 2. Rain gauge Station data, 3. District Resource Map (DRM)

IV. SURVEYING AND SAMPLING OF SOIL/ROCK/ STONE FRAGMENTS FOR SOIL TESTING

Surveys were carried on the seven possible sites identified based on the calculation tests of SPT number (Standard Penetration Test performed). Out of those sites one site was selected for proposing dam. Samples of soil, rock fragments and stones were taken to test in laboratories.

V. METHODOLOGY

A. Selection of Type of Dam

Here are some reasons why we selected gravity dam.

- A Gravity dam is a dam constructed from concrete or stone masonry and designed to hold back water by primarily utilizing the weight of the material alone to resist the horizontal pressure of water pushing against it. Gravity dams are designed so that each section of the dam is stable, independent of any other dam section.
- Gravity dams generally require stiff rock foundations of high bearing strength although they have been built on soil foundations in rare cases. Gravity dams provide some advantages over embankment dams. The main advantage being that they can tolerate minor over topping flows as the concrete is resistant to scouring. Large overtopping flows are still a problem, as they can scour the foundations if not accounted for in the design.

B. Cross-Section of Gravity Concrete Dam

- For any suitable conditions, gravity dam may be constructed to greater heights. Grand Dixence dam in Switzerland is highest concrete gravity dam and its height is
- 284 m and highest concrete gravity dam in India is a Bhakra dam with a height of
- 226m.
- In such structure, the ratio of base width to height is less than 1.1. Fig. shows a typical cross-section of concrete dam (Gravity).
- To release the uplift pressure, a drainage gallery is provided with respect to base of the dam as shown in Fig. The upstream face of concrete dam may be vertical throughout the height of a dam or partly kept slanting for some of its length as shown in Fig. uplift pressure is caused by the seeping water.

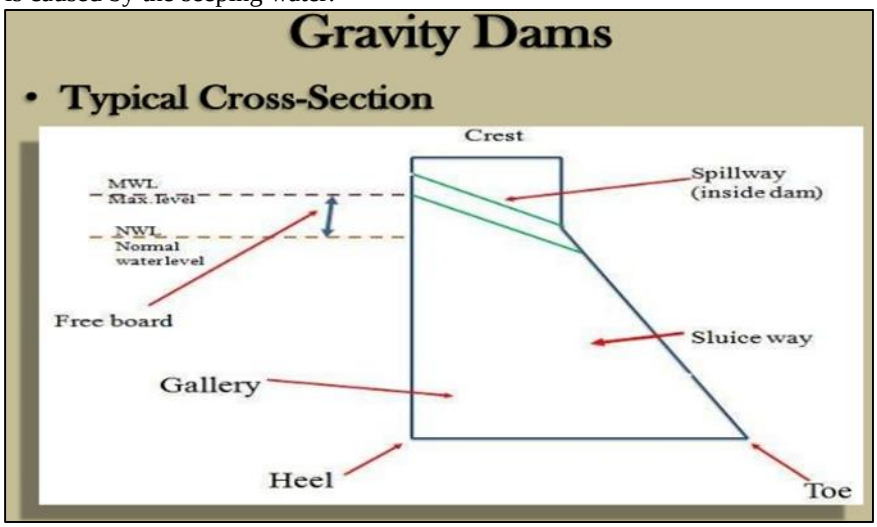

Fig. 1: Cross section of gravity DAM

C. Loading on Concrete Gravity Dam (Concept and Criteria)

Various types of loading or forces acting on concrete gravity dam are as follows:

1) Water Pressure
2) Silt Pressure

3) Uplift Pressure
4) Wave Pressure
5) Ice Pressure
6) Weight Of The Dam
7) Earthquake Forces

S. No.	*Weight*	*Symbols*	*Weight*
1.	*Weight of density bottle*	*W1*	*661 g*
2.	*Weight of density bottle + dry soil*	*W2*	*1139 g*
3.	*Weight of density bottle + dry soil + water*	*W3*	*1955 g*
4.	*Weight of density bottle + water*	*W4*	*1675 g*
5.	*Specific gravity of soil @ T1*	*G = (W2 – W1)/ {(W4- W1) – (W3 – W2)}*	*2.41*
Average specific gravity of soil @ room temperature			*2.65*

Table 1: Tests Performed on Soil for foundation

D. Sand Replacement Method

IN LAB CALCULATION		
MASS OF MOLD IN g	*W1*	*1633.7*
VOLUME OF THE MOLD IN cm^3	*V1*	*1178.1*
MASS OF THE APPRATUS + SAND(BEFORE) g	*W2*	*7044.3*
MASS OF THE APPRATUS + SAND(AFTER) g	*W3*	*4921.3*
MASS OF MOLD + SAND g	*W4*	*3308.7*
BULK DENSITY OF THE SAND g	*$P(g+cm^3)=(W4-W1)/V1$*	*1.4217*
MASS OF THE SAND IN CONE g	*W5=W2-W3-(W4-W1)*	*448*
IN THE SITE CALCULATION		
WATER CONTENT	*W*	*0.23*
MASS OF THE APPRATUS + SAND(BEFORE) g	*W6*	*7027.7*
MASS OF THE APPRATUS + SAND(AFTER) g	*W7*	*6242.9*
MASS OF SAND THAT FILLED THE HOLE g	*W8=W6-W7-W5*	*336.8*
MASS OF SOIL TAKEN FROM THE HOLE g	*W9*	*261.6*
VOLUME OF THE cm^3	*V2=W8/p*	*236.8860*
BULK DENSITY OF THE EXCAVATED SOIL	*$P_B(g/cm^3)=W9/V2$*	*1.1043*
DRY DENSITY OF THE EXCAVATED SOIL	*$P_D(g/cm^3)=P_B/(1+W)$*	*0.8978*

E. Liquid Limit & Plastic Limit Test

1) Liquid Limit

DETERMINATION NUMBER	*1*	*2*	*3*
NUMBER OF BLOWS	*17*	*23*	*27*
CONTAINER NUMBER	*I*	*II*	*III*
WEIGHT OF CONTAINER W0 g	*20.18*	*21.37*	*24.28*
WEIGHT OF CONTAINER + WET SOIL W1 g	*38.24*	*36.10*	*40.14*
WEIGHT OF CONTAINER + OVEN DRY SOIL W2g	*33.52*	*32.46*	*36.43*
WEIGHT OF WATER (W1-W2) g	*4.72*	*3.64*	*3.71*
WEIGHT OF CONTAINER + OVEN –DRY SOIL (W2-W0) g	*13.34*	*11.09*	*12.15*

*WATER CONTENT w=(W1-W2)/(W2-W0)*100%*	*35.38*	*32.82*	*30.52*

Liquid Limit W_l (Average) = 31.5%

2) Plastic Limit

DETERMINATION NUMBER	*1*	*2*	*3*
CONTAINER NUMBER	*I*	*II*	*III*
WEIGHT OF CONTAINER W0 g	*26.10*	*21.86*	*23.91*
WEIGHT OF CONTAINER + WET SOIL W1 g	*32.29*	*34.74*	*30.15*
WEIGHT OF CONTAINER + OVEN DRY SOIL W2g	*31.20*	*32.51*	*29.06*
WEIGHT OF WATER (W1-W2) g	*1.09*	*2.23*	*1.09*
WEIGHT OF CONTAINER + OVEN –DRY SOIL (W2-W0) g	*5.10*	*10.65*	*5.15*
*WATER CONTENT w=(W1-W2)/(W2-W0)*100%*	*21.37*	*20.94*	*21.17*

Plastic Limit Wp (Average) = 21.16%

Plasticity Index (I_p) = Liquid Limit (W_l) – Plastic Limit (W_p)

= 31.5-21.16

I_p = 10.34

3) Proctor Test

GS	*2.69*
DIAMETER IN mm	*104.3*
h IN mm	*115.26*
VOLUME cm³	*984.7752*

WC	*MASS OF THE MOLD*	*MASS OF THE FULL MOLD*	*SOIL MASS*	*BULK d*	*DRY d*
0.128	*4980*	*6990*	*2010*	*2.0410*	*1.8094*
0.145	*4980*	*7072*	*2092*	*2.1243*	*1.8553*
0.156	*4980*	*7094*	*2114*	*2.1466*	*1.8569*
0.168	*4980*	*7080*	*2100*	*2.1324*	*1.8257*
0.198	*4980*	*7035*	*2055*	*2.0867*	*1.7418*

	0	*5%*	*10%*
0.15	*1.9166*	*1.8208*	*1.7249*
0.17	*1.8458*	*1.7535*	*1.6612*
0.19	*1.7801*	*1.6911*	*1.6021*

F. Factors Considered in the Planning and Analysis of Dam Site

1) Planning & Investing of Dam Site
1) Aim of water resource management
2) Physical factor
3) Economic consideration
4) Selection of project plan
5) Environment factors
6) Investigation
7) Planning of reservoir

2) Investigation
1) Hydrologic data
2) Geologic data
3) Topographic data
4) Reservoir site cost data
5) Environment factor
6) Economic data

3) Preliminary Investigations
1) Not too precise
2) Site Survey with topographical site map
3) Few borings 6 to 50, according to may of project and character of foundation.
4) A preliminary geologic investigation and report.
5) Investigations of available construction materials, such as earth and concrete aggregates

6) The deformations of public utilities which the dam may affect, such as road, bridges, railroads, telephone lines, pipe lines, power plant.
7) In the relocation of the above facilities fairly accurate topographical map of the basin is essential.

G. Hydraulic Studies

The checking of high water barks & their use in determining spillway capacity

- Large project > 2000 MCM
- Medium Project 1000-2000 MCM
- Small project < 1000 MCM

H. Final Investigations

1) To determine the relative merits of two or more sites for the clam in question. So that a final location can be adopted.
2) To determine type of m to be used
3) To settle a doubt by sub-surface investigations, the nature of foundation as affecting a safety & cost of the dam.
4) To limit the land to be controlled for flowage, for the sites of structures & for other necessary structures.
5) To determine the extent & character of relaxation of railroads & public highways necessary on account of rising the water surface
6) To ascertain the characters of the govt. regulation to be observed.
7) To obtain sufficient information for an accurate estimate of cost
8) To determine finale location of dam

I. Choice of Location of Dam

1) Characters of foundation
2) Topography
3) Availability & character of materials for construction
4) Geology & nature foundation
5) The value of necessary lands & water rights
6) Transportation facilities & accessibility
7) Availability of suitable sites
8) Earthquake zones
9) Purpose & economics

J. Choice of Type of Dam

1) Adoptability of different type of dams which have been built
2) Outline the important characteristic which influence their location for a particular site
3) Topography
4) Spillway location
5) Safety consideration
6) Availability of construction material
7) Life of dam

K. Considerations

1) Choice of type suited to a particular location or use is a matter of experienced engineers differ considerable
2) Quite often it is purely a matter of judgment and experience
3) Intelligent study of existing condition and requirements will assist materially in the choice
4) Safety
5) Cost of the structure
6) Cost is limited by funds
7) Different in cost b/w expensive dam and in expensive structure with adequate safety but by short life
8) Most permanent dam is found to be most economical and usually adopted for ordinary site

All the criteria's were tested, analyzed and performed.

VI. DATA ANALYSIS

A. Hydrologocal Analysis

Rational Method

For 2 year

	Duration	*5*	*10*	*15*	*20*	*25*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*	*110*	*115*

	10ci	*484.1272 65*	*351.9310 31*	*299.0012 83*	*269.6132 61*	*249.5410 76*	*235.7320 05*	*213.5879 27*	*197.8892 13*	*185.8578 49*	*175.6522 42*	*167.1216 49*	*159.8953 8*	*154.3436 63*	*147.9320 8*	*144.9002 46*
	10ci	*1954.272 48*	*2876.347 56*	*3692.027 5*	*4461.524 44*	*5182.142 97*	*5893.437 09*	*7156.109 12*	*8320.466 89*	*9407.825 12*	*1040 1.44 73*	*1133 6.81 85*	*1222 7.91 24*	*1313 9.31 14*	*1387 6.23 03*	*1422 0.83 56*
	10ci	*9461 165. 89*	*1012 2759 .6*	*1103 9209 .6*	*1202 8861 .5*	*1293 1575 .3*	*1389 2717 .4*	*1528 4585 .1*	*1646 5306 .5*	*1748 5181 .4*	*1827 0375 .5*	*1894 6277 .9*	*1955 1867*	*2027 9694 .5*	*2052 7396 .1*	*2060 6025 .8*
Total 10ci		*9463 604. 29*	*1012 5987 .9*	*1104 3200 .6*	*1203 3592 .7*	*1293 7007*	*1389 8846 .6*	*1529 1954 .8*	*1647 3824 .8*	*1749 4775 .1*	*1828 0952 .6*	*1895 7781 .9*	*1956 4254 .8*	*2029 2988 .1*	*2054 1420 .2*	*2062 0391 .5*
4001 78	*Acers*															
Total Discharge		*3.78 713E +12*	*4.05 22E +12*	*4.41 925E +12*	*4.81 558E +12*	*5.17 711E +12*	*5.56 201E +12*	*6.11 95E +12*	*6.59 246E +12*	*7.00 102E +12*	*7.31 564E +12*	*7.58 649E +12*	*7.82 918E +12*	*8.12 081E +12*	*8.22 022E +12*	*8.25 183E +12*

Similarly analysis has been done for For 5 year, 10 year, 20 year, 50 year and 100 year.

VII. EMPIRICAL RELATIONS TO EVALUATE DISCHARGE

Empirical formulae's suitable for the regions were deployed to find out the discharge

Sr. No.	*Scientist*	*Formulae Name*	*Formulae (Q=)*	*Discharge Value (Cumecs)*	*Remarks*
1	*Dicken's*	*Dicken's Formula*	*CA^3/4*	*3573.25*	
2	*Dredge or Burge's*	*Dredge or Burge's Formula*	*19.6*(A/L^2/3)*	*1970.15*	
3	*Inglis*	*Inglis Formula*	*123A/(A+10.4)^1/2*	*4933.31*	*May be adopted as per geological/ geographical reasons*
4	*Jarvis*	*Jarvis Formula*	*CA^1/2*	*4425*	
5	*Modified Myer's*	*Modified Myer's Formula*	*177pA^1/2*	*4425*	
6	*Ryve's*	*Ryve's Formula*	*CA^2/3*	*1406.365*	

VIII. FLOOD FREQUENCY ANALYSIS AND DESIGN FLOOD

Flood frequency analysis has been carried out and design flood has been evaluated. Also the design flood is checked with the flood data provided by Irrigation and water resources department, Udaipur district. Due to data privacy the table has not been showed but the estimated PMF was found to be 12132 cumecs and Design flood adopted for 25 year return period is 9423 cumecs.

IX. GEOLOGICAL ANALYSIS

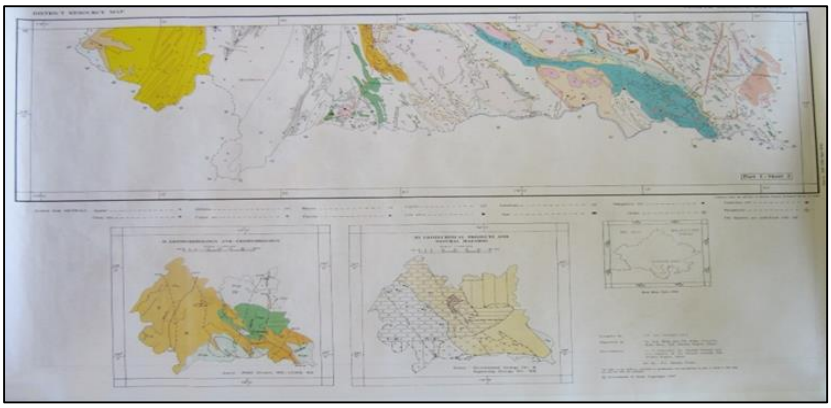

Fig. 3: DRM Map of Udaipur District

X. MODELING AND ANALYSIS USING SOFTWARE

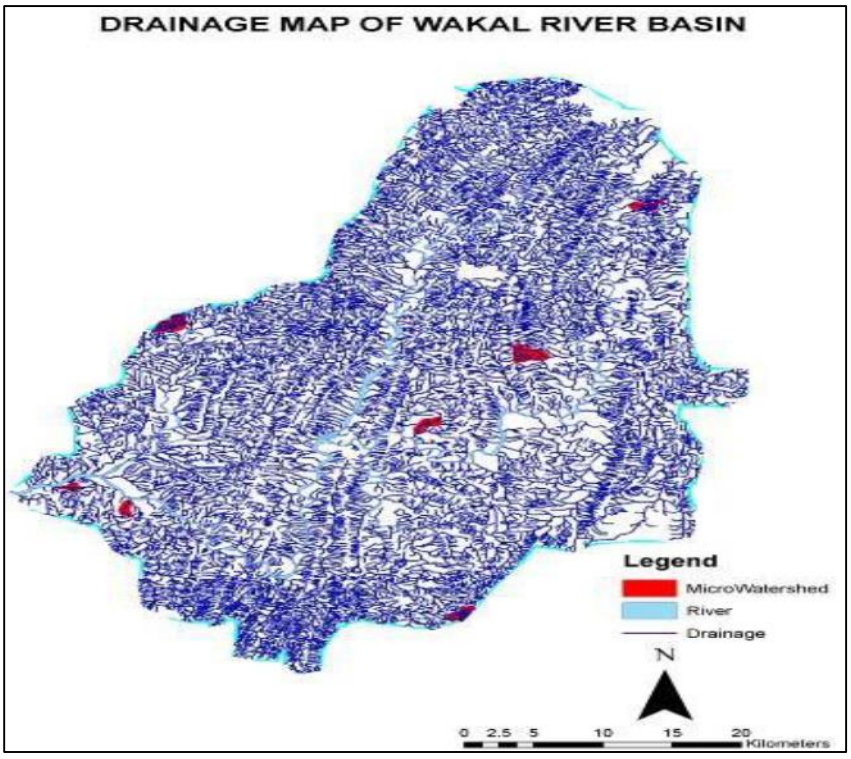

Fig. 4: Drainage map of wakal basin

A. Topography

The General topography of the area is hilly and undulating. Most of the cultivated lands are located in the valleys. Surface drainage of the area is generally good due to slight undulations in the topography. About 96,625 ha of the land falls under the slope group of 30 to 50%.

Water flows through seasonal with high velocity which is a main cause of erosion in the area. Small and scattered land holding situated on varying slope gradient is also a measure cause of soil erosion in the area. The drainage map of the basin.

Fig. 5: Analysis in Google Earth Pro software

XI. RESULTS AND CONCLUSION

The present study can be summarized as, the following mentioned points:

- The present study aims to design the dam proposed on Wakal river basin. The suitable dam site & its healthy catchment is very helpful in putting the reservoir. The estimated potential of the catchment area as per investigation is 135m. Also various other investigation & tests have been performed.

- The problems of water supply, irrigation, water use etc. may be solved by constructing dam. Also ground water recharge may also increase in the other investigation will be carried out in future in addition to performed test.
- The dam site has rocky foundation which is suitable & gravity dam. To control flood, Gravity dam may preferred. Various other observation will be carried out in future in addition the perform tests. Analysis of flood magnitude has been done using Rational method, Empirical formulas, Geological surveys, software based various analysis has been carried out.

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