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WORLD ENVIRONMENT DAY

On the theme of

"Join the Race to Make the World a Better Place"

JUNE – 2016

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Engr. Ch. Ghulam Hussain
President 74th Session

WELCOME ADDRESS

By

ENGR. CH. GHULAM HUSSAIN[1]

PRESIDENT, PAKISTAN ENGINEERING CONGRESS

AT THE WORLD ENVIRNOMENT DAY

HELD ON JUNE 04, 2016

ON THE TOPIC OF

"JOIN THE RACE TO MAKE THE WORLD A BETTER PLACE"

The Honorable Chief Guest, Members of Executive Council/Members of Pakistan Engineering Congress, Distinguished Delegates & Ladies and Gentlemen!

اَلسَّلَامُ عَلَيْكُمْ وَ رَحْمَةُ اللّٰهِ وَبَرَكَاتُهٗ

Ladies and Gentlemen!

This year theme of World Environment Day-2016 is "Let us join the Race to make the World a Better Place". It is an epitome of Socio-economic agenda, highly challenging for the planners and above all a pious dream for sanity in utilization of natural resources, controlling Environment degradation, and maintaining Bio-Diversity and peaceful co-existence.

The dream race is in a highly competitive world comprising advanced economies emerging economies and under-developed countries yarning change for better.

Ladies and Gentlemen!

We are lucky to witness at first hand the intellectual, scientific and Engineering Revolution in the world in flex every minute due to Research and Innovation. Look at the advancement in tools of Communication, especially the Facebook.

A country can contribute significantly in transformation of a "Better World" only if it devotes its resources for human development of its people, world Class affordable education, infrastructure Development, Medical Services and above all `optimum utilization of resources/avoidance of wasteful uses. Let us see what are the problems facing the Nation and without solving which sustained Socio-Economic advancement will remain a pipe dream.

[1] President, Pakistan Engineering Congress and

Chief Executive, National Development Consultants (Pvt) Ltd (NDC)

DEMOGRAPHIC IMPACT

Our population was 34-million in 1951, 188 million now and is expected to grow to 217 million. (1.40% increase) by 2025 putting immense demographic pressure. Urbanization is fast, 80 million vis-à-vis 33 million in 1990. Karachi now boasts of 23.5 million population with little infrastructure& Lahore around 10 million people. 64% of the population i.e. 128 million is between 15-29 years of age. If not properly equipped with educational/technical know-how, this youthful population will become a liability and a source of political instability and chaos. There are 24 million out of school children and the education spending lowest in South Asia. The country would need 15 million jobs every year. The challenge is big and requires robust budgetary allocation without remorse. Here I quote Mark Carney, Governor of Bank of England,

"Prosperity requires not just investment in economic Capital, but investment in social capital. Carney argues having defined social capital as "the links, shared values and beliefs in a society which encourage individuals not only to take responsibility for themselves and their families but also to trust each other and work collaboratively to support each other."

Ladies and Gentlemen!

GHG emissions of major pollutants are:

Name of Country	**Percentage of World Emission (%)**
China	22.7
India	5.7
United States	15.6
Russia	5.4

The consequences of out of control GHG emissions is causing 3% to 4% rise in temperature globally that is causing horrific damages.

- Urban Heat Island Effect-Urbanization/High Rise Buildings
- Glacier Melt-Floods
- Sea Intrusion and Loss of Valuable Land-being witnessed in coastal areas of Sindh
- Tsunamis/cyclones/Droughts
- Ground Water depletion- Pakistan is already caught in over-mining of Ground Water, falling Water Levels and inadequate recharging of the reservoir

The Paris agreement recently agreed to 26% to 28% reduction in GHG by 2015. Mass adoption of Electric cars by 2030 and enhanced investment in Solar/Wind

Energy are other measures to control the adverse economic consequences. Thermal generation of electricity is expensive and should be avoided at every cost. Even America is adopting solar energy with $ 7.4 billion investment. Nuclear energy is other way out. Pakistan have tremendous Hydropower potential which as the cheapest source of energy is required to be developed on priority basis. The construction of Diamer Basha Dam, which has national consensus, should be started without any further delay.

Pakistan is on 137th number of global emission levels contributing only 0.47% GHG in Global emission but it is highly vulnerable to its natural climate conditions and I quote:

> **"Over the years Pakistan has been experiencing severe weather Patterns, killing countless people and wiping out acres of farmland. Green Watch, an International think tank, warned that Pakistan is amongst the top ten countries at risk due to Climate Change"**

We have to use the coal deposits lying unutilized in the face of severe energy shortage which would also adversely affect the weather climate. This would require massive forestation campaigns all over the country. Let us see the picture in this respect.

Ladies and Gentlemen!

We are fast denuding our forest resources causing enormous change to climatic conditions. Eco-system set back to flood contract etc. as depicted below:

Sr. No	Country	% of Land Area
1	China	18.2
2	Indonesia	46.46
3	India	24.68
4	Turkey	27.60
5	Malaysia	59.50
6	Iran	6.72
7	Pakistan	5.31

Its Mangrove forests along the coast have shrunk from 604,870 hectors to less than a Lac hectors in 2005 adversely affecting Marine resources, cheap fire wood, medicines, and cattle grazing etc. the provincial/federal Government's ought to embark upon massive afforestation to come out of this miserable position. There should be separate forest area for supply of fire wood and hardwood forests as

done in Malaysia. Forests should be multi-purpose growing vegetables, sheep breeding, poultry etc. with public private participation.

Ladies and Gentlemen!

Water and food security is a sine qua non for sustainable economic advancement. Pakistan is faced with extreme water scarcity from 5000 cubic meters in 1950 to 1000 cubic meters in 2016 presently and is visualized to further slide. Pakistan's rank is 32 with 4.31 score in countries facing water stress. It is mainly attributed to lack of Govt. interest in building adequate storage capacity and control structures.

Pakistan has failed to construct any sizeable Reservoir in more than 30 years. It has only 30 days storage facility compared to 220 days in India and 1000 days in Egypt. Water is harbinger of life. It is of vital significance for agricultural development as it is mainstay of food security, supply of Raw material for fueling industrial development, export of cash crops. It has been estimated that agriculture production is required to be enhanced by 70%, globally and 50% in Pakistan, to feed the growing population. Alleviate hunger, poverty and above all to bring more lands under cultivation. Construction of Mega Reservoirs, canals, small dams, Rain harvesting, controlling of Hill Torrents is the need of the time, without which socio-economic development will remain a mirage. Let the Govt. forth with start construction of Kala Bagh Dam which will be a catalyst for advancement. The world is adopting vertical Agriculture i.e. even growing food vegetables at roof tops and we are lagging behind.

Conclusion:

The world is in spin. The concept of free market economy has resulted in unchecked over consumption, spiral of debt over equity with the result that most of the economies of European countries America, Asia are caught in Recession & there is no sizeable change despite Zero Bank Rate. Diversion of resources in productive development channels, avoidance of cheap credit facilities can alone save the humanity.

PAKISTAN PAINDABAD

POLLUTION LOAD ASSESSMENT OF OPEN WATER CHANNELS IN ISLAMABAD CITY IN RELATION TO URBANIZATION PRESSURE

Mehwish Haq Nawaz[2], Dr. Audil Rashid[3] and Dr. M. Anwar Baig[4]

ABSTRACT

Anthropogenic activities have affected the integrity and quality of water resources worldwide. Among main causes of water pollution are urbanization and increase in human population density. To monitor the increasing urban population of Islamabad and its negative impacts on surface water quality, a study was designed to assess pollution status of open water channels originating from Margalla Hills to residential sector I–9, Islamabad with respect to population density. Water quality was identified in terms of its physico–chemical parameters: Temperature, pH, TSS, TDS, Hardness, EC, COD, Cl, Na, Pb and Zn. It was observed that parameters EC, COD, Cl and Pb were relatively high in the water channel when compared with National water quality standards. It was observed from sample analysis that water quality was better in low density population sectors but it was alarmingly high when these channels passed through the densely populated area like E-11, G-11, G-10 and I-9. Hence this study therefore provides considerable evidence of strong linkage between urbanization and pollution loads in water channels. The study aimed to contribute substantially towards improving policy making, better management and utilization of hydrological resources through provision of information on scientific basis. Assuming future rise in the population of Islamabad city, proper management practices need to be adopted to minimize deterioration of water quality.

INTRODUCTION

Humans, wildlife and environment is dependent of water, which is one of the most integral and fundamental resource. (Cheng and Jia, 2010). Therefore, it is very mandatory for aquatic systems to have the strength for fulfilling the need of food and water for life, and different life activities (Wei *et al*., 2009). Humans can approach on a very small proportion of water 0.01% from 3 – 4 % of the total fresh water present on earth (Hinrichsen and Tacio, 2002). Water is under extreme pressure of shortage due to the complex linkages of quick population growth, developments, unjustifiable use of water for developmental activities (Azizullah *et al.,* 2011). Surface water is heavily used in industry, agriculture and municipal facilities, resulting in vulnerability of water to pollution. Also the demand of clean water in polluted areas is increasing rapidly (Cheng and Jia, 2010). In Pakistan it

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has been risky to use the water of rivers, lakes, streams and ground aquifers because of contamination (Azizullah *et al.,* 2011). Human activities like atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use clearly represent the level and quality of surface and ground water (Niemi *et al*., 1990).

Surface and ground water is being used in Pakistan for drinking water which is present in the form of rivers, lakes and reservoirs. But surface and ground water both get contaminated due to indiscriminate way to get rid of agricultural, industrial and domestic effluents into natural aquifers (Kazi *et al*., 2009). Also, because of degradation through anthropogenic influences and natural processes water is becoming unsuitable for human basic needs and other developmental activities. (Carpenter *et al*., 1998; Fergusson, 1990). So today value of surface water is a matter of thoughtful alarm for consideration (Sing *et al.,* 2005). With the increase of water pollution and its effect on human health, deterioration of environment has become a great concern being an issue in Pakistan (Azizullah *et al.,* 2011). Consequently there is a great need to deal with the protection of water bodies which is a major challenge all over the world. Therefore this situation requires serious development of low cost assessment methodologies, which will help to save the water from risk of deterioration (Sall and Vanclooster, 2009).

Over population has become todays major issue of the world, and this is problematic in developing countries (Zakria and Faqir, 2009). High-growth rates are expected in Lagos, Nigeria, Dhaka Bangladesh, and Pakistan (Alirol *et al.,* 2010). Islamabad is growing rapidly in terms of population, economy and urban development. Islamabad the capital of Pakistan has population more than doubled since the last census in 1998. According to 1998 census 800,000 population has increased to 1.7 million in Islamabad (Raza, 2011). Increasing population is a primary cause of surface water pollution. In Islamabad rapid population increase (Federal Bureau of Statistics, 2007) has caused water resources to become increasingly polluted and degraded. Hence it has become extremely important to recognize the need of assessing water quality and pollution load for better resource management and utilization and improved policy making. Existing condition of open water channels pose threats of increasing toxicity as well as risk of diseases prevalence. A devastating rain flood that hit Islamabad recently (July, 2010) has further aggravated the situation. As previously these conditions were unraveled by Rashid *et al.* (2001) in city Islamabad. The present study was designed to investigate the pollution load in water channels from Margalla Hills to I–9, Islamabad and to relate it to population density of the area. Main objectives of this study were the determination of physico–chemical pollution load in water channels from Margalla Hills to I–9, Islamabad, to high light the relationship between population increase and prevailing water pollution in that area, and identification of high risk areas to inhabitants living along the water channel.

SAMPLING SITES

Water samples were obtained from the open water channel of Islamabad along selected sectors (E–11, G–11, G–10, H–10 and I–9). Five samples were taken from the each sector (Fig.1).

STORAGE OF SAMPLES

Samples were collected and stored at room temperature in pre washed Polyethylene (PET) bottles. These bottles were rinsed two or three times with open water channel water before sample collection. All the sampling and preservation methods carried out for the assessment of pollutants in water samples were according to Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

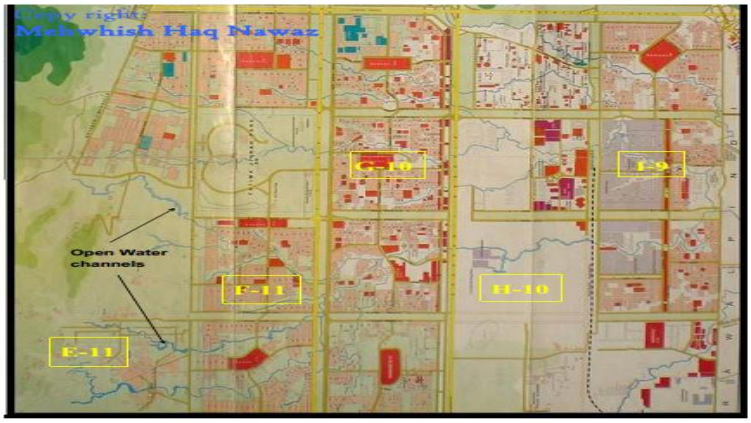


Figure 1: Study area represented by circle. Pollution status red> pink> yellow> dark blue> light blue star

ANALYTICAL PROCEDURES

Water quality parameters, their units and methods of analysis are summarized in (Table. 1). The temperature of water samples was measured at the sampling point by mercury thermometer. In laboratory all the samples were analyzed for different physico–chemical parameters. pH, electrical conductivity (EC) and total dissolved solids were measured by pH, EC and TDS meters respectively. TSS was determined gravimetrically at 103–105 °C. Total hardness was measured by EDTA complexometry titration, with indicator Eriochrome Black T. The COD and chlorides were determined by closed reflux titrimetric method and argentometric method. Na was measured by flame photometry and Pb and Zn were analyzed using electrothermal atomic absorption spectrometer. The quality of the analytical data was /ensured through careful standardization, procedural blank measurements and triplicates.

Table 1: Water quality parameters associated with their abbreviations, units and analytical methods used.

Variables	**Abbreviations**	**Units**	**Analytical Method Used**
Temperature	Temp	°C	Thermometer
pH	pH	pH unit	pH meter
Total suspended solids	TSS	mg L^{-1}	Gravimetric
Total dissolved solids	TDS	mg L^{-1}	TDS meter
Electrical conductivity	EC	mS cm^{-1}	Electrometric
Chemical oxygen demand	COD	mg L^{-1}	Titrimetric
Chloride	Cl	mg L^{-1}	Titrimetric
Total hardness	T– Hard	mg L^{-1}	Titrimetric
Sodium	Na	mg L^{-1}	Flame photometer
Lead	Pb	µg L^{-1}	ETAAS*
Zinc	Zn	µg L^{-1}	ETAAS

DATA ANALYSIS USING STATISTICAL TOOLS

All mathematical and statistical computations were made using Excel 2003 (Microsoft Office). The data collected after measuring different water quality parameters was statistically analyzed by using single factor analysis of variance (ANOVA). Correlation analysis was performed to find the relationship between increasing population and pollution load.

RESULTS

The analytical results of physico-chemical water quality parameters were significantly different for all the five sectors of Islamabad. Comparison of physico-chemical parameters in five sectors E–11, F–11, G–10, H–10 and I–9 is depicted in (Fig.2 and 3) respectively. Main descriptive statistics for all the samples is shown in (Table. 3). Temperature of water samples ranged from 14.2 to 20.5 °C, lowest mean temperature was recorded in samples of E–11 and highest in samples of G–10. Trend of temperature in sectors was found as E–11< I–9< F–11< H–10< G–10. The temperature of water samples from all the sectors were within the permissible level of WHO (Table.2).

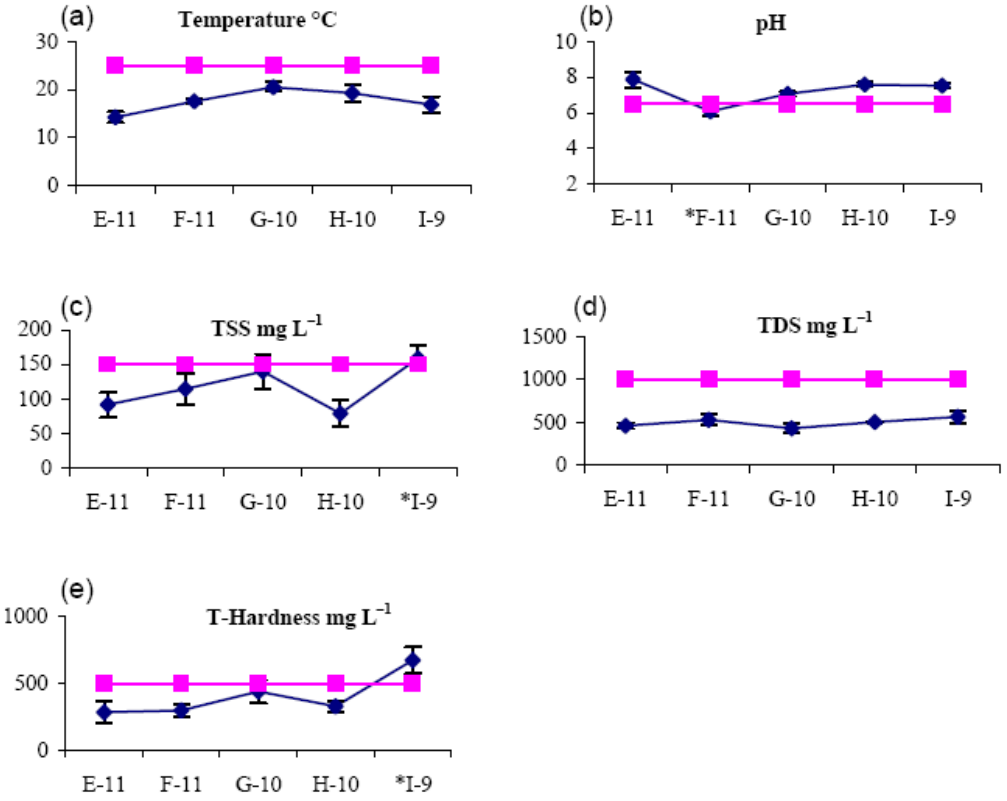


Figure 2: Comparison of mean values observed for physical parameter's in waste water samples of Islamabad (ANOVA, n=15) solid line, dotted line and asteric indicating mean values, WHO and Pak- EPA and exceeding limits respectively. E–11, F–11, G–10, H–10, I–9 are sectors of Islamabad.

* showing values greater than WHO//Pak-EPA limits.

pH of these water samples ranged from 6.07 to 7.86. All the water samples were neutral or near to neutral except sector F–11 (6.07) (Table.2). Lowest mean value was found in samples of F–11 and highest mean value was found in samples of E–11. The trend of pH values of water samples followed the trend F–11<G–10<I–9< H–10<E–11. The TSS were determined in the range of 91.6 to 159 mg L^{-1}.

Minimum mean value was determined in the samples of H–10 and maximum mean value was determined in the samples of I–9 (159 mg L^{-1}) which was slightly higher than the permissible level of Pak-EPA (Table.2). TDS analysis showed trend in all five sectors as H–10< E–11< F–11< G–10< I–9. TDS were measured in the range of 430 to 565 mg L^{-1}. Lowest mean value was measured in samples of G–10 and highest mean value was measured in samples of I–9. None of the samples exceeded the WHO limit.

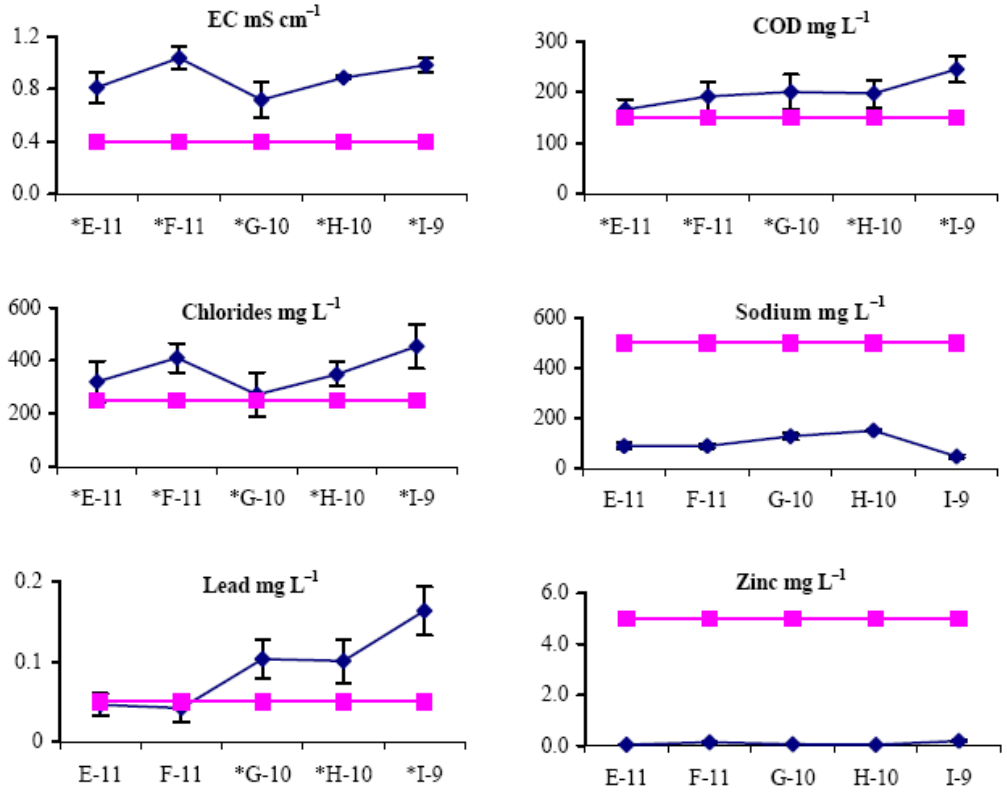


Figure 3: Comparison of mean values observed for chemical parameter's in waste water samples of Islamabad (ANOVA, n=15) solid line, dotted line and asteric indicating mean values, WHO and Pak- EPA and exceeding limits respectively. E–11, F–11, G–10, H–10, I–9 are sectors of Islamabad.

* showing values greater than WHO//Pak-EPA limits.

TDS values were following the trend G–10< E–11< H–10< F–11< I–9. Hardness of water samples from selected sectors ranged from 284 to 674.67 mg L^{-1}. Lowest mean value was observed in samples of E–11 and highest mean value was observed in sample of I–9. Only water sample of I–9 exceeded the limits recommended by Pak-EPA. Data regarding EC ranged from 0.81 to 1.04 mS/cm. Lowest mean value was recorded in samples of E–11 and highest mean value was

recorded in samples of F–11. EC had high values, (exceeding WHO limits) in all sectors. Trend of EC was observed as G–10< E–11< H–10< I–9< F–11. COD was recorded in range of 166.4 to 245.33 mg L^{-1}. Lowest COD mean value was recorded in samples of E–11 and highest in I–9. COD values in all the sectors showed pollution load to exceed the limits recommended by Pak-EPA. Chloride's concentration in water samples exceeded the WHO proposed limits and ranged from 272.07 to 454.28 mg L^{-1}. Lowest mean concentration was found in samples of G–10 and highest mean concentration was found in samples of I–9.

The trend for chloride concentration was the same as that for hardness of water. Lead showed alarming results in G–10, H–10 and I–9 by exceeding the permissible limit of Pak standards, and ranging from 0.04 to 0.16 mg L^{-1}. Lowest concentration of lead was observed in samples of F–11 and highest in I–9. Hardness, COD and lead gave trend as E–11< F–11< H–10< G–10< I–9. Zinc concentration in all the water samples were within permissible limit of Pakistan standards, while concentration of zinc ranged from 0.05 to 0.2 mg L^{-1}. The trend of zinc was in the following order E–11< H–10< G–10< F–11< I–9. The recorded readings of sodium for all the water samples were in a permissible level recommended by Pak-EPA. Concentration of sodium in water samples ranged from 90.2 to 151.65 mg L^{-1}. Lowest mean value was recorded in samples of I–9 and highest in samples of H–10. Trend for Na concentration was found as I–9< E–11< F–11< G–10< H–10. Correlation between pysico-chemical water quality parameters is demonstrated in (Table 4).

Table 2: Water quality parameters: WHO and Pak-EPA Standards associative with observed ranges. Sources: (WHO, 2008; Pak-EPA, 2008).

Parameters	**Units**	**WHO Guideline**	**Pak Guideline**	**Observed Range**
Odor		Non objectionable	Non objectionable	
Temperature	°C	25		14.5–20.5
pH	pH unit	6.5–8.5	6.5–8.5	6.07–7.86
TSS	mg L^{-1}		150	91.67–158.87
TDS	mg L^{-1}	1000	1000	430–565
EC	mS cm^{-1}	0.4	0.4	0.72–1.04

Parameters	Units	WHO Guideline	Pak Guideline	Observed Range
COD	mg L^{-1}	10	150	166.4–245.33
Cl	mg L^{-1}	250	250	320.51–454.28
Total Hardness	mg L^{-1}	100	500	284–674.67
Na	mg L^{-1}	200	500	90.2–151.65
Pb	mg L^{-1}	0.01	0.05	0.04–.16
Zn	mg L^{-1}	3	5	0.02–0.2

In the present study temperature, TSS, COD, hardness, Pb and Zn showed positive correlation with population and negative correlation of pH, TDS, EC, Cl and Na with population was estimated (Fig. 4).

Table 4: Correlation between population and water quality parameters.

	Temp	*pH*	*TSS*	*TDS*	*EC*	*COD*	*Cl*	*Hard-ness*	*Na*	*Pb*	*Zn*
Temp	1										
pH	–0.327	1									
TSS	0.185	–0.201	1								

	TDS	EC	COD	Cl	Hardness	Na	Pb	Zn	
Temp	–0.233	–0.249	0.465	–0.316	0.118	0.630	0.143	–0.169	
pH	–0.191	–0.468	–0.105	–0.226	0.195	0.033	0.536	–0.318	
TSS	0.280	0.088	0.728	0.338	0.854	–0.605	0.581	0.709	
TDS	1	0.921	0.582	0.989	0.474	–0.607	0.334	0.856	
EC		1	0.335	0.923	0.145	–0.500	–0.055	0.745	
COD			1	0.540	0.870	–0.287	0.771	0.700	
Cl				1	0.480	–0.706	0.296	0.899	
Hard-ness					1	–0.567	0.904	0.712	
Na						1	–0.306	–0.820	
Pb							1	0.425	
Zn								1	

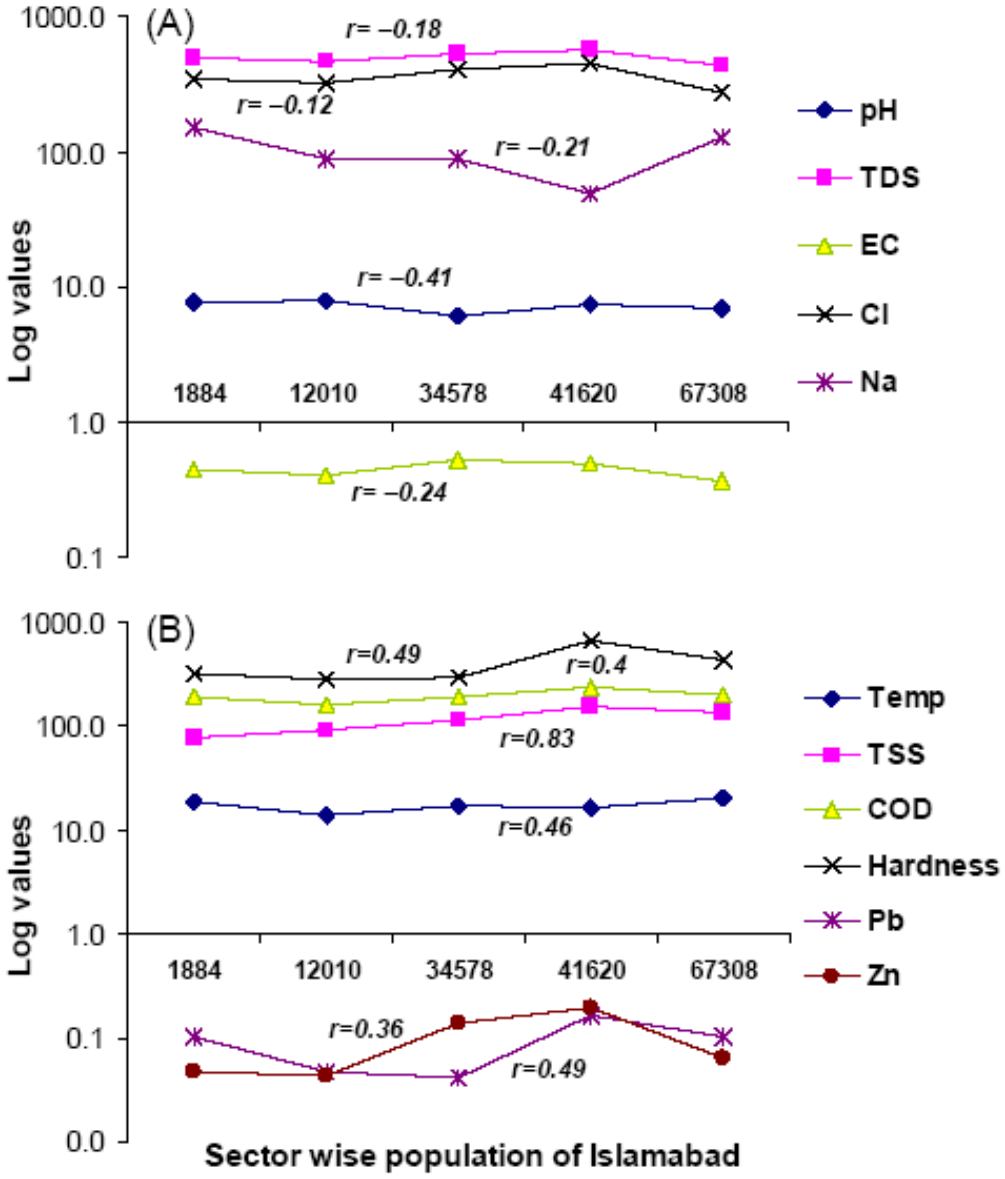


Figure 4: Relationship between population and physico-chemical water quality parameters (A) negatively correlated, (B) positively correlated parameters.

Table 3: Sector-wise comparison of physical and chemical parameters water samples

Parameter		**E–11**	**F–11**	**G–10**	**H–10**	**I–9**	**ANOVA df, (P-value)**
Temperature °C	Mean	14.50^{a}	17.50^{b}	20.50^{c}	19.20^{d}	18.80^{b}	4, (< 0.000)
	SD	1.17	0.45	1.00	1.72	1.72	
	Minimum	13.00	17.00	19.00	19.00	15.00	
	Maximum	16.00	18.00	22.00	21.00	20.00	
pH	Mean	7.86^{a}	6.07^{b}	7.05^{c}	7.58^{d}	7.51^{d}	4, (< 0.000)
	SD	0.43	0.24	0.14	0.13	0.11	
	Minimum	7.38	5.71	6.89	7.45	7.37	
	Maximum	8.69	6.30	7.26	7.83	7.70	
TSS mg L^{-1}	Mean	91.67^{a}	114.40^{b}	140.00^{c}	79.00^{a}	158.87^{d}	4, (< 0.000)
	SD	17.77	22.56	24.87	19.33	18.5	
	Minimum	68.00	74.00	100.00	49.00	130.00	
	Maximum	124.00	159.00	188.00	120.00	182.00	

Parameter		E–11	F–11	G–10	H–10	I–9	ANOVA df, (P-value)
TDS mg L^{-1}	Mean	460.33^{a}	530.13^{bc}	430.00^{a}	501.20^{b}	565.00^{c}	4, (< 0.000)
	SD	32.19	57.56	57.68	8.49	68.84	
	Minimum	428.00	408.00	427.00	493.00	496.00	
	Maximum	504.00	609.00	518.00	513.00	683.00	
Hardness mg L^{-1}	Mean	284.00^{a}	298.93^{a}	440.00^{b}	328.00^{a}	674.67^{c}	4, (< 0.000)
	SD	81.39	45.22	85.33	41.10	98.92	
	Minimum	160.00	200.00	356.00	292.00	540.00	
	Maximum	400.00	360.00	592.00	400.00	720.00	
EC mS cm^{-1}	Mean	0.813^{a}	1.039^{b}	0.718^{a}	0.889^{c}	0.983^{b}	4, (< 0.000)
	SD	0.12	0.09	0.13	0.01	0.06	
	Minimum	0.67	0.91	0.49	0.87	0.918	
	Maximum	0.95	1.17	0.88	0.90	1.098	

Parameter		**E–11**	**F–11**	**G–10**	**H–10**	**I–9**	**ANOVA df, (P-value)**
COD mg L^{-1}	Mean	166.40^{b}	192.20^{a}	200.80^{a}	197.80^{a}	245.33^{c}	4, (< 0.000)
	SD	19.79	27.84	34.24	26.95	25.62	
	Minimum	136.00	153.00	152.00	153.00	220.00	
	Maximum	206.00	239.00	244.00	256.00	288.00	
Cl mg L^{-1}	Mean	320.51^{a}	411.19^{ab}	272.07^{c}	348.46^{a}	454.28^{b}	4, (< 0.000)
	SD	76.67	54.70	83.05	45.90	83.96	
	Minimum	232.90	345.60	1640.0	301.30	410.05	
	Maximum	428.60	487.40	452.00	359.80	624.80	
Sodium mg L^{-1}	Mean	90.87^{a}	89.93^{a}	128.81^{b}	151.65^{c}	48.26^{d}	4, (< 0.000)
	SD	12.98	8.80	13.04	2.83	6.03	
	Minimum	73.00	81.00	103.00	148.00	41.60	

Parameter		E–11	F–11	G–10	H–10	I–9	ANOVA df, (P-value)
	Maximum	108.00	105.00	138.00	156.60	59.80	
Lead mg L^{-1}	Mean	0.044[a]	0.042[a]	0.103[b]	0.101[b]	0.164[c]	4, (< 0.000)
	SD	0.01	0.02	0.02	0.03	0.03	
	Minimum	0.056	0.023	0.058	0.056	0.128	
	Maximum	0.089	0.075	0.169	0.144	0.210	
Zinc mg L^{-1}	Mean	0.043[a]	0.142[b]	0.065[c]	0.047[a]	0.195[d]	4, (< 0.000)
	SD	0.02	0.03	0.01	0.02	0.03	
	Minimum	0.031	0.097	0.041	0.009	0.145	
	Maximum	0.095	0.194	0.084	0.094	0.269	

Note: Mean values in a row, sharing similar letters are NOT significantly different.

DISCUSSION

Findings of the present study focused on water samples collected from five residential sectors of Islamabad city showed considerable variations in the physico-chemical parameters such as temperature, pH, TSS, Hardness, EC, COD and concentration of sodium, chlorides, lead and zinc. These variations appeared to be influenced by population rise over the past few years and their subsequent effect on pollution load in open water channels.

The temperature of water samples ranged from 14.5°C to 20.5°C, which was within WHO limits. This was probably due to the presence of vegetation at the sampling sites that were characteristically observed in all sectors of Islamabad. Although wide and narrow ranges have been reported such as 15 to 35°C range was

observed in Gomti river (Singh *et al.,* 2005) and from 11 to 13°C in Pinios river (Loukas, 2010) but at the same time, significant effect of stream shade resulting from unmanaged native forest sites has also been cited as the cause of significantly lower temperature mean values (Miserendino *et al.,* 2011). Further we emphasized on pH of water samples which is considered an important parameter for testing water quality and interpreting aqueous chemistry (Baig *et al.,* 2009). The pH of the water samples from all study sites was within WHO limits except in sector F–11 where the pH value of the water sample were slightly acidic (6.07). This indicates that urban domestic waste generated in residential sectors of Islamabad located along open water channel is not disturbing the background pH values. However, in sector F–11, effluent discharged from the fabric painting industrial unit may have caused acidity in water. It is, therefore, reasonable to believe that effluents discharge, if present in any area, would have definite effect on pH of adjacent water bodies. Reports have shown contrasting pH results when compared to neighboring localities such as in Patancheru industrial area where all samples, except one have neutral to basic and alkaline values (Krishna *et al.,* 2009).

The EC of water samples were found (0.72–1.04 mS cm^{-1}) to be higher than WHO permissible level, the high level of EC was due to significant amount of dissolved salts, high salinity and mineral contents in all the sampling sites, same result of EC due to significant amount of dissolved salts, high salinity and mineral contents has been repoted in water samples (Arain *et al.,* 2009; Kazi *et al.,* 2009). It also corresponds to the highest concentration of dominant ions, which are the result of exchange and solubilization in the aquifer (Sanchezperez and Tremolieres, 2003). The range of TDS and conductivity in water samples was found in the range of 430 to 565 mg L^{-1} and 0.72 to 1.04 mS cm^{-1} respectively. Kazi *et al.* (2009) reported the range of TDS and conductivity in lake water 3580 to 4440 mg L^{-1} and 5.01 to 6.22 mS cm^{-1}, respectively. The EC and TDS showed range of 0.055 to 0.337 mS cm^{-1} and 35.3 to 219 mg L^{-1}, respectively in Jinshui River (Bu *et al.,* 2009). Chlorides concentration was observed in a range of 320.51 to 454.28 mg L^{-1}. This high level of major anion Cl in water samples was observed with the increase of EC. Same results of Cl concentration has been shown previously (Zacheus and Martikainen, 1997; Kazi *et al*., 2009).

The calculated COD values for all the water samples exceeded the Pak-EPA limits. Parameter COD is widely used for deteriorating waste concentration and is applied primarily to pollutant mixtures such as domestic sewage, agricultural and industrial waste. The concentration of Na ranged from 90.2 to 151.65 mg L^{-1}, and Mastoi *et al*. (2008) reported Na concentration 460 to 590 mg L^{-1} in Mancher lake Jamshoro. But in Kallar Kahar lake sodium was observed from 250.1 to 650.1 mg L^{-1} (Raza *et al.,* 2009). Pb and Zn probably the most harmful because of their non–biodegradable nature and sorption. Domestic, industrial and agricultural activities are partly responsible for higher concentration of heavy metals in water resources (Ma *et al.,* 2009). Lead concentration in water samples showed alarming results in sector G–10, H–10 and I–9 by exceeding the permissible limits of Pak-EPA. Mastoi *et al*. (2008) reported a low concentration of lead (0.004–0.0096 mg L^{-1}) in the drain of Sehwan. But alarming results were found by Nazif *et al*. (2006) in Bara River of Nowshera, lead concentration ranged from 0.43 to 0.63 mg L^{-1}.

With the increase of population, temperature, TSS, COD, hardness, Pb and Zn gradually increased, showed pollution load. Present study estimated positive correlation of temperature, TSS, COD, hardness, Pb and Zn with population. Increased value of COD represented high pollution load due to domestic and industrial waste water discharge. Alarming increase in Pb and Zn was calculated with the increase in population. All the sources of water pollution, i.e. industrial and domestic wastes not only contribute toxic chemicals to water but they also result in an increase of parameters like COD, TSS, TDS and thus deteriorate the water quality and make it unfit for drinking and other purposes. A lack of improper sewage disposal and of solid waste disposal system is threatening water resources in urban areas. The lack of organized collection of solid waste in the study area is the problem that leads to indiscriminate dumping of refuse. Thus waste disposal can create serious pollution of water resources, especially where there is no control of waste disposal in or near water. In a study area, a lack of adequate sanitation facilities continues to threaten water resources in urban areas. Sharp increases in population and economic development in the study area mean that human activity has become an important geological agent that affects surface water and ground water both directly and indirectly leading to imbalance in the chemical composition of water.

Water of sector E–11 was loaded with the pollution of EC, COD and Cl concentration. This pollution load gave the evidence of water quality deterioration. pH, EC, COD and Cl threaten the water quality by loading pollution in water of F–11. Load of pollution in G–10 water was determined in terms of EC, COD, Cl and lead concentration. Water of H–10 was unfit for any use, contaminated by EC, COD, Cl and lead concentration. Water of I–9 was highly polluted and showed alarming conditions of water quality having the pollution load of TSS, hardness, EC, COD, Cl and lead concentration. TSS, T–Hardness, EC, COD, Cl and Pb were found to be very high in sector I–9 (Table. 4). It is the main contributing source of pollution in the open water channel. Major cause of water pollution in I–9 is industrialization. Most of the industries in Pakistan are located in or around the major cities. They dispose their waste effluent directly into the nearby drains, rivers, streams, ponds, ditches and open or agricultural lands (Ullah *et al.,* 2009). Even in the capital city Islamabad there is no proper management of industrial effluents (Mian *et al.,* 1998).

In all the sectors population was higher in G–10 and pollution load was higher than the other sectors except sector I–9 which was covered by industrial area. Protecting the water resources in the study area will be a formidable challenge. To control the damage being done to the sources, several steps will be required: First, consumption of water must be decreased until it reaches the sustainable level permitted by the available resources. Achieving this goal will require more efficient water use by industry, agriculture and area's domestic population. Second, discharge of wastes into the surface water must be drastically reduced so that the ecosystem's natural ability to degrade wastes will not be exceeded. Achieving this goal will require modernization of all the industrial and domestic processes that use water, thereby improving the recovery and recycling of waste water encouraging the use of high efficiency toilets to minimize the amount of sewage

that is created. Third, additional water treatment facilities must be available and old facilities must be upgraded to increase the capacity. To create more sustainable means of production, there must be a shift in attitudes towards proactive waste management practices that represent a move away from control measures towards preventive measures in city.

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HYDRAULIC MODELING FOR FLOOD HAZARD ASSESMENT AND MITIGATION MEASURES - A CASE STUDY

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ABSTRACT

The historical profile of natural disasters in Chitral is stuffed with major natural events having varying degrees of loss to human and materials. On July 2015, riverine and flash floods along with Glacial Lake outburst Flood (GLOF) events of high to very High intensity hit different areas of Chitral sub-division and Mastuj Sub-division, which were caused by heavy rains. The floods washed away livestock, destroyed buildings, houses and assets, and damaged roads, bridges, irrigation infrastructure, water supply schemes, crops, schools and health facilities. The present paper envisages hydraulic modeling for the flood hazard assessment in a thickly populated booni town, a major tributary of chitral river. Based on the results hydro-dynamic modeling inundation extents were computed using ARC-GIS software for various return periods. Flood hazard zoning was also carried out to identify high, medium and low risk areas on the land use maps. Quantifications of sediment from the upper catchment of Booni Gol have also been estimated. Further recommendations for mitigation of on-shore and off-shore watershed protection measures are also outlined.

Keywords: Chitral, HECRAS, flood hazard, watershed, ARC-GIS

1. INTRODUCTION

Chitral District is located in the Koh Hindu Kush range in Khyber-Pakhtunkhawa Province of Pakistan. It shares a border with Afghanistan to the west and north and with Gilgit-Baltistan, the northernmost part of Pakistan. Geographically, it is one of the largest districts in Khyber-Pakhtunkhawa Province, covering an area of around 14,800 km^2 with a population of over 450,000 people. Hydrological & Hydraulic modeling were carried out for design of preventive and mitigation measures for natural hazard spot for Booni village in District Chitral. The present studies include collection of all available hydrological data and related information, its analysis and estimation of hydrological parameters for the design of the project. As described earlier, keeping in view the site specific requirement, hydrological studies will include the different aspects of the hydrological parameters necessary

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for the project. Hydrological parameters comprise description of catchment area, runoff conditions, peak flood estimation and design of protection measures for mitigation of flood hazards at site.

2. OBJECTIVES OF STUDY

- To consolidate the relief work done so far and evaluate the damage and losses for further winterized relief assistance
- To evaluate the need for short, medium and long term rehabilitation and recovery activities adapted to local needs and conditions
- To assess humanitarian situation and living conditions of affected population [shelter, food/Livelihood, health care, water and sanitation etc] focusing on women, children, person with disabilities, elderly and minorities at worst affected areas of the target union councils (UCs)and villages
- To understand the extent of the emergency situation and gather data and information that helps us to know the scale of the problem and the number of people affected by the disaster
- To assess government, NGOs/NGO's response, their capacity to cope with the situation and identify gaps and needs
- To look at coordination issues and gaps and their impact on efficiency and effectiveness of responses
- Propose an emergency response intervention and early recovery interventions based on the findings, with clear objectives, type of assistance, geographical location and number of population to be reached

3. METHODOLOGY

Following steps were carried out for flood hazard assessment of the case study site i.e. Booni Town, Chitral River

- Collection and evaluation of all available meteorological, topographic, hydrological and sedimentation data necessary for study of the Project.
- Collection of stream flow/sediment data of the main river and it's processing and analysis.
- Carrying out hydrological/flood studies for estimation of Peak Flood Discharges for different return periods
- Carrying out hydro-dynamic routing of flood waves in the reach of interest of nullah and river (using cross-sectional/topographic survey) for floods of various return periods and determination of Flood extents and water levels at peak flood conditions.
- Determination of scour/deposition conditions at proposed site during peak floods and proposal for remedial measures.

- Preparations of hazard assessment report based on hydrology and results of hydro-dynamic modeling and propose preventive and mitigation measures for Booni.

4. COLLECTION OF HYDRO-METEOROLOGICAL DATA

There is no meteorological station on the Booni Gol catchment. The stream is perennial round the year and carries snow melt and rain fed. Booni Gol is the tributary of Mastuj river (name of Chitral river in upper reaches). The nullah is ultimately becoming the part of the Chitral basin where stream flow records are available. Flow data of Chitral river at Chitral has been collected from Surface Water Hydrology (SWH) of WAPDA for the period 1964-2013.

As the Booni Gol is un-gauged and no flow records are available, so precipitation/rainfall records of nearest rain gauging station has been collected for estimation of peak flood discharges at the tail of the nullahs. Chitral rain gauging station operated by Pakistan Meteorological Department (PMD) lies in the vicinity of the project area where the rainfall records are available for the period of 1965-2015.

5. CLIMATE OF THE PROJECT AREA

The climate of the area at the Project site can be classified as cold and semi-arid. Weather conditions are dominated by its geographical location, a valley in a mountainous area, southwest of Kunar valley. During the year there is little rainfall. Summers are generally pleasant but the winters are extremely cold. Chitral has unpredictable weather during spring with frequent rains and snowfall. The best weather for many may be autumn when it is pleasant with mild temperatures. Chitral is the nearest weather station near the project site which is operated and maintained by Pakistan Meteorological Department (PMD).

Climate station of Chitral provides a fair representative estimate for the climate parameters of the project site. Chitral receives significant rainfall, averaging about 479 millimetres (19.0 in) annually. The summer season is brief and hot. The piercing sunrays may raise the temperature up to 28 °C, yet it is always cool in the shade. As a result of this extremity in the weather, landslides and avalanches are frequent in the area. The prominent climate parameters of Chitral are described as under.

5.1 Precipitation

Mean monthly rainfall data and the number of rainy days recorded at the Chitral Met Station are given in Table 1. The average annual rainfall of the area is about 490 mm (19.0 inches). The maximum rainfall occurs during the months of January to April, which is about 63% of the annual rainfall. Winter rains generally occur during the months of January to March, whereas, July and August are normally the months with least precipitation. The distribution of average monthly rainfall is shown in Figure 1 below.

Table 1: Mean Monthly Rainfall in Chitral

Month	Mean Monthly Rainfall (mm)	Rainy Days (No.)
January	47.0	4.7
February	65.1	7
March	110.9	10.3
April	78.7	9.3
May	42.5	7.2
June	12.2	2.7
July	7.0	2.3
August	6.6	2.5
September	13.1	2.9
October	25.2	3.7
November	30.5	3.8
December	39.9	5.1
Annual	**478.7**	**61.5**

(Source: Pakistan Meteorological Department)

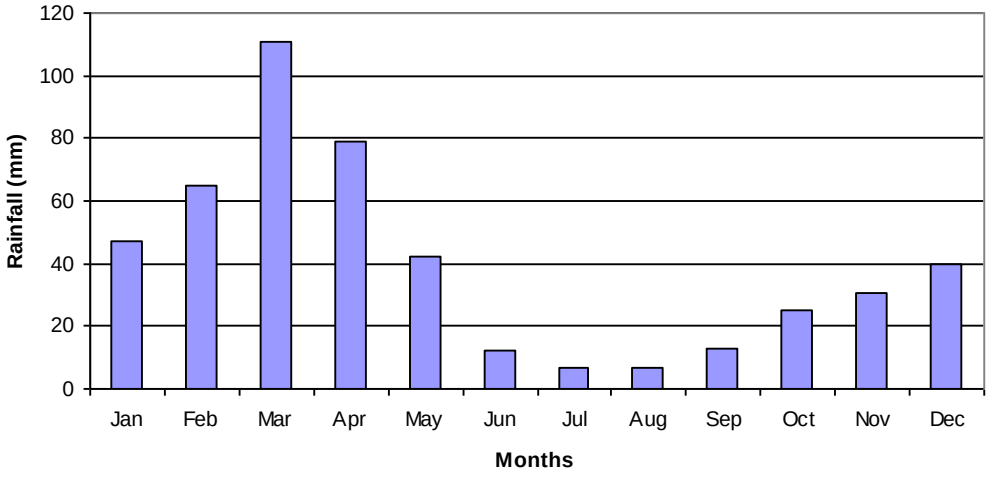


Fig. 1: Mean Monthly Distribution of Rainfall at Chitral (1981-2010)

5.2 Temperature

The mean daily temperature ranges from (July being the hottest month) 20.6°C to 27.7°C in the summer season (May to September) and 4.6°C to 6.3°C in winter season (December to February). Mean monthly temperature in July rises to a highest value of 27.7°C and falls to the lowest value of 4.6°C in January. June, July and August are the hottest months in summer season. December, January and February are the coldest months in winter season. The monthly averages of minimum, maximum and mean daily temperatures are given in Table 2 and shown graphically in Figure 2.

Table 2: Mean Monthly Temperatures in Chitral

Month	Temperature (°C)		
	Min	Max	Mean
January	-0.7	9.8	4.6
February	0.8	11.2	5.9
March	4.3	16.2	10.2
April	8.2	22.9	15.5
May	12.1	29.0	20.6
June	16.4	34.2	25.3
July	19.4	36.1	27.7
August	18.2	34.7	26.5
September	12.9	31.4	22.2
October	6.9	25.6	16.2
November	2.4	19.2	10.8
December	0.2	12.5	6.3

(Source: Pakistan Meteorological Department)

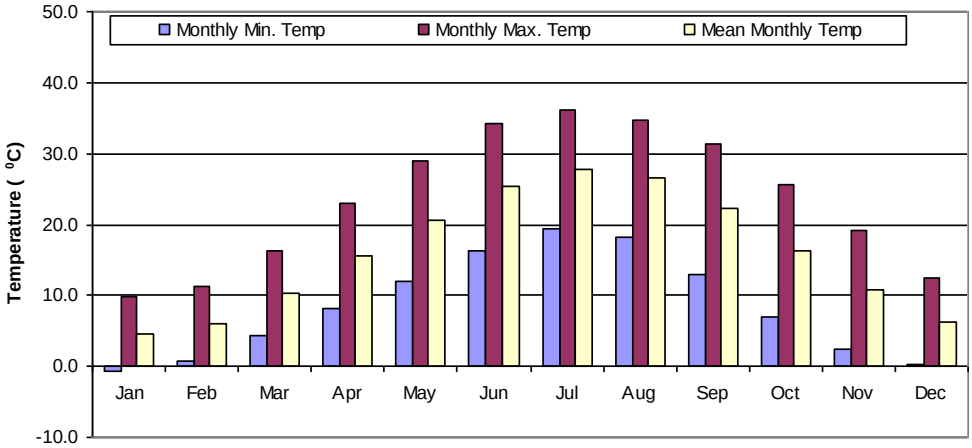


Fig. 2: Mean Monthly Temperatures in Chitral (1981-2010)

5.3 Relative Humidity

The relative humidity data at 00:00, 03:00 and 12:00 hours was collected from PMD. Mean monthly relative humidity is given in Table 3. At 00:00 hr the relative humidity varies from lowest value of 58.7% in June to highest value of 82.3% in September. At 12:00 hr the lowest value is 21.1 % in June to highest value of 39.9 % in February.

Table 3: Mean Monthly Relative Humidity in Chitral

Month	Relative Humidity (%)		
	00:00 hr	03:00 hr	12:00 hr
January	65.4	67.0	39.3
February	67.1	67.8	39.9
March	70.1	69.5	38.6
April	71.8	68.1	34.4
May	68.8	55.9	29.4
June	58.7	43.8	21.1
July	69.0	59.1	25.8
August	78.7	77.4	30.0
September	82.3	83.9	28.3
October	77.0	76.6	31.2
November	70.4	68.7	34.4
December	66.8	66.2	39.6

(Source: Pakistan Meteorological Department)

5.4 Wind Speed

The mean monthly wind speed in knots is given in Table 4. The data reveals that at 00:00 hours, the wind speeds are generally lower while higher wind speeds are recorded at 03:00 and 12:00 hours. During summers wind speeds are generally higher than wind speeds in winters.

Table 4: Mean Wind Speed at Synoptic Hours in Chitral

Month	Mean Wind at Synoptic Hours (Knots)		
	00:00	03:00	12:00
January	4.0	3.5	6.2
February	3.2	3.1	4.9
March	2.6	2.6	4.2
April	2.8	2.9	5.1
May	2.4	3.0	6.1
June	2.1	2.6	7.9
July	0.7	0.9	11.4
August	0.3	0.4	13.3
September	0.3	0.3	10.7
October	1.6	1.6	6.2
November	2.5	2.4	3.9
December	3.1	3.2	4.6

(Source: Pakistan Meteorological Department)

6. ESTIMATION OF PEAK FLOOD DISCHARGES

This section describes the catchment area, available flow data records at project site, synthesis of stream flow and rainfall data for estimation of peak flood discharges and inundation extents.

6.1 Collection of Hydro-Meteorological Data

The flood study for a location depends upon the hydro-meteorological data of the location/area. For gauged locations, recorded data is used to estimate peak flood discharges, whereas, for un-gauged locations synthetic storm is used which is estimated with recorded intense rainfall events in the area. In case of non-availability of rainfall data in the study area, the data of a station in the vicinity with similar climatic conditions is synthesized over study area. In the study area, the nullah is not gauged so the rainfall data from reliable source has been used to estimate design discharges. Using rainfall data, peak flood discharges of various return periods have been estimated by development of rainfall runoff model. As described in previous section that Chitral rain gauging station lies in the vicinity of the project area where the rainfall records are available for the period of 1965-2015.

6.2 Methodology for Computation of Peak Flood Discharges

The peak flood discharges can be estimated directly by the frequency analysis of observed instantaneous peak discharge data. In case of Mastuj (Chitral) river, instantaneous peak discharge data of Chitral river is available at Chitral for the period 1964-2013. The catchment area of Chitral river at Chitral is about 11,396 sq. km, whereas, catchment area of Mastuj (Chitral) river near Booni Town is about 4,568 sq. km. As the difference of catchment area is very high, so the instantaneous peak flood may not be directly transposed using catchment area proportionate technique. Hence, it will be better to estimate the floods using rainfall-runoff technique.

As no discharge data is available for the Booni Gol in the project area, hence rainfall runoff model has been developed to estimate the peak flood discharges of various return periods at desired location.

The catchment area of Booni Gol and Mastuj river at desired location in the project area is greater than 1 km^2 so synthetic unit hydrograph technique has been used for the computation of peak flood discharges and developing flood hydrographs.

Synthetic Hydrograph Method

The synthetic unit hydrograph technique has been used for developing the flood hydrographs of the streams. Curve Number method of US-SCS (United States Soil Conservation Service) (Ref. 2) has been used which takes into account the type of soil, density of vegetal cover and antecedent moisture conditions of the drainage area prior to the occurrence of storm. Flood hydrograph has been developed on the basis of various catchment characteristics and storm rainfall data.

6.3 Catchment Characteristics of Booni Gol

The catchment of Booni Gol is located on the southern slope of Mastuj River in Hindu Kush mountain range. Booni Gol is left tributary of Mastuj River.

The catchment area of Booni Gol near Booni Town is shown in Figure 3. The catchment area elevation varies from 2,100m asl to 6,300m asl at its extreme boundary with mean elevation of 4,200m asl. The catchment area of Booni Gol at confluence with Mastuj River is about 72 sq. km. The terrain has very steep slopes.

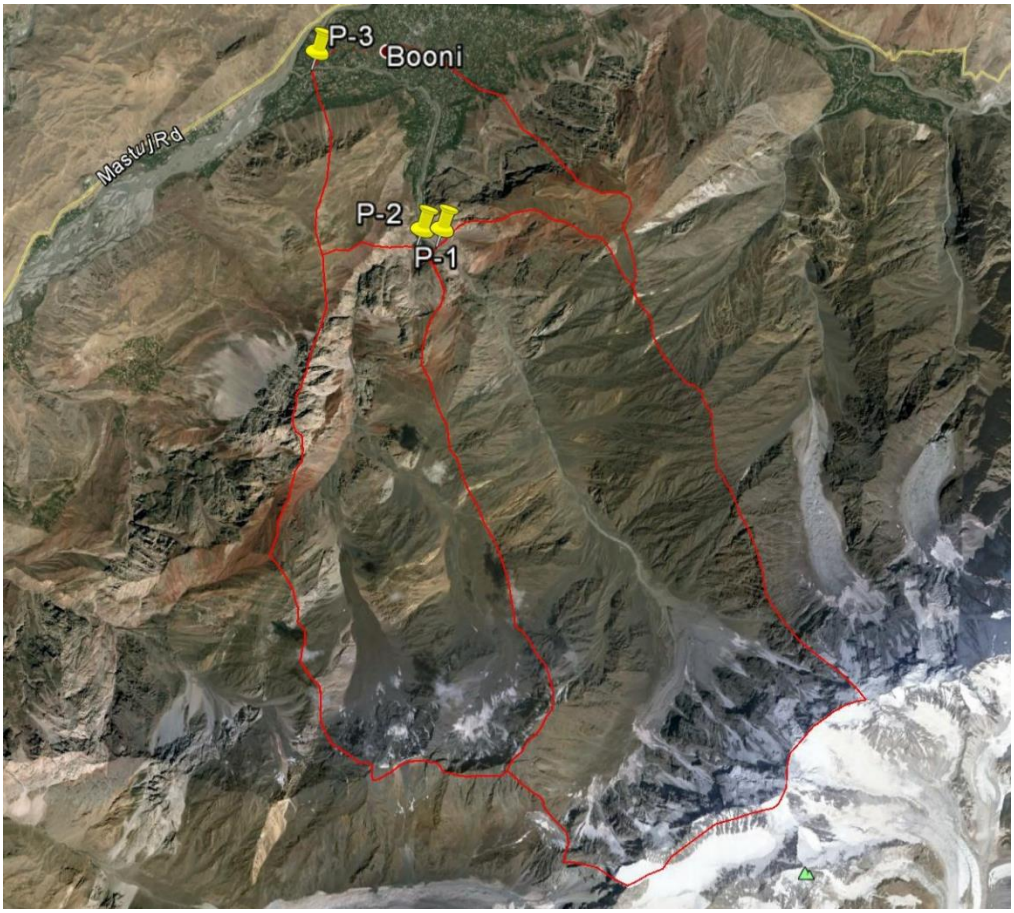


Fig. 3: Catchment Area of Booni Gol Near Booni Town

The weather of the catchment area is characterized by moderate summer and severe winter. The monsoon hardly penetrates the project area and the main mechanism for producing rain is western disturbances. The summer month's runoff is contributed from precipitation and snow/glacier melt. The flow in winter is contributed mainly from precipitation and base flow generation by exfiltration of summer month recharge in the area. In this region, flash floods occur during spring and winter and they mainly originate from precipitation. Precipitation can contribute to maximum floods.

Catchment characteristics can be sub-divided mainly into two categories i.e. physical characteristics and hydrological characteristics. Physical characteristics of the catchment include catchment area, length and weighted slope of the longest stream draining to the point of interest. These physical characteristics have been determined from the topographic maps of 1:50,000 scale and Digital Elevation Model (DEM) obtained from Shuttle Radar Topography Mission (SRTM).

The site is in hilly terrain. The catchment area is sparsely covered with green bush. The slopes in upper reaches are steep and the floods are of flashy nature. The longitudinal slopes and lengths of the natural streams/nullahs have been determined from the topographic maps and SRTM data. The hydrologic characteristics of the catchments i.e., conditions of the area; soil cover, land use, soil type and extent, and other flow controlling parameters have been investigated through soil maps and satellite imagery.

Time of Concentration

Kirpich formula has been used for the computation of time of concentration as given below:

$$T_c = 0.00032x\frac{L^{0.77}}{S^{0.385}}$$

Where,

T_c = Time of Concentration (hours)

L = Length of the longest stream (m)

S = Surface slope, given by H/L (m/m)

H = Difference in elevation between the remotest point and outlet in the drainage basin (m)

Selection of Curve Number (CN)

The soils of the catchment area belong to a mix of C and D categories (Ref. 2) and the historic rainfall data indicates that the antecedent moisture conditions would be in the category of AMC-III conditions during flood season. The weighted average curve number used in synthetic hydrograph method for the stream/nullah and river catchment has been estimated as 90 and 86 respectively keeping in view its soil cover and future landuse.

The catchment characteristics/parameters and computed 'Times of Concentration (T_c)' are given in Table 5 below.

Table 5: Catchment Parameters at Various Locations

Location	Catchment Area	Longest Stream Length	Top Elevation	Bottom Elevation	T_c	Curve No.
	Km^2	Km	m	m	hrs	
P1	38.67	12.6	6274	2347	0.86	90
P2	22.73	10.9	5509	2410	0.76	90
P3 (Booni Gol at Booni Town)	71.64	17.3	6274	2015	1.27	90
Mastuj river near Booni Town	4568	186	5845	2030	20.41	86

6.4 Rainfall Data Analysis

One-day annual maximum rainfall data of Chitral is available for 1965-2015 (51 years) and is given in Table 6. The recorded highest one-day annual maximum recorded rainfall at Chitral during the period of record is 124.9 mm in 2005 and minimum recorded one day annual maximum rainfall is 21.6 mm in the year 1976 at this gauging station.

Table 6: One Day Annual Maximum Rainfall at Chitral

Year	Rainfall (mm)	Year	Rainfall (mm)
1965	90.7	1991	46.0
1966	54.6	1992	51.2
1967	63.8	1993	76.6
1968	54.1	1994	50.7
1969	35.6	1995	32.0
1970	22.4	1996	36.7
1971	34.0	1997	72.3
1972	61.7	1998	59.7
1973	50.8	1999	41.7
1974	37.3	2000	55.8
1975	63.2	2001	30.4
1976	21.6	2002	27.0
1977	29.8	2003	41.3
1978	40.9	2004	109.0
1979	24.6	2005	124.9
1980	25.3	2006	38.0
1981	51.5	2007	105.6
1982	44.0	2008	59.8
1983	23.6	2009	37.0

Year	Rainfall (mm)	Year	Rainfall (mm)
1984	30.6	2010	73.0
1985	35.8	2011	57.0
1986	43.2	2012	29.0
1987	35.4	2013	33.0
1988	55.8	2014	44.0
1989	36.2	2015	62.0
1990	48.3		

Considering the location of the catchment, frequency analysis of one-day annual maximum rainfall data of Chitral have been carried out using Gumbel's Extreme Value Type-1 Distribution. The results of frequency analysis for various return periods have been determined as listed in Table 7. Plotting positions have been computed by Weibull's formula. Fig. 4 shows the plotted data and the fitted line.

Table 7: Results of Frequency Analysis 1-Day Annual Maximum Rainfall at Chitral

Return Period (Years)	Estimated Rainfall	
	(mm)	(inches)
5	66.9	2.63
10	80.9	3.18
25	98.6	3.88
50	111.7	4.40
100	124.7	4.91
500	154.8	6.09
1000	167.7	6.60

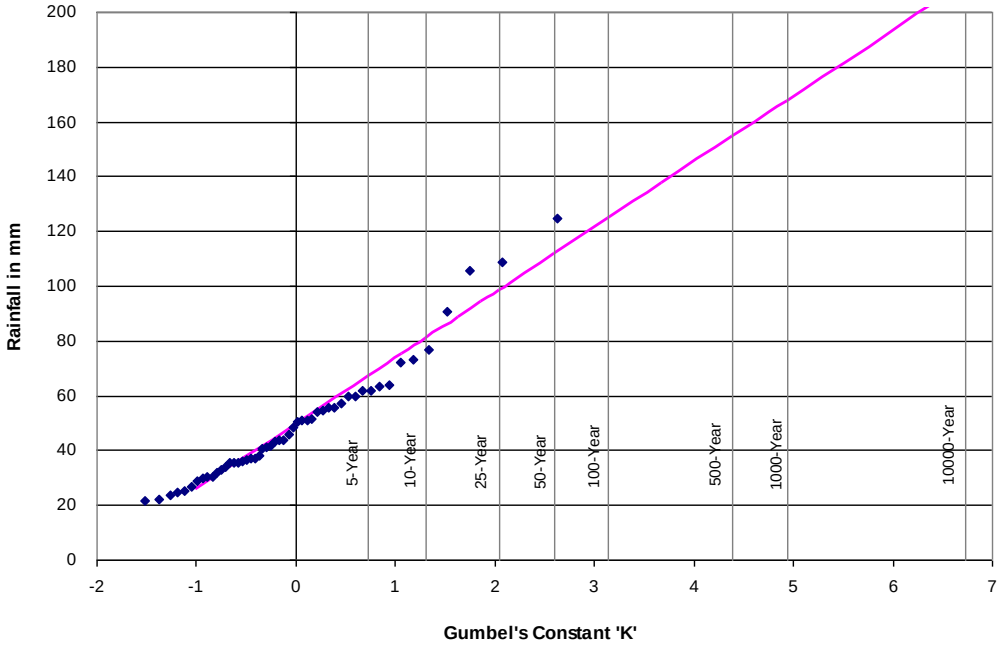


Fig. 4: Frequency Analysis of 1-Day Annual Maximum Rainfall at Chitral

6.5 Time Distribution of Rainfall Storm

Total storm rainfall determines the magnitude of flood while its pattern gives the shape of hydrograph. Rainfall storm pattern has been established by using the hourly rainfall data of Chitral. Hourly rainfall data of Chitral has been analyzed for some intense storms. The storm pattern of rainfall is used as a relationship between time and rainfall which is as stated below:

$$P_t = \left(\frac{t}{24}\right)^n$$

Where P_t is ratio of rainfall at time 't' with 24-hr rainfall, t is time in hours and n is an exponent depending on hourly rainfall pattern, taken as 0.40. The rainfall distribution with time is then re-oriented to have a centrally loaded rainfall pattern. The hourly rainfall pattern used for distributing 24-hour rainfall is shown in Fig. 5 below:

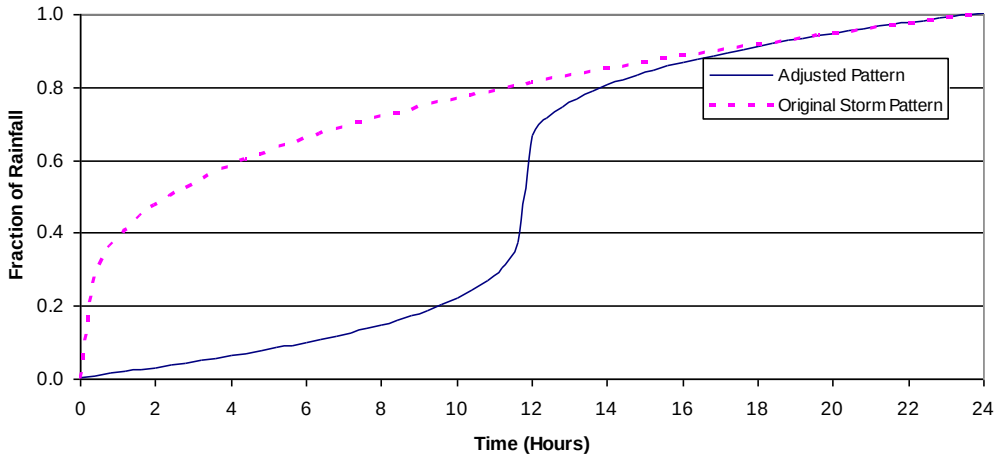


Fig. 5: Time Distribution of Rainfall

6.6 Estimated Peak Flood Discharges

The catchment area of Chitral river at Chitral is about 11,396 km^2, whereas the catchment area of Chitral/Mastuj river near Booni town is about 4,596 km^2, hence transposition of instantaneous peak flood discharges by catchment-area proportionate is not providing any rational results and estimates are on quite lower side. Computation of peak flood discharges by regional methods as determined by GTz for northern areas also estimate floods on upper side. This method is applied where no met data for the catchment is available. So, the best technique to estimate peak flood in the reach of interest in project area is computation of floods by rainfall-runoff technique. In case of Booni Gol, the slopes are very steep and flash flood emerges in case of a heavy rainfall events. Similarly slopes of Chitral river in upper reaches are also steep so weighted slopes of the river and nullah reaches were computed for computation of times of concentration of rainfall generated floods.

Using the rainfall depth for various return periods, its temporal distribution over the catchment areas and on the basis of synthetic unit hydrograph technique, estimation of peak discharges for nullah and rivers near Booni Town has been made for various return periods as given in Table 8 below.

Table 8: Estimated Peak Flood Discharges for Various Return Periods

S. No.	Location	Catchment Area	Peak Flood Discharges (Cumecs)		
		(km^2)	25 yrs	50 yrs	100 yrs
1	P1	38.67	196	240	287
2	P2	22.73	128	158	187
3	P3 (Booni Gol at Booni Town)	71.64	311	379	447

S. No.	Location	Catchment Area	Peak Flood Discharges (Cumecs)		
		(km^2)	25 yrs	50 yrs	100 yrs
4	Chitral (Mastuj) river near Booni Town	4568	1,363	1,683	2,016

6.7 Recommended Design Flood for Booni Gol and Chitral River

To carry out further design studies for proposing preventive and mitigation measures for Booni Town, 100-year return period flood peaks of 447 m^3/s and 2,016 m^3/s for Booni Gol and Chitral/Mastuj river were recommended.

7. COMPUTATION OF SAFE PLATFORM LEVELS

As described earlier, flood levels along the reach of Chitral/Mastuj river and Booni Gol passing through Booni Town has to be determined. Following methodology has been opted for determination of flood levels as described hereunder:

7.1 Methodology for Inundation Modelling

Topographic survey for the project area has been used for the reach of interest of river and nullah. The survey is available in 3D Point/contour format which covers well both the river and nullah reaches near the project area for this study.

7.2 Development of Geometric Model

The survey data has been processed using ArcGIS software and TIN (Triangulated Irregular Network) is generated as shown in Fig. 6. A TIN is constructed by triangulating a set of vertices. The vertices are connected with a series of edges to form a network of triangles. HEC-GeoRAS, an extension in ArcGIS has been used to prepare Geo-database. The only essential data required for HEC-GeoRAS is the terrain data (TIN or DEM). Additional data sets that may be useful are areal photograph(s) and land use information.

Delineation of river and nullah centerlines have been done keeping in view the location of the lowest levels in plan and provided survey. Cross-sections have been extracted at an interval of about 400-500 m in river reach and 200-300 m in nullah reach, however, the interval between the cross-sections is further reduced at locations where there is a bend or at a crossing structure across the nullah. The demarcation of the cross-sections have been made with respect to the Chainage from the downstream end and represented by river/nullah station number as shown in Figs. 7 & 8.

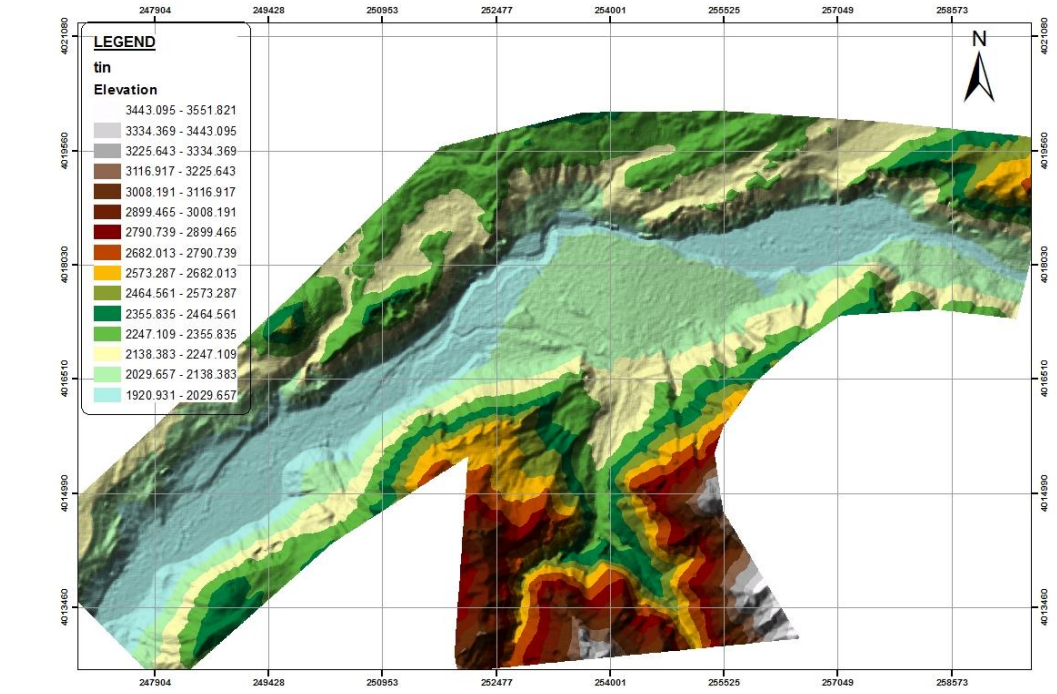


Fig. 6: TIN Developed from the Processing of Survey

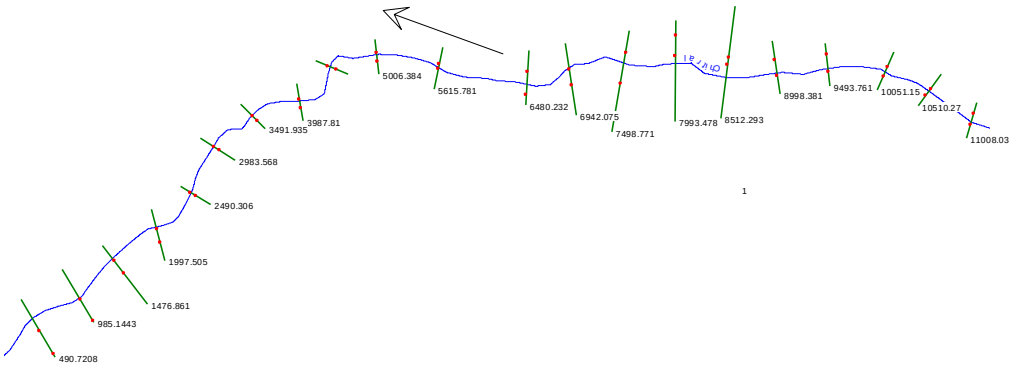


Fig. 7: Layout of Cross-sections in the Study Reach of Chitral River

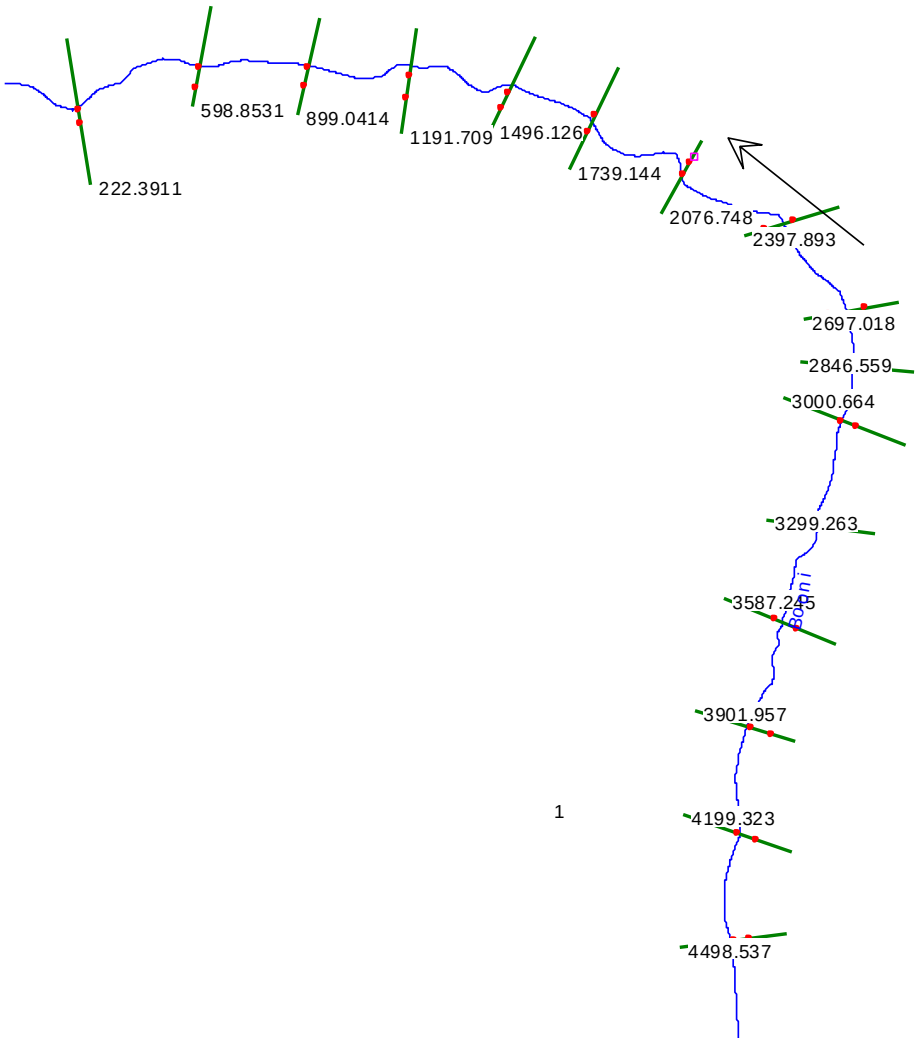


Fig. 8: Layout of Cross-sections in the Study Reach of Booni Gol

7.3 Hydraulic Analysis by HEC-RAS Model

Flood simulations have been carried out using 1-dimensional hydrodynamic model HEC-RAS (Ver 4.1.0) developed by United States Army Corps of Engineers (USACE). The model makes use of stream geometry and user defined flows to compute water surface profiles.

The geometric data for HEC-RAS model has been imported from ArcGIS. The flood hydrographs of 25, 50 and 100 year return periods having flood peaks of 1363, 1683 and 2016 m^3/s have been keyed in HEC-RAS model for obtaining water surface profiles in the Chitral river reach. The flood hydrographs of 25, 50 and 100 year return periods having flood peaks of 311, 379 and 447 m^3/s were keyed in HEC-RAS model for obtaining water surface profiles in the Booni Gol reach passing through Booni. As the river and nullah reaches are confined with

hills and flood water remains within the channel except at the few locations where extent of flood water is bit more than the normal in river reach for which provision of dykes has been considered for reclamation of land for Booni. The resulting water surface profiles in river and nullah reach for various return period floods are shown below in Figs. 9 & 10.

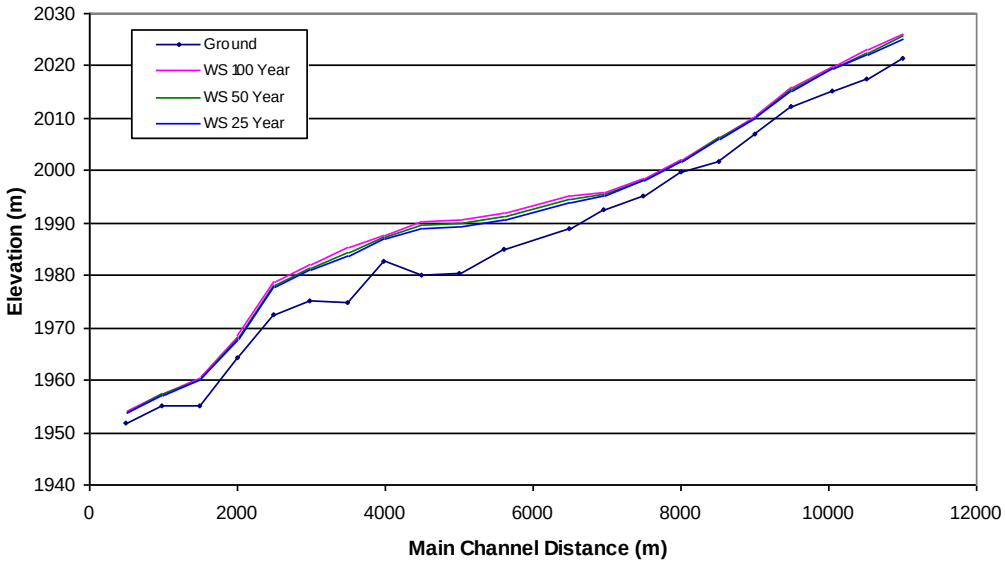


Fig. 9: Water Surface Profiles for Various Return Period Floods in Chitral River

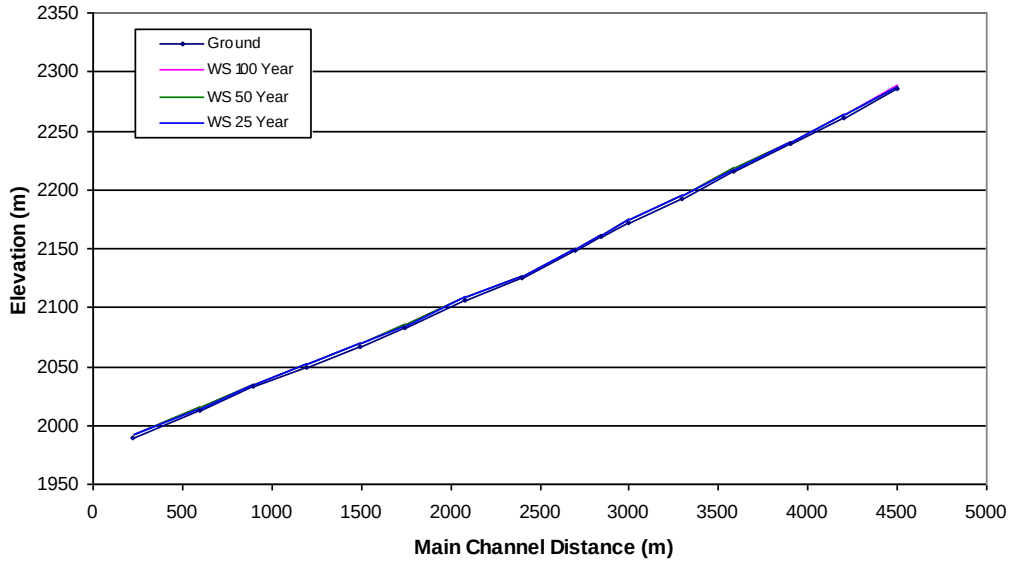


Fig. 10: Water Surface Profiles for Various Return Period Floods in Booni Gol

7.4 Determination of Inundation Extents and Flood Levels

Simulations have been carried out in HEC-RAS model corresponding to the above described floods in the reach of interest of Chitral river and Booni Gol near the project area. Simulation result indicates that in the reach of interest of Chitral river, the average velocities are in the range of about 4.5 m/s and depths of flow varies from 2.25 m to 10 m. Similarly, the average velocities are in the range of about 4.25 m/s and depth of flow varies from 1.6 m to 3.2 m. The results have been exported to ArcGIS and water depths have been extracted for flood plain delineation and flood inundation mapping. The flood/inundation extents in Chitral river and Booni Gol reaches for 100 year return period are shown in Figs. 11 & 12. The flood levels in Chitral River and Booni Gol reaches computed by hydraulic modeling for various return periods at all the cross-sections are given in Tables 9 to 11.

Table 9: Flood Levels of Various Return Periods in Chitral River

Sr. No.	X-Sec River Station	Min Channel Elev.	W.S. Elevation for Flood of		
			25-Year	50-Year	100-Year
		(m)	(m)	(m)	(m)
1	11008.0300	2021.39	2025.22	2025.68	2026.12
2	10510.2700	2017.40	2022.12	2022.57	2023.00
3	10051.1500	2015.14	2019.36	2019.65	2019.93
4	9493.7610	2012.35	2015.25	2015.53	2015.83
5	8998.3810	2006.91	2009.89	2010.09	2010.37
6	8512.2930	2001.88	2006.10	2006.25	2006.51
7	7993.4780	1999.66	2001.69	2001.82	2001.94
8	7498.7710	1995.12	1998.05	1998.28	1998.49
9	6942.0750	1992.50	1995.31	1995.57	1995.78
10	6480.2320	1988.96	1993.81	1994.57	1995.32
11	5615.7810	1984.84	1990.69	1991.32	1991.95
12	5006.3840	1980.44	1989.17	1989.84	1990.47
13	4497.1990	1979.98	1988.86	1989.50	1990.10
14	3987.8100	1982.75	1986.84	1987.29	1987.73
15	3491.9350	1974.88	1983.58	1984.41	1985.20
16	2983.5680	1975.22	1981.11	1981.55	1982.05
17	2490.3060	1972.43	1977.62	1978.20	1978.76
18	1997.5050	1964.32	1967.56	1967.90	1968.23
19	1476.8610	1955.20	1959.93	1960.20	1960.46
20	985.1443	1954.96	1957.09	1957.28	1957.47
21	490.7208	1951.83	1953.73	1953.90	1954.07

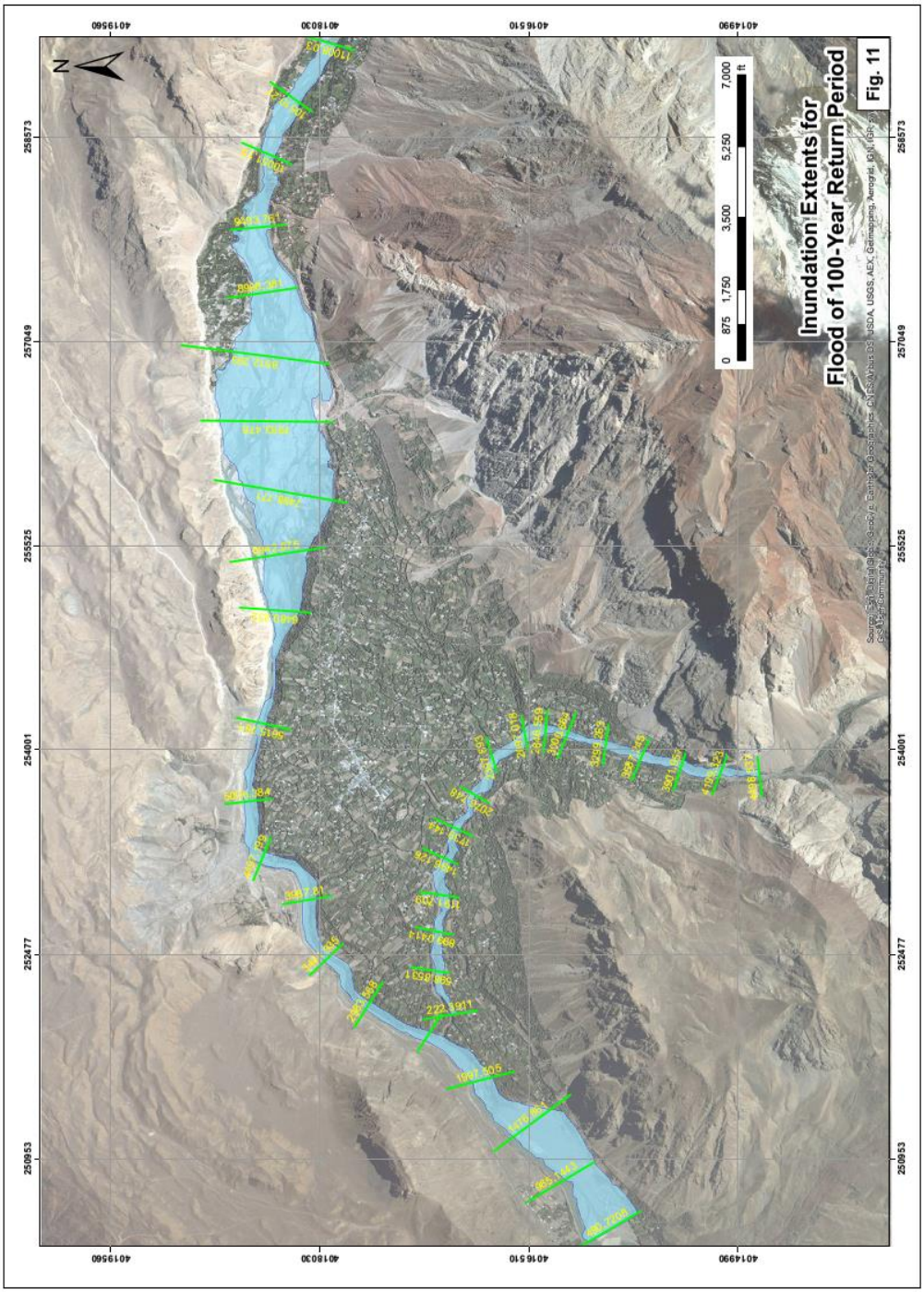


Fig. 11: Inundation Extents for Flood of 100 Year Return Period

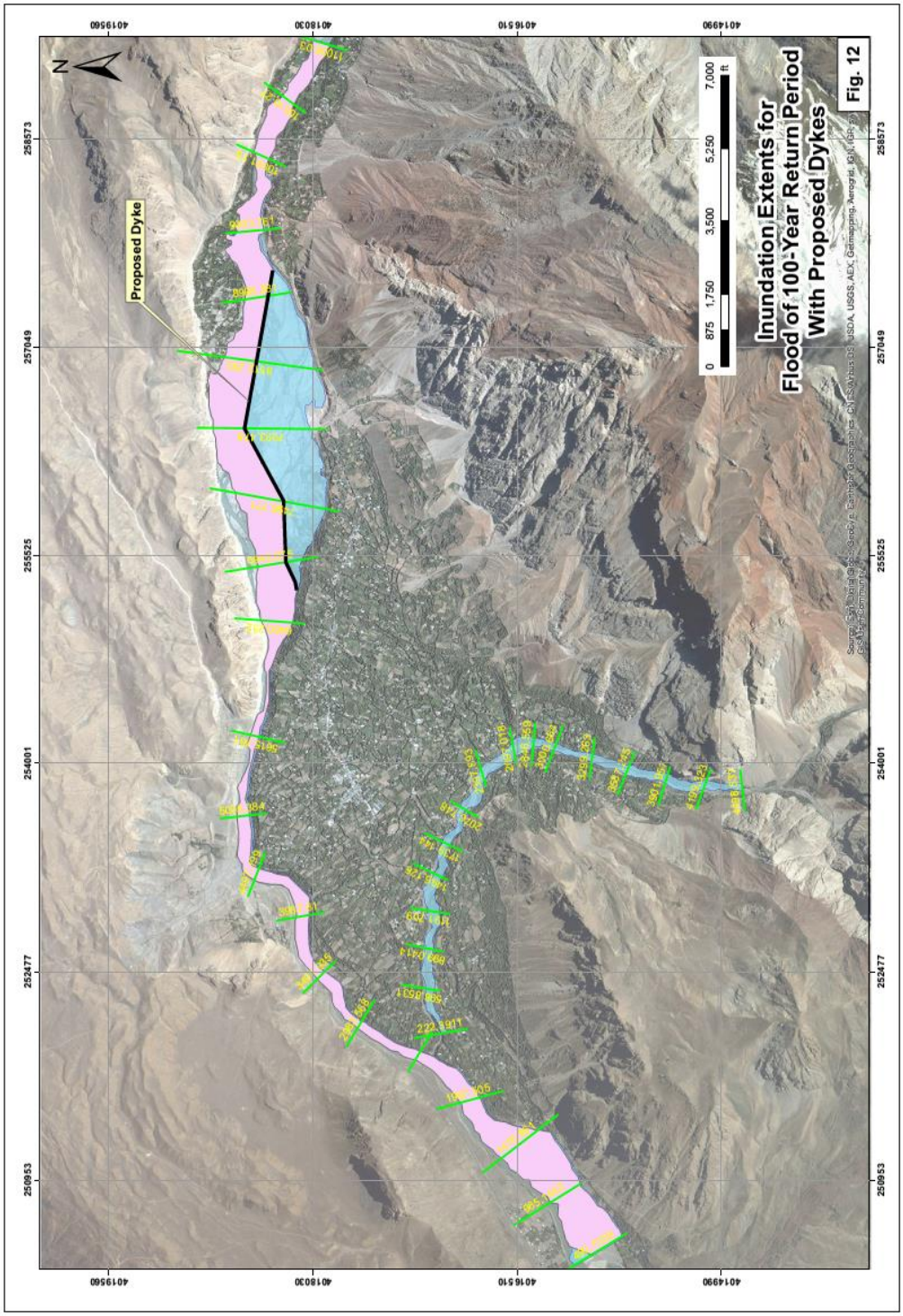


Fig. 12: Inundation Extents for Flood of 100 Year Return Period With Proposed Dykes

Table 10: Flood Levels of Various Return Periods in Chitral River with Dykes

Sr. No.	X-Sec River Station	Min Channel Elev.	W.S. Elevation for Flood of		
			25-Year	50-Year	100-Year
		(m)	(m)	(m)	(m)
1	11008.0300	2021.39	2025.23	2025.68	2026.12
2	10510.2700	2017.40	2022.11	2022.57	2023.00
3	10051.1500	2015.14	2019.36	2019.65	2019.93
4	9493.7610	2012.35	2015.25	2015.53	2015.83
5	8998.3810	2006.91	2009.85	2010.18	2010.48
6	8512.2930	2001.88	2006.67	2006.98	2007.26
7	7993.4780	1999.66	2001.93	2002.17	2002.41
8	7498.7710	1995.12	1998.41	1998.68	1998.94
9	6942.0750	1992.50	1995.23	1995.50	1995.75
10	6480.2320	1988.96	1993.81	1994.57	1995.32
11	5615.7810	1984.84	1990.69	1991.32	1991.95
12	5006.3840	1980.44	1989.17	1989.84	1990.47
13	4497.1990	1979.98	1988.86	1989.50	1990.10
14	3987.8100	1982.75	1986.84	1987.29	1987.73
15	3491.9350	1974.88	1983.58	1984.41	1985.20
16	2983.5680	1975.22	1981.11	1981.55	1982.05
17	2490.3060	1972.43	1977.62	1978.20	1978.76
18	1997.5050	1964.32	1967.56	1967.90	1968.23
19	1476.8610	1955.20	1959.99	1960.25	1960.51
20	985.1443	1954.96	1957.20	1957.43	1957.65
21	490.7208	1951.83	1954.04	1954.26	1954.47

Table 11: Flood Levels of Various Return Periods in Booni Gol

Sr. No.	X-Sec River Station	Min Channel Elev.	W.S. Elevation for Flood of		
			25-Year	50-Year	100-Year
		(m)	(m)	(m)	(m)
1	4498.5370	2285.15	2287.56	2287.80	2288.07
2	4199.3230	2261.26	2263.34	2263.55	2263.76
3	3901.9570	2238.44	2240.38	2240.57	2240.76
4	3587.2450	2215.58	2217.71	2217.91	2218.09
5	3299.2630	2193.00	2195.49	2195.72	2195.95
6	3000.6640	2171.95	2174.35	2174.60	2174.83
7	2846.5590	2159.86	2161.95	2162.19	2162.40
8	2697.0180	2148.17	2149.48	2149.63	2149.76
9	2397.8930	2124.58	2126.41	2126.58	2126.73
10	2076.7480	2106.57	2109.10	2109.37	2109.62

Sr. No.	X-Sec River Station	Min Channel Elev.	W.S. Elevation for Flood of		
			25-Year	50-Year	100-Year
		(m)	(m)	(m)	(m)
11	1739.1440	2082.74	2084.90	2085.12	2085.34
12	1496.1260	2067.08	2069.34	2069.59	2069.81
13	1191.7090	2049.46	2051.60	2051.79	2051.97
14	899.0414	2032.50	2034.86	2035.09	2035.31
15	598.8531	2012.59	2014.87	2015.09	2015.29
16	222.3911	1989.34	1992.00	1992.29	1992.57

8. HYDRAULIC DESIGN STUDIES

Hydraulic design studies have been carried out to meet the following objectives:

i. Identification of reaches for design of Flood Protection structures in Booni Gol reach

ii. Estimation of sediment/debri in nullah reach (Booni Gol)

iii. Recommendations/Proposals for offshore protection measures to control debri in Booni Gol

8.1 Hydraulic Evaluation for Reach Identification for Flood Protection in Booni Gol

Based on the 100-year return period flood of Booni Gol (447 m^3/s) as given in Table 8 and corresponding topographic survey data, hydraulic analysis of wall has been carried out using HEC-RAS computer model.

Based on simulation of HEC-RAS numerical model, water levels in the Booni Gol reach corresponding to 100 year return period flood have been computed and are given at each cross-section in Table 11. Based on levels mentioned in Table 11, it is found that the freeboard available at river station 2076.748 is much lower as compared to adjacent stations as shown in Table 12.

Table 12: Available Freeboard at River Station 2076.748 in Booni Gol

S. No.	River Station ID	HFL (m)	Bank Elev (m amsl)	Available Freeboard (m)
1	2397.89	2126.73	2135.06	9.33
2	2076.748	2109.62	2111.18	2.0
3	1739.14	2085.34	2088.62	3.28

It is, therefore, recommended that raising of banks shall be carried out in order to avoid breeching of bund at this point. The remaining water surface profile remained well within the existing right bank (country side).

8.2 Protection Works in Booni Gol

The water from the foothill joins the rivers with a quite high velocity. As the flood passes through the nullah (Booni Gol), it has a velocity ranging from 3.5m/s to 4.5 m/s. Therefore, the entire right bank of the nullah upto confluence with river shall be protected with stone apron and stone pitching. The stone apron width alongwith its thickness is presented in the Table 13.

Table 13: Proposed Protection Works in Booni Gol

S. No.	Apron Length (m)	Stone Size (m)	Thickness of Apron (m)
1	7	0.82	1.5

8.3 Estimation of Sediment/Debri in Booni Gol Reach

Dendy and Bolton presented soil erosion soil loss formula, used to compute average annual erosion rate of the sediment from the catchment of Booni Gol. As discussed earlier that the average annual is 4.91 in corresponding to 100-year return period flood. The sediment yield is computed as shown in Table 14.

Table 14: Average Annual Estimated Sediment Yield in Booni Gol

S. No.	Catchment Area (km^2)	Mean annual 100yr runoff (in)	Sediment yield (tons/km^2/yr)
1	71.64	4.91	1421.5

8.4 Hazard Identification and Zoning of Booni Gol

Satellite imagery of the catchment area has been reviewed to assess the general usability of land and mountain areas by using the GIS techniques. The existing land use map is prepared using ARC GIS as shown in Figure 13. The land use descriptions is shown in Table 15.

Table 15: Description of Land use in Booni Gol

S. No.	Land use Type	Qty
1	Commercial	114 No.
2	Residential	1200 No.
2	Agricultural	1500 Acres

The units are briefly discussed in as under:

Land category	Description
Agricultural Land	the land under cultivation, orchards, trees and forest etc.
Settlements	the area of land occupied by settlements, area of villages.
Barren Land	the land which is deprived of vegetation but have settlements at places, fans etc.
Broken Land	the land damaged by geomorphic processes and cannot be used for vegetation or settlements.
River & Nullah Beds	land consumed by the beds of river and nullahs.
Barren Mountain	the area consists of high relief mountain, deprived of vegetation.
Vegetated Mountain/Slopes	Mountain area having moraine deposits and vegetation.

8.5 Hazard Identification

During high flows, surrounding villages located along the banks of river and streams are vulnerable either from submergence of the rising water or from flood debris or erosion of the river banks due to fast flowing water. It is also observed that occasionally after a major flood event, active channel of the river changes its course and endangers the surrounding inhabitants. Potential risk areas along the river and streams have been identified according to the types of threat on the basis of field visits and analyses of the data collected during field investigations.

8.6 Flood Hazard Zoning

Flood risk areas have been identified according to hazard potential and are marked as Zone A and Zone B in map shown in Fig. 14.

Zone A:	Highly hazard prone area: The area/settlement lie very near or within the nullah as per 100-year return period flood extents
Zone B:	Less Hazard prone area: The area/settlement lie very outside the nullah as per 100-year return period flood extents

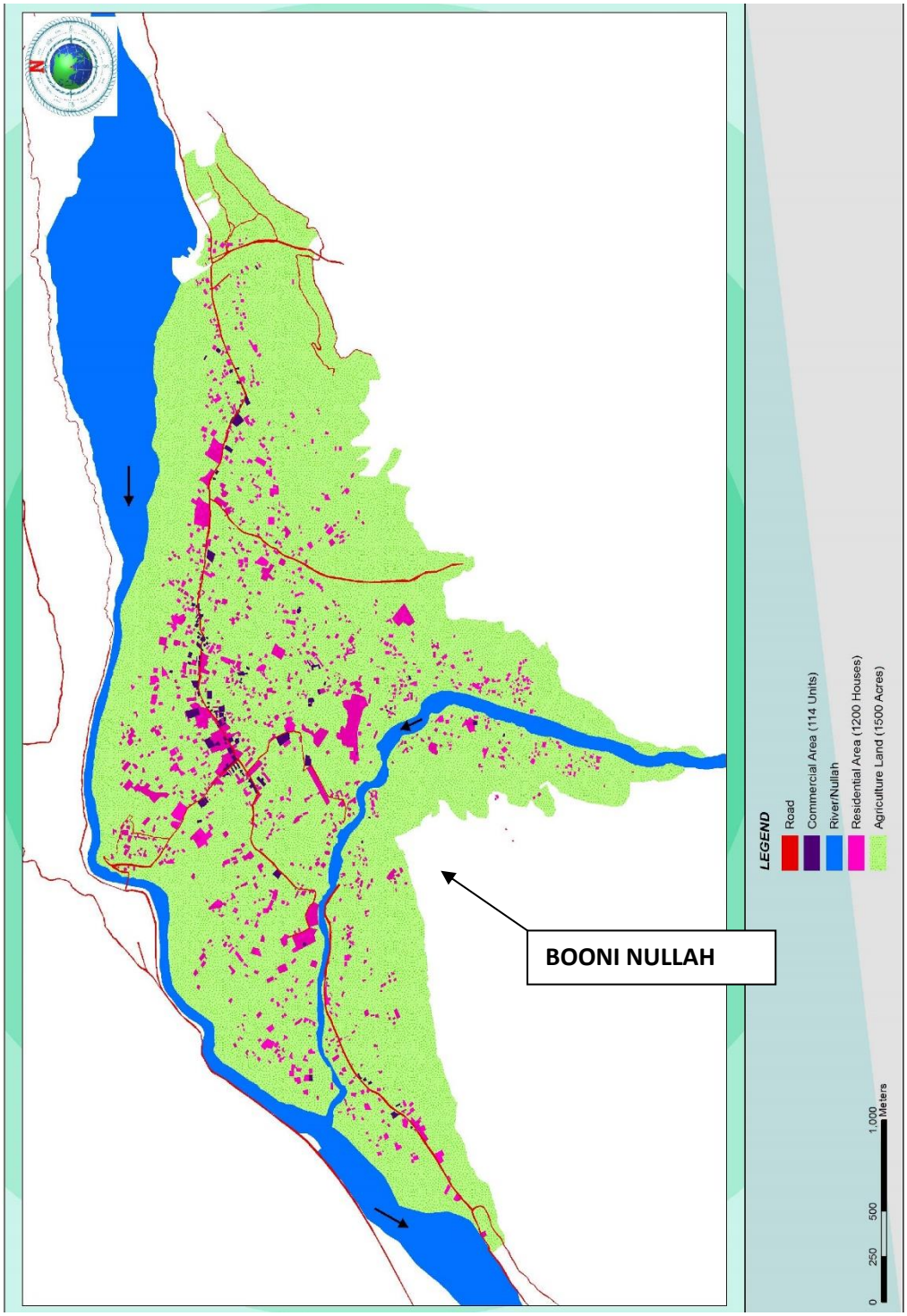


Fig. 13: Land use map in Booni Town

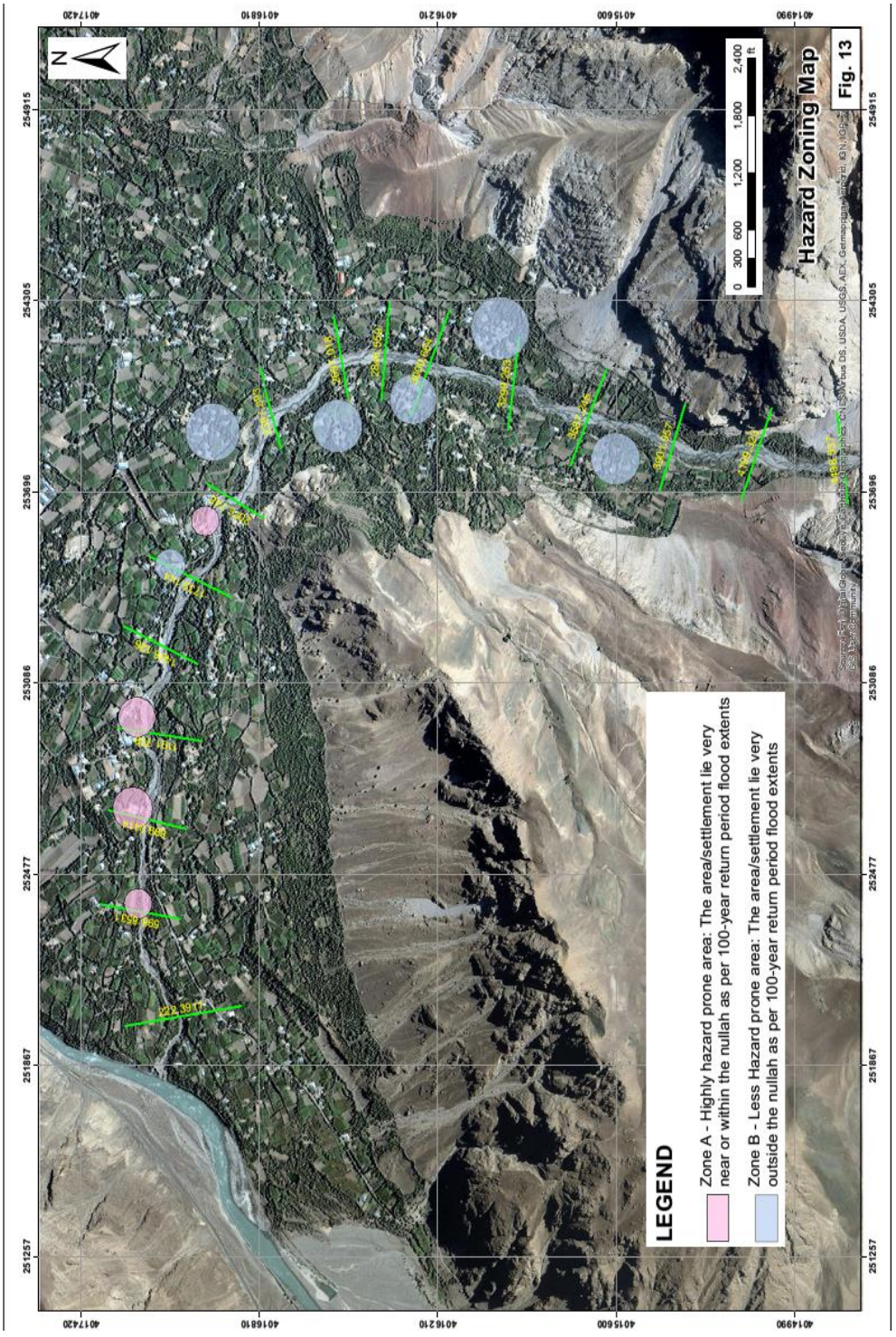


Fig. 14: Flood Hazard Zoning Map

8.7 Recommendations for Offshore Protection Measures to Control Debri

Following measures are recommended in order to minimize sediment entry into the Booni Gol.

1. Provision of check dams/sediment traps at suitable location in upstream catchment reach may reduce debri flow in the nullah. The tentative locations of proposed check dams have been marked using stream network generated from ASTER data and is shown in Fig. 15.
2. Minimization in exposed soils may cause reduction in debri flow. Exposed soils can be covered which may include top-soiling in conjunction with one or more of the following; seeding, mulching, hydro-seeding, sodding, erosion control blankets, turf reinforcement matting (TRM), riprap, gabion mat, aggregate cover and paving etc.
3. Debri may be controlled in the catchment area by surface roughening (slope texturing).
4. Existing drainage systems must be maintained in a way so that they remain active all-round the season. This may cause reduction in erosion in the catchment.
5. Use of bio-engineering methods may cause reduction in debri flow. This can be achieved by introducing foilage that decreases impact erosion of rain drops, and increases infiltration of rain into the soil resulting in anchoring of the soil with root systems. As the plants grow, the strength of the bio-engineered erosion control system strengthens. Typically bio-engineering is used to prevent erosion where there are environmental or aesthetic enhancement requirements; however, if properly selected and implemented, it will provide a simple and cost effective measure for controlling long-term erosion problems.
6. The debri flow in the catchment may be reduced by the use of Compost blankets. Compost blankets enhance the soil fertility and improve the vegetation. This will directly reduce the soil erosion.

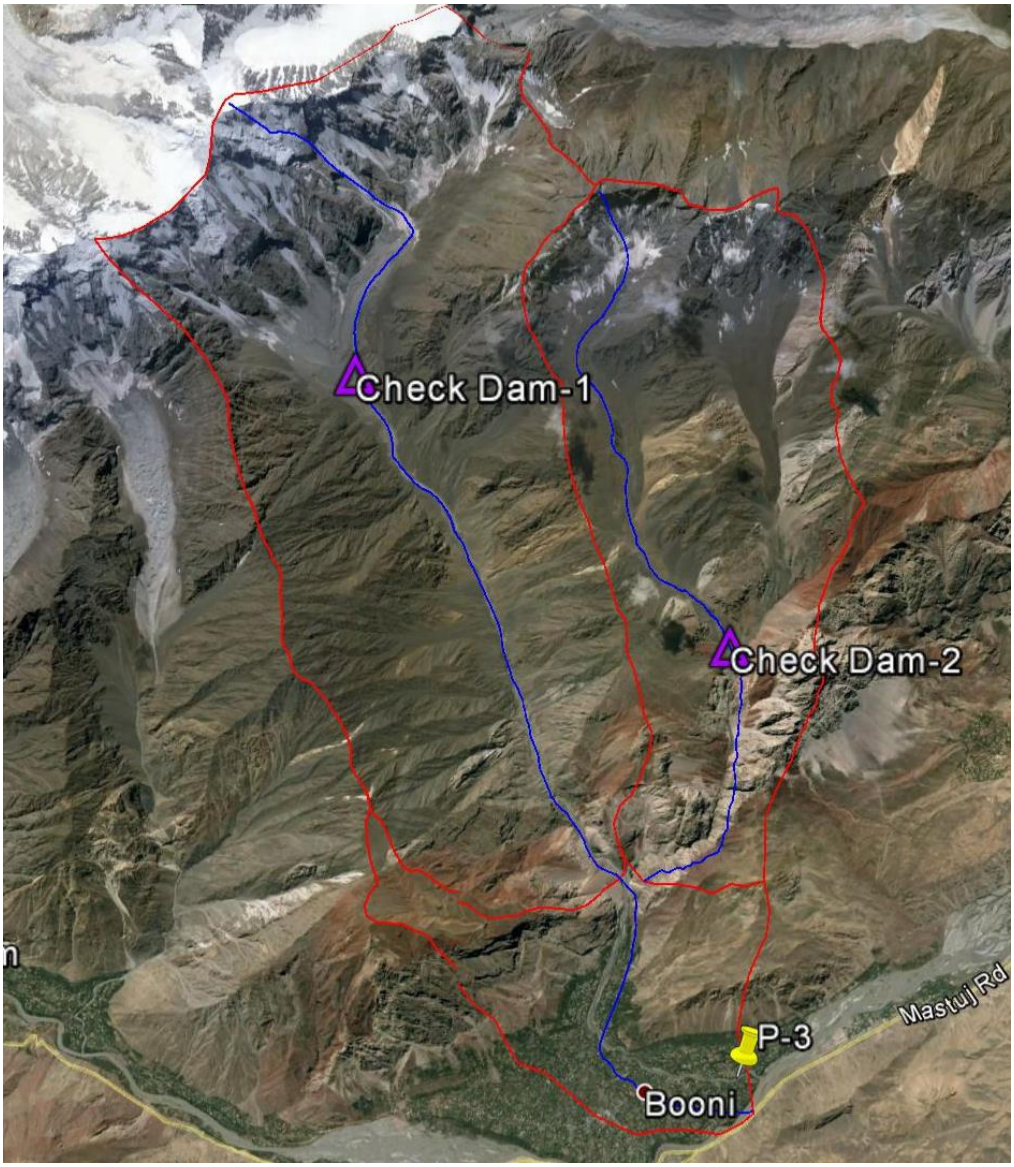


Fig. 15: Tentative Locations of Check Dams

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EXPERIMENTATION STUDY TO INVESTIGATE THE EFFECT OF GREEN ROOF CONSTRUCTION ON INDOOR TEMPERATURE IN LOCAL CLIMATIC CONDITIONS

Imran Tariq[9]

ABSTRACT

Pakistan has been suffering from acute energy crisis; energy outages and its high price are common problems of population around the country. The situation worsens when mechanical cooling turns in, to cool the buildings against scorching summer sun; whereas during winter, keeping the living places warmth is also an expensive business. Migration to big cities has also posed threats like land scarcity and high property prices leaving very little green spaces around. In such scenarios an effort has been made to investigate the impact of green roof construction on indoor temperature of the building in climatic conditions of Lahore city. Extensive green roof was laid using locally available materials, on existing experimental modules constructed on roof top of Department of Architectural Engineering & Design (AED), in University of Engineering & Technology (UET), Lahore. The temperature variations were monitored for 30 days during September and October, 2014. The results showed a significant reduction in indoor temperature peaks in comparison to ambient temperature. Similarly considerable reduction in green roof surface temperature was observed as compared to traditional roof surface.

Key Words: Green Roof, Ambient Temperature, Indoor Temperature.

1. INTRODUCTION

Thermal performance of any building in summer and winter climates is of great concern to inhabitants. Mechanical cooling and heating of the building pose burden to overall living expenses, and in the country like Pakistan which is facing acute shortages and high prices of energy, the situation is exponentially worsens.

Lahore has a very rich architectural background, the Mughal and Colonial buildings have massive walls and roofs, which provide an excellent insulation against climate and keep indoor environment comfortable. However, modernization of architectural practices and increasing prices of real states has reduced the overall thickness of building envelop. Such buildings retain thermal energy more than normal diurnal cycle and do not allow enough time to dissipate it. The population influx has also posed additional burden to real estates [1], resultantly the green spaces within and around the cities are on continuous decline and given rise to urban heat island phenomenon [2].

Lahore is situated in semi arid climate. The summer is usually very long and hot and temperature exceeds 40 ^{o}C [3], whereas in winter temperature drops below 22 ^{o}C [4]. In Lahore both summer and winter conditions demand substantial

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amount of energy to create comfortable indoor environment. This situation necessitates implementation of passive cooling and heating techniques to reduce dependency on mechanical means and hence reduce the overall living expenditures.

Roofs are the most ubiquitous component of the building envelops which contribute significantly to the overall thermal gain of the building.

Green roofs are relatively new in Pakistan as compared to other parts of the world. There is no substantial technical data available regarding its performance in local climatic conditions. In this context an endeavor is made to study its impacts on indoor climate of building. Extensive green roofs were laid on two Experimentation Modules (EM) constructed on roof top of Department of Architectural Engineering & Design in University of Engineering and Technology, Lahore. A total eight Experimentation Modules on different orientations were constructed by Dr. Sabahat Arif in her doctorate Research titled "*Energy Efficient Design, Effect of Orientation on Indoor Temperature Profile"* [5].

In order to establish the thermal performance of green roof, ambient air temperature, surface temperature of traditional roof, surface temperature of green roof and inside temperature of Experimentation Modules 1 & 2 were observed and compared to determine the impact of green roof on indoor temperature of the building.

2. RESEARCH REVIEW

Jim C.Y. et al (2012) compared the thermal performance of an extensive green roof, bare roof and a controlled bare roof of a railway station building in humid-subtropical Hong Kong region. It was concluded that thermal performance of green roof was optimum on sunny summer day, declines on cloudy day and was negligible on rainy day. The extensive green roof constructed over 484 m^2 of area saved an overall 2.80 x 10^4 KWh of electricity for summer air conditioning [6].

Sonne J.K. (2006) studied the energy performance of a green roof constructed on roof of Central Florida University building, during summer and winter of year 2005. The green roof consisted of 6" to 8" of growing media containing plants native to Florida, was executed on 1650 square foot of area, whereas remaining equivalent half was conventional light colored membrane roof. It was concluded that summer heat flux of a green roof was 18.3% less than the conventional roof heat flux. Similarly during winter the weighted average heat flux of a green roof was 49.5% less than the conventional roofing system [7].

Ascione F. et al (2013) reviewed the economic feasibility of green roofs in different climatic conditions of European Countries using numerical procedure implemented in Energy Plus through dynamic energy simulation. The investigated model was a typical traditional European building, insulated in accordance to recent international standards. Five different green roof typologies were modeled and compared their thermal performance with traditional roof system. It was concluded that in warm climates green roofs reduced the cooling energy demand from 0% to 11%. In cold climates green roofs reduce the cooling and heating energy demand

by 1% to 7%. The variables like roof maintenance cost, water tariff and energy cost make green roofs scarcely feasible. However, additional benefits e.g. pollution reduction, aesthetic values etc. justify the adoption of green roofs [8].

Yang J. et al (2008) studied the level of air pollution removed by green roofs in Chicago, using a dry deposition model. It was concluded that 19.8 ha of green roofs removed 1675 kg of air pollutants in Chicago at an annual rate of 85 kg/ha/yr [9].

Bianchini F., et al (2012) analyzed the Net Present Value (NPV) per unit area of green roof by taking into account probabilistic social cost benefit over its lifecycle. It was concluded that green roofs are low risk, short term investments in terms of net returns. The probability of profits out of green roofs is considerably greater than the potential financial losses [10].

Speak A.F. et al (2013) investigated the effect of intensive green roof on air temperature 300 mm above its surface in comparison to the conventional roof. The research was carried out in Manchester, UK. The results indicate that the temperature above green roof was 1.06 ^{o}C lower than the conventional roof. Similarly greatest cooling effect was observed at night with an average difference of 1.58 ^{o}C [11].

3. Experimentation

Experimentation was carried out on 2 No. Experimentation Modules (EM) constructed on roof AED Department in UET, Lahore. Layout plan of the modules is represented in Figure-1. After initial investigation of EM 1, 2, 3 & 4, Experimentation Modules 1 & 2 were selected for construction of green roof.

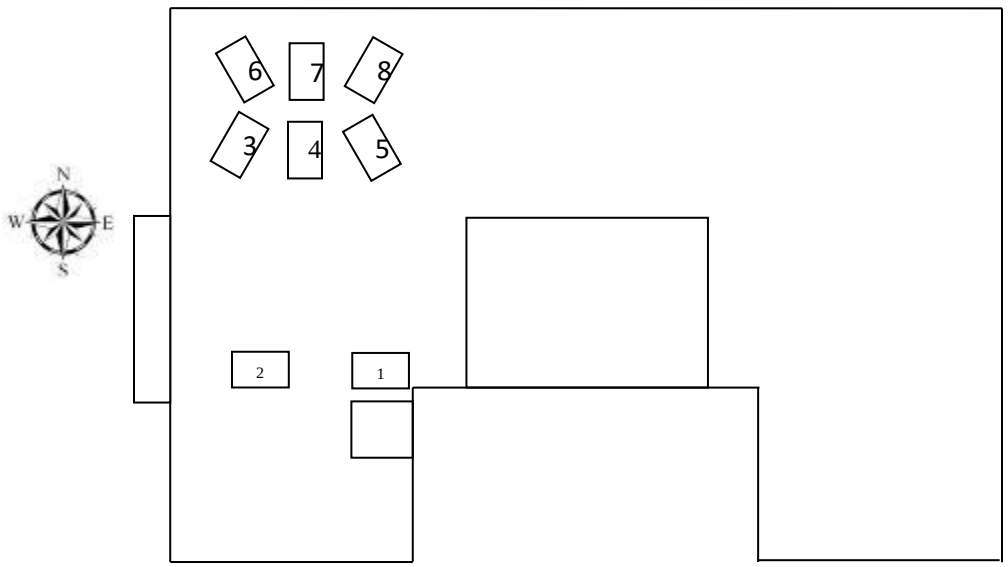


Figure – 1: Schematic Layout of Experimental Modules Constructed on Roof Top of AED Department

3.1. Description of Experimentation Modules

The dimensions of experimental module are 5.5 ft x 7.5 ft x 6.7 ft, each module is constructed in 9 inches thick brick masonry on west wing roof of AED Department at 22 ft above road level. 4 inches thick precast RCC slabs are used as roofing system. Galvanized iron door 6 ft x 2.5 ft and glass panned window 4 ft x 5 ft are installed on shorter walls of each module. Figure-2 indicates plan and x-sectional views of a typical experimentation module.

The windows of each EM was closed from inside as well as from outside with 4.5 inches thick brick masonry, whereas doors were closed from outside with 4.5 inches thick brick work.

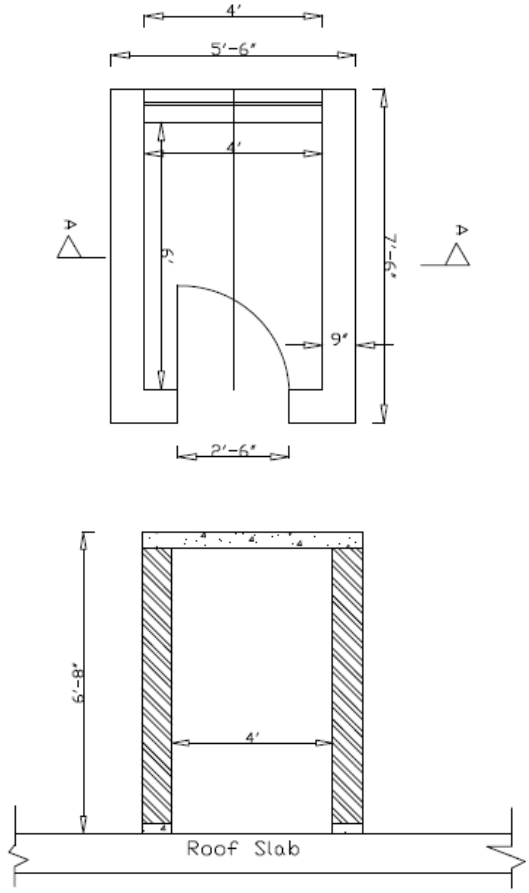


Figure – 2: Typical Construction of Experimental Modules.

3.2 Construction of Green Roof

The existing roofing system of Experimental Modules was modified by providing 1.3^{o} slope to roof slabs to facilitate drainage through substrate. The joints between precast RCC slabs were sealed with 1:3 cement sand mortar. 6 inches high parapet wall was constructed as retention to green roof substrate along periphery

of each EM. Three drainage holes were provided along longitudinal retention wall of each EM. Each hole was fitted with plastic mesh and filtration cloth to retain fines of substrate. Two coats of Fospak Expanbrush were applied on roof and retention walls for water proofing. One inch thick layer of coconut husk was laid over the roof as water retention and filtration layer, over which 4 inches thick layer of growing media, prepared by mixing 2:1 soil and organic fertilizer, was laid. Figure – 3 indicates various green roof construction steps and Figure – 4 shows the x-sectional details of completed Experimentation Module. Plantation for the green roof were as selected which were resilient to micro and macro climatic conditions at roof top, have low irrigation requirements, thick foliage and locally available at low cost. Market survey of various nurseries in the city was carried out for the availability of such plants, and finally ornamental sweet potato vine was selected for plantation on the roof. Plantation was done in the last week of March, 2014. Figure – 5 shows the fully grown green roofs over Experimentation Module 1 & 2. Each green roof was irrigated every alternate day and 20 liters of water was applied each time to each roof.



Figure – 3: Various Steps Showing Construction of Green Roof.

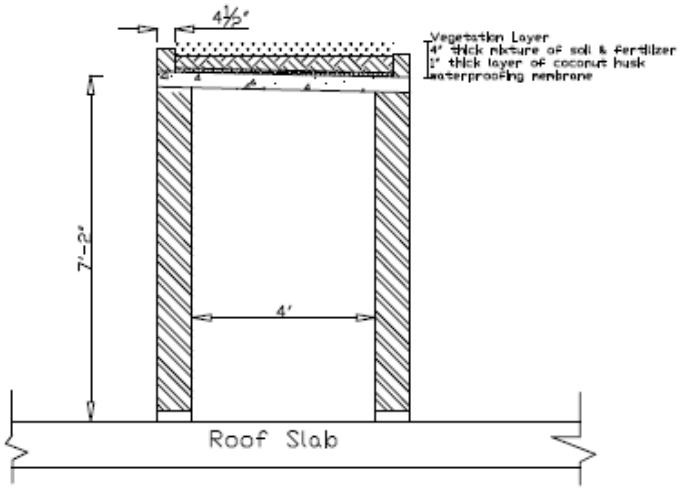


Figure – 4: X-sectional View of Completed Experimentation Module

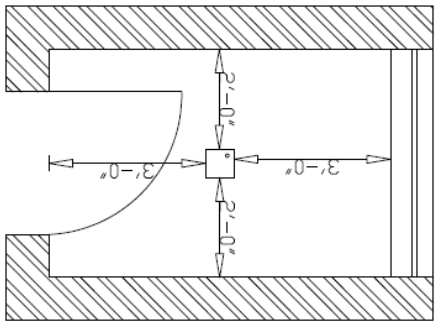


Experimentation Module # 1 b) Experimentation Module # 2

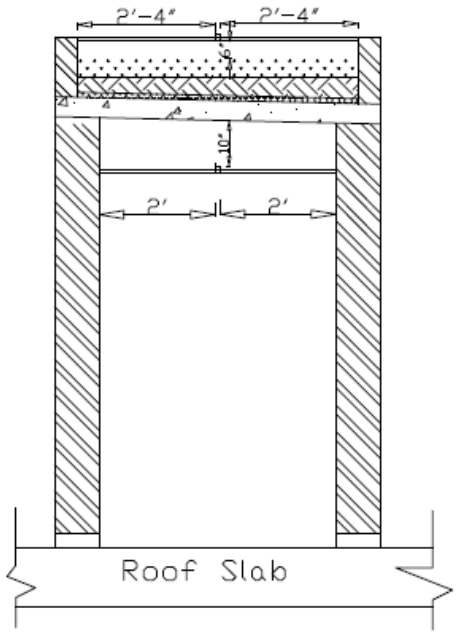
Figure – 5: Fully Grown Green Roof on Experimentation Modules.

3.3 Temperature Monitoring

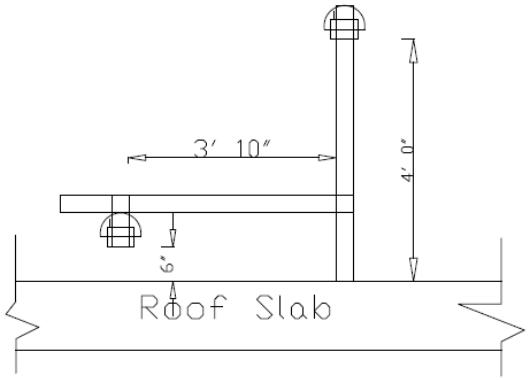
Temperature was monitored using Testo Saveris System, five temperature sensors were installed at various locations to monitor and record temperatures at half an hour time interval. Two temperature sensors were installed at 6 inches height to measure traditional roof surface and green roof surface temperatures respectively. Two temperature sensors were installed 10 inches below the inside roof surface in middle of each Experimentation Module and one sensor was installed at 4 feet height to measure ambient temperature [11]. Figure – 6 indicates location of different temperature sensors.



a) Location of Inside Temperature Sensor



b) Location of Inside and Green Roof Surface Sensors



c) Location of Traditional Roof Surface and Ambient Temperature Sensors

Figure – 6: Location of Temperature Sensors

4. Experimentation Results

Temperature measurements were taken on half hourly basis from September 24th, 2014 to October 23rd, 2014. Table – 1 shows the 30 days average of half hourly temperature measurements at all five locations. Figure – 7 is the graphical representation of temperature variations indicated in different colors.

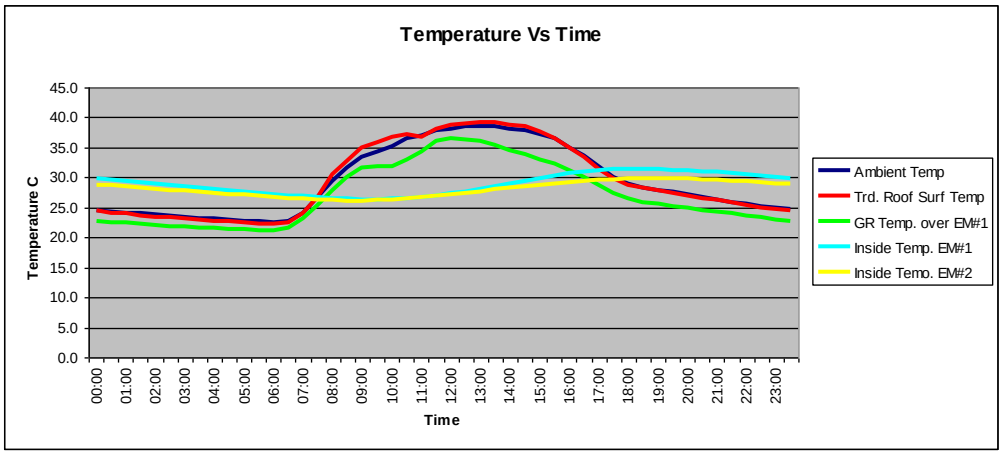


Figure – 7: Average Half Hourly Monitored Temperature Profile

Table – 1: 30-Days Average of Half Hourly Monitored Temperature

Average Half Hourly Temperature °C														
Sr	Time	Ambient	Trad. Roof Surface	Green Roof Surface	Inside EM#1	Inside EM#2		Sr	Time	Ambient	Trad. Roof Surface	Green Roof Surface	Inside EM#1	Inside EM#2
1	00:00	24.6	24.4	22.8	29.7	28.8		25	12:00	38.1	38.8	36.6	27.4	27.2
2	00:30	24.4	24.2	22.6	29.5	28.6		26	12:30	38.6	38.9	36.4	27.7	27.4
3	01:00	24.2	24.0	22.6	29.3	28.5		27	13:00	38.5	39.2	36.1	28.1	27.7
4	01:30	24.0	23.7	22.3	29.1	28.3		28	13:30	38.5	39.2	35.5	28.5	28.0

Average Half Hourly Temperature °C																								
Inside EM#2	28.2	28.5	28.8	29.0	29.2	29.4	29.6	29.7	29.8	29.9	29.9	29.9		Inside EM#2	28.1	27.9	27.8	27.6	27.4	27.3	27.1	26.9	26.8	26.6	26.4	26.3
Inside EM#1	29.0	29.5	29.9	30.3	30.7	31.0	31.2	31.3	31.4	31.4	31.4	31.3		Inside EM#1	28.9	28.7	28.5	28.2	28.0	27.8	27.6	27.4	27.2	27.0	26.9	26.7
Green Roof	34.5	33.8	33.1	32.3	31.3	30.1	28.7	27.5	26.4	25.9	25.6	25.2		Green Roof	22.0	21.9	21.9	21.7	21.6	21.4	21.3	21.3	21.2	21.6	23.2	25.5
Trad. Roof Surface	38.9	38.6	37.7	36.6	35.0	33.5	31.4	29.8	28.8	28.2	27.8	27.4		Trad. Roof Surface	23.4	23.3	23.1	22.9	22.8	22.6	22.4	22.3	22.2	22.6	24.2	26.7
Ambient	38.2	37.9	37.1	36.6	35.1	33.6	31.9	30.0	28.9	28.3	27.9	27.6		Ambient	23.7	23.6	23.4	23.2	23.1	22.9	22.7	22.7	22.5	22.7	24.0	26.8
Time	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30		Time	02:00	02:30	03:00	03:30	04:00	04:30	05:00	05:30	06:00	06:30	07:00	07:30
Sr	29	30	31	32	33	34	35	36	37	38	39	40		Sr	5	6	7	8	9	10	11	12	13	14	15	16

Average Half Hourly Temperature °C																								
Sr	Time	Ambient	Trad. Roof Surface	Green Roof	Inside EM#1	Inside EM#2		Sr	Time	Ambient	Trad. Roof Surface	Green Roof	Inside EM#1	Inside EM#2		Sr	Time	Ambient	Trad. Roof Surface	Green Roof	Inside EM#1	Inside EM#2	
17	08:00	29.4	30.5	27.8	26.6	26.2		41	20:00	27.2	27.0	24.9	31.2	29.8		1	00:00	26.7	26.5	24.4	30.6	29.4	
18	08:30	31.7	32.8	30.1	26.5	26.1		42	20:30	26.7	26.6	24.5	31.0	29.7		2	00:30	26.5	26.3	24.3	30.5	29.3	
19	09:00	33.4	35.0	31.7	26.4	26.1		43	21:00	26.3	26.2	24.3	30.9	29.6		3	01:00	26.4	26.2	24.2	30.4	29.2	
20	09:30	34.3	36.0	31.9	26.4	26.2		44	21:30	25.9	25.8	24.0	30.7	29.5		4	01:30	26.3	26.1	24.1	30.3	29.1	
21	10:00	35.3	36.7	31.9	26.5	26.4		45	22:00	25.6	25.4	23.6	30.5	29.3		5	02:00	26.2	26.0	24.0	30.2	29.0	
22	10:30	36.6	37.2	33.0	26.6	26.5		46	22:30	25.2	25.1	23.3	30.3	29.2		6	02:30	26.1	25.9	23.9	30.1	28.9	
23	11:00	37.0	36.8	34.2	26.8	26.8		47	23:00	24.9	24.7	23.0	30.1	29.0		7	03:00	26.0	25.8	23.8	29.9	28.8	
24	11:30	37.9	38.1	36.1	27.1	26.9		48	23:30	24.7	24.5	22.8	29.9	28.9		8	03:30	25.9	25.7	23.7	29.8	28.7	

5. Data Analysis

5.1 Comparison between Ambient and Traditional Roof Surface Temperature

Figure – 8 indicates the 30 days average half hourly ambient and traditional roof surface temperatures. The data shows a general cyclic trend. The roof surface remained warmer than the ambient temperature during 0700 hrs till 1500 hrs. whereas ambient temperature was greater than roof surface temperature . Maximum difference between traditional roof surface temperature and ambient temperature was 1.7 ^{o}C, which can be interpreted as; traditional roof surface was 4.7% warmer than the ambient temperature.

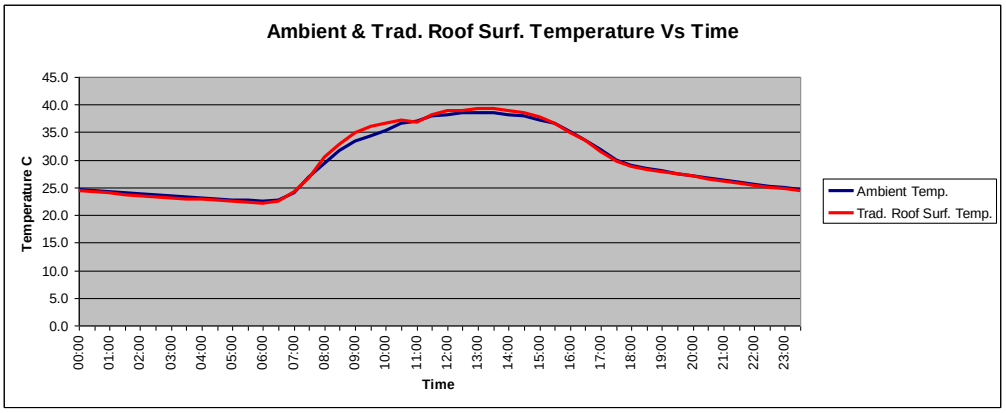


Figure – 8: Ambient and Traditional Roof Surface Temperature Profile

5.2 Comparison between Ambient and Green Roof Surface Temperatures

Figure - 9 shows 30 days average half hourly temperature data of ambient and green roof surface temperatures. Maximum difference between ambient and green roof surface temperature was 4.3 ^{o}C, which means ambient temperature was 13.2% greater than the green roof surface temperature. The data reveals that the ambient temperature remained warmer than the green roof surface temperature round the clock.

5.3 Comparison between Green Roof Surface and Traditional Roof Surface Temperatures

Figure - 10 represents the 30 days average half hourly temperature observation of traditional roof surface and green roof surface temperatures. Maximum difference between traditional roof surface and green roof surface temperature was 4.8 ^{o}C, which means traditional roof surface was 15.1% warmer than the green roof surface. The data further reveals that the traditional roof surface remained hotter than the green roof surface round the clock.

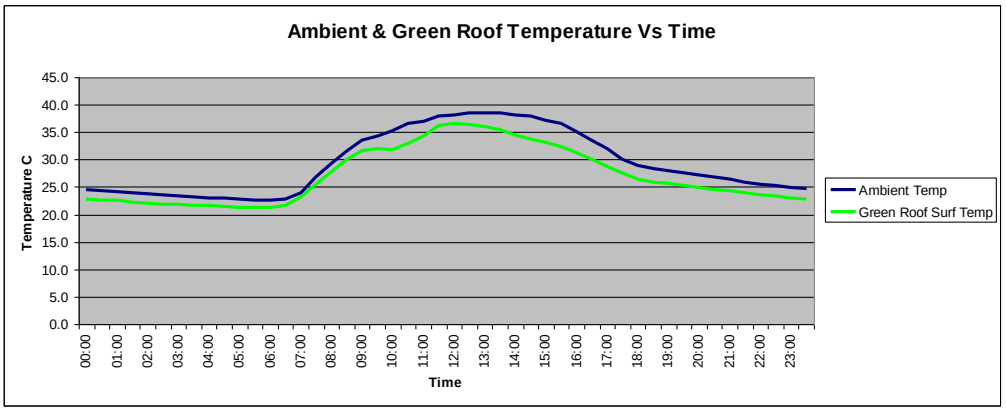


Figure – 9: Ambient and Green Roof Surface Temperature Profile

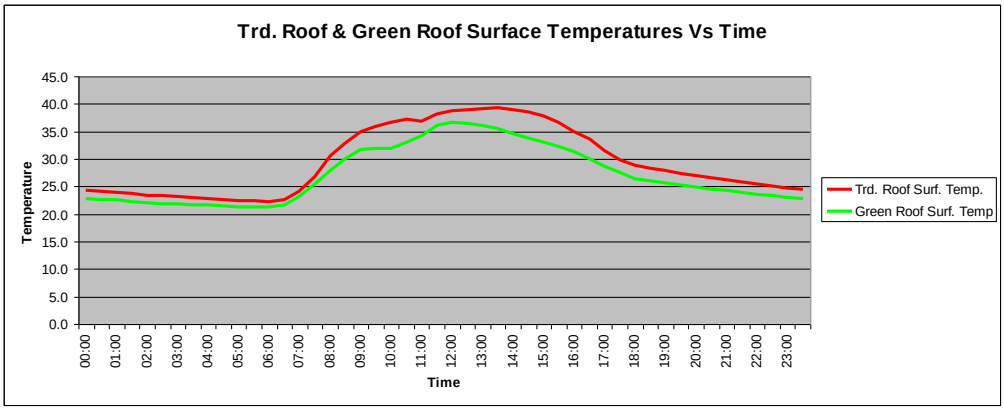


Figure – 10: Traditional Roof Surface and Green Roof Surface Temperature Profile

5.4 Comparison between Ambient and Inside Temperature of Experimentation Module # 1

Figure - 11 shows 30 days average half hourly records of ambient temperature and inside temperature of experimentation module#1. Maximum difference between ambient and green roof surface temperature was 10.9 ^{o}C, which means ambient temperature was 39.2% greater than the inside temperature of EM#1. 24 hrs inside average temperature of EM#1 was 28.9 ^{o}C. The data revels that inside temperature of EM#1 remained lower than the ambient temperature from 0730 hrs till 1700 hrs, whereas inside temperature of EM#1 remained warmer than ambient temperature from 1730 hrs till 0700 hrs in next morning.

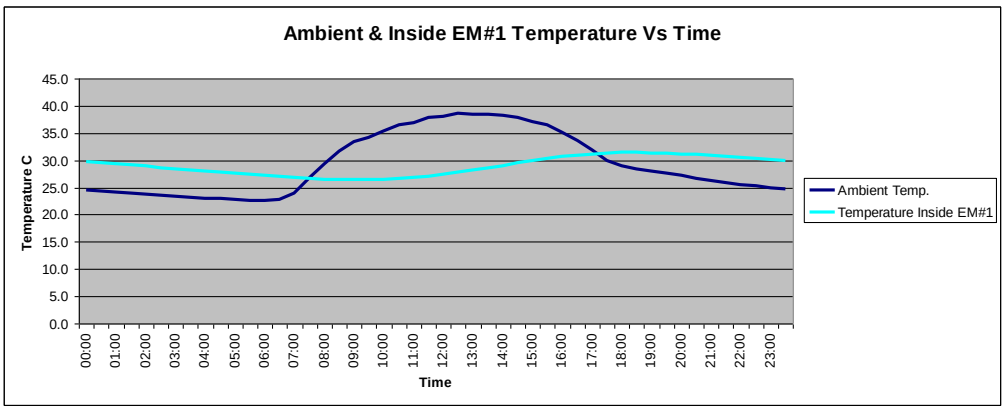


Figure – 11: Ambient and Inside of Experimentation module # 1 Temperature Profile.

5.5 Comparison between Ambient and Inside Temperature of Experimentation Module # 2

Figure -12 shows 30 days average half hourly data of ambient temperature and inside temperature of experimentation module#2. Maximum difference between ambient and green roof surface temperature was 11.2 ^{o}C, which means ambient

temperature was 40.7% greater than the inside temperature of EM# 2. 24 hrs inside average temperature of EM#1 was 28.1 ^{o}C. The data revels that inside temperature of EM#2 remained lower than the ambient temperature from 0730 hrs till 1730 hrs, whereas inside temperature of EM#2 remained warmer than ambient temperature from 1800 hrs till 0700 hrs in next morning.

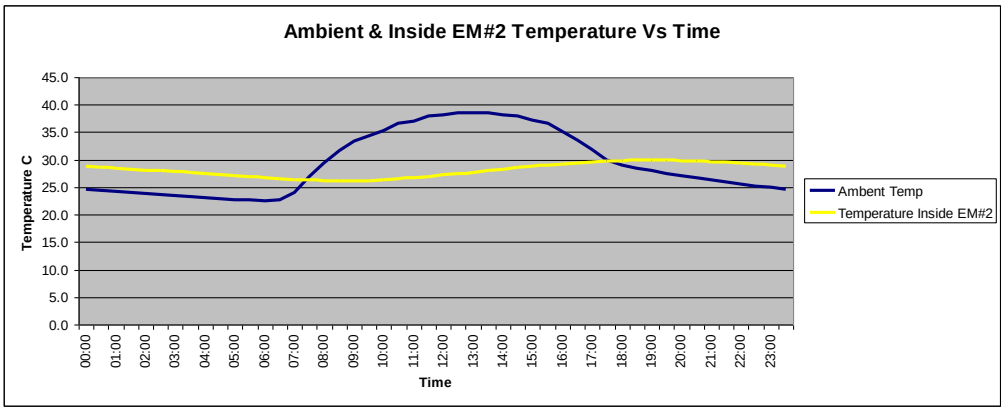


Figure – 12: Ambient and Inside of Experimentation module # 2 Temperature Profile

6. Discussion on Results & Analysis

The research was carried out to determine the impact of green roof system on indoor air temperature. It involves measurement of ambient, surface temperature of traditional roof and green roof and inside temperature of experimentation modules. The measurements were taken for 30-days and average half hourly temperature was analyzed. The observations revealed that green roof has significantly impacted the inside temperature of experimentation modules. Maximum difference of 11.2 ^{o}C has been observed between ambient and inside EM temperature. Green roof has imparted significant insulation effect to the modules, which kept the maximum inside temperature peak to 31.4 ^{o}C in EM#1 and 29.9 ^{o}C in EM#2. Temperature of inside experimentation modules remained higher than ambient temperature from 1730-1800 hrs till 0700 hrs, whereas ambient temperature remained higher than inside EM temperature from 0730 hrs till 1700-1730 hrs of EM#1 & EM#2 respectively. The green roof has also impacted the surface temperature, a difference of 4.8 ^{o}C has been observed between traditional and green roof surfaces.

7. Conclusions

This research work clearly demonstrates the significance of green roof system in prevailing energy crisis. Green roof system has kept the overall inside temperature peak well below the ambient temperature also green roof has reduced the surface temperature, from where it can be concluded that by constructing green roof system, cooling and heating loads of the building can be reduced significantly. Furthermore, green roof was also helpful in reducing overall surface temperature. The reduced surface temperature will ultimately be helpful in reducing the urban

heat island effect if executed at vast scale. Further research should also be carried out to study the effect of intensive and semi-extensive/intensive green roofs on indoor and surface temperatures in local environmental conditions.

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Artificial Recharge and IWRM at Community Level – The Balozai Project in Balochistan

Dr Abdul Majeed[10]

Abstract

Balochistan Province of Pakistan lies in the hyper-arid to arid type of climate making irrigation an absolute necessity for practicing sustainable agriculture. Because of the overall mismanagement in the water sector, the province is facing acute water availability problems. In the absence of assured and timely availability of surface water supplies the people of the province have come to depend heavily on groundwater. Continued unabated abstraction of groundwater through tubewells has resulted in mining of the groundwater resource in most aquifer systems. An innovative project was undertaken by IUCN – the World Conservation Union in Balozai community of Pishin District of Balochistan Province of Pakistan principally to introduce, demonstrate and promote artificial recharge technology for replication in other areas. Small scale limited interventions related with Integrated Water Resource Management (IWRM) were also introduced in the area with the participation of the local community. These include improvement of local ecology and scenic beauty through successful plantations of local plant species on the dam body, income generation through fish culture and conversion of the area into a picnic spot, improving access of rural women to clean drinking water and washing point for laundering, improving water conveyance and on-farm water use efficiencies, green house technology, etc. The initial results of the project during the test phase are very encouraging and prove the success of the project in elevating water tables and increased availability of water for agriculture. It is recommended that the technology should be replicated in those river basins of Balochistan where water resource mining is occurring and water tables are receding.

Key words: Artificial recharge, Integrated Water Resource Management, aquifer buildup, high efficiency irrigation system, community participation

1. Introduction

Balochistan has 13 major perennial river systems, which receive water from many inland and coastal streams; the potential is crudely estimated at 12 BCM. There is great variation in this potential from year to year depending on precipitation intensity and duration. Also the estimates are not accurate as they are based on

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empiricism and on the available meteorological data from stations located in the valleys where precipitation is lower than the mountain slopes, which contribute greatly to the run-off.

Most of the streams and springs in the Province are of small capacity with wide temporal variation in their discharges. Large-scale development of surface water resources is problematic on account of high variability in their flows, lack of sufficient and reliable data, huge development costs involved, high rates of evaporation, and large quantities of silt loads brought in by the streams.

In the absence of assured surface water supplies the people have come to depend heavily on groundwater to meet their requirements. The resource was traditionally exploited through the Karez[11] system, which was quite efficient and met various requirements and kept the water tables in balance. However, the advent of electricity in the province in late 60s and installation of a large number of tubewells to pump groundwater completely changed the groundwater regime. The problem was compounded further by the perverse government subsidy (flat rate) on energy use for tubewells, which acted as an incentive to continuous pumping.

The unabated abstraction of groundwater, over the years, has resulted in heavy over-pumping of the resource resulting in depletion of water tables in many aquifer systems. This problem has become more acute in recent years due to the continued and extended drought faced by the country. The most affected areas all lie in upland Balochistan and are in the Pishin Lora Basin, comprising the districts of Quetta, Mastung, Pishin, and Kalat. It is estimated that the water tables are going down at rates exceeding 3 meters per year depending on the geology of the affected area and the extraction rates. Other river basins are also faced with the problem of depleting water tables.

The underlying reasons for this decline have been mostly the increasing trend of growers towards horticulture (apple orchards) and the flat rates of electricity use for tubewell operation, which serves as an incentive to operate the tubewells for increased hours and thus use water injudiciously. Though detailed studies have not been undertaken, it is also suspected that the climatic change over the years due to the ozone layer depletion phenomenon may also be responsible for reduced rain/snow falls resulting in lower recharge. The poor watershed conditions (denuded slopes) are also contributing the reduced natural recharge rates.

The seriousness of the issue requires finding ways and means to increase recharge to the aquifers. Being alive to the problem the government focused its attention on technical solutions and constructed numerous (over 200) delay action dams at various locations with the sole purpose of recharging the aquifer systems.

[11] Karez is underground tunnel, often 3 to 4 km long, interspersed with vertical open shafts and laid at a gradient to convey water from the foothills in the alluvial fans to the center of the valley for agriculture/domestic use.

The underlying idea was the beds of the reservoirs created by the dams would act as recharging surfaces. The efforts were never complemented with watershed improvement/management practices to reduce erosion, reduce silt loads in streams, thereby maintain the natural rates of infiltration in the beds of the reservoirs.

The water use practices in Balochistan leave much to be desired. Most often flood irrigation is practiced for irrigating orchards. The water use efficiency under this irrigation method is very low and ranges from 17-2 percent. Even with some improved field layouts and use of furrow irrigation the efficiency never exceeds 50%. This is colossal loss of water particularly as the water is scarce and meager resource in the province and majority of farmers have to pump water from depths greater than 500 feet.

Poor access to safe drinking water for the women of the area is another area where interventions are necessary to be carried out. Currently, though water is available in sufficient quantities for drinking purposes, yet it is found to be highly contaminated almost everywhere in the province due to various point and non-point sources of pollution. Consequently incidences of cholera, hepatitis, enteric fever, and mal-nutrition are very common in Balochistan.

The continued degradation of watersheds of the river basins in Balochistan is another serious problem which needs urgent and immediate attention at all levels of stakeholders including the communities who live in these watershed boundaries.

The IWRM concepts and principles are ever gaining increased acceptance by majority of the stakeholders involved in water management all over the world. While translating these concepts and principles into practice is a real challenge for Pakistan, the situation in the Balochistan province of Pakistan is rather more difficult and complex, as there is inadequate capacity in implementing the water sector projects, especially the integrated projects. The multitude of problems enumerated above calls for integrated approach to approach the problem from all angles. These include resource development and protection, resource management and its rational use by different competing sectors of economy in particular the domestic, agricultural, and environmental ones.

2. Current Approaches

The efforts of the government to restore the aquifer conditions have been mostly directed towards finding engineering solutions (structural means), by building delay action recharge dams across some of the ephemeral streams in the foot slopes of the mountains. The technique apparently is fine, as it was hoped that the deep percolation in the beds of the reservoirs created by these dams would recharge the aquifers beneath. The hopes unfortunately could not become facts, as field observations clearly establish that the high content of fine clay in the river, brought in during rainstorms, gets deposited and rapidly seals the supposedly

recharging beds of the reservoirs created by the recharge dams. Additionally the flash floods sometimes cause the dams to be washed away at the height of the flood, which causes loss of life and property.

Meanwhile, more boreholes continue to be drilled, and the water table continues to drop causing the traditional Karez systems in the province to dry up and the tubewells to be deepened almost every couple of years. Currently water is being pumped from over 500 feet in many places raising serious questions of economic and technical sustainability of the resource. There is now urgent need for taking all possible remedial actions to control the situation and increase recharge to balance the groundwater abstraction.

Experience has shown that engineering solutions alone are not able to control the situation. It is of utmost necessity that an integrated approach consisting of engineering, biological, and regulatory be applied in the affected areas to rejuvenate the depleting aquifers. Taking cognizance of the importance of achieving greater water balance between abstraction and recharge, the IUCN Pakistan's Water Programme, has given the highest priority to promote artificial recharge practices in Balochistan. The idea is to make the best use of the huge investment already made in these dams, where water does get collected but is either totally or partially lost to evaporation due to the filling in of the pores of the underlying soil beneath the bed of the reservoir created by these dams. The efforts were coupled with other technological solutions in water conservation and practices aimed at income generation to help alleviate poverty.

3. Pilot Demonstration Project Area

The site identified for this purpose is the Balozai village near Khanozai town in Pishin District on the border between Pishin and Qila Saifullah districts. The site has a delay action dam constructed by the Irrigation department for improving recharge to the local aquifer so that the Karez system in the area remains operational. There is no outlet provided in the dam to release water on the downstream side. The location map is given as Fig. 1 and the Balozai Dam is shown in Fig. 2.

The village gets its water from a Karez system supposed to receive/augment its water from the reservoir created by construction of the Balozai delay action dam just after crossing the Khanozai Town on the left side of the road leading to Qila Saifullah. The dam has visible signs of silting by deposits of fine clayey sediments; in fact the dam was once de-silted but the problem has continued seriously impeding the likelihood of the reservoir contributing to recharge the flowing Karezes in the area. The local communities have stated that most of the times the Karez remains dry despite the fact that there is water in the dam, which adds to the evidence that the dam is not contributing recharging the aquifer, where water is below the level of the mother well and thus there is no Karez flow.

Besides agriculture (orchard and vegetable growing) the water from these Karezes is also used for drinking and other domestic use like cooking and laundering clothes, etc. The community is facing serious problems of water borne diseases like dysentery, hepatitis, typhoid, etc. which is indicative of severe problems of bacterial pollution in the water. Most of the village people are poor and, due to low water availability in the Karez, depend on subsistence level agriculture/ horticulture and livestock production.

4. Project Cycle and Interventions

Fig. 3 is the project cycle followed in the project design and implementation. Gender concerns and poverty and livelihood matters have also been included in the project implementation cycle. Following this cycle the following activities in chronological order have been undertaken:

1. Identifying the location of the artificial recharge systems and technique to be used.
2. Getting permission and concurrence of the Government of Balochistan, Irrigation Department.
3. Dialogues with the community to educate them on the proposed artificial recharge system to seek their concurrence to laying the system and to get their active involvement in reforestation activities and water conservation.
4. Designing the proposed system based on the local available data, linkage to the Karez and other on-ground conditions.
5. Organizing the beneficiary community for participating in project activities, sharing the cost of lining the channel, maintaining the system and tree plantation works.
6. Lining of the channel from daylight point of Karez system on the downstream side of the dam to the users' fields.
7. Installing appropriate number of high efficiency irrigation systems on beneficiary farmer's land with their active collaboration. In financial terms, the collaboration would be 30 (farmer):70 (IUCN) ratio. It is proposed to install at least 25 acres of orchard areas with bubbler and other similar efficient systems.
8. Providing a bed and furrow shaper and rain-gun sprinkler to help them in water conservation on their agricultural fields.
9. Plantation in the area immediately surrounding the dam reservoir.
10. Introducing fish in the reservoir in collaboration with the Fisheries Department.
11. Monitoring impact of the project on local water tables and Karez discharge.

Based on the issues identified in the area, the following interventions have been carried out in the project area as part of the design.

i. **Artificial recharge mechanism:**

Under this component both inverted well technology for access to local aquifer and siphon pipe technique for taking out water from dam reservoir are being demonstrated. The inverted well technology basically consists of drilling a large diameter borehole in the ground down to aquifer to provide direct path for water to infiltrate into the ground and thus recharge aquifer. The water can then flow under gravity or may be forcefully injected through reverse pumping; though this is not planned. The basic requirements for an artificial recharge inverted well scheme are adequate source of water to recharge and the right hydro-geological environment to support such activity. In operation it is essentially the opposite of groundwater abstraction, a recharge mound forms rather than a cone of depression due to pumping of water downward.

As means to discharge water from dam reservoir are not available in most delay action dams constructed by the Irrigation Department – the Balozai dam being one of them – siphon pipe has been used for the purpose to allow conveyance of water from the reservoir to the recharge wells on the downstream side of the dam. Basically the system is a simple one and consists of providing inverted siphon pipes to allow flow of water over the body of the dam to be released and spread on the downstream riverbed for recharge to take place in the highly permeable riverbed. In this particular project the siphon pipe conveys water to the recharging inverted wells.

Figure 4 is a schematic diagram of the recharge system installed in the field.The major components of the mechanism are the following:

- **Siphon pipe** The siphon pipe used is a 2 ½ inch diameter almost 2,200 feet long PVC pipe fitted with a foot valve at the intake side and a gate valve at the delivery side. The intake/suction pipe is placed under a floating plate-form to ensure that the intake valve always keeps it position in accordance with the rising or falling water level in the reservoir.
- **Sand and gravel filter:** The pipe delivers water to a 2' X 2' surface area and 8 feet deep water tight filter tank filled with sand and gravel so that any suspended particles are trapped and do not find their way into the recharge wells. The outlet pipes from the sand filter are placed at appropriate height above the bottom to ensure the gravitational flows occurs from the filter to the network. Photo 1 shows the filter tank.
- **Recharge mechanism:** The recharging mechanism consist of a network of six 18" diameter boreholes going right up to the

water table and placed 200 to 250 feet apart. In the boreholes are installed slotted PVC pipes of 12" diameter surrounded by washed gravel to act as filtering media and reduce the cost. The boreholes themselves are placed in water tight tanks of the same sized as the sand filter with the purpose to ensure that the water goes into the boreholes directly through the slots and nowhere else.

Fig. 5 shows a section of the recharge borehole along with the water receiving tank. The inlet pipes are fitted with measuring devices (water meters) for monitoring purposes. Photo 2 shows the inside of the recharge tank and borehole/well with monitoring devices.

ii. Water conservation technologies

Conveyance channels from the daylight point of the Karez to the command area in the Balozai are earthen and unlined resulting in considerable losses. In Balozai, the losses as per reconnaissance survey undertaken, were estimated at 50% from the head to the tail end in a length of 4500 feet.

Lining consists of 9" thick Pacca Cement masonry on the sidewalls plastered with 1:4 ratio cement plaster and 4" thick Pacca Cement Concrete (PCC) on the floor. The Cementing plaster and PCC was enriched with Pudlo chemical to ensure water tightening for reduced leakage. Sections of the unlined and lined channel can be seen in Photo 3.

The project has installed for demonstration purposes a number of high efficiency irrigation technologies in the project area. These include trickle/bubbler, sprinkler (rain-gun), bed and furrow, and zero tillage irrigation practices.

iii. Tree plantation on dam to improve scenic beauty.

This activity was planned to integrate recreational and environmental use of water component in the project. The local community has contributed by providing labor for excavation. A number of different tree varieties have been planted on the body of the dam and are being irrigated through trickle irrigation. Photo 4 depicts comparison of the tree plantation at the time of plantation in July, 2006 and current (May 2007).

iv. Slow sand water filtration systems to improve access to safe water by women.

This activity was found necessary to cover the IWRM component of "Water for Drinking". As already stated earlier the local population is exposed to water borne diseases of various kind due to the presence of Coliform and E.Coli proved by doing analysis of water samples from the

drinking water sources. The Community has been advised of the consequences and remedial measures like boiling are already taken by the local community. However, to ensure that the Karez water use for drinking is safe and free from pollution sources, a small scale slow sand filtration technology and other means has been constructed and is operational.

v. Washing point for women to do their laundering.

Balozai area women are using the daylight point of the Karez for doing their washing and laundering, which is causing pollution of the water used downstream for ablution in the mosque and for drinking further downstream. A separate washing place has been provided near the daylight point to ensure that no pollution occurs because of this practice.

vi. Raising income through fish culture in the dam reservoir.

The history, as assured from the community, shows that water in the dam reservoir remains for a considerable length of time (at least 6 months) even if no rain occurs during this time. This makes it possible to practice fish culture to increase the community's income. Seeds of two varieties of fish (Gulfam and China Grass Carp) were introduced. These have now grown to 4 lbs in weight. However due to lack of technical knowhow with the local community the fish crop could not be harvested.

v. Monitoring impacts

Two Master of Science students from the Balochistan University of Information Technology and Management Sciences (BUITMS) have worked on the projects site to collect and analyze data on the impact of the project on the local aquifer and discharge in the Karez.

7. Results and Discussions

The project activities that have been completed and our experience with the communities have highlighted the importance of taking the communities along all stages of concept clearance, project formulation, project development, project execution, and operation and maintenance. In this particular case the community coming from a backward of Balochistan was sensitized fully after a long process of dialogues on the project concept and the benefits that were likely to accrue from the project implementation. As a result the community fully participated in all activities and is sharing the cost of irrigations technology components in cash.

This artificial recharge approach is the first of its kind not only in Balochistan but in Pakistan as well. The Water Programme of IUCN now has made elaborate plans to monitor the impact of the project on the local communities and undertake a number of outreach workshops at the project site in which farmers from other areas with similar problems, policy makers, and water managers would be invited to

participate and see the project components. The ultimate aim is to achieve the ends of effective dissemination of the technologies.

Initial results during 11 days (15,715 minutes) of test runs in the project area have been very encouraging. A total of about 431,995 gallons was released from the dam in 4 days (5,855 minutes) and allowed to recharge the aquifer. During this period the recharge wells never overflowed which indicates that all water was recharged. Fig. 6 shows the water level behavior as recorded from the observation well. It can be seen that the water table started rising in the observation well after 1,335 minutes and continued to rise by 126 cm till 5,755 minutes. The system was closed after 5,855 minutes of running. However, the water table remained stable at the same level for 1500 minutes after closing. The water table started falling after 8,355 minutes. The trend was observed till 15,755 minutes when the overall gain in water level was recorded at 20 cm. It must be remembered that during all this period the Karez continued to flow with increasing discharges as can be seen from Fig. 7.

It is concluded that the observation well, which is about 100 meters away from the recharge system, recorded the impact after 1335 minutes and thus the average travel speed of groundwater flow was 7.5 cm/minute. Similarly the water table dropped by 106 cm in 7350 minutes or 1.44 cm/minute. It can be seen from the Karez impact figure that flow at daylight point (1280 meters away from system) started showing increase after 2725 minutes of system operation when 199,240 gallons of water had been recharged. The discharge increased by 16 gallons/minute after 7,175 minutes of system operation by which time 1,320 minutes had elapsed since the system had been closed.

The following recommendations are made:

1. Because of successful demonstration of the technology and its positive results, replication of the technology of artificial recharge be done for all delay action dams in the province so that they become effective once again for the purpose they were designed and constructed at huge cost to the provincial exchequer.
2. Beneficiary communities can easily share the cost of the artificial recharge system, as it is very cheap. However, technical and financial support can be provided by the government.

The project is too young at this stage to carry out an in-depth analysis of impact on poverty. It is recommended that this monitoring be done at least after one year of system running.



Fig. 1: Location of Project Site (Balozai)



Fig. 2: Balozai Dam and surrounding areas

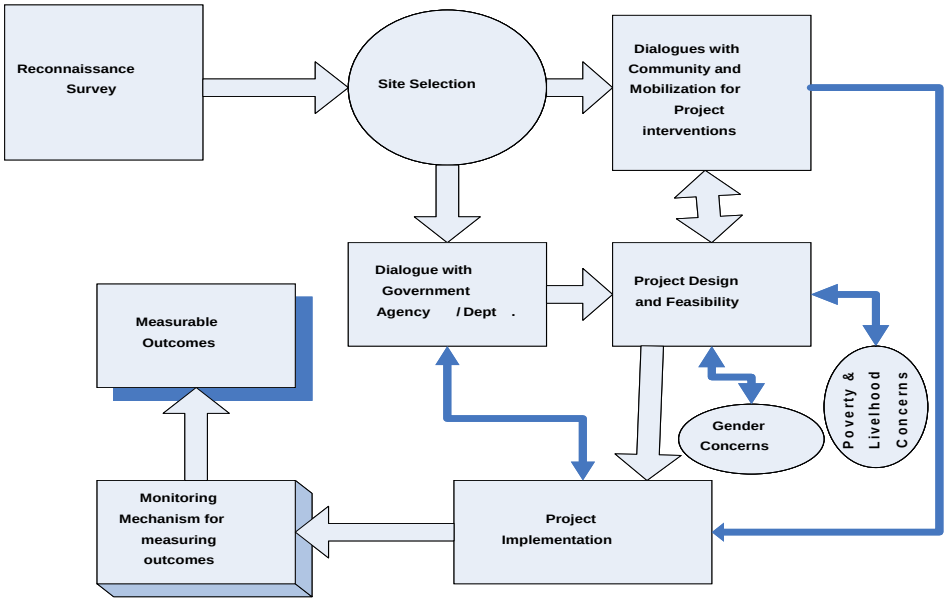


Figure 3: Project cycle followed during planning and implementation

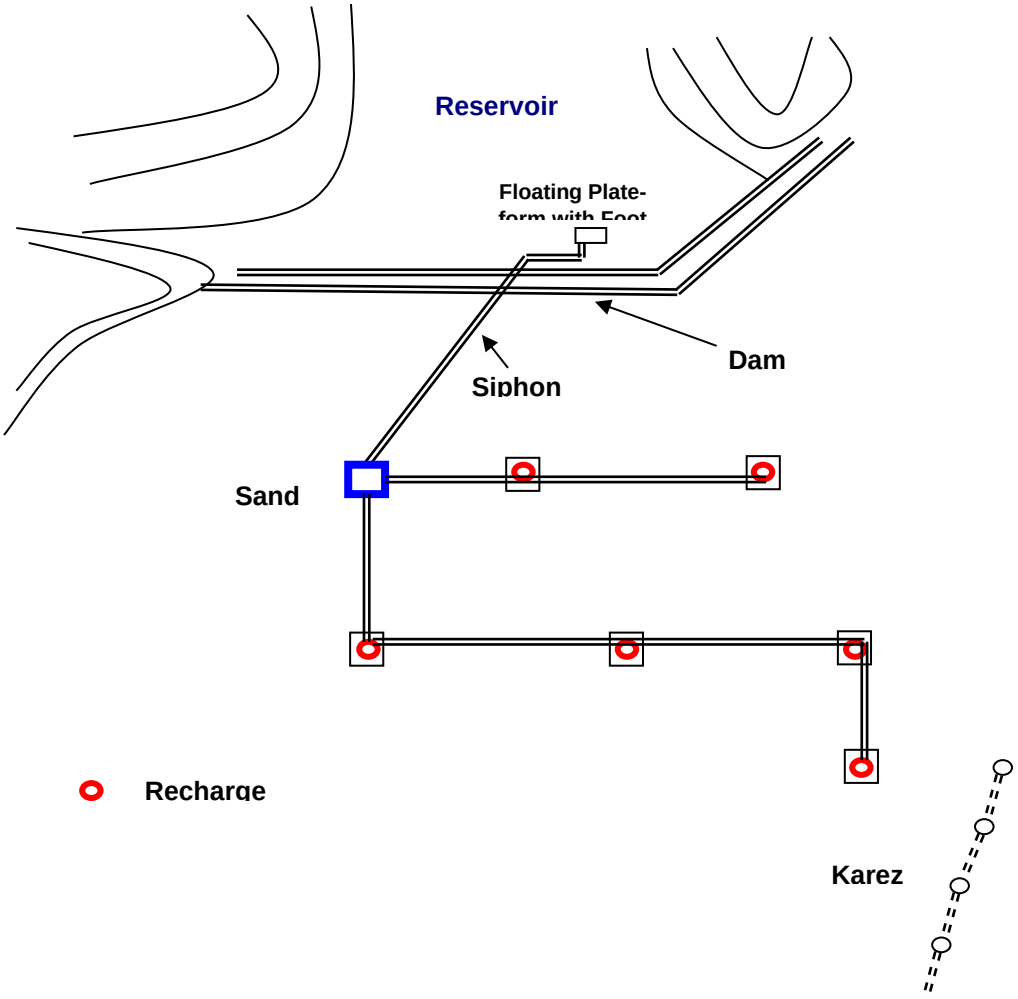


Figure 4: Schematic diagram of Artificial Recharge Project layout (Not to scale)

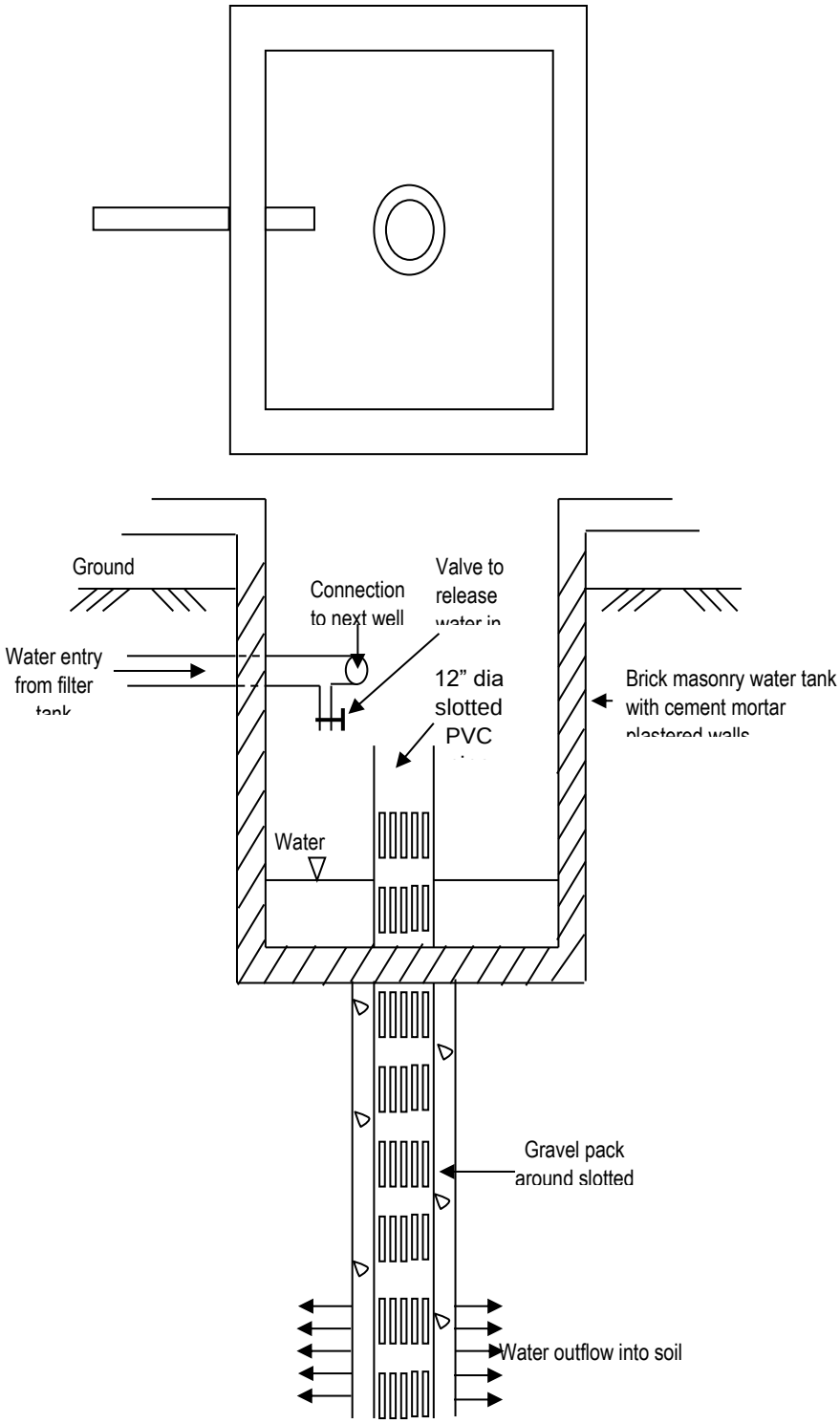


Figure 5: Schematic diagram showing the recharge pipe and water tank

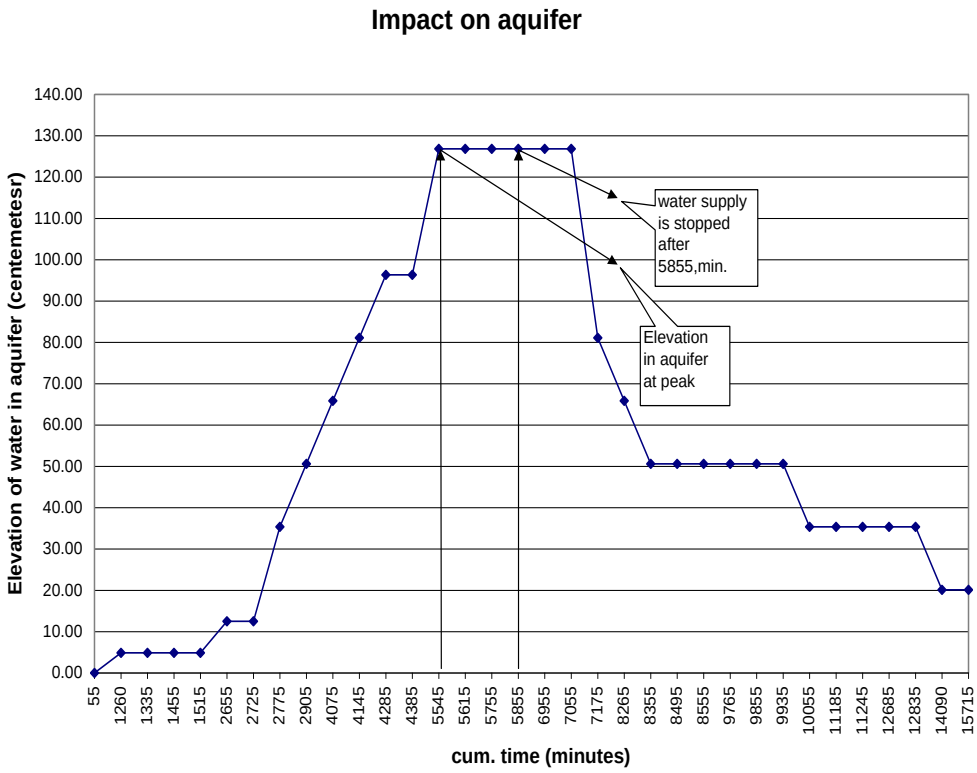


Fig. 6: Water levels in aquifer vs. time

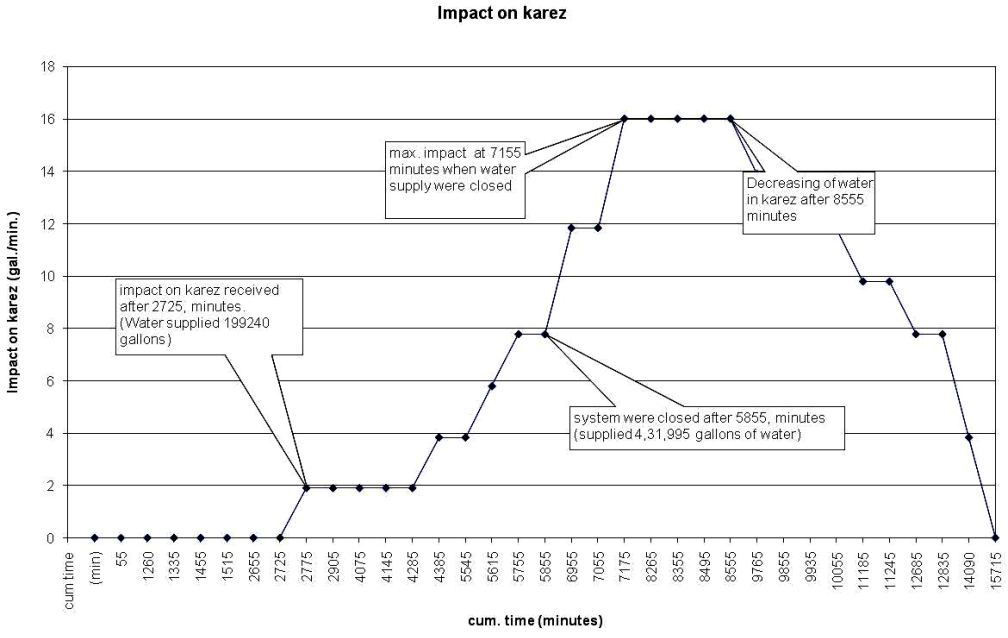


Fig 7. Impact on Karez



Photo 1: View of water flowing into sand filter tank before flowing to recharge wells network



Photo 2: View of recharge well with monitoring mechanism. Photo on right shows water flowing into well as a shower



Photo 3: View of a section of lined channel conveying water from Karez to fields

Analyzing High-Altitude Temperature Series Using Mann-Kendall and Sen's Slope Tests to Assess Trends in Climate for Upper Indus Basin

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Abstract:

Temperature is an important parameter in assessing the trends in the climate of an area. Being an important component of hydrology of a region, it influences the overall environment of that region, the snow and glacier melt components of the river runoff in particular. Therefore, temperature can be used as a tool for assessing climate change for an area and assess its impacts on the environment. Various researchers suggest that the study of meteorological parameters on local scale give good results than those studies which are done on global scale because trends and their effects can be different from one region to the other especially in high mountain regions like the Upper Indus Basin where the clino-climate plays a crucial role. Keeping this fact in mind, trends in the temperatures were studied using Mann-Kendall and Sen's Slope tests. Data from high-altitude weather stations installed by WAPDA in the Upper Indus Basin (UIB) were analyzed. The temperatures data show a significant falling trend for most weather stations for the late summer months of August and September. This has an important bearing on the Indus River flow which is highly dependent on glacier melt in the latter part of the summer season.

Keywords: Mann-Kendall, Sen's Slope, Trend Analysis, Upper Indus Basin Temperatures, Temperature Trend Analysis.

Introduction:

Climate change has gained attention of not only researchers but policy makers as well around the world. Impact of climate change on water resources are extremely crucial to be studied by experts in arid and semi-arid regions such as Pakistan. The 5th assessment report of IPCC (Intergovernmental Panel on Climate Change) says that the global temperatures have increased by 0.85 degrees Celsius in the period of 1800-2012 (IPCC, 2012). For the period of 1905-2006, the increase is 0.74 ± 0.18. All the representative pathways suggest a rising trend in the global temperatures (Mahmood and Babel, 2014). Various researchers on the basis of their findings suggest the significant warming of the earth (Parker and Hourton, 1999; Jones and Moberg, 2003; del Rio, 2005). The warming of the earth is also being reported by IPCC (IPCC, 2001). The availability of water resources could be affected by the hydrological changes caused by climate change (Bates et al., 2008). The availability of water which is an important source for food production, energy generation, domestic and municipal use, could significantly change in time and space as a result of climate change. Climate change is reported to have been

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[13] As above.

impacting the global weather systems by making them more unpredictable, warmer, wetter and some places while drier at others and windier (Rajindra and Pachuri, 2005). Human activities are causing increase in the global temperatures which increases the evaporation and hence results in the increase in the average precipitation in some regions while lesser than average precipitation in others. The increase in the evaporation rate and shifting of storm patterns causes heavy rainfall in some regions which results in floods and devastations while in some regions, due to less rainfall drought like situation is developed. (Gadiwala and Burke, 2013).

Therefore, monitoring of the climate data is of prime importance in view of its relationship with the water resources. The Upper Indus Basin (UIB) is of extreme importance to Pakistan as it is the source of fresh water for irrigation, energy, drinking and other purposes. It is a life line for the population of Pakistan. The Glacier Monitoring Research Center (GMRC) of WAPDA has established a network of high altitude weather stations in the UIB to assess the impacts of climate change and future water availability in the basin.

The month wise trend analysis is very important especially in the regions such as the Indus Basin where glacier melt waters are a major source river runoff. For most of the glaciers in the high mountain region of Pakistan, melting occurs in July and August and any increase in the temperature would mean an increase in the glacier melting.

Mann-Kendall and Sen's Slope test are widely used for trend analysis by many researchers. Mann-Kendall test is capable of determining the significant trends in hydrological and meteorological series (Modarres and Silve, 2007). Man Kendall Sen's Slope estimator was used by Kundu et.al. 2015 to study the trends in meteorology of Rajasthan India. A significant trend in temperature was reported by Karabulut et.al. 2008 from 1974-2004 for Sansun Turkey by using Mann-Kendall and Sen's Slope estimator. Various other researchers have also used the trend analysis techniques (Van Belle and Hughes 1984; Hipel et al. 1988; Taylor and Loftis 1989; Zetterqvist 1991; Bouchard and Haemmerli 1992; Yu et al. 1993; Hamed 2008; Hamed 2009; Tabari et al. (2011); Sayemuzzaman and Jha 2014).

Study Area:

The study area is the Upper Indus Basin located which contains three renowned mountain ranges namely Karakoram, Hindu Kush and Himalaya. Indus is the major River of this region. The flow in this river is mostly due to snow and glacier melt whose contribution is about 85% of the total flow (Hewit, 1985).

According to modelling studies, the snow contributes about 40% of the total flow (Immerzel et al., 2009). According to Archer and Flower (2004), a 1 C increase in mean monthly temperature will cause a rise of 16% of summer runoff in the Hunza River located in the UIB.

In this study, data from high-altitude weather stations located in the UIB were studied. These high altitude stations have been installed by Glacier Monitoring Research Center (GMRC) WAPDA at elevation of 3000 meters to 4700 meters above sea level. The automated weather stations record data and transmit the

following data on hourly basis from remote locations in the Upper Indus Basin to a Master Station established near Lahore: temperature, precipitation, relative humidity, solar radiation, snow water equivalent, wind speed and direction.

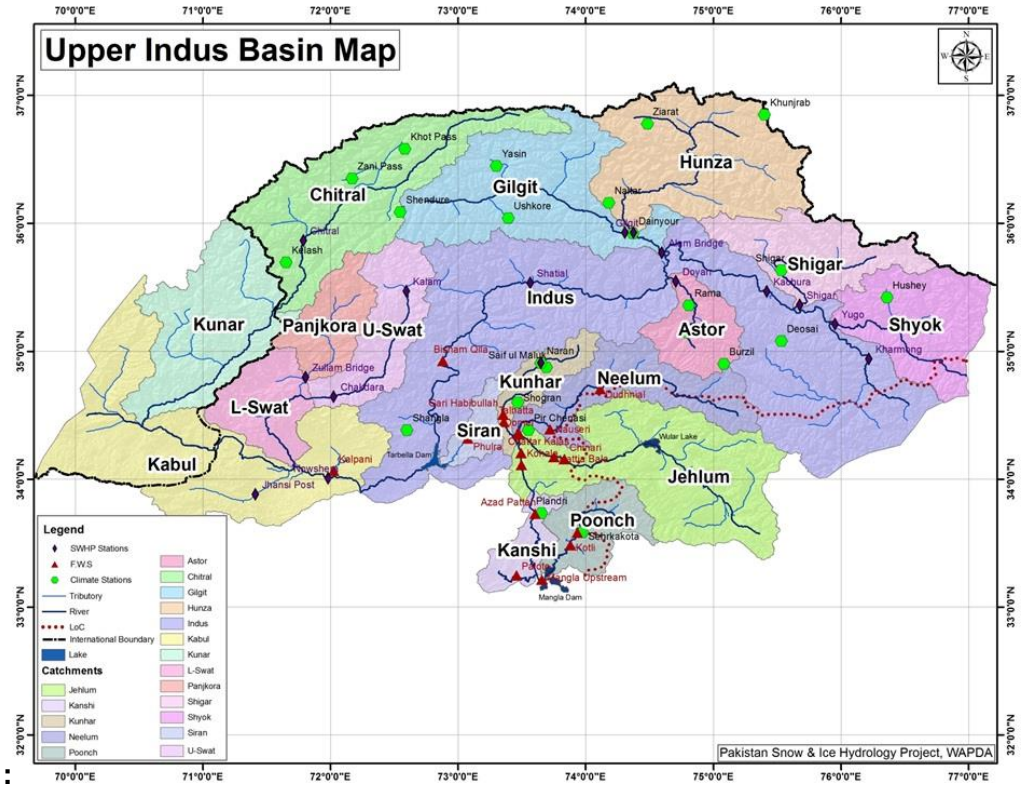


Figure 1: Map of Upper Indus Basin Showing Boundaries of Catchments and Locations of High-Altitude Weather Stations.

Mann-Kendall (MK) Test

Mann-Kendall (MK) is a non-parametric test used for detection of trend in a time series. It is widely used in hydro meteorology especially for trend detection in temperature, rainfall or streamflow series. MK has the ability to resist the effect of outliers (Hirsch et al., 1993). The World Meteorological Organization (WMO) suggest the use of MK for trend detection in meteorological data series (WMO, 1998). MK is a non-parametric test which has the ability to resist the influence of extreme values, is useful for skewed data and powerful than other linear tests (Önöz and Bayazıt, 2003; Lazaro et al., 2001; Kahya and Kalaycı, 2004). The sign values in the series are obtained by the following equation.

$$x_a - x_b = \begin{cases} +1 \; if \; x_a > x_b \\ 0 \; if \; x_a = x_b \\ -1 \; if \; x_a < x_b \end{cases}$$

The Kendall static “S” can be found out by the following equation.

No.	DP Station	Longitude	Latitude	Ft a.s.l	m.a.s.l
1	**Shangla**	72° 35' 27" E	34° 52' 51" N	7350	2240
2	**Rattu**	74° 48' 00" E	35° 09' 00" N	8918	2718
3	**Rama**	74° 48' 42" E	35° 21' 33" N	10429	3179
4	**Shogran**	73° 29' 08" E	34° 37' 12" N	8990	2740
5	**Ushkore**	73° 23' 56" E	36° 02' 44" N	10010	3051
6	**Hushey**	76° 22' 00" E	35° 25' 26" N	10090	3075
7	**Kelash**	71° 39' 17" E	35° 41' 73" N	9581	2920
8	**Zani Pass**	72° 10' 14" E	36° 20' 10" N	12596	3839
9	**Yasin**	73° 30' 00" E	36° 24' 04" N	10763	3280
10	**Khot Pass**	72° 36' 00" E	36° 31' 00" N	11891	3624
11	**Shendure**	72° 33' 00" E	36° 05' 27" N	12179	3712
12	**Ziarat**	74° 26' 00" E	36° 13' 00" N	9910	3020
13	**Burzil**	75° 10' 00" E	34° 54' 03" N	13909	4239
14	**Khunjerab**	75° 25' 09" E	35° 50' 28" N	14568	4440

Table 1: Automated Weather Stations

$$S = \sum_{a=1}^{n-1} \sum_{b=a+1}^{n} sgn(x_a - x_b)$$

In the above "S" equation, n represents the number of data points.

The following equation is used to find the variance of S

$$var(S) = \frac{n\,(n-1)(2n+5)\sum_{l=1}^{m} t_l(t_l-1)(2t_l+5)}{18}$$

And at the end, Mann-Kendall static "Z" is computed through the following equation

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{var(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \dfrac{S+1}{\sqrt{var(S)}} & if\ S < 0 \end{cases}$$

A positive value of Z indicates a rise in the trend and vice versa. The magnitude of Z shows the significance of a trend. If |Z| is greater than a critical values "Z_{cric}", the trend is said to be significant.

Sen's Slope Estimator

This technique was developed by Sen (1968). This method estimates slope by dividing the change in the measurement by change in time. This time of estimate requires equal spaced data. The governing equation of this technique is given below.

$$Q = \frac{xj - xk}{j - k}$$

In the above formula, x_j and x_k are the data points in time j and k.

Results and Discussion

In this study, month wise and year wise trends were studied and their MK static "Z" and Sen's Slope "Q" were found out at 90% confidence level. The mean temperatures of fourteen high-altitude weather stations located in the UIB were checked. The table is showing the results of all the months for all the stations in terms of Mann-Kendall (Z) and Sen's Slope (Q) values (Table 2). The colored months in the table are showing a significant trend in the data. Their signs shows their respective rising or falling trends.

There is a rising trend in temperature in January for all stations except Rattu and Kelash with no significance. Similarly, rising trend was observed for February. However, two stations Ziarat and Khunjerab showed a significant rising trend and five out fourteen stations showed non-significant falling trend. March also showed a rising trend with only Rattu showing non-significant falling trend. For March, Shogran, Zani pass and Khunjerab have a significant rising trend. The test result of April, May and June indicates rising trend for most of the stations and none of the stations has significant trend.

Table 2		January	February	March	April	May	June	July	August	Septemb	October	Novemb	Decemb	Year
Khunjerab	O	0.10	0.11	0.13	0.06	0.04	0.02	0.01	0.02	-0.07	0.04	0.08	0.04	0.01
	Z	1.24	1.66	2.80	0.70	0.35	0.53	0.45	0.27	-0.98	0.33	1.36	0.75	0.45
Burzil	O	0.03	0.08	0.03	-0.02	-0.03	0.00	-0.01	0.02	-0.06	0.07	0.03	0.02	0.01
	Z	0.51	1.36	0.60	-0.56	-0.11	0.00	-0.07	1.09	-1.66	1.07	0.42	0.13	0.33
Ziarat	O	0.04	0.10	0.07	0.01	0.15	0.04	-0.03	-0.08	-0.08	0.05	0.01	0.01	0.02
	Z	0.78	2.50	1.62	0.11	1.61	0.56	-0.65	-1.53	-1.98	1.51	0.25	0.11	0.81
Shendure	O	0.00	-0.01	0.02	0.02	0.08	-0.05	-0.10	-0.06	-0.12	-0.01	0.05	0.04	-0.03
	Z	0.00	-0.37	0.29	0.10	0.64	-0.27	-1.64	-1.24	-1.94	-0.08	0.33	0.68	-0.45
Khot Pass	O	0.01	-0.02	0.05	0.04	-0.04	-0.06	0.03	0.14	-0.04	0.04	0.01	0.16	0.05
	Z	0.15	-0.38	0.72	0.87	-0.23	-0.72	0.12	1.40	-0.39	0.29	0.16	0.81	1.54
Yasin	O	0.02	-0.01	0.03	0.01	0.07	0.00	-0.06	-0.07	-0.15	0.02	-0.01	-0.01	-0.02
	Z	0.70	-0.11	0.56	0.19	0.98	0.00	-0.57	-0.99	-2.42	0.12	-0.21	-0.14	-0.51
Zani Pass	O	0.05	0.13	0.25	0.01	0.04	0.02	0.03	-0.09	-0.11	0.11	0.07	0.09	-0.03
	Z	0.93	0.98	2.44	0.06	0.07	0.06	0.71	-2.06	-1.44	0.79	0.11	0.67	-0.40
Kelash	O	-0.01	-0.05	0.06	0.02	0.02	0.02	-0.03	-0.07	-0.09	0.02	-0.01	-0.12	-0.05
	Z	-0.06	-0.94	0.79	0.35	0.07	0.36	-1.30	-2.18	-2.02	0.27	-0.15	-1.54	-1.81
Hushey	O	0.02	0.05	0.06	-0.03	0.07	0.01	0.00	0.04	-0.11	0.00	-0.01	0.02	-0.01
	Z	0.10	1.18	1.36	-0.53	0.77	0.10	0.00	1.06	-1.87	0.00	-0.39	0.21	-0.16
Ushkore	O	0.03	0.04	0.05	0.04	0.08	0.00	0.00	-0.03	-0.11	0.02	0.02	0.01	-0.01
	Z	0.58	0.42	0.75	0.70	0.74	-0.07	0.00	-0.65	-2.30	0.36	0.26	0.10	-0.29
Shogran	O	0.10	0.01	0.16	0.23	0.05	-0.03	-0.05	0.00	-0.09	-0.01	0.03	0.01	0.03
	Z	1.22	0.00	2.09	1.22	0.24	-0.77	-1.93	-0.28	-2.08	-0.16	0.27	0.07	0.30
Rama	O	0.00	0.04	0.02	-0.02	0.09	0.07	-0.04	-0.01	-0.12	-0.03	0.02	0.03	-0.07
	Z	0.04	0.84	0.39	-0.42	0.72	0.59	-0.38	-0.33	-2.16	-0.42	0.56	0.70	-1.78
Rattu	O	-0.02	-0.01	-0.03	0.00	0.09	0.00	-0.03	0.00	-0.09	-0.02	0.03	0.02	-0.05
	Z	-0.21	-0.18	-0.75	-0.07	0.91	0.11	-0.75	0.00	-1.95	-0.23	0.29	0.19	-2.11
Shangla	O	0.02	0.01	0.15	0.09	-0.08	-0.07	-0.12	-0.01	-0.04	-0.10	-0.11	-0.39	-0.01
	Z	0.00	0.00	1.22	0.06	-0.31	-0.49	-2.14	-0.83	-0.72	-0.99	-0.49	-1.28	-0.33

Table 2: MK and Sen's Slope Test Results

Nine of fourteen stations have shown falling trend for July in which two stations, Shangla and Shogran are showing significantly falling trend. August also has negative trends with Kelash and Zani Pass having significantly falling trends. September is a month with most significant trends. All the stations are showing falling trends with ten stations having significant trends. October, November and December have rising trend for majority of the stations with no significance. Considering the year wise trends, nine out of fourteen stations showed falling trend with three significant ones.

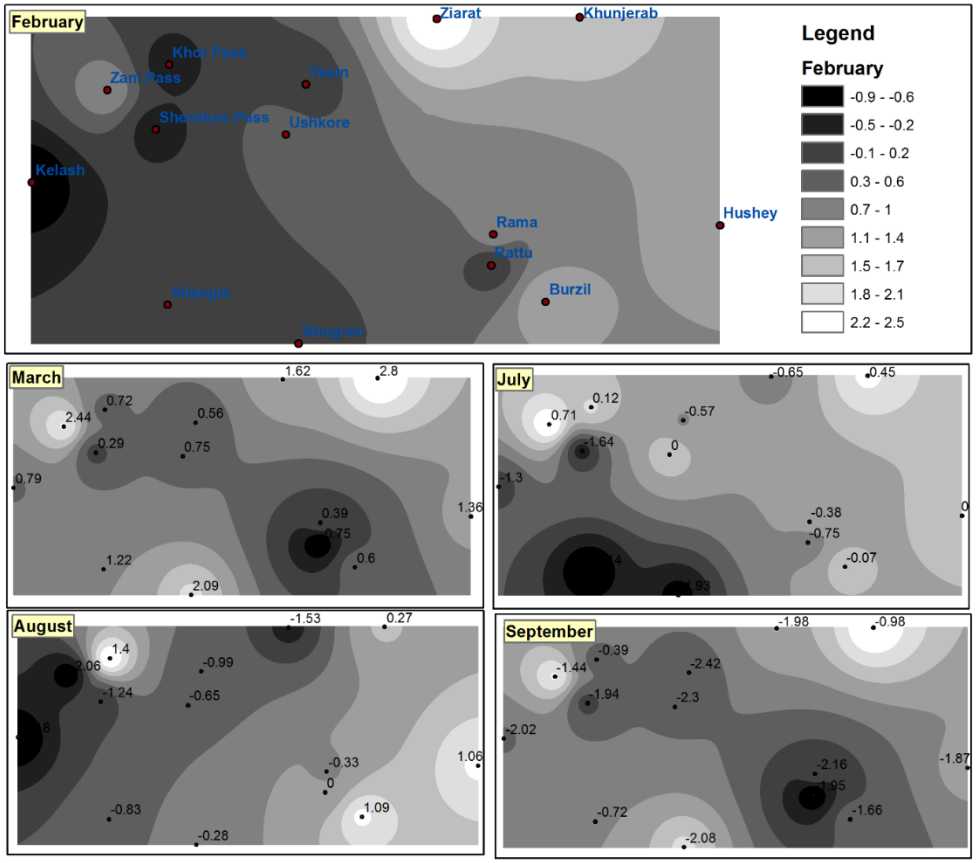


Figure 2: Map Showing Mann-Kendall Values of Significant Months

Conclusions

The application of MK and Sen's Slope tests revealed the month wise and year wise trends in temperatures for selected fourteen stations in the UIB. Some significant trends were reported by the tests both in month wise as well as year wise analysis. In month wise analysis some stations showed significant trends for the months of February, March, July, August and September. For February and March, the trends were rising while for July, August and September, all the significant trends were falling. There were three stations which showed significant falling trend in temperature in the year wise analysis.

From the results, it is evident that winter is getting warmer while summer is getting cooler. Similarly, spring is also getting warmer. The most important result of the analysis was the significant falling trends in temperatures in the latter part of the summer i.e., July to September. This is the period when melt waters from glaciers are the prime contributors towards total river runoff in the Indus.

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Water Availability and Tragedy of Commons

Ruth Naymat Gill

Abstract

Lahore is the cultural hub of Pakistan and plays a pivotal role in shaping and representing the traditions and norms of the country. It is the best place to meet people coming from different backgrounds and study their different approaches towards major social, environmental and economic issues. This paper review water as resource impacting the social, environmental and economic conditions of peri-urban areas of Lahore and is viewed in the context of tragedy of commons. A survey was conducted at eight sites of Lahore and it was found that most of the people living in the areas are facing availability issues. These areas cover the scope of this study but locals fail to realize the gravity of the situation and short term solutions shift their focus from the problem. It has been observed that sites where level of education is higher than the other sites, people are aware that there is a water availability issue and this situation will become more grave in near future if nothing is done to mitigate the problem. It was also observed that almost ninety per cent people believe that water availability issue is human induced, due to poor resources management. The ground water level is gradually going down and over-exploitation is continuously in practice without enough measures to recharge the aquifer. It can be inferred from the findings that awareness at a massive level is required to highlight the problem also giving it the importance it requires. Participation of communities in addressing the shared problems is very important for developing a strategy to counter such issues and finding the right solutions. A relation between poverty and resource exploitation can be seen as well.

Introduction

Lahore is the second largest city of Pakistan and a cultural hub of the country. It supports a population of more than 6 Million people and the number is increasing day by day. Most of the population comprises of people who have migrated from surrounding villages, towns and small cities in search of better economic options. These people have settled down in the underprivileged areas of the city and have to struggle for basic necessities of life every day. Adding to woes of the city is another factor that is its continuous urban expansion over land area. It is estimated that from 1991 to 2000 there was an overall in urbanization from 2279.7 km^2 to 5214.9 km^2 (Mehboob, 2015). The rapid urban sprawl has created a lot of pressure on resources of the city and has increased its demands of energy, food, and water many times as compared to a decade ago. The number of industries has also increased in recent years out of all 2700 industries are registered, and around 2025 are categorized as large scale industries (Qureshi, 2014). In the premises of Lahore District and these units are also major consumers of the city's energy and water consumption.

Good quality of water is a fundamental need of life and almost all activities of our routine directly or indirectly are based on water. It is estimated that for the city of Lahore, domestic use of water remains the largest account for the whole water utilization circle (Qureshi, 2014). It has been observed that the level of depth at which ground water was available a few years ago is going down as time passes; on the other hand, the demand of water is increasing. 484 tube wells of WASA provide 2.2 million cubic water per day to the city which is distributed among 600,000 connections. Other than WASA, Lahore Cantonment Board, Defense Housing Authority, Walton Cantonment Board, Model Town Society and Pakistan Railway are also providing water in their respective areas. It is sadly asserted that a great number of residents of Lahore draw water from many private bore which are not monitored. The difference between recharge and discharge of ground water reservoir is 0.6 7 MCM/day. This shows that the ground water level of Lahore is dropping at the rate of 55cm per year. (Qureshi, 2014)

People have already started to face water availability issues in many part of the city. The establishment of large scale industries around Lahore has increased the competition of consumption for both the domestic users and industrial users. However, a general awareness regarding rising availability issue is lacking, even though many parts of the city are already facing shortages of water. This paper takes a position that lack of education correspondingly affects the level of awareness about water issues in the peri-urban areas of Lahore which further results in poor management of water availability issues.

Area and Scope of Study

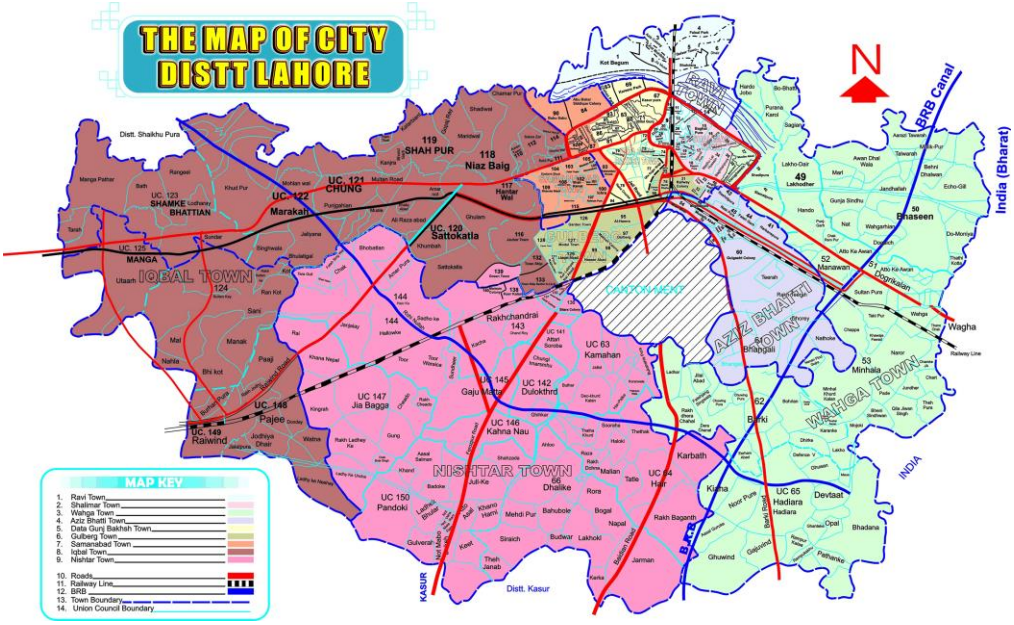
The areas selected for this study are some of the peri-urban areas of the city, where people are poorly educated and have from lower to middle economic background. Eight areas of Lahore were selected for the study. These include Basti Sayedan Shah, Haji di Khui, Kambou Colony, Delhi gate, Masti Gate, Thokar Niaz Baig, Gajjumatta and Salamatpura.

The scope of the study was to find out residents' response when asked about water availability issues and their level of understanding about why they are facing the availability issue.

Material and Methodology

A checklist was developed for the selection of the study and a survey questionnaire was designed in order to gather the required data. A total of two hundred and forty people participated in the survey. Thirty residents from each area were interviewed. The data sample was selected randomly for each area. Efforts were made to get a good ratio of male and female respondents. Interviewees were met either at their houses or at their work places which included respondents from shops in the residential area of the selected sites. All the data collected was saved

in the excel sheet for further analysis. Graphs were generated for each part of the survey for comparative study



Source: Qureshi, 2014

Results and Observations

Parameters assessed during these surveys are as follow:

- Education
- Income group
- Recognition of water availability issue
- Cause of water availability issue

All of these parameters are discussed below.

Education

Education is the tool that opens one's mind to new ideas and trains us to analyze and question. The first step to awareness is, to educate people so that they may think and make connections. The survey conducted at eight selected sites gives insight about the education level of the people residing there and can be taken as a reference to the level of awareness people shows towards water issues. It can be gathered from the graph, that of all the people who were interviewed in this survey, very few had any high education. Most of the respondents had very little or no education. Only Masti gate's results showed that seventy percent people of that area has high education and correspondingly there were a very low percentage of illiterate people observed.

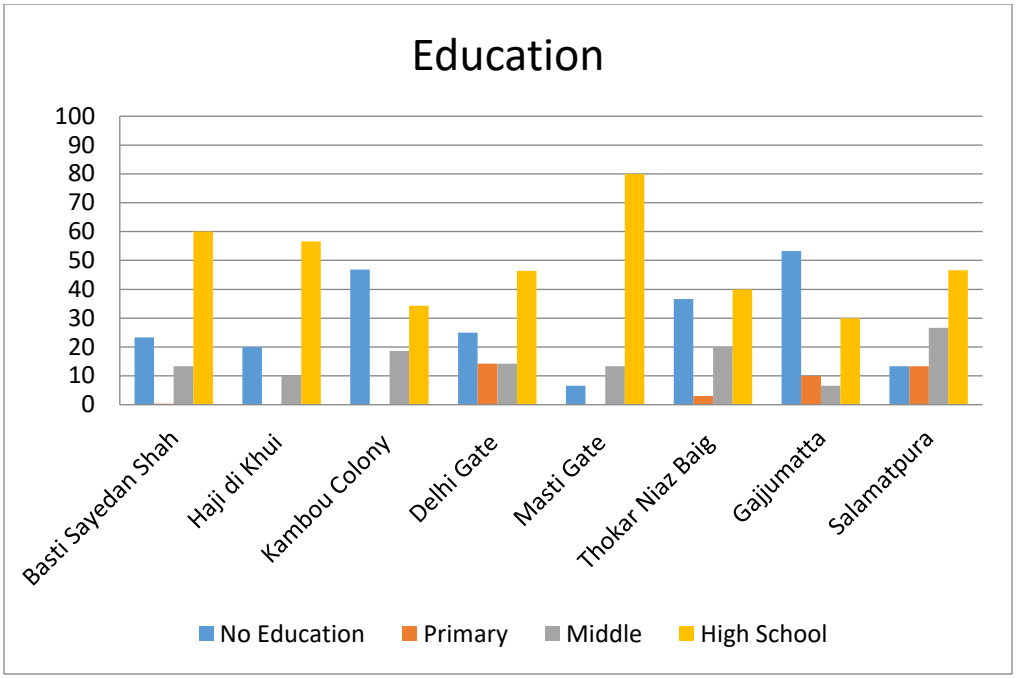


Figure 1: Graphical representation education in the selected sites

One of the reasons that this fluctuation is there is because of the fact that most of the area of Masti gate is in commercial use and there is a big market of shoes, clothes and stepney. Most of the people run business here and residential area is rapidly converting into commercial area. These people are not the locals of old city but are coming from other part of the modern Lahore and are better educated. Besides Masti gate, a higher percentage of education is evident from the figures of Basti Sayedan Shah while Gajjumatta has the highest percentage of illiteracy.

Income Group

As explained earlier, the study aimed the peri-urban areas of Lahore. Because of low education level, most of the people living in these areas have low profile job and do not earn much. The living conditions are overall poor. Many live in rented houses with a single source of income.Women in these areas stay at home and do not earn however, some worked in factories on daily wages or sewed clothes. Almost sixty to eighty per cent respondent in all sites said that their income is inadequate and it is hard for them to afford the basic necessities of life.

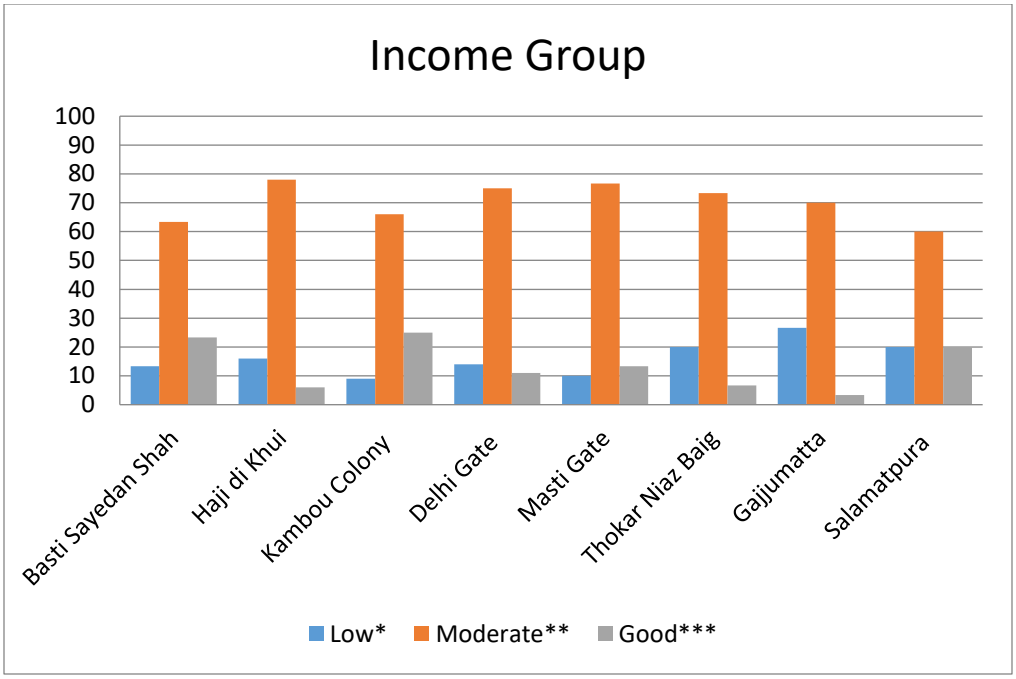


Figure 2: Graphical representation of various income groups

*0- 15,000 Rs, ** 15,000-30,000 Rs, ***30,000- 45,000 Rs

As most of the people in the peri- urban areas, live on daily wages, non-availability of work plays a vital role in determining the living conditions of a family. Another important factor effecting economic status is the family size in relation to the number of family members earning. It must be understood that people's perception of having good living conditions vary a lot from person to person. Some people live a very simple life but they are found to be more content than the families who are living in slightly better conditions and earn more but they find their needs not fulfilled and their supplies inadequate.

Recognition of Water Availability Issue

Water is a precious source that has a role to play in each and every activity that any living being performs on the planet. However, our fresh water resources are rapidly depleting and it is stated that the South Asian Countries have the highest rate of ground water abstraction (Shamsudduha, 2013). And with this the changing weather pattern has further deteriorate the clean water availability. Even in a city like Lahore, people are facing prominent water availability issues. It was found, that most of the people living in the selected sites are facing water availability issues and recognize this as problem which is worsening day by day.

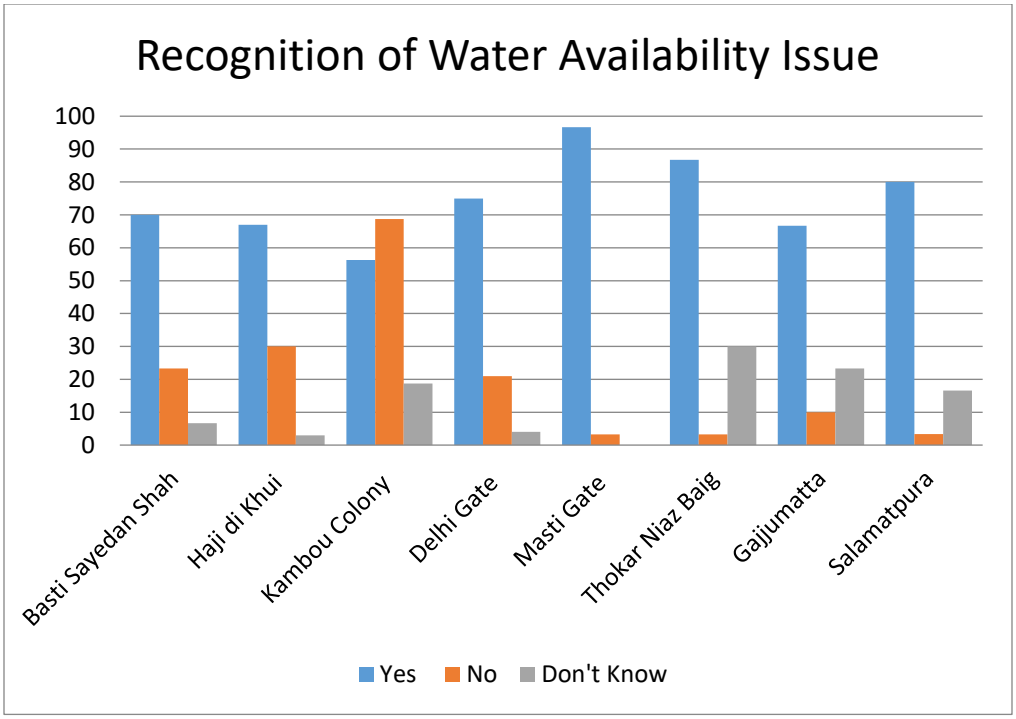


Figure 3: Graphical representation of awareness of water availability issue

Conversely, another interesting finding was that people of Kambou Colony do not recognize this problem and asserts that they are getting continuous supply of clean water so there is no issue of availability. With further investigation of the area it was found that there is a recent installation of a WASA tube well with a much deeper bore than before, that's why people are no longer facing any availability issue. There is also a percentage of people who gave no opinion on this issue as they were not sure whether this is a problem or not. The reason for such a response is the use of large water storage tanks which are filled once a day and are utilized the whole day. Due to this particular practice, these people were not able to tell if there is any time of the day when water is not available. Another important factor that affects the result generated is that the source water supply in these areas is not uniform. Similarly, power outage or load shedding also affects supply of water. In some of the selected site, water is supplied by WASA and in others residents get their water supply from private bores in their own premises.

Cause of Water Availability Issue

When a problem is recognized, we often tend to see what the cause of that problem and identifying the cause of any issue, solve half of the problem. When asked about the cause of water availability issue in their opinion, most of the respondents said that human mismanagement is the cause of this problem. While almost twelve per cent respondents from all sites had no opinion on what may be the cause of this issue.

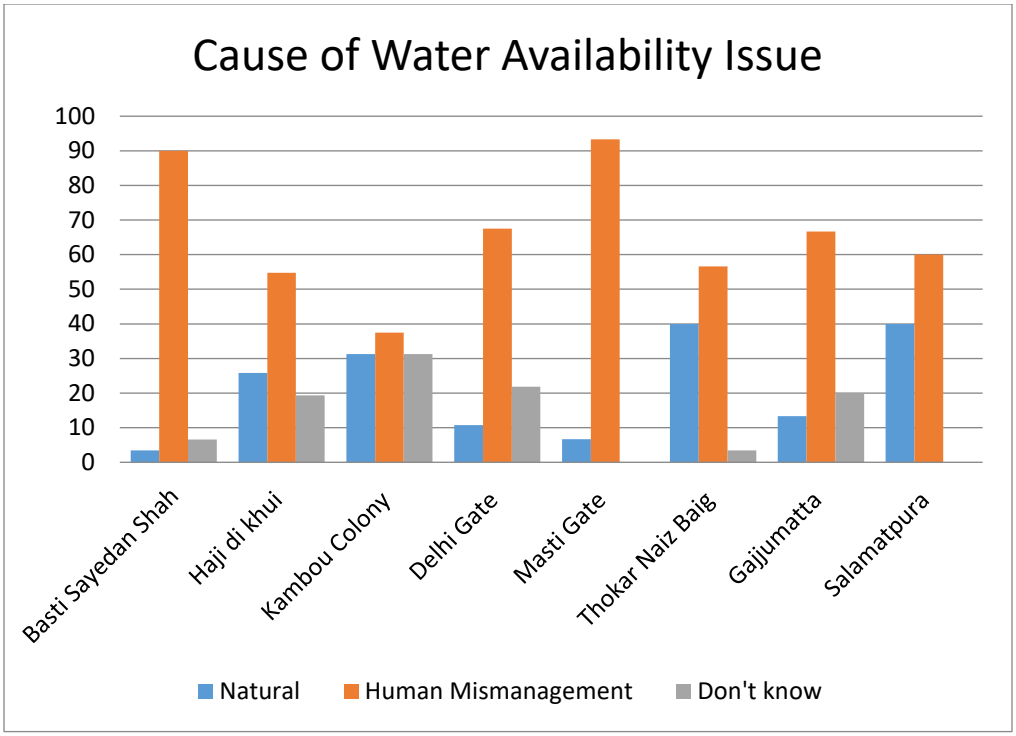


Figure 4: Graphical representation of cause of availability issue

It can be seen from the graph that ninety three percent of the community of Masti Gate believes that the water availability issue is the result of mismanagement of our water resources. It can be inferred from the graph that a significant number of people believe that water availability issue is not natural caused.

Discussion

From the observations and results generated as a result of the surveys conducted in all eight selected peri-urban areas of Lahore, it can be said that education plays a major role in giving vision to people and helping them to see in the right direction. As can be seen in the graph, there is a high level of education at Masti gate, correspondingly there is a higher percentage of awareness regarding water availability issue in the area. Other examples can be Basti Sayedan Shah and Haji di Khui. Another important finding is that there is general understanding on the water availability issue but people are not able to understand the significance of the situation and a temporary solution, such as, a deeper bore acts as the end of the issue in their opinion. People do not realize that water resources can be depleted if not handled properly. They are unable to comprehend the long term impacts of water mismanagement. It is also observed that people in peri-urban areas are unable to recognize the cause of the water availability issue specifically. They generally held the water service provider responsible for the unavailability of water and do not comprehend that the growing industries in the surrounding areas and agricultural activity are creating competition for water resources. Another important issue that emerged as a point to ponder is that poverty and exploitation

of resources are interlinked with each other. When people do not have enough money to meet the ends of the month, they tend to overlook issues that are shared with other members of the society. A sense of 'let others take care of this issue because I cannot" arises and spread in the society like a plague and as a result a classical case of tragedy of commons occur. Similarly, since people are getting water as almost free they ignore any leakages or other maintenance issues in the supply line at their houses. The continued ignorance of such events eventually results into a lot of wastage of ground water without being utilized.

Conclusion

It has been heard many times that in order to solve a problem you need to realize that there is one. Awareness about any issue that is present in the society is the first step towards solving it. Water shapes our environment, affects our society and is the backbone of our economy. Any issues related to water directly affect peoples' lives in all the three pillars of sustainability. Tragedy of commons is a common issue globally; however, ground water exploitation in Lahore presents a classic example the theory, especially considering the fact that Pakistan is among the top water stressed countries. In order to counter this situation a massive awareness and mobilization campaign is required to make people acknowledge the problem and take measures to save water and counter water availability issues.

Community participation is very crucial for a successful program to carter shared problems like water mismanagement. Communities are major stakeholder of our ground water resources and they should be a part of water governance and policy as without the active participation of members of community, no mutually beneficial strategy can be developed. In order to achieve this, it is required that people are informed of the cause and its implications on their life so that they get to be actively involved in it and contribute their part effectively.

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Climate Change and Poverty Alleviation

By

Professor Shahida Saleem

ABSTRACT

This paper focuses on the link between climate change, vulnerability and poverty. A comparison of the Global map of CO2 emitters with the Global map of vulnerability reveals that poor countries which have contributed the least to CO2 emissions are the ones that are extremely vulnerable to climate change. It also shows that rich countries that have contributed most to global warming are in high and medium latitude regions where climate is very cool, while all the vulnerable countries are in the low latitude regions where climate is very hot. A small increase in temperature can have devastating effects on the economies of the low income countries. Moreover the less developed countries are projected to suffer most as they do not have the infrastructure and technology to mitigate climate change. Ending poverty, therefore, is going to be difficult without mitigating climate change.

1. OVERVIEW

One of the greatest challenges facing humanity in the 21st century is climate change and its devastating effects on the people, especially the poor. It represents a direct and immediate threat to economic growth and poverty alleviation through the effects of declining water availability, biodiversity loss, decreasing agricultural yields, climate-related humanitarian disasters (like floods and droughts), increased incidence of water related and vector-borne diseases, weakened infrastructure, political instability due to heightened conflicts over resources and movement of people, as well as through the secondary effects of these phenomena.

Climate change refers to the rise in average surface temperature on Earth. It can manifest as changes in mean or seasonal temperatures, precipitation, increase in carbon dioxide emissions and sea level rises. In the last 130 years, the world has warmed by 1.4 degrees F. Each of the last three decades has been successively warmer than any preceding decade, since 1850. It is further expected to rise as much as 11.5°F over the next hundred years (Environmental Protection Agency).

1.1.1 Environmental analysts are of the view that very minor changes to temperature can have major impacts on human environment, including changes to water availability and crop productivity, the loss of land due to sea level rise, more and severe storms, droughts and fires, heat waves and the spread of diseases.

There is an overwhelming scientific consensus that climate change is due primarily to the human use of fossil fuels such as oil and coal which releases carbon dioxide and other greenhouse gases into the air. Other human activities such as agriculture and deforestation also contribute to the proliferation of greenhouse gases that cause climate change.

Climate-related risks, such as floods and droughts, have always existed, but global warming is increasing these risks. Predictions are that there will be more frequent and extreme climate disasters for decades and this is already happening

Droughts and glacial melts will affect access to clean water. According to UNDP, an additional 1.8 billion people could be living in a water scarce environment by 2080.

Global warming is also exacerbating the spread of water-borne and water-washed diseases which are more prevalent in poor counties. In Africa alone 90 million more people could be exposed to malaria by 2030, because of rising temperatures.

Coastal communities will flood as sea level rises. According to NASA, global sea levels have risen by about 20 cm since 1880, and are projected to rise to another 2.5 to 10 cm by 2100 (Oxfam). Currently about 100 million people live within about 1 meter of sea level, the majority of them in the river deltas of Asia and Africa.10 of the 15 largest developing countries are in low-lying coastal areas vulnerable to rising sea levels.

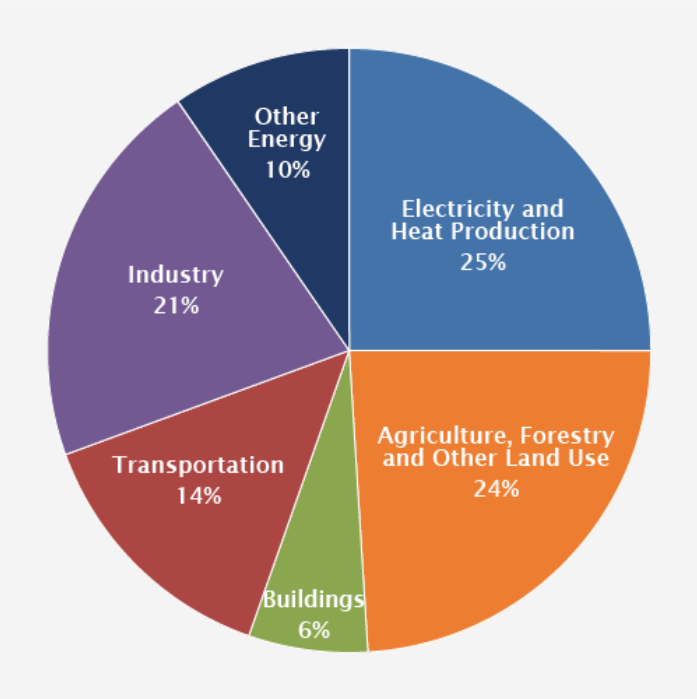
2. Causes of increase in CO_2 emissions

Globally, economic and population growth continue to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion. The contribution of population growth between 2000 and 2010 remained roughly identical to the previous three decades, while the contribution of economic growth has risen sharply. Growing wealth supposedly correlates with increasing emissions. Total greenhouse gas emissions have continued to increase over 1970 to 2010 with large absolute increases towards the end of this period. About half of CO_2 emissions, between 1750 and 2010, have occurred in the last 40 years. Increased use of coal relative to other sources of energy has reversed the longstanding trend of gradual de-carbonization of the World's energy supply (IPCC, 2014).

According to the World Resource Institute CO_2 emissions from human activities are now 150 times higher than they were in 1850 mainly due to rapid industrialization.

Without additional efforts to reduce greenhouse gas emissions beyond those in place today, emissions growth is expected to persist driven by growth in population and economic activities.

Fig. No. 1 Global Greenhouse Gas Emissions by Economic Sector



Source: IPCC (2014); based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*

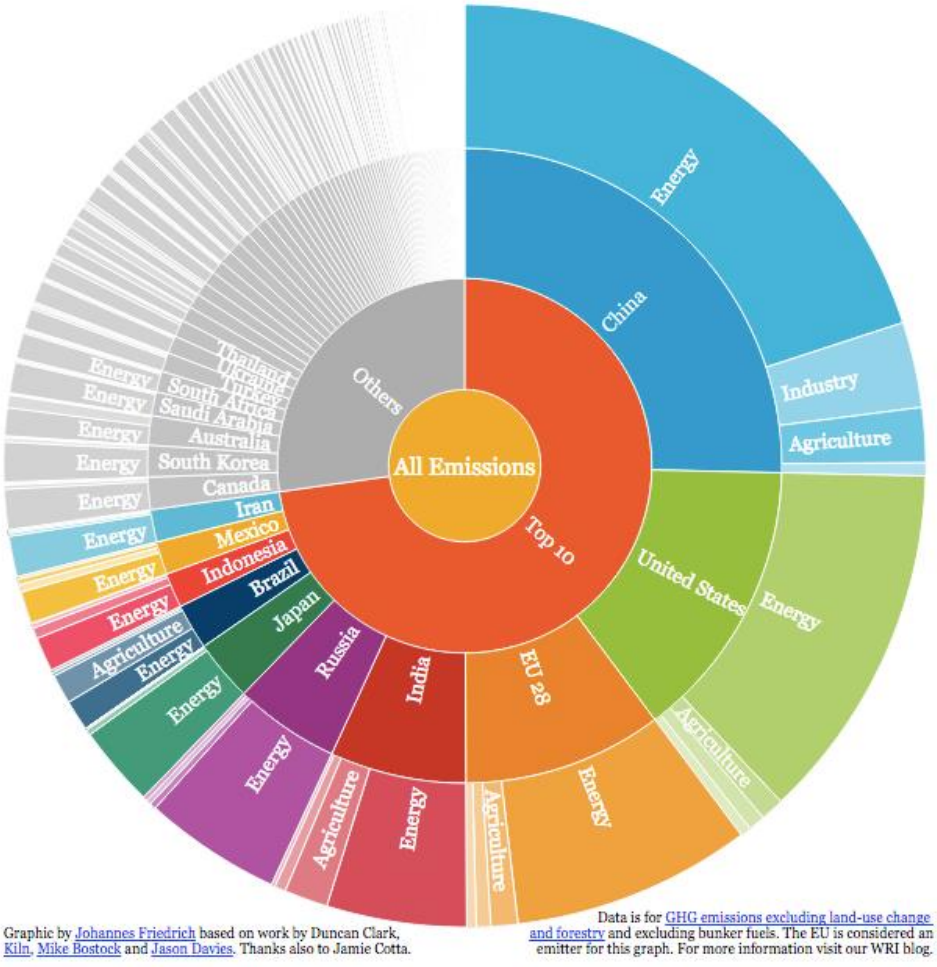
The data shows that energy sector is the dominant source of greenhouse gas emissions. Next is agriculture, land use change and forestry followed by industry and transportation.

3. Countries responsible for global warming

Historically rich countries are responsible for two-thirds of the CO2 emissions but today poor and middle-income countries already account for over half of total emissions. Although poor countries have been least responsible for the rise in greenhouse gas emission that has already occurred, much of the anticipated increase in emissions in the next few decades is expected to occur in the developing countries. Most emerging economies like India and China are fuelling economic development with fossil energy (Oxfam).

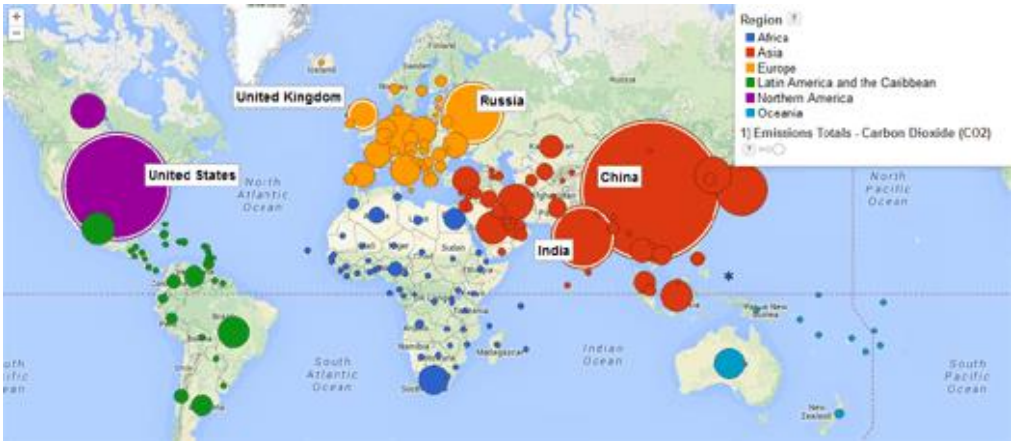
In 1850 the top five emitters were UK, USA, France, Germany and Belgium. In 2011, China ranked as world's largest emitter followed by USA, India, Russia and Japan. Between 1850 and 1960 the world experienced a constant growth of emissions due largely to industrialization and population growth, particularly in USA. After 1960 while USA kept its place as the emitter until 2005, Asian countries also started to emerge led by China (WRI).

Fig. No. 2 Top Ten CO2 emitters



The top ten emitters shown in the above circle contribute 72% of global greenhouse gas emissions (excluding land use change and forestry). On the other hand the lowest 100 emitters contribute less than 3%. It is interesting to note that six of the top ten emitters are developing countries. According to the data, China contributes 25% of global emissions, making it the top emitter. India, Indonesia, Brazil, Mexico and Iran are also contributing relatively large shares of global emissions as their economies are growing. Although developed countries used to dominate the list of top ten emitters, the visual represents the changing emissions (geopolitical) landscape (WRI, 2015).

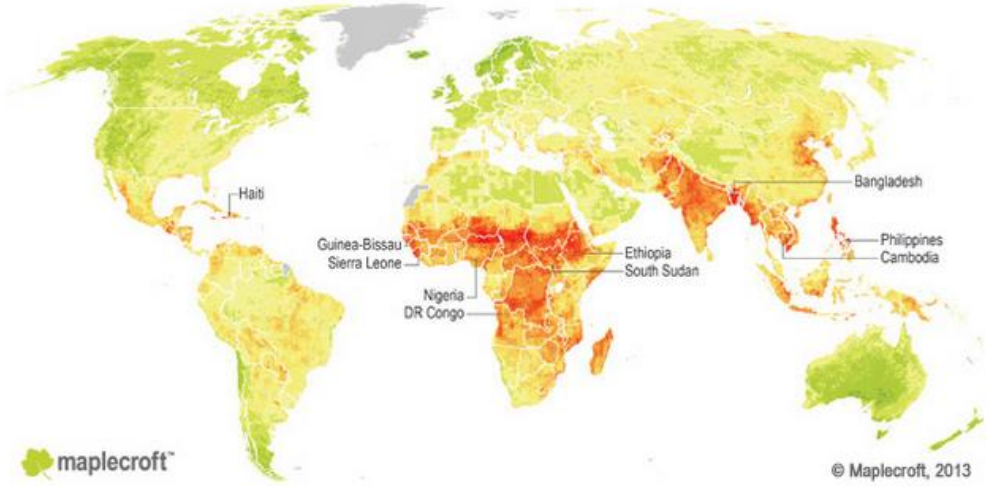
Fig. No. 3 Global Map of CO2 Emissions 2015



Source: World Resource Institute

China has now taken the lead followed by India.

Fig. No.4 Global Map of Climate Vulnerability 2015



Rank	Country	Category
1	Bangladesh	Extreme
2	Guinea-Bissau	Extreme
3	Sierra Leone	Extreme
4	Haiti	Extreme
5	South Sudan	Extreme

Rank	Country	Category
6	Nigeria	Extreme
7	DR Congo	Extreme
8	Cambodia	Extreme
9	Philippines	Extreme
10	Ethiopia	Extreme

Legend
Extreme
Low
No data

Countries that are most vulnerable to climate change are in Asia, Africa and Central America. Those which have been highlighted in this map as extremely vulnerable to climate change are Bangladesh, Nigeria, Philippines, South Sudan, Ethiopia, Eritrea, Sierra Leon, Chad, Central African Republic (C.A.R) and Haiti.

The growing economies of Cambodia, India, Myanmar, Pakistan, and Mozambique also fall in the extreme risk category (Maplecroft, 2014).

It is disturbing to note that all these countries are in the poorest regions of the world and have contributed the least to carbon dioxide emissions. India is the only country which is highly vulnerable to climate change and is also making major contribution to global warming. Haiti is the poorest country of the Western Hemisphere and all others are in South Asia and Africa, where about 83% of the world's poor live.

Countries that are least vulnerable to climate change are USA, Canada, European Countries and Russia who have been major contributors to greenhouse gas emissions.

It is important to note that these rich countries, that have contributed most to global warming, are in the high and medium latitude regions, where climate is very cool, while all the vulnerable poor countries are in the low latitude regions where climate is already very hot. A small increase in temperature can create havoc in the poor countries.

4. Climate Change, Vulnerability and Poverty Nexus

When looking at climate change vulnerability, we must consider not only exposure but also sensitivity and ability to adapt to the consequences of extreme weather conditions. The less developed countries do not have the necessary infrastructure and technology to mitigate the impacts of climate change. Hence the world faces the double irony, the countries which contribute least to global warming are both the most impacted and the least able to adapt.

Historically major polluters are the advanced countries of Europe and America including Canada. Despite their climate change exposure, their overall vulnerability is low compared to the countries of extreme risk in Africa, Asia and Central America. The reason is that the rich countries have a high adaptive capacity that helps mitigate the outcomes of climate change. Even the most devastating events with substantial impacts have left their infrastructure largely intact.

According to IPCC (Inter- Governmental Panel on Climate Change) the low latitude regions will be hard hit by climate change. Low income countries will experience gradual sea-level rises, stronger cyclones, warmer days and nights, more unpredictable rains, larger and longer heat waves. Drought prone areas will become drier and wet tropical regions wetter (IPCC).

Almost all the poor countries of the world are in low latitude with hot and dry climates and are projected to suffer greater damages due to global warming than the rich countries which happen to be in the mid to high latitude which are currently cool. High latitude countries of Europe and America are expected to have more rainfall while many sub-tropical and semi-arid regions will likely experience less precipitation. Since the low latitude regions are home to the world's poor, they will suffer most due to climate change and it will be more difficult to eradicate poverty from these regions.

Globally poverty reduction has been mostly due to progress in the rapidly growing economies of East Asia and to a lesser extent South Asia. The world's most populous countries China and India have played a central role in global poverty reduction as measured by the $ 1.25 poverty line. Together they lifted some 232 million out of poverty from 2008 to 2011(World Bank, 2014). While poverty has also declined in Africa from 56% 1990 to 43% in 2015, the number of extremely poor has increased due to high population growth (World Bank, 2015).

Almost three-fifths of the world's extremely poor are concentrated in just five countries: Bangladesh, China, The Democratic Republic of Congo, India and Nigeria. Adding another five countries (Ethiopia, Indonesia, Madagascar, Pakistan and Tanzania) would comprise just over 70% of the extremely poor (Global Monitoring Report, 2014-2015). According to the World Bank poverty is rampant in Asia and Africa where almost 83% of the world's poor live.

Economic growth is the major driver of poverty reduction and was instrumental in halving extreme poverty between 1990 and 2010 (World Bank Report, 2014). The problem is that with economic growth, greenhouse gas emissions increase and that in turn exacerbates climate change which hurts the poor countries the most. With the acceleration of economic growth, the developing countries have also started contributing towards greenhouse gas emissions, which in turn is increasing the intensity of severe weather conditions and throwing more people below the poverty line. This is exactly what is happening in India.

The impacts of climate change will reverse the worth of human development gains and threaten achievements of the Millennium Development Goals (UNDP). Ending poverty, therefore, is unlikely to become a reality without changing economic growth patterns and mitigating climate change.

5. Impact of Climate Change on the Poor

Major economic sectors of the less developed countries that are being directly affected by climate change are agriculture, forestry, water, energy, coasts and health. Of all these sectors agriculture and forestry are the most climate sensitive sectors. Climate change is also severely affecting the vulnerable and disempowered groups in the communities, including women and children who have the potential of being strong actors in current and future development.

5.1 Declining agricultural yields, food insecurity and food inflation

One of the unifying characteristics of these economies is that they are heavily dependent on agriculture with 65% of their working population employed in this sector, while 28% of their overall economic output relies on agricultural revenues. Changing climate is inevitably going to hurt crop production and thereby disrupt the incomes of the people in the rural areas. According to the World Bank crop yields are expected to decline by 15% to 20% in the poorest regions of the world if the temperatures rise above 2 degrees Celsius. UNIPCC figures estimate declines of upto 50% for staples such as rice, wheat and maize in some locations over the next 35 years due to the impacts of climate change. Food security in African and South Asian countries is already rated "high risk" and this situation

could worsen given the extreme weather events such as droughts (Maplecroft, 2015).

Global demand for food is projected to grow over the next 15 years, including increases around 60% in Sub-Saharan Africa and 30% in South Asia (World Bank, 2015). Food prices are therefore going to increase the most in these regions and this could be devastating for the poor as they spend from 60 to 70 percent of their income on food. Rising temperatures and more extreme weather are going to increase the pressure on food supplies around the world, risking shortages in the least developed and developing countries causing food inflation, and potentially pushing millions of people into deeper hunger and malnutrition.

Climate change also poses enormous challenges for forests in the developing countries. Forests support the livelihoods of more than a billion people living in extreme poverty worldwide and provide paid employment for over 100 million people. They are home to more than 80% of the world's terrestrial biodiversity and help protect watersheds that are critical for the supply of clean water to most of humanity (FAO).

5.2 Water Scarcity

Water scarcity has been recognized as a growing global problem of tomorrow's world since the mid 1980's. Several studies have sounded alarms about how climate change is influencing the availability of water in different parts of the world by shifting precipitation patterns, speeding glacial melt, altering water supplies and intensifying floods and droughts.

Renewable surface water and ground water have significantly reduced in the dry and subtropical regions intensifying competition for water among agriculture, industry, energy production and domestic consumption. It is feared that water scarcity may complicate socio-economic development, enhance food insecurity by limiting food production and thereby increase poverty and hunger. More than a billion people currently live in water scarce regions and as many as 3.5 billion could experience water scarcity by 2025 (World Resource Institute). The most affected parts of the world are South, Southeast and Northeast Asia; Africa and South America where the flood hazards are projected to increase.

Rain-fed agriculture covering 96% of cultivated land in Sub-Saharan Africa, 87% in South America and 61% in Asia will be particularly hit by the effects of climate change. According to the Food and Agricultural Organization, the challenge of feeding everyone in 2050, is expected to require 50% more water than is needed now for producing food.

Melting glaciers, rising sea levels and droughts are expected to have dire consequences for agricultural production. Poverty, hunger and malnutrition tend to be the largest in arid climatic regions dominated by unreliable rainfall, monsoon climate and high evaporative demand.

Climate change is already jeopardizing gains in the fight against hunger and it looks set to worsen it. A hot world is a hungry world. (Oxfam)

5.3 Coastal Zones

There are major threats of inundation along the coasts in Eastern Africa and coastal deltas such as the Nile delta, and in major cities, due to sea level rise, coastal erosion and extreme weather events. Tens and millions of people in the low lying coastal areas of South and Southeast Asia are being affected by sea level rise and an increase in the intensity of tropical cyclones. Coastal inundation is likely to seriously affect the aquaculture industry and infrastructure, particularly in the heavily populated mega deltas. Stability of wetlands, mangroves, and coral reefs is also increasingly threatened by climate change (UNFCC).

5.4 Natural disasters

Natural disasters hurt the poor and vulnerable the most and the impacts of disasters will rise with the exacerbating trends of climate change. Globally the number of reported weather- related natural disasters has more than tripled since the 1960's. Risks associated with extreme events will continue to increase as the global temperatures rise (IPCC). In 2007, Africa, Mexico and South Asia experienced unusual floods, while Europe, Australia and California saw above average heat waves and forest fires. The number of floods and cyclones quadrupled between 1980 and 2006 from 60 to 240 per year. Heat waves increased more than five-fold during a similar period (Oxfam International, 2007). Throughout 2010, changes in weather patterns resulted in a series of devastating natural disasters especially in South Asia, where heavy floods caused major damages to property, livestock, agricultural production and human life. In Pakistan, floods affected more than 20 million people (over 10% of the total population) and killed more than 1700 people in 2010.

In 2014, landslides triggered by heavy rains killed at least 350 people in Afghanistan, displaced many families and caused widespread damage to homes and agriculture. Millions of people in Philippines were affected throughout 2014 by typhoons, tropical storms and landslides. Less rainfall in March 2014, threatened food security of poor households in Pakistan. In the same year heavy monsoon rains and floods in September caused 361 deaths, affected more than 25 million people and destroyed nearly 130,000 houses and over one million acres of cropland causing a loss of 2220.527 million US $ (Germanwatch, 2016). The Internal Displacement Monitoring Centre (IDMC) has estimated that between 2008 and 2014 an annual average of at least 22.5 million people were displaced by the direct threats or impacts of floods, landslides, storms, wild fires and extreme temperatures. For example, in 2014, ten largest events of storms and floods in Asia, each displaced about 500,000 to 3 million people in the Philippine, India, Pakistan, China, Japan, and Bangladesh.

According to United Nations economic losses from natural disasters since 2000 are in the range of $ 2.5 trillion a figure at least 50% higher than the previous estimates. According to the Germanwatch, more than 525,000 people died as a direct result of approximately 15000 extreme weather events and losses between 1995 to 2014 amounted to over 2.97 trillion USD (in purchasing power parity).

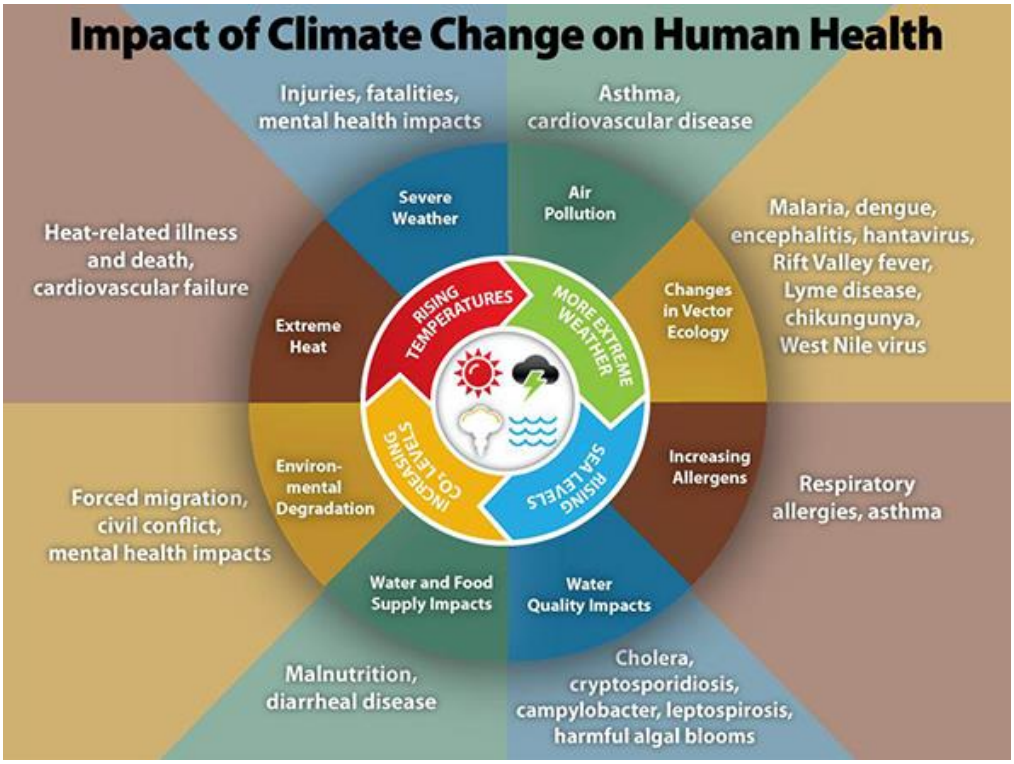
These examples indicate how destructive extreme precipitation can be and how much damage they can cause to the poor living in the developing countries.

5.5 Health risks beyond malnutrition

Climate change affects the social and environmental determinants of health_ clean air, safe drinking water, sufficient food and secure shelter. Public health can be seriously threatened by the disruption of physical, biological and ecological systems.

People living in small islands, coastal regions, megacities and mountainous regions are particularly vulnerable to climate- related health hazards. Women and children living in poor countries are among the most vulnerable to the rising health risks and will be exposed longer to the health consequences.

Fig. No.5 Impact on Health



Source: CDC (Centers for disease control and prevention)

Extreme heat directly contributes to deaths from cardiovascular and respiratory diseases particularly among the elderly people. Rising sea levels and increasingly extreme weather events may trigger asthma, cause mental disorders and increase the risk of communicable diseases. Lack of safe water can compromise hygiene and increase the risk of water- washed, water-borne and vector-borne diseases. According to the World Bank report, 2015, a small rise in temperature could increase the number of people at risk for malaria by up to 5% or more than 150 million people more affected.

In poor countries half of all health care expenses are paid out of pocket which means a major cut on their meager earnings. Hence, climate change has the potential to cause financial ruin or push the world's poor into deeper poverty making their lives even more miserable.

Conclusions

Climate change is likely to damage more harshly the poor countries of the world than the rich countries which are actually responsible for global warming.

Almost all the poor countries of the world are in low latitude with hot and dry climates and are projected to suffer greater damages due to global warming than the rich countries which happen to be in the mid to high latitude which are currently cool. High latitude countries of Europe and America are expected to have more rainfall while many sub-tropical and semi-arid regions will likely experience less precipitation. Since the low latitude regions are home to the world's poor, they will suffer most due to climate change and it will be more difficult to eradicate poverty from these regions.

The rich countries have a high adaptive capacity that helps mitigate the outcomes of climate change. Even the most devastating events with substantial impacts have left their infrastructure largely intact. The less developed countries, on the other hand, do not have the necessary infrastructure and technology to mitigate the impacts of climate change. Hence the world faces the double irony; countries which contribute least to global warming are both the most impacted and the least able to adapt.

The most disturbing finding is that the developing countries have also started contributing to greenhouse gas emissions and this could have serious damaging effects on their newly emerging economies.

Climate change, therefore, is a major threat to the economies of low and middle income countries along with the challenges of low agricultural productivity, depletion of natural resources, water scarcity and natural disasters. Without mitigating these challenges and adapting to climate change the dream of poverty alleviation cannot be fulfilled.

Suggestions

In order to protect people from the devastating effects of climate change, carbon efficient new technologies and renewable energies must be used. Old equipment should be made more energy efficient.

Advanced countries must help the less developed countries to move towards low-carbon and environment friendly societies, as they have the knowledge and technology to mitigate climate change.

For lowering the level of greenhouse gases in the atmosphere more trees should be planted and deforestation must be discouraged.

Reducing the impact of climate change on poverty requires strengthening the social protection system to make programs scalable and targeted to those in need.

Devastating effects of disasters should be minimized by effective disaster preparedness and its management.

Unless governments move now to reduce emissions, no one will be safe from the effects of climate change.

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Development of Alternative Water Resources in Pakistan: A Review of Rainwater Harvesting Practices

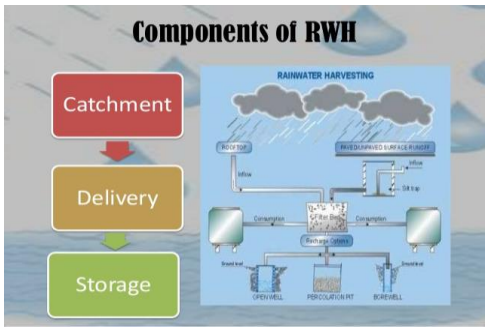
Dr. Abdullah Yasar ,Dr. Amtul Bari Tabinda, Muhammad Muzzammil Nadeem and Khadija Inayat[14]

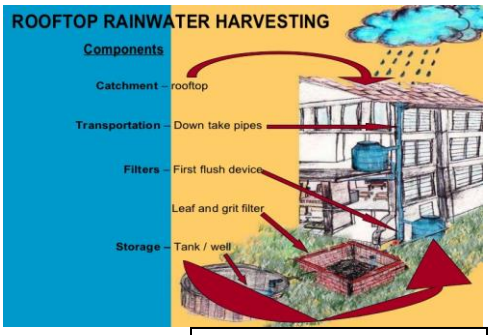
ABSTRACT

Water is the basic necessity of life and unluckily it can only be conserved. The water scarcity is the major problem now a day in the whole world. This problem can be easily avoided by appropriate forecasting and doing rainwater harvesting on the victim areas. It is a technique which is used for collection and storage of rainwater from land surfaces, rock catchments or rooftops by using simple methods like ponds and reservoirs. In Tokyo rainwater collection and consumption systems has been introduced in about 750 public and private buildings. About 1000 rainwater harvesting systems have been arranged in Bangladesh since 1997. PCRWR has developed 92 rainwater harvesting systems in Cholistan desert. ERRA Water and Sanitation (WatSan) experts along with international partners projected that about 140,000 liters of water with 90% efficiency could be collected easily every year from a house comprising 2-3 rooms with a 30 ft x30 ft roof (100 sqm). The rainwater harvesting is the efficient and effective technique that we can use in the developing countries as an alternative water resource to overcome water scarcity.

1) INTRODUCTION

Rainwater harvesting is defined as “the collection and management of floodwater or rainwater runoff to increase water availability for domestic and agriculture use as well as ecosystem sustenance” (Mekdaschi and Liniger, 2013). All water harvesting systems consists of following components; a catchment, a storage facility and a target (Oweis et al., 2012). Rainwater harvesting is a technique which is used for collection and storage of rainwater by using simple methods like ponds and reservoirs then after collection rainwater is a source for drinking, sanitation and for use in agriculture. Rainwater harvesting seems to be a valuable and cost effective method for reducing water scarcity in developing countries.



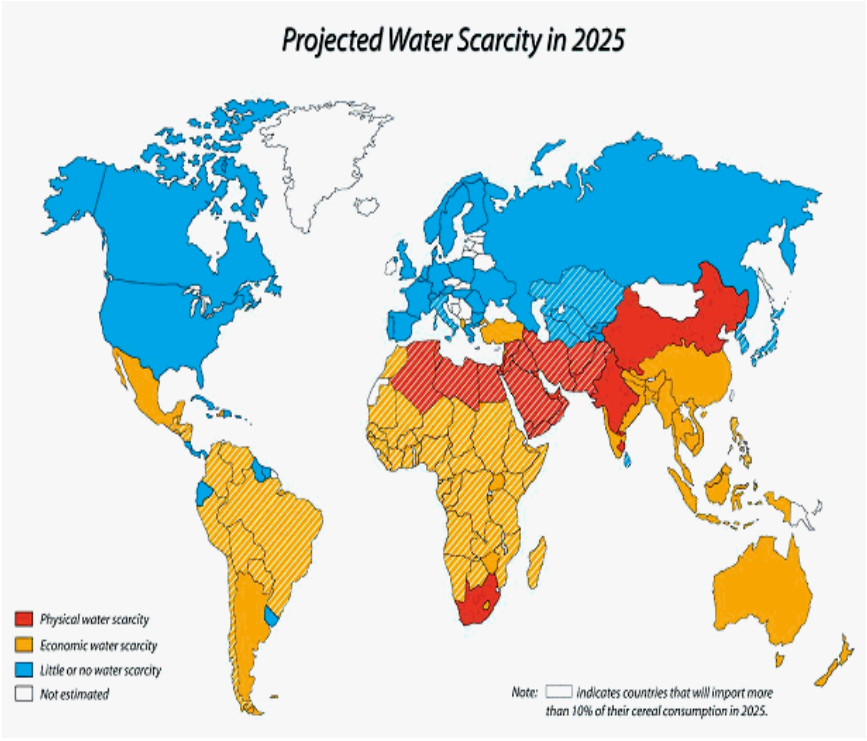


Source: (Wright. D)

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The water which is commonly wasted via ducts installed on the roofs of the commercial, residential or any other structure and drains off without any suitable advantage and usage. In order to solve this problem we just installed storage tanks to let the rain water be stored in an effective way.

Water scarcity is among one of the major problems to be faced by the World in the 21st century. Population increasing rapidly so, water use has been also increasing at more than twice the rate of population increase in the last century. Around the world 700 million people undergo today from water scarcity. About 1.8 billion people by 2025 will be living in countries with absolute water scarcity, and two-thirds of the world's total population could be living under life threatened water stressed conditions (Abid, M. et al., 2016). With the present climate change circumstances, approximately half the world's population by 2030 will be living in areas of high water stress.



Economic: water is available in nature but access is limited by economic barriers.

Physical:

More than 75% of water is being withdrawn for agriculture, industry and domestic use.

Figure 1.1: worldwide water scarcity projection in 202 (Rijsberman. R. F., 2004)

The problem of water scarcity is mainly because of urbanization, because in urban areas the ground is almost covered with cemented material that does not let the rainwater to percolate in the soil and reach the underground water tank as its final destination, what happens because of urbanization is; that rainwater is wasted in the form of evaporated water without being used.

There are twelve UN Millennium Development Goals and one of them is to reduce by half percentage of people without access to safe drinking water. In few countries

this goal is far from being satisfied until 2015. Most of the developing countries are categorized as water-scarce countries which results in high chance of droughts and frequent food insecurity (Qadir, M. et al., 2007).

1.1) Rainwater harvesting worldwide

Singapore, which has increasing demand for water, is on the lookout for substitute sources and modern methods of water harvesting. Almost 86% of Singapore's population resides in apartment buildings. A slightly larger rainwater harvesting system exists in the Changi Airport. Rainfall from the runways and surrounding green areas is abstracted to two reservoirs. One of the reservoirs is considered to equalize the flows and the other reservoir is used for runoff collection. Such collected water accounts for upto 33% of the total water used.

In Tokyo, rainwater harvesting system is promoted to lessen water shortages. The RyogokuKokugikan Sumo-wrestling Arena, built in Sumida City in 1985, is a famous facility that utilizes rainwater. The catchment surface of the rainwater system is 8,400 m^2 rooftop of this arena. Rainwater which is collected through the arena rooftop is shattered into underground tank of 1,000 m^3 storage capacity. About 750 buildings in Tokyo have introduced rainwater collection systems.

In Bangladesh, rainwater collection is a feasible substitute for safe drinking water provision. About 1000 rainwater harvesting systems have been set up since 1997 in the rural areas of country, by the NGO Forum for Drinking Water Supply & Sanitation. Its prime objective is to improve access to safe and affordable water facilities in Bangladesh. The rainwater harvesting tanks range in size from 500 liters to 3,200 liters. The composition of the tanks includes Ferro-cement, brick and RCC ring.

The national capital territory, (NCT), of Delhi which receives 611 mm of rainfall annually. Delhi has high vertical permeability as compared to the horizontal permeability. This makes the conditions suitable for artificial recharge of ground water. Thus most of the urban rainwater harvesting practices in Delhi city revolves around recharge of aquifers which is the most excellent alternative available.

Table 1.1: Potential of rooftop water availability in National Capital Territory of Delhi

Roof area in sq m	Annual rainfall (liters)	Quantity of rainfall available for harvesting (liters)
50	30,550	18,330
100	61,100	36,660
500	305,500	183,300
1000	610,000	366,600

Source: (Centre for Science and Environment)

1.2) Rainwater harvesting in Pakistan

Water is basic necessity of life and unluckily it can only be conserved. According to experts among developing countries Pakistan is also facing one of the worst water catastrophes at the present. Because of population migration to urban areas from rural and demographical changes, the household water demand has increased in the country. Earthquake 2005 brought destruction and almost four thousand water supply schemes were subjected to damage. The earthquake also affected the level of water and making the task more challenging (Mahmood, S., & Ullah, S. 2016).

The earthquake affected areas receives an average annual rainfall of 1500 millimeters. So ERRA reconstructed the damaged facilities, took the initiative of rain water harvesting as an alternative method to conserve water. Preservation of rain water is the solution of water scarcity issues (Hussain, I. et al., 2010). Rain Water Harvesting provides the supplementary and alternative source of water in circumstances where present water sources are not sufficient to meet the needs of a growing population.

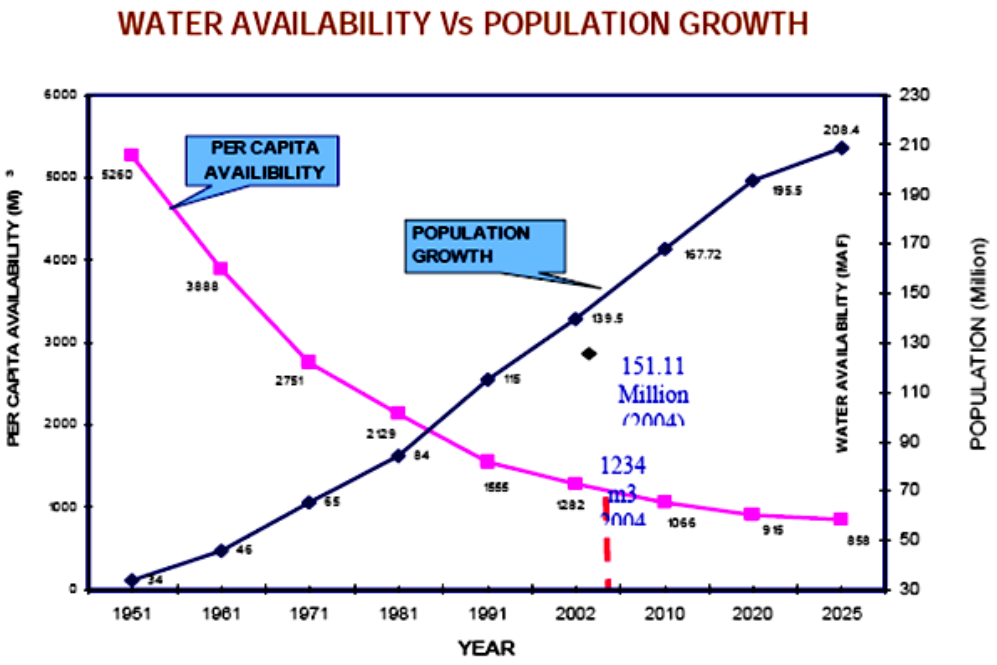


Figure 1.2: Availability of water Vs projected population growth (Jamil. R., 2010)

The earthquake of 8 October 2005, harshly affected the sanitation systems and drinking water-supply in Pakistan. In response to the tragedy, water and sanitation (WS) emergency release program was launched by the Government of Pakistan, in partnership with international partners UNICEF, UNDP, etc. The program entailed following aims; water-supply systems restoration, storage tanks provision, rainwater usage and water purification systems, etc. Regardless of the difficulties, clean water is being provided for a number of people. In mountain areas hill torrent is used for rainwater collection that slide down in the mountain in the form of a stream. Micro rooftop rainwater harvesting projects at household level were suggested in the affected areas (Amin, M. T., & Han, M. Y., 2009).

For Domestic Rain Water Harvesting (DRWH), rainwater is collected from rooftops and low frequented streets and can be stored. The storage tanks for rainwater collection can be constructed above or below the ground. DRWH has many advantages like provision of water near the household and reduce the water collection burden. On the other hand, domestic rain water could be polluted by hazardous substances. Many methods are available for disinfection purpose. GIS technology might intensify locating potential areas for RWH.

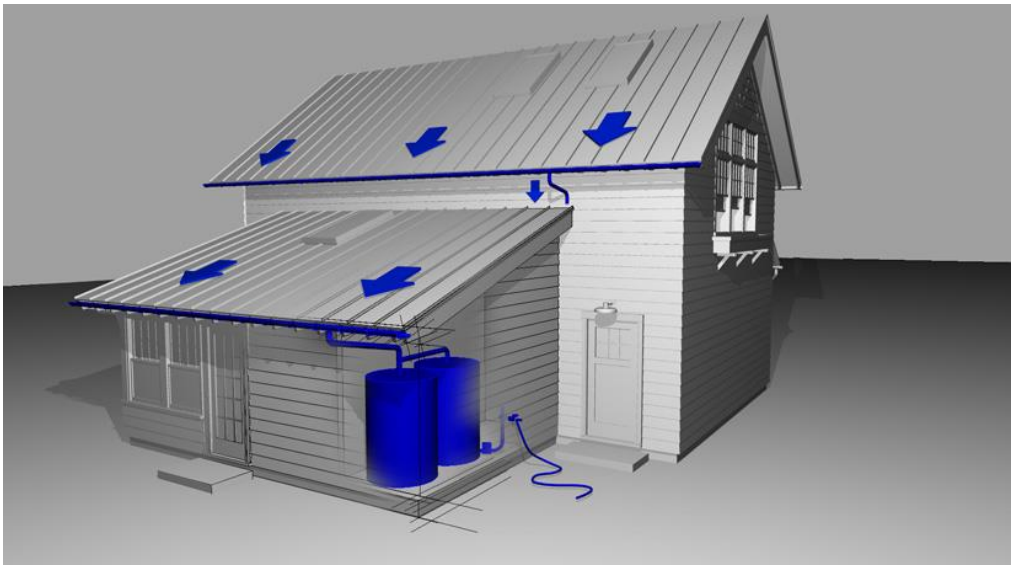


Figure 1.3 Rainwater harvesting model at household level (Rainwater Harvesting, 2011)

So to stop the problem of water scarcity we need to build Inverted recharge wells, this idea in Pakistan has been introduced by CDA (Capital Development Authority) Islamabad, the Deputy Director General of CDA said that this system has been installed behind Faisal mosque and are mainly the concrete made underground water reservoirs that has a bore hole through which a pipe is installed to guide the excessive water into the ground to help in water percolation. We can say that the water scarcity problem can be easily avoided by appropriate measures and doing rainwater harvesting on the victim areas.

ERRA Water and Sanitation (WatSan) experts expected that almost 32,000 gallons of water could easily be collected annually with 90% efficiency from a house consisting of 2-3 rooms. Under this project about 12,000 Rain Water Harvesting Systems have been installed on houses, school buildings and hospitals of 20 Union Councils of KPK and AJ&K. The system provides simple way of rainwater collection, management and utilization at a negligible cost. This project was successful in the Earthquake Affected Areas because the safe houses rebuilt in the area support the Rain Water Harvesting system. (Mahmood, S., & Ullah, S. 2016). The water crisis problem in areas with high rainfall can be resolved by replicating this model according to the community needs.

1.2.1) Rainwater harvesting in Cholistan desert:

Cholistan desert cover the land of 2.6 million hectares where water shortage is the primary crisis for human and livestock. Rainfall is the only supply of freshwater, which happens typically from July to September. The Pakistan Council of Research in Water Resources (PCRWR) has been carrying out research in the Cholistan desert and they have done through making catchments by many technology and building ponds with unique storage volume limit between 3000 and

15000 m^3 (Dasti, A., & Agnew, A. D. Q. 1994). These ponds designed to save highest amount of rainwater in the minimum available time and to lessen leakage and evaporation losses.

After profitable sphere study on rainwater harvesting, 92 rainwater harvesting systems in different areas of Cholistan desert has been developed by PCRWR (Ammar, A. et al., 2016). All these rainwater harvesting activities lead towards the innovation in the socio-economic conditions of the population. These actions are cost effective and have also saved million of rupees during the drought.

1.2.2) Rainwater Harvesting in Mountain Areas of Pakistan:

Pakistan is located in the arid and semiarid area of the world between 24°N and 37°N latitude and between 61°E and 77°E longitude. Typically yearly precipitation ranges from 2000mm in the north to 100mm in the south (PCRWR, 1994). Pakistan has two mountain ranges in the Hindu Kush-Himalayas (HKH), namely the western mountains and northern mountains. Many rivers current from these mountains to join river Indus.

Mountain agriculture is yet mainly rain fed. A number of native water harvesting methods in mountain areas, such as rod kohi system (water of hill torrents collected in reservoirs and used for agriculture) in southern KPK; sailaba and khushkaba systems in Balochistan has been developed over time. To enhance surface water, ground water use through tube wells is popular both in KPK and Balochistan.

1.2.3) Water Harvesting in Northern Balochistan

Main sources of drinking water in the province are wells, spring, river, stream, and ponds. Three fourth of the population use these sources to cop-up many water needs. The piped water is available to 15 percent houses. Piped water is mainly available in the urban areas. Rural inhabitants depend upon spring, stream and pond water (Census 1981). Agriculture in the district is mostly rain fed (Barani).

Pishin like other upland areas of Balochistan is a water insufficient district. There are many significant factors responsible for scarcity of water in the district, like terrestrial division of water flows, inappropriateness between mountain territory and usual method of irrigation methods and collapse to build up irrigation designs appropriate and to mountain situations. The shortage of water in the district identify and approve complete water harvesting and managing approaches in order to meet up the demands (Khalil, S. K. et al., 2014).

Rain has been regarded as a blessing for mankind, providing it with its most basic necessity; water. In the city of Lahore, typically 710 millimeters rain was recorded per year from past four years. The region that catches 250 millimeters or more is considered as an agricultural terrain with more rainfall, that the city has a high capability of stock up and harvesting rainwater, on this base AkzoNobel made a project for rain water harvesting and successfully consumes 5000 liters of rainwater in direct paint making in 2011. They are the first in Pakistan to consume rainwater directly in water based paint manufacturing.

The scheme of rainwater harvesting was promoted around June'11 with achievability studies and development completed the next month. When summer monsoon started, 5000 liters of rain water was captured, by August, in small storage vessels on the new warehouse roof. A sample of the stored water was sent to the laboratory for a chemical analysis and laboratory scale batches was lashed up using this rainwater for any abnormalities and verify that it is certainly fit for use.

CONCLUSION

Major developing countries are water-scared which are distinguished by low rainfall, droughts, dry spells and food insecurity. Rainwater harvesting techniques are easy and simple to establish and operate. Though there are certain factors that can alter the local climatic conditions, rainwater can be a persistent water source. Rainwater harvesting has very few negative environmental impacts. So it is concluded that rain water harvesting offer the best achievable substitute and complementary supplier of water in a condition where presented water supplies are exhausting and be unsuccessful to accomplish the needs of an increasing population.

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IMPACT OF GLOBAL CLIMATIC CHANGES ON SUSTAINABLE USE OF GROUNDWATER IN PUNJAB

By

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ABSTRACT

Groundwater is an essential part of the hydrology cycle which not only supports the life and eco-system on planet but also plays the role of backbone in many commercial, industrial and development activities. Nature has blessed Pakistan with plenty of water resources and specially a large groundwater reservoir underlying the Indus Basin. In Punjab province, groundwater resource is being extracted through hand pumps and about more than 1 million tube wells. This natural resource is contributing about more than 40% crop water requirements at farm gate and thus has gained the vital potential in irrigated agricultural economy of the country. Climatic changes occurring globally have become a great challenge due to their potential impacts on life, integrity of ecosystems and national and global water resources during the last quarter of the past century. Pakistan has also suffered from the climatic changes like other parts of the world. Extreme events like floods and droughts have disturbed the hydrologic-cycle posing severe impacts on water resources. Groundwater quality and levels are changing abnormally due to these events causing issues like water and land degradation, waterlogging and salinity, spatial and temporal uncertainty in availability, access to users etc. Increase in droughts in some areas has increased the frequency of water shortage and led to more restriction on water usages and resulted in more pressure on groundwater. In urban areas, like Lahore City, threat is very severe where annual average depletion rate of water level is 2.5 ft. mainly due very low flows in Ravi River. Global warming, temporal/areal variations in rainfall patterns, uncertainty in river flows, glacier melting are the major challenges to water resources of Pakistan. At the same time it has been found that during flood 2014, average groundwater table rose up to 2.5 ft. in some areas of Rechna Doab in Punjab province. Impacts of theses global climatic changes on groundwater have been evaluated and some options for sustainable use of groundwater have been suggested.

INTRODUCTION

Water is essential for life, but its availability at a sustainable quality and quantity is threatened by anthropogenic and natural factors, of which climate plays important role. The Intergovernmental Panel on Climate Change (IPCC) defines climate as "the average weather in terms of the mean and its variability over a certain time-

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span and a certain area" and a statistically significant variation of the mean state of the climate or of its variability lasting for decades or longer, is referred to as climate change.

According to another definition, Climate change refers to the long-term changes in the components of climate such as temperature, precipitation, evapotranspiration, etc. The major cause of climate change is the rising level of greenhouse gases (GHGs) in the atmosphere such as CO2, CH4, N2O, water vapour, ozone and chlorofluorocarbon **(S. Panwar and G. J. Chakrapani, 2013).**

Industrialization process and its associated production and consumption patterns in the Developed countries have resulted to increase the three-fourth time emissions of greenhouse gases into the atmosphere since the start of the Industrial Revolution (i.e. from around 1850 to the present). Currently, it has been estimated that developed countries account for 45 per cent of CO_2 emissions **(UNDP, 2005).**

In developing countries population high growth rate is main factor of climate change. According to the United Nations, developing countries' populations are estimated to grow by almost half by 2050 (from around 5.3 billion in 2005 to 7.9 billion in 2050 (M Werinke, **2010)**. Developing countries – despite their larger populations have much less contribution in anthropogenic emissions. Developing countries, especially Least Developed Countries (LDCs) and Small Island Developing States (SIDS), who are already facing difficulties in alleviating poverty as a result of their economic situation, are particularly vulnerable to the adverse effects of climate change because they "have fewer resources to adapt: socially, technologically and financially **(UNFCCC, 2007).**

The effects of global warming and climatic change require multi-disciplinary research, especially when considering hydrology and global water resources. The Intergovernmental Panel on Climate Change (IPCC) estimates that temperature of the Earth is continuously rising and it has increased 0.6 ± 0.2 ^oC since 1861, and predicts an increase of 2 to 4 ^oC over the next 100 years. Global sea levels have risen between 10 and 25 cm since the late 19th century (IPCC 2007). Pakistan, as part of South Asia has also observed warming in spite of less discharge of greenhouse gases as compared to industrialized developed countries **(Pant and Kummar, 1997)**.

Climate change has local, regional and globally impacts, some examples of major projected impacts are increased water related stresses such as droughts, sea level rise, decreased freshwater availability, increased floods, decrease agricultural productivity, food production and security etc., **(IPPC 4th report, 2007).** Climate change actually accounts for about 20% of the global increase in water scarcity. Climate variability and change can affect the quantity and quality of various components in the global hydrologic cycle. It includes atmospheric water vapor content, precipitation and evapotranspiration patterns, snow cover and melting of ice and glaciers, soil temperature and moisture, and surface runoff and stream flow with increasing temperatures **(Bates and others, 2008).** However, the extra precipitation will be unequally distributed around the globe. Some parts of the world may see significant reductions in precipitation or major alterations in the timing of

wet and dry seasons. Information on the local or regional impacts of climate change on hydrological processes and water resources is becoming more important.

Water resources, both in terms of quantity and quality, are critically influenced by human activity, including agriculture and land-use change, construction and management of reservoirs, pollutant emissions, water and wastewater treatment. Water use is linked primarily to changes in population, food consumption **(IPPC, 2007)**.

Global water use is probably increasing due to population and economic development but also changing societal views on the value of water. Predictions include higher incidences of severe weather events, a higher likelihood of flooding, and more droughts. The impact would be particularly severe in the tropical areas, which mainly consist of developing countries, including Pakistan.

GROUNDWATER RESOURCES AND CLIMATE CHANGE

According to **USGS**, 96.5 % of Earth's water is oceans, 0.9 % other saline and 2.5% is freshwater - the amount needed for life to survive. Freshwater is locked up in ice and in the ground. Only a little more than 1.2% of all freshwater is surface water, which serves most of life's needs. About 70% of fresh water is locked up in ice, and another 20.9% is found in lakes. Rivers make up 0.49% of surface freshwater. Although rivers account for only a small amount of freshwater, this is where humans get a large portion of their water from. About 60% of groundwater withdrawn worldwide is used for agriculture; the rest is almost equally divided between the domestic and industrial. In many nations, more than half of the groundwater withdrawn is for domestic water supplies and globally it provides 25% to 40% of the world's drinking water **(Vrba, J., and J. van der Gun. 2004)**.

Pakistan is the 4th country out of 15 nations with the largest estimated annual groundwater extractions **(Margat, J., and J. van der Gun. 2013)**. According to United Nations World Water Development Report, 2.5 billion people worldwide depend solely on aquifers, which include 273 transboundary aquifer systems, as their primary water resource to meet their daily needs. Groundwater contributes flow to rivers, lakes, and wetlands. Water reserves of the 21 out of 37 largest aquifer of the world have been declined.

Although the most noticeable impacts of climate change could be fluctuations in surface water levels and quality, the greatest concern of water managers and government is the potential decrease and quality of groundwater supplies, as it is the main available potable water supply source for human consumption and irrigation of agriculture produce worldwide.

The rise in groundwater use associated with predicted population growth would pose a higher threat to the aquifer than climate change **(Loaiciga 2003)**. The unscientific abstraction of groundwater resources has extent of the interface and seawater intrusion into the aquifer (**Sherif and Singh, 1999; Ghosh Bobba, 2002)**. Irrigation generates about 40% of total agricultural output **(Fischer et al., 2006)**. The area of global irrigated land has increased approximately linearly since

1960 at a rate of roughly 2% per annum from 140 million ha in 1961/63 to 270 million ha in 1997/99 representing about 18% of today's total cultivated land **(Bruinsma, 2003**).

Different studies using different models have been carried out to study the impact of Climate changes on aquifer preamble **(Kirshen, 2002)** and groundwater resources **(Scibek and Allen, 2006)** including groundwater levels **(Croley and Luukkonen, 2003)** and deterioration of water quality **(Hsu et al, 2007)**. Groundwater aquifers are recharged mainly by precipitation or through interaction with surface water bodies, the direct influence of climate change on precipitation and surface water ultimately affects groundwater systems. All these studies indicate that climate changes have severe impacts on groundwater level, quality and its recharge.

CLIMATE CHANGES IN PAKISTAN

Pakistan is highly vulnerable to climate change as its economy is heavily reliant on climate-sensitive sectors like agriculture and forestry, and its low- lying densely populated deltas are threatened by a potential risk of flooding. Climate change leads to changes in precipitation and evapotranspiration rates, which show a direct effect on the quantity and quality of both surface and subsurface water. Increase in temperature increases the capacity of the atmosphere to hold water and thus precipitation rate may increase. However, its effect on climate is spatio-temporal, being controlled by local or regional factors such as topography, vegetation, wind velocity, etc

In Pakistan, annual mean surface temperature has a consistent rising trend since the beginning of 20th century. Mean annual temperature increased around 0.36 °C/decade (**S. del Río et al., 2012**). During the last century, average annual temperature over Pakistan increased by 0.6 °C. Studies based on the ensemble outputs of several Global Circulation Models (GCMs) project that the average temperature over Pakistan will increase in the range 1.3-1.5 °C by 2020s, 2.5-2.8 °C by 2050s (**Planning Commission Govt. of Pakistan, 2010**). The summer of 2010 caused a temperature of above 50 °C in twelve cities of Pakistan. The distribution of rainfall in Pakistan varies on wide ranges, mostly depending upon the monsoon winds and the western disturbances, but the rainfall does not occur throughout the year. Like in Punjab and Sindh receive 50- 75% of rainfall during monsoon season (Salma, S et al., 2012). Precipitation over Pakistan also increased on the average by about 25 % (Planning Commission Govt. of Pakistan, 2010). Annual temperature and annual precipitation trends in Pakistan are presented in Figs 1and 2 while annual rainfall trend in Punjab is depicted by Fig 3.

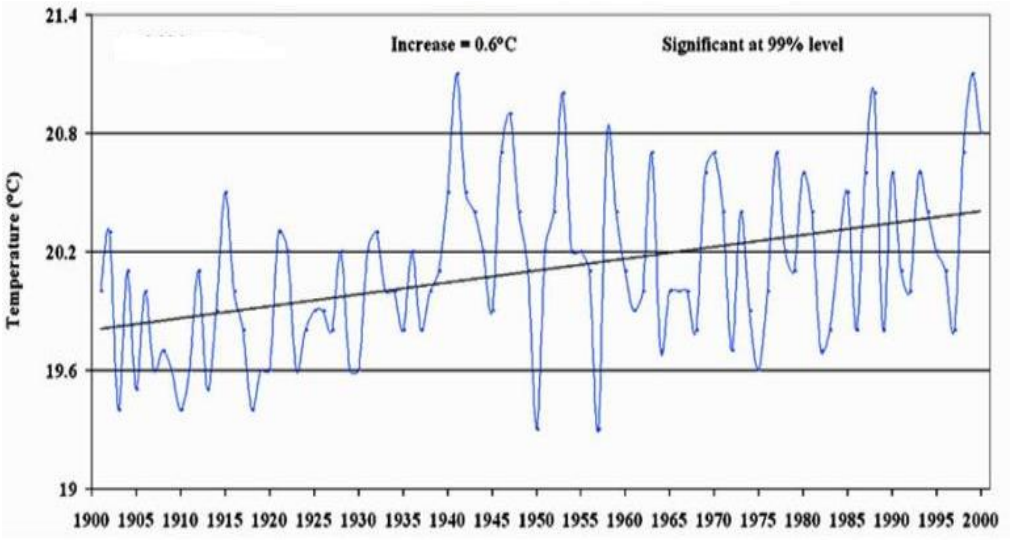


Fig1: Annual Temperature (°C) Trend 1901-2000 for Pakistan (source: M. Touseef, 2009)

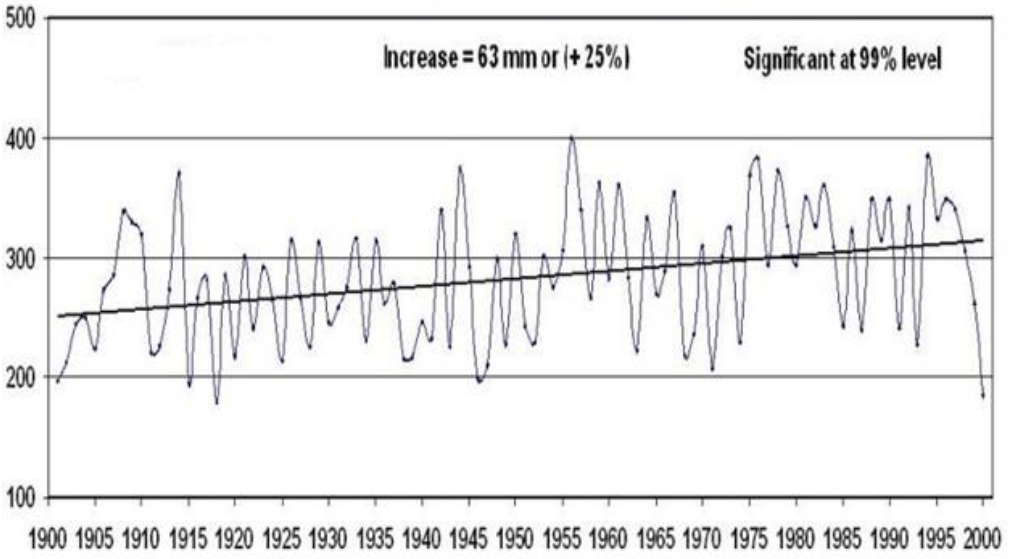


Fig2: Annual Precipitation (mm) Trend 1901-2000 for Pakistan

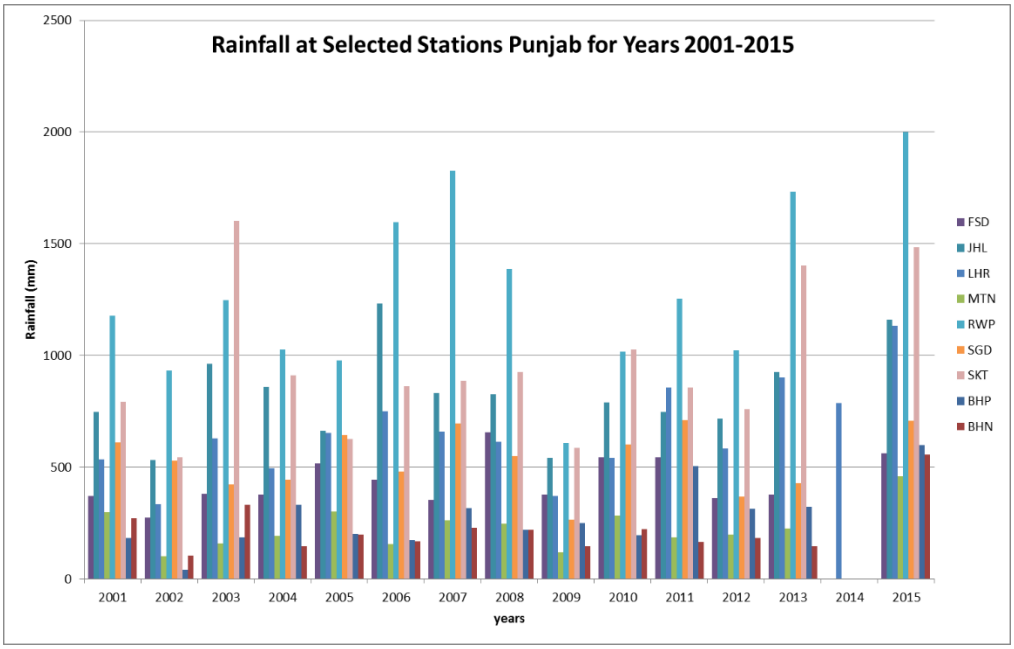


Fig3: Annual Precipitation (mm) at selected station in Punjab for Years 2001-2015. (Data Source PMD)

IMPACT OF CLIMATE CHANGES ON GROUNDWATER

The effects of climate change on groundwater includes as:

i. A long term decline in groundwater storage
ii. Increased frequency and severity of groundwater droughts
iii. increased frequency and severity of groundwater-related floods
iv. movement of saline water intrusion into fresh water aquifer

The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge. If drier, warmer summers lead to the seasonal deficits in the moisture content of soils extending into the autumn, the winter groundwater recharge season may be shortened. This could be compensated, at least to some extent, by an increase in winter rainfall. However, aquifers are recharged more effectively by prolonged steady rain, which continues into the spring, rather than short periods of intense rainfall.

The impacts of climate change could increase the cost of providing water supplies, already rising as a result of deteriorating groundwater quality. Groundwater, of course, cannot be considered in isolation - impacts of climate change not necessarily related to groundwater, such as changing land use and population density, will have a knock-on effect on groundwater, for example through changes in water demand.

GROUNDWATER- PAKISTAN

Pakistan is 4th largest user of groundwater after India, USA & China. Groundwater is also used for domestic & industrial purposes. Canal irrigation system in the IBIS was designed during the 19th century to meet the designed cropping intensity of 60- 70%. Presently, the cropping intensity in the IBIS is around 150%. This increase in cropping intensity is primarily due to the use of groundwater or efficient irrigation practices in areas where surface water is insufficient. Due to shortage of surface water supply, groundwater has been used more than 40% for Agriculture for Pakistan. There were about 0.55 M tubewells in the country in 2000 which have reached about to 1 Million tubewells. Groundwater is also used for domestic & industrial purposes. Status of Tubewells in Punjab for groundwater abstraction is shown in Fig 4. High extraction of the groundwater by tubewells has resulted negative effects including a decrease of groundwater levels which is positive in areas where fields are waterlogged or salinized due to capillary rise from shallow groundwater **(IWASRI 1991).**

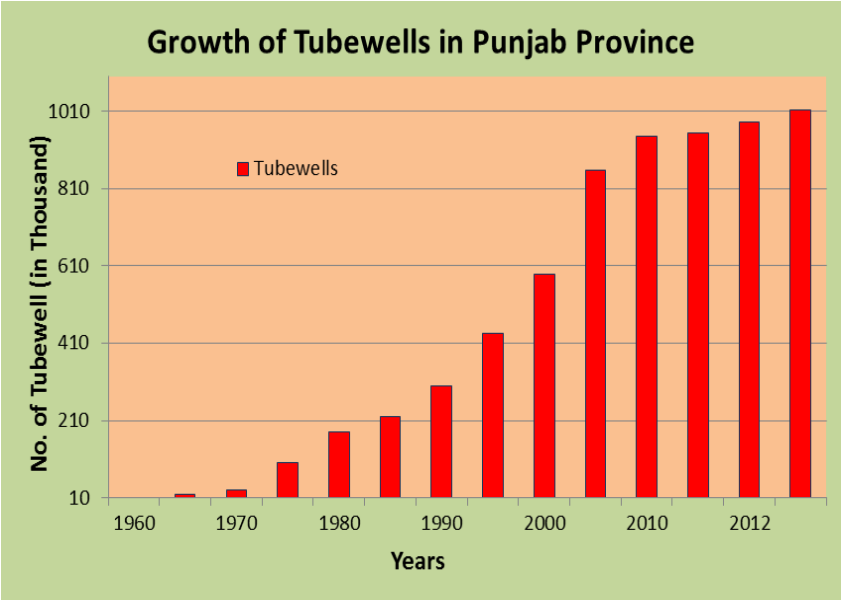


Fig 4: Status of Growth of Tubewells in Punjab Province

Climate changes show both negative and positive impact on the use of groundwater for agriculture and domestic purposes. In the areas, where low rainfall and drought periods existing the intensity of groundwater extraction has enhanced resulting declining of water levels. In the areas where high rainfall exist and flooding occur, less extraction of groundwater and more recharge of aquifer take place. Maximum depth to water table in the different areas of Punjab is shown in Fig.5. Due to lowering of watertable deeper and deeper, pumping cost has also increased in the critical areas of Punjab as shown in Fig. 6.

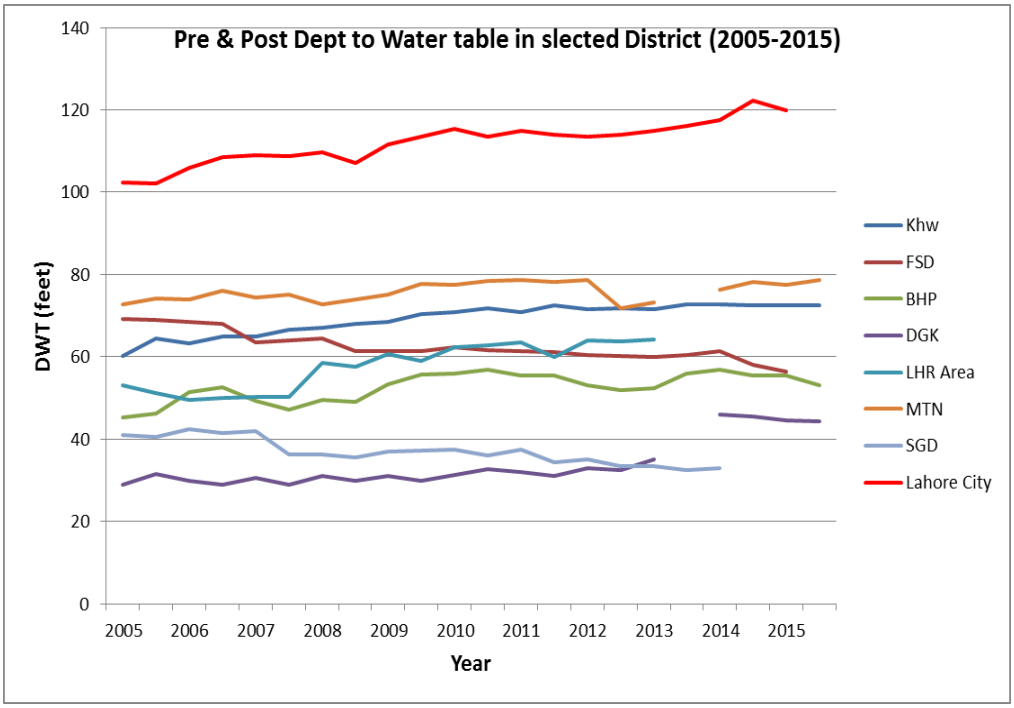


Fig 5: Maximum depth to water table in selected districts of Punjab (2005-2015)

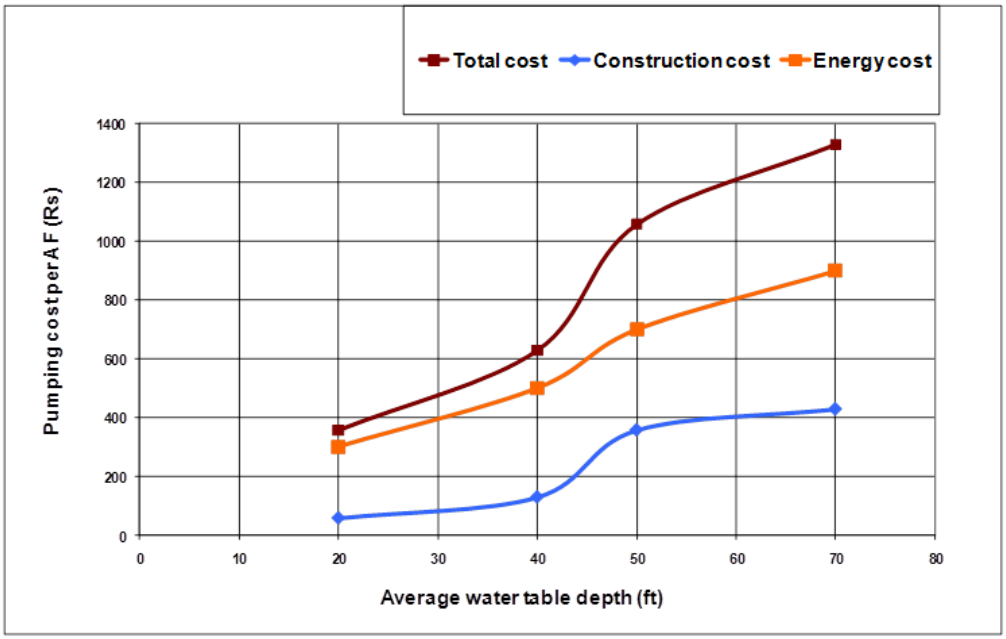


Fig 6: Increase in Cost of Ground Water Pumping with Decline in Water Table

About 40 to 50 % agriculture water requirement is met from groundwater and 100% of the water supply in Lahore is dependent on groundwater and due to unplanned

discharge of groundwater; the levels are continuously falling down. Groundwater level in district Vehari, Multan, khanewal, some area of district Chiniot, etc groundwater level is declining continuously due to high pumpage by farmers and public tubewells. The water table in Lahore is falling at a rate of 2.5 ft every year. It has been predicted that an average drop in groundwater level by 1 m would increase carbon emissions by over 1%, because for the withdrawal of the same amount of water by diesel operating tubwells, there will be increased fuel consumption.

1.1.1.1 GROUNDWATER RECHARGE IN FLOOD PRONE AREAS

Due to climate changes, Punjab Province has experienced flood events during the past several decades. Flood 2014 resulted in significant infrastructural damages, population displacement and loss of lives in the province of Punjab. However floods and local rainfall have significant positive impacts on shallow groundwater. Depth to ground water table during flood 2014 has reduced. Groundwater level of pre monsoon 2014 and post monsoon was compred and it was showed that average groundwater level raised after monsoon in districted of Punjab was 2.57 feet as shown graphically by Figs 7, 8 and 9 which indicate significant recharge of aquifer.

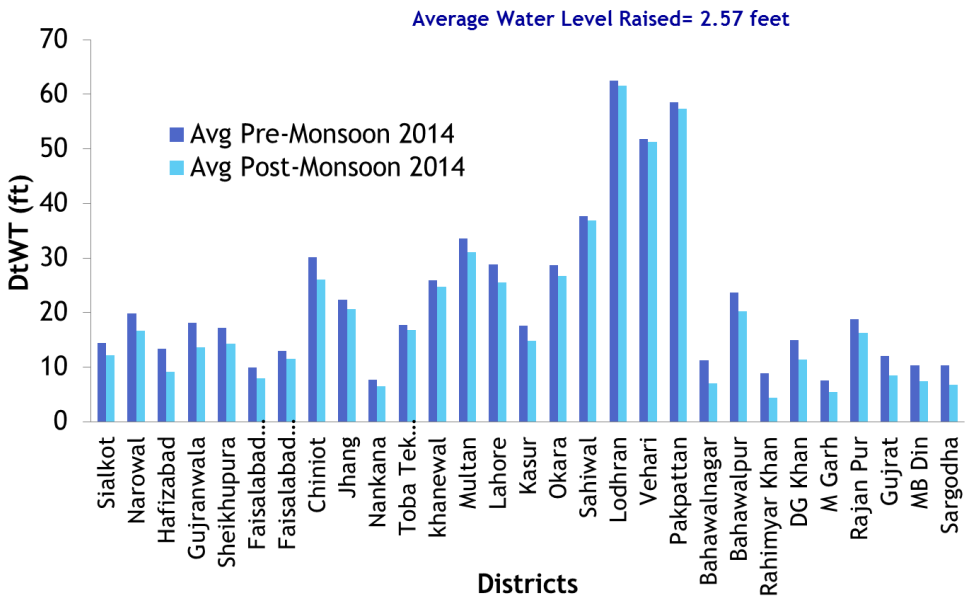


Fig7: Average depth to water table (ft) in district wise of Punjab Province

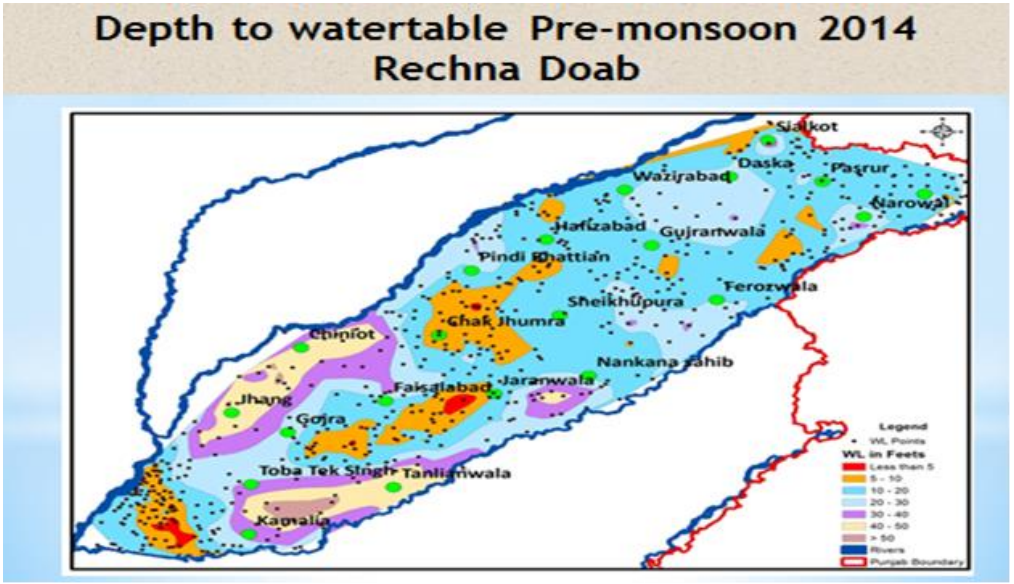


Fig 8–: Pre Monsoon Depth to water table in Rechna Doab in 2014

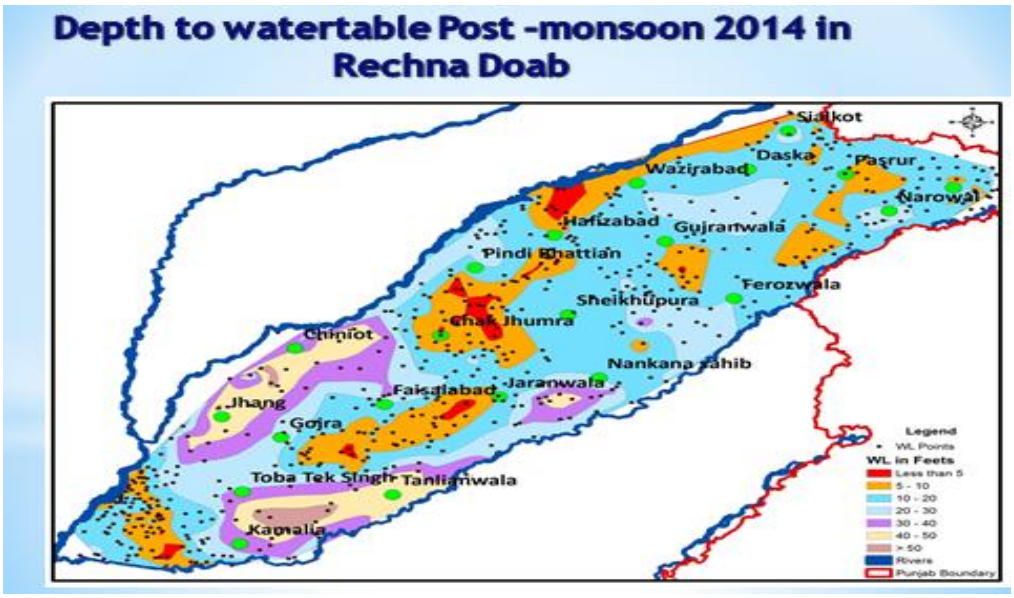


Fig 9: Post Monsoon Depth to water table in Rechna Doab in 2014

Climate change is of most concern where aquifers are either heavily allocated or particularly vulnerable to changes in recharge. In the systems the reduction in water availability due to climate change may impact on groundwater use and entitlements. The impacts of climate change are also likely to be more profound for unconfined aquifer systems, which may respond rapidly to changes in the recharge regime. In a climate change scenario, unconfined aquifers of semiarid and arid regions are considered to be more vulnerable than aquifers of wet regions.

In dry areas, there is a shift in the annual balance between precipitation and evapotranspiration, whereas the aquifers of wet regions may renew themselves because of high precipitation (Sherif, M. M. and Singh, V. P, 1999).

STATUS OF QROUNDWATER QUALITY

Quality assurance of groundwater is much more essential as it relates to the various uses of water. The groundwater quality relates to the physical, chemical and biological properties of the aquifers, which are controlled by climatic fluctuations. The spatial and temporal variation of precipitations and unsustainable groundwater extraction by humans can result in change of quality groundwater. Groundwater quality of Punjab Province is varies widely, ranging from less than 1,000 ppm to more than 3000 ppm. Different areas have different groundwater quality. About 5.75 mha are underlain with groundwater having salinity less than 1000 ppm, 1.84 mha with salinity ranging from 1000 to 3000 ppm and 4.28 mha with salinity more than 3000 ppm. During a dry season, the increase in total dissolved solids may deteriorate the groundwater quality by increased salt content. The higher saline water may also result in scaling of industrial boilers.

Groundwater quality is better especially along the rivers and irrigation network while in central of Doabs, quality is saline to brackish. Groundwater quality of flood prone areas has improved after flood 2014. The small layers of fresh water is lying over the saline water but due to huge pumpage, fresh water layers are declining and intrusion of saline water is occurring resulting deterioration of fresh water in some areas of Punjab.

CONCLUSIONS

The climate change poses many positive and negative impacts on groundwater resources; one of the important consequences is bringing about changes in the quality and quantity of the groundwater resources. The recent global warming caused by the increased emissions of GHGs to the atmosphere by anthropogenic processes, has its effect on continental surface water, oceans, ocean productivity, vegetation, etc. In addition, it has a significant effect on the energy cycle and groundwater. We perceive the immediate climate change effects in terms of floods, drought conditions, glacial melts, etc. The effect of climate change is significantly more on the semiarid, arid and coastal aquifers of the world. In Pakistan, the vulnerability is extremely high because of overexploitation of the groundwater and accompanied land subsidence in urbanized areas. Groundwater is one of the most utilized resources in Pakistan for drinking and irrigation purposes. Due climate change, demand of groundwater has increased for irrigation. More pumpage caused lowering of water table due to which cost of installation and operation of tubewells has increased. The effects of climate change on groundwater resources in our country should be assessed under new environmental condition for better planning and management of this vital resource.

OTHER ISSUES/CHALLENGES GROUNDWATER

1. In Indus Basin, the native groundwater is saline due to underlying marine geological formations

2. Disposal of industrial waste into groundwater aquifers and surface water bodies
3. Solid waste municipal sites are the permanent source of organic and biological pollution
4. Anyone can install any number of wells of any capacity, at any depth and can pump any amount of water at any time.
5. Lack of holistic groundwater management policy framework.
6. Development of groundwater uses much beyond the sustainable limits: Abnormal lowering of water table in some areas.
7. Multiple groundwater uses.
8. Complexities in defining groundwater entitlements and enforcement.
9. General lack of awareness among the stakeholders climate change and groundwater issues.
10. Increasing cost of groundwater pumping with decline in water table.

GROUNDWATER MANAGEMENT ISSUES

1. Groundwater management is being compromised - combating water logging but causing groundwater mining in sweet zones.
2. Groundwater pumping is expensive as compared to surface water charges - generous subsidies on tubewells encourage lavish use.
3. Efforts for groundwater management may have negative impact on small farmers, cropping intensity and cop production - groundwater command areas giving 50-100% more production than surface irrigated areas.
4. Irrational cropping pattern- water intensive crops (rice, sugarcane).
5. Lack of comprehensive plan for groundwater recharge.
6. No regularity authority for groundwater management, licensing and registration.
7. No artificial recharge from flood water

RECOMMENDATIONS

1. Nationwide resource assessment and groundwater mapping using state of the art tools and techniques
2. Involves building infrastructure and/or modifying the landscape to intentionally enhance groundwater recharge.
3. Waste and water quality management to protect the aquifers.
4. Watershed Management
5. Artificial Recharge /Rainfall harvesting.
6. Adoption of advance research, assessment and monitoring tools and techniques for mitigating the climatic impacts.
7. Adopting agro-climatic water productivity based cropping

8. Formulation of Policy, Regulations/legal framework for sustainable use of groundwater in rural and urban areas.
9. Promotion of water conservation culture among the consumers.
10. Supply management through judicious exploitation of surface and groundwater through demand base system instead of supply based at present.
11. Integrated water resources management.

CLIMATE CHANGE ADAPTATION STRATEGIES

1. Adjustment of cropping calendar and pattern.
2. Changes in management and farming practices.
3. Use of heat-resistant varieties.
4. Development of water efficient crops.
5. Technological change and substitution that reduce resource inputs and emissions per unit of output.
6. Development of several social, economic and technological policies for emission reduction.
7. Strengthening of R&D capacity, trans-disciplinary systems and human resources to deal with climate change impacts.

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ENVIRONMENT AND EASTERN RIVERS (VIEWS AND OPTIONS)

Engr. Usman-e-Ghani[17]

1. ABSTRACT

The world now stands fully conscious of environmental concerns over sources of fresh water including the river courses. The impacts have been found as multi-dimensional, wherever the disregard to environmental concerns has been noticed. The damage caused because of complete disregard even to the minimum quantum of flows needed for environmental sustainability in the Eastern Rivers of the Indus Basin is currently being seen under the similar premise. Though the flows in these rivers are being governed under the provision of Indus Waters Treaty signed between Pakistan and India in 1960, but it is being expected that minimum quantum of flows required for the sustainability of the ecosystem associated with the Eastern Rivers would duly be considered by India in view of global cause to save environment.

The importance of the issue may be seen as acknowledged in the form of several agreements and conventions which have globally been signed to save the environment or the ecosystems linked with international water courses. The same hold for the transboundry aquifers which are connected with those water courses as a source of their recharge.

The paper under reference may thus be expected to narrate a short background and to list few of the possible references which could be taken as guide to resolve the issue of minimum quantum of environmental flows in the Eastern tributaries of the Indus Basin River System (i.e. Ravi, Beas and Sutlej). These tributaries were separated from the three Western tributaries (i.e. Indus, Jhelum and Chenab) and were given to India under the provisions of Indus Waters Treaty 1960. The transfer of rights was made for an unrestricted use, depriving the reaches downstream of all the historic flows.

2. KEYWORDS

Environmental Degradation, River Ravi, River Beas, River Sutlej, Indus Waters Treaty 1960, Groundwater Depletion.

3. INTRODUCTION

The plains of Punjab, the very nomenclature for whom has been drawn or has actually been based on the existence of five tributaries of River Indus (Punj

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means five and Aab means waters, hence Punjab), with two dying rivers, have virtually become the land of three. The experts note for instance that in case of River Ravi the clear waters now stand clogged because of low or no flow. The whole of the life inside the river, including rare fish (khagga), has heavily been endangered. The experts thus admit that River Ravi, along with the River Sutlej, is at the helm of death as the reduced level of water in these rivers, particularly River Ravi, has left the flows just to be termed as an accumulation of industrial waste and sewerage. The water, which is subsequently being used for irrigation has also become a source of varied diseases through vegetation grown from it.

As per one estimate, River Ravi receives 1,500 cusecs of untreated waste daily. To this volume, an additional 500 cusecs is added from the Indian Punjab through the drains which enter into Pakistan from the Indian side.

It may be noted that the Indus River System in Pakistan is one of the most significant of all the irrigational river systems in the World. The system feeds a population of more than 180 million people. The ecosystem of the similar size and extent is associated with it. The system efficiency, therefore, remains the subject of numerous studies. The dimensions which contribute to the efficiency of the system are made foci of research and investigation. Beside other, these also include the variation in the system flows due to various reasons including the impacts of Indus Water Treaty 1960.

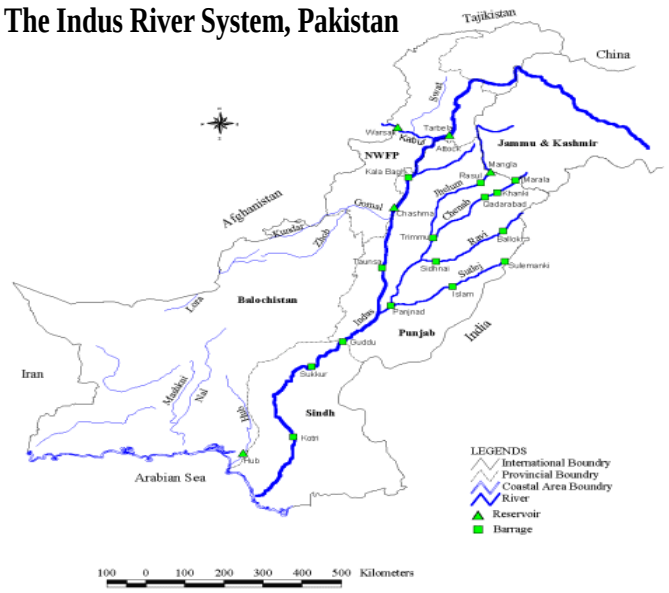


Fig-1: Indus River System - Pakistan

It has been considered that beside the implementation of Indus Waters Treaty 1960 in letter and spirit, the issue of minimum environmental flows in the Eastern tributaries of the system is required to be adequately addressed. The damage to the ecosystem and the underground water resource, which has already been caused, may be taken as a bench mark to this effect. Several instruments, which exist in the form of global conventions and agreements or initiatives could be resorted upon in this respect so that an amicable solution to the problem could be achieved.

4. THE INDUS RIVER SYSTEM

The Indus River System comprises of the Indus and its five main tributaries i.e. the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej. They all combine into one river near Mithan Kot in Pakistan, which outfalls into Arabian Sea south of Karachi. The boundary of the Indus Basin are defined on the West, the north and north-east, by mountain ridges (watersheds). However, the boundary on the south is not so clearly defined due to absence of hills and active rivers.
The total area of the Indus Basin is roughly 350,000 square miles. Most of it lies in Pakistan and the rest in occupied Jammu and Kashmir, India, China and Afghanistan. The climate in the Plains downstream of the rim stations ranges from semi-arid to arid. Annual rainfall ranges from about 30 inches to about 2 inches in the south. The total annual average discharge of these rivers at the rim stations is about 170 MAF (Million Acre Feet).

5. GEOGRAPHY OF RAVI, BEAS AND SUTLEJ (RBS)

Out of the various tributaries of the Indus River System, a short look at the geography of Ravi, Beas and Sutlej, being the subject of this paper, is being given hereunder:

Ravi: This 475 mile (764 km) long river rises in Himachal Pradesh. The Thein Dam (Ranjit Sagar Dam), commissioned in the year 2001, is located on this river at the tri-section of Punjab, Himachal Pradesh and J&K State and feeds the Upper Bari Doab Canal which irrigates NW Punjab.



Fig-2: Ravi River near Chamba

Beas: This 290 mile (467 km) long river originates near Rohtang Pass in Himachal Pradesh and flows through Kulu Valley and the Siwalik Range. The Pandoh Dam is situated on this and diverts water to Sutlej through the Beas-Sutlej link. After the complete diversion of the river, it no more enters into Pakistan.

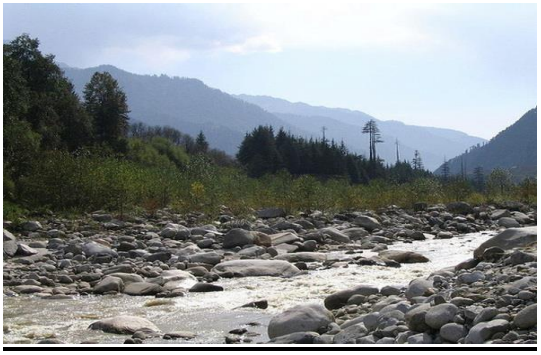


Fig-3: The Beas River

Sutlej: The longest of the five tributaries, the Sutlej originates near Mount Kailash along with the Indus and runs a course of 964 miles (1550 km) through the Panjal and Siwalik mountain ranges and enters Pakistan through the plains of Indian Punjab. The huge 740 feet (225 m) high Bhakra Dam, which Prime Minister Nehru termed "the new temple of resurgent India," is also situated on this river. This Eastern tributary combines with the main river at Mithan Kot.

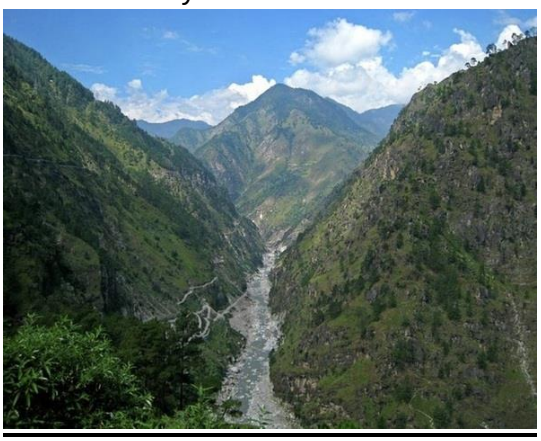


Fig-4: Sutlej River in Kinnaur, Himachal Pradesh

6. INDUS WATERS TREATY 1960

In August 1947 when South Asia was divided into two independent countries there existed one of the most highly developed Irrigation System in the world and approximately 37 Million Acres received irrigation from the flow of waters of the Indus System of Rivers. All of the available water supplies were allocated

to the various Princely States and Provinces in conformity with the principle of equitable apportionment of the waters with preferential right to existing uses.
At the time of Independence major portion of the Indus Basin formed a part of Pakistan and out of 37 Million Acres which received irrigation; 31 Million Acres were in Pakistan. But unfortunately, the boundary line between the two countries was drawn without any regard to the irrigation works. It was, however, affirmed by the Boundary Commission and expressly agreed by the representatives of the affected zones before the Arbitral Tribunal that the authorized shares of the two zones in the common waters would continue to be respected.

However, on 1st April 1948, India suddenly stopped the supplies of water to Pakistan from the structures under their control. The water dispute between the two countries was thus obvious to emerge. After protracted negotiations of 12 years on the issue, under the good offices of the World Bank, when the World Bank was able to ascertain that the existing uses in Pakistan could not be met by transfer of waters from the Western Rivers and that the Storages on the Western Rivers would be required for the purpose, the Indus Waters Treaty was signed in 1960.

The Treaty consists of 12 Articles and 8 Annexures (A to H). It is based on the division of the Rivers between the two countries. The waters of the Sutlej, Beas and Ravi named in the Treaty as “Eastern Rivers” are for the unrestricted use of India and the waters of Indus, Jhelum and Chenab, named in the Treaty as “Western Rivers” are for the exclusive use of Pakistan except for certain specified uses allowed to India in their upper catchments. In terms of Treaty, these aspects are reproduced hereunder:

A) PROVISION REGARDING EASTERN RIVERS (RAVI, BEAS AND SUTLEJ)

1) *All the waters of the Eastern Rivers are available for unrestricted use by India.*
2) *Pakistan is allowed limited Agriculture Use of 45,500 Acres from tributaries of river Ravi namely Basantar, Bein, Tarnah and Ujh.*

B) PROVISIONS REGARDING WESTERN RIVERS (INDUS, JHELUM AND CHENAB)

1) *Pakistan shall receive for unrestricted use all the waters of Western Rivers.*
2) *India shall not interfere with the waters of Western Rivers except for following uses:*
   - *(a) Domestic Use*
   - *(b) Non-Consumptive Use*
   - *(c) Agricultural Use (limited)*
   - *(d) Generation of Hydro-electric Power*
   - *(e) Storage Works (limited)*

Under the Treaty, Pakistan was required to construct and bring into operation a system of works, which would accomplish the replacement of water supplies from the Western Rivers for irrigation canals in Pakistan, which on 15th August 1947 were dependent on water supplies from the Eastern Rivers. These replacement works, comprising of two storages Dams (One on Indus River and one on Jhelum River), six new barrages (diversion dams), remodeling of two existing barrages, seven new inter-rivers link canals and remodeling of two existing link canals, have since been completed.

7. PRE PARTITION UTILIZATION FROM RAVI, BEAS AND SUTLEJ (RBS)

As already said, Ravi, Beas and Sutlej are three Eastern Rivers of Indus basin, which have been allocated to India under the provisions of Indus Waters Treaty signed between Pakistan and India in 1960. The Western Rivers, i.e. Chenab, Jhelum, and Indus have been allocated to Pakistan, with certain uses allowed to India. The quantum of pre-partition uses by India from Ravi, Beas and Sutlej are discussed hereunder:

a) Ravi River

On this river, Madhopur Headworks were constructed in 1902 to feed the Upper Bari Doab Canal. This was a diversion work meant to use the river flow and no storage was provided. Part of the command was situated in India and part in Pakistan. The pre-partition utilization in Indian Punjab as worked out by Ministry of Irrigation and Power was 1.476 MAF.

b) Beas River

Prior to partition, there was no irrigation structure on this river and the flow was utilized beyond its confluence with Sutlej through Ferozepur Headworks on Sutlej. Although the Ferozepur Headworks are situated on Sutlej, but the actual utilization from it was that of Beas River. Sutlej pre-partition utilization through Rupar Headworks was amalgamated with

Bhakra Nangal Project and it is now being governed by a separate agreement known as Bhakra Nangal Agreement of 1959.

The total pre-partition utilization based on average of 10 Years (1936-46) on Ravi, Beas and Sutlej was as under:

Table-1: Pre-Partition Utilization from Ravi, Beas and Sutlej

Sr.	Name of work/canal	Pre-partition utilization (MAF)	Say (MAF)
1	Eastern Canal (Punjab)	0.494	0.50
2	Bikaner Canal (Rajasthan)	1.110	1.11
	(a)Total utilization of Beas river	1.604	1.61
3	Upper Bari Doab Canal (Punjab)	1.476	1.48
4	Kashmir Canal (J&K)	0.035	0.04
	(b)Total utilization of Ravi river	1.511	1.52
	Grand Total	3.115	3.13

c) Sutlej River

On this river, headworks at five places existed in 1947. These were mainly for diversion of river flow, depending upon the available supplies. There was no storage on the river. The five headworks were as under:

(i) Rupar Headworks for feeding Sirhind Canal and Doab Canal with the capacities of 12,620 Cs and 1,452 Cs respectively.
(ii) Ferozepur Headworks downstream of confluence of Sutlej and Beas.
(iii) Sulemanki Headworks.
(iv) Islam Headworks and
(v) Panjnad Headworks.

Through Rupar Headworks, the perennial river flow was utilized by the canals taking off from this place. The escape during winter season and regeneration below Rupar were exclusively used by Bikaner Canal, in addition to its Beas share. Only monsoon flows used to escape downstream, which were later harnessed by the construction of Bhakra Dam.

Ferozepur Headworks are situated just at the Indo-Pakistan Border and used to feed Dipalpur Canal on right flank (now lying in Pakistan). This has become redundant after partition.

On the left flank there were two canals viz. Eastern Canal in Punjab and Gang Canal mainly meant for use in Bikaner State. Eastern Canal was a non-perennial canal depended only on monsoon supplies while Bikaner Canal was perennial canal. The full authorized discharge capacities of Eastern Canal and Bikaner Canal were 3,320 Cs and 2,720 Cs respectively. The distribution was governed by tripartite agreement of 1920 and the recommendations by Anderson Committee made in 1935.

The canals taking off from Ferozepur Headworks were mainly dependent on the supplies from river Beas and also upon the regenerations in river Sutlej (both perennial and non perennial). The pre-partition uses of Bikaner Canal and Eastern Canal were fixed as 1.110 MAF and 0.494 MAF annually, respectively.

The other three headworks, viz. Sulemanki Headworks, Islam Headwork and Panjnad Headworks lie in Pakistan and are not relevant to India now.

8. OUTLINE OF INDIAN DVELOPMENT ON EASTERN RIVERS

Now a short description of the Indian Projects on Eastern Rivers follows:

a) Ranjit Sagar Dam

Ranjit Sagar Dam (Thein dam) is a multipurpose project constructed on river Ravi in 2001, 24 km upstream of Madhopur Headworks. The construction of Ranjit Sagar Dam is a part of plan for utilization of the waters of three Eastern Rivers for irrigation and power generation.

Ranjit Sagar Dam is located in a gorge section of river Ravi near village Thein in J&K State, in seismically active zone of Himalayas constituting the Siwalik Range. The Project is an embodiment of inter-state relationship and co-operation amongst the States of Punjab, J&K and Himachal Pradesh. The power production from the project was envisaged as 600 MW with gross storage of 3.280 MAF.

Ranjit Sagar lake, named after Maharaja Ranjit Singh, the renowned Ruler of Punjab, has been formed upstream of the dam extending upto 22 km with maximum width of 5 km and a depth of 130 m.

b) Beas-Sutlej Link

Beas Sutlej Link Project was the largest tunneling project of the time in India. It comprises of 13.1 km long tunnel with 25 ft diameter, through which the water is taken from Pandoh Reservoir upto the Baggi Control Works.

This tunnel is capable of carrying 9,500 Cs water. Control works have been provided at the exit point of the Pandoh-Baggi Tunnel for regulation of outflows from Pandoh Reservoir to meet the fluctuating demands of Dehar Power Plant.

The 11.8 km long Sundernagar Hydel Channel, taking off from the exit portal of Pandoh-Baggi Tunnel, outfalls into Sundernagar Balancing Reservoir. It has got a carrying capacity of 9,000 Cs.

A Balancing Reservoir with a live storage capacity of 3,000 Acre feet has been constructed at tail of the channel to provide balancing storage to take care of the variation between the supply required for the actual load on Dehar Power Plant and discharge in water conductor system.

The last link of the Project comprises of Sundernagar-Sutlej Tunnel, which is 12.35 km long power tunnel with 28 ft diameter and having carrying capacity of 14,250 Cs. The tunnel starts from Sundernagar Balancing Reservoir and terminates into surge shaft from where three penstock headers fan out. The tunnel has been concrete lined throughout its entire length, reinforced in reaches where the rock is poor or where the rock cover is inadequate.

c) Dehar Power Plant

The Dehar Power Plant is located on the right bank of river Sutlej, a little upstream of Slapper Bridge on National Highway No. 21. There are six generating units of 165 MW each. At the exit of the Sundernagar-Sutlej Tunnel, the tunnel has been trifurcated into 8 ft. diameter steel outlet pipes. Each outlet pipe has been further transitioned into rectangular conduits to accommodate the gates. After generating power at Dehar, the Beas water is left into Sutlej. Thus, Beas water meets with the river water at this point.

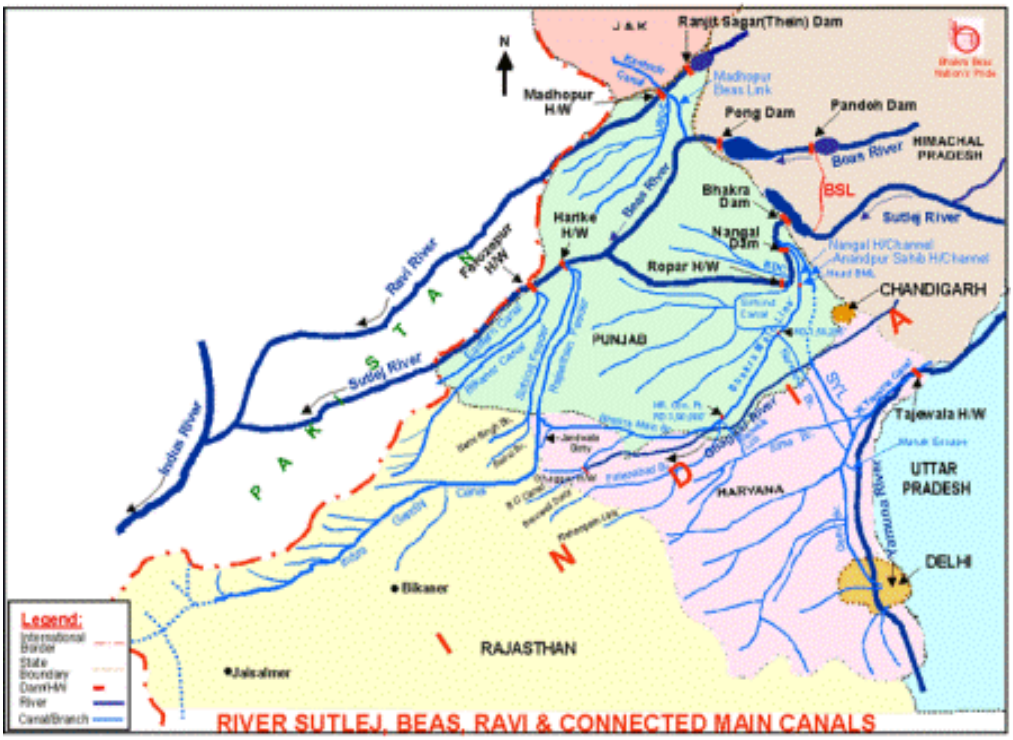


Fig-5: Schematic Diagram of Indian Projects on Eastern Rivers

d) Pong Dam

Pong Dam was primarily envisaged for meeting the irrigation water requirements of Rajasthan, Punjab and Haryana. Presently, it is being used for power generation too. The Dam is located at Pong across river Beas in Kangra district of Himachal Pradesh. It is the highest earth fill Dam so far constructed in India. Rajasthan draws its maximum share of water from Pong Dam.

A chute spillway has been provided for passing the flood which is located on the left abutment of the dam. The spillway caters with maximum discharge of 437,000 Cs.

Pong Power Plant is a reinforced concrete framed structure, located in the stilling basin downstream of penstock tunnels. The power plant has an installed capacity of 360 MW having six units of 60 MW each. The project has a gross storage capacity of 6.95 MAF.

e) Nangal Dam

Nangal Dam situated about 13 km downstream of Bhakra Dam is 29m (95 ft) high & comprises 26 bays of 9.14 m (30 ft) each. It is designed to pass

a flood 9,910 cumecs (350,000 Cs). Dam diverts the water of river Sutlej into Nangal Hydel Channel & Anandpur Sahib Hydel Channel for power generation and irrigation purpose. Nangal pond acts as a balancing reservoir to smoothen out the diurnal variation in releases from the Bhakra Power Plant.

Nangal Hydel Channel is a lined channel taking off from the left bank of river Sutlej just above the Nangal Dam. The natural fall available along the channel is utilized at Ganguwal and Kotla for generating power.

Anandpur Saheb Hydel Channel takes off from Nangal Barrage and along the left bank of river Sutlej almost parallel to and on the left side of the Nangal Hydel Channel. It is 33 km long with a discharging capacity of 10,150 Cs. It has two power houses at Gangway and at Kola. The total length of Nangal Hyde Channel is 64.5 km.

f) Pando Dam

Pando Dam is a diversion dam of the River Beas at Pando, an earth-cum-rock fill dam, 76.20 m (250 ft) high above the deepest foundation. A chute spillway with flip bucket for maximum design outflow of 350,000 Cs has been provided on left abutment. There are five bays in which high pressure top seal type radial gates have been installed for regulating flow of water. Total width of the dam at the top is 255 m (835 ft).

RBS USES IN 1947	
• TOTAL	= 33 MAF
• PAK USES (1947)	= 16 MAF
• INDIAN USES (1947)	= 08 MAF
• D/S FLOWS	= 09 MAF

KNOWN RBS DEVELOPMENT BY INDIA	
• RAVI	= 3500 MW
• BEAS	= 4000 MW
• SUTLEJ	= 7000 MW

g) Bhakra Dam

Bhakra Dam is a majestic monument across river Sutlej. Its construction was taken up after independence for the uplift and welfare of the people of Northern Region. The construction of this project was started in the year 1948 and was completed in 1963. It is 740 ft high above the deepest foundation as straight concrete dam, being more than three times the height of Qutab Minar.



Fig-6: Bhakra Dam across Sutlej River

Bhakra Dam is the highest Concrete Gravity dam in Asia and Second Highest in the world. The gross Storage Capacity of the dam is 7.57 MAF with command area of about 6 million acres. The planned upgraded capacity of power production is 1,325 MW.

Table-2: List of Indian Projects on Eastern Rivers

- *Ranjit Sagar Dam*
- *Madhopur*
- *Ravi Beas Waters*
  - *Madhopur-Beas Link*
  - *Bikaner Canal (Gang Canal)*
  - *Indira Gandhi Nehar (Rajastan Feeder)*
- *Beas Sutlej Link*
  - *Dehar Power Plant*
  - *Pandoh Baggi Tunnel*
  - *Baggi Control Works*
  - *Sundernagar Hydel Channel*
  - *Sundernagar Balancing Reservoir*

- *Sundernagar Sutlej Tunnel*
- *Pong Dam*
- *Sutlej Waters (Rajasthan via Punjab)*
  - *Bhakra Nangal Projects*
  - *Rupar*
  - *Harike*
  - *Ferozepur*

9. GROUNDWATER PROBLEM AND INDUS WATERS TREATY 1960

The nature of the ground water in the Indus Basin is such that there are adjoining pockets of both sweet and brackish water. In some cases the water at upper layer is sweet and at the lower level it is brackish. If not carefully exploited there is always a fear of inter mixing of brackish water with sweet water zone. As such its exploitation in conjunction with the river flow waters was not considered in working out the Replacement Plan under Indus Waters Treaty 1960. Consequently, a look at the impact of such a missing is highlighted in the table below, which indicates the ground water scenario of the city of Lahore at the bank of River Ravi:

Table-3: Population of Lahore and Groundwater Abstraction

Yr.	POPULATION OF LAHORE DISTRICT (MILLION)	ABSTRACTION BY MUNCIPILITY/ WASA (Mm^3/YEAR)	ABSTRACTION BY PRIVATE AND OTHERAGENCIES (Mm^3/YEAR)	TOTAL ABSTRACTION (Mm^3/year)
1980	3.06	232	92.20	324.20
1990	4.09	366	160	526
2000	5.45	495	225	720
2010	8.50	650	309.37	959.37
2015	9.70	721	361	1082

The indication hereinabove has been placed only for the city of Lahore. The entire region under the influence of Ravi, Beas and Sutlej exhibit a similar trend and could further be explored in the relevant studies/literature.

10. A CASE STUDY OF RIVER RAVI

River Ravi is one of the Eastern Rivers given to India as a result of Indus Water Treaty 1960 and the smallest of five main rivers of Indus River System. It

originates from the basin of Bangahal and drains in the southern slopes of Dhanladhar. After flowing through the Chamba valley in the North West direction parallel to the Dhanladhar range it leaves the Himalayas at Baseeli in India. While in the mountainous area, the river Ravi flows for about 130 miles with the drop of about 15,000 feet. After crossing District of Gurdaspur it enters Pakistan near Jassar, which is 120 km upstream of Lahore. The river then flows down for about 520 km and joins the River Chenab.

Due to extremely low flows in the winter season the river just acts like a dirty drain due to the discharge of municipal sewage from Lahore city as well as industrial flows generated from industrial clusters from various locations like Kala Shah Kaku, Lahore-Sheikhpura Road, Kot Lakhpat Industrial Estate and Multan Road, etc.

It may be noted that the use of water of river Ravi for irrigating the crops and vegetables is severely harmful for soil as well as for crops and vegetables. Various research studies show accumulation of harmful heavy metals in crops due to irrigation with contaminated water.

Average annual flow of river Ravi in various years may be seen as has gradually been declined over years. In the years between 1922 to 1961 it was 7 million acre feet (MAF), which became 5 MAF between 1985 to 1995 and it further reduced to 1.1 MAF between years 2000 to 2009. While in the years 2009-10 it was 0.28 MAF. The figure given below illustrates the decline of flow in river Ravi:

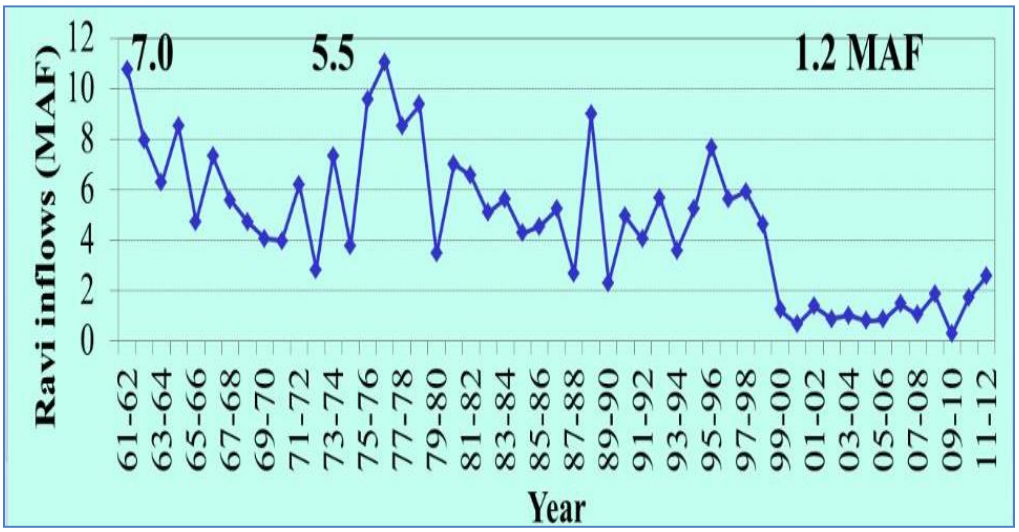


Fig-7: Ravi Flows

According to International Panel of Experts, a minimum flow is required to be 5,000 cusecs/day and 25 MAF once in five years. But the reduced flow has

brought devastating effects on the river ecology, fish species, ground water quality, socio economic status and the health of the communities settled along the river.

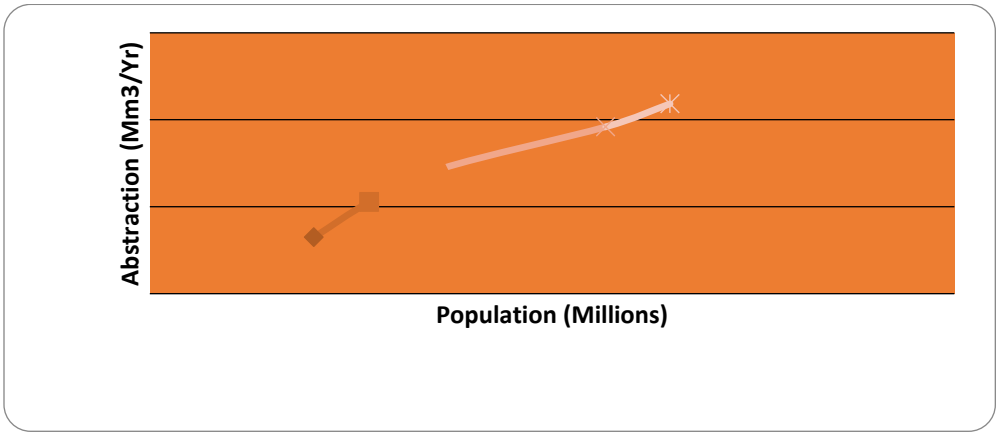


Fig-8: Population and Groundwater Abstraction

Hudiara drain discharges maximum pollution load into the river which is around 430 cusecs. According to an estimate the total daily discharge into river Ravi from point and non-point pollution sources is 2,000 cusecs/day.

Faecal pollution is also common in the adjoining areas which has resulted increased diarrheal diseases as well as various abdominal and skin related illnesses. During the low flow or zero flow from India the river serves just the purpose of DRAIN. The recharge from the sewerage water is very much detrimental for human beings, livestock and agriculture. The reducing water-table scenario for the city of Lahore is noted below:

Table-4: Water Level below Ground Surface

YEAR	MIN. (ft)	MAX. (ft)	LOCATION
1980	18.70	65.04	New Ravi Bridge & Mozang
1990	26.83	82.82	New Ravi Bridge & Mozang
2000	35.00	105.00	New Ravi Bridge & Shadman
2010	60.19	137.82	New Ravi Bridge & Shadman
2015	68.55	150.00	New Ravi Bridge & Gulberg

Hence, it is the need of the hour that the environmental laws relating to protection of water resources should strictly be implemented both on limited and wider scales.

THE POLLUTED WATERS – I
• Presently River Ravi is a sewage carrier. All the seepage from it is nothing but sewage. • Half of total IRS waste is dumped into river Ravi. • Flow of sewage in River Ravi is polluting the groundwater reservoir under Lahore. The direction of groundwater flow in the area is from River Ravi towards centre of the city due to water level difference. • Through the result of water sampling it has been clarified that the source of pollution is seepage from River Ravi. • Mixing of shallow and deep groundwater, especially in the centre of the city reveals that the aquifer is highly vulnerable to pollution. • Mixing of sweet and saline water layers in the unconfined system has also been noticed.

THE POLLUTED WATERS – II
• *Because of Ravi, Lahore has changed, losing its vigor that was its identity. Though this has got much to do with IWT 1960, but lack of concern, ill management and municipal pollution have also transformed river into a sewage channel.* • Same holds for the city of Bahawalpur located on the bank of River Sutlej.

11. THE COMMON WATER LAW UNDER UNECE

As noted in the opening sections of this paper, it may be seen that the protection of water bodies all over the globe in now being considered in a serious and concerted way. A number of joint efforts exist at present at various levels to address the issue. At the topmost tier, the UN is also working in this respect for the closest cooperation among all the states of the world through its various bodies such as the UNESCO, the UNECE, etc. The UNECE environmental conventions, i.e. multilateral environmental agreements, which are already in force, include following:

- Convention on Long-range Transbounday Air Pollution.
- Convention on Environmental Impact Assessment in Transboundary Context.

- Convention on the Protection and Use of Transboundary Watercourses and International Lakes.
- Convention on the Transbounday Effects of Industrial Accidents.
- Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters.

These conventions have further been supplemented by a number of protocols including:

- Protocol on Water and Health.
- Protocol on Strategic Environmental Assessment.
- Protocol on PRTRs.
- Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transdoundary Waters.

12. THE COMMON WATER LAW AND THE EASTERN RIVER

Each of the Conventions and the Protocols has a part to play for revival of the degraded environmental systems associated with the Eastern Rivers. A detailed discussion on these Conventions and Protocols is not being undertaken in the paper. It is intended that each of these may separately be studied and discussed so as to ascertain the extent of their applicability to address the damages caused because of no or low flow in the Eastern Tributaries of Indus River System.

13. INTERNATIONAL CONVENTIONS ON TRANSBOUNDRY AQUIFERS

In addition to the measures being initiated for surface water resource, the global community/organizations are fully concerned about the sustainability of groundwater as well. UNESCO has noted that aquifers contain about 96% of the available freshwater. Out of the usage from this resource, 65% is used for irrigation, 25% as a drinking water and 10% for industry. It has further been noted the aquifers account for more than 70% of the water used in the European Union and are often the only source in arid and semi-arid zones even upto the extent of 100% as in case of Saudi Arabia and Malta, 95% in Tunisia and 75% in Morocco.

Generally because of their transboundary nature, the uses from aquifers have usually been seen as subject to the mutual agreements for their joint management so as to prevent their over-exploitation by a single entity. For instance, Chad, Egypt, Libya and Sudan established a joint authority in 1990s for managing the Nubian Sandstone Aquifer System.

Being conscious of such an important issue, UNESCO prepared the Law of Transboundary Aquifers through International Hydrological Programme (IHP)

and the UN International Law Commission. The Law was endorsed by the UN General Assembly in its 63rd session in the year 2008. By the virtue of this Law, the concerned states were encouraged 'to make appropriate bilateral or regional arrangements for the proper management of their transboundary aquifers'. The provisions also include the cooperation among states to reduce/control pollution of shared aquifers in view of the importance of these 'invisible resources'.

14. ENVIRONMENT AND TRANSBOUNDRY AQUIFERS

In the words of UNESCO, the simple way of looking at the environmental aspect of transboundary groundwater/aquifers management is by considering all possible functions that groundwater and aquifers perform. One of these functions is that it sustains eco-systems. To sustain these groundwater-dependent ecosystems, groundwater resources are partly environmentally committed. This notion can be associated with three different motivations:

- First, the notion of sustainability is associated with the control on groundwater depletion and the possible compromise on future uses. In this meaning, sustainability is much related with use efficiency as in case of classic groundwater development paradigm. Within this paradigm, the motivation for sustainability is profit-oriented and does not implicitly mean an environmental sustainability.
- Secondly, the people value the natural environment/ecosystems since they provide essential ecological services for the human society. For example, the natural attenuation capacity of aquifers is a low-cost alternative for the expensive artificial contamination remediation techniques. And in this sense, ecosystems provide an indirect economic value.
- And thirdly, the ethical and esthetical motivation for the preservation of the natural environment. People value the non-use aspects of natural environments and ecosystems because of its pure existence. They perceive utility from it since they consider it beautiful or think they should take care of it for future generations. Extinct of certain species and loss of biodiversity would be perceived as a loss for humankind.

The need to look into the more hidden, in-situ functions and values of groundwater or aquifer systems has also been emphasized. These, as noted by UNESCO in general, may include following:

- Groundwater has a strong dissolving capacity and substances can be stored in dissolved shape. Also large quantities of energy can be stored in it.
- Flowing groundwater may transport and dilute these dissolved substances and energy.
- It may have a buffering capacity and diluting capacity in case of spilled toxics.
- Groundwater forms a habitat for all kinds of micro-organisms that are important in sustaining biochemical processes.
- Bacteria found in groundwater and in the soil matrix are found to 'eat' various contaminants giving aquifers natural attenuation.
- Groundwater and the aquifer material have strengths for creating an excellent platform for building eco-systems in and on top of it.
- All the transport, storage, buffering, natural attenuation, habitat and carrying capacities of groundwater and aquifer systems are crucial in ecosystem processes.

15. CONCLUSION

The discussion above indicates that the Indus Waters Treaty 1960 is a unique Treaty as it has divided the rivers between the two countries. Such treaties in general accounts for sharing of the waters. Because of such a mode of sharing, the Eastern Tributaries of the Indus River System have lost the flows even to the extent of the minimum quantum required for sustainability of the ecosystems associated with these rivers. Hence, for an effective redressal of the issue, a resort to the various international agreements and the conventions is required to be made which amply recognize the importance of sustainability of the ecosystems and subsequently the whole of global environments. The whole of the global environment is being considered as one and single entity for the purpose. If parts of the whole are allowed to sustain damage then a stage may come where the losses may reach to the point of no return; a point where the neglect caused could only be taken as criminal – or else a deceit – to our generations to come.

In order to revive and subsequently sustain the ecosystems associated with the Eastern Tributaries of the Indus River System, all these measures are too important to be considered and initiated. Side by side, the true implementation of the Indus Waters Treaty 1960, in letter and spirit is also emphasized.

Hence, if summarized, perhaps the most rational course of action under the context of environmental sustainability of Eastern Tributaries of the Indus River System, or the important levels, which are required to be pursued in view of

various multilateral instruments/approaches readily available at hand, may be seen as shown in the boxes hereunder:

IMPORTANT LEVELS – I
▪ *Complete implementation of Indus Waters Treaty 1960.* ▪ *Referral to various conventions on Climate Change, like those under UNECE, UNFCCC, etc.* ▪ *Resort to various groundwater agreements and conventions on international aquifers.*

IMPORTANT LEVELS – II
▪ *Public awareness campaign (electronic, print and social media and seminars, etc.).* ▪ *Community participation.* ▪ *Groundwater resource development projects for the areas under impact (the innovations, conservation, crop pattern changes, etc.).*

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Improving Harvested Rain Water Quality of NUST Lakes by Three Stage Portable Water Filter

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ABSTRACT

Rainwater Harvesting Systems have the potential to provide low - cost decentralized water to urban and rural population without access to treated water. But contaminated harvested rain water poses significant aesthetic and public health risk if consumed without treatment. Among main causes of harvested rainwater contamination are addition of raw sewerage and surface runoff from surrounding area. To monitor the contamination of harvested rainwater in NUST lakes, a study was designed to assess the pollution status of three lakes located there. In order to treat it by using portable domestic water filter employing physico-chemical methods for improving its quality. Water quality was identified in terms of its biological and physico-chemical parameters: bacterial count, color, odour, turbidity, EC, TDS, pH, temperature, hardness, chlorides, alkalinity, phosphorus, and nitrates. It was observed that bacterial count, turbidity, hardness and color of water relatively high when compared with national water quality parameters. This study, therefore provides considerable evidence of water pollution load. The effectiveness of treatment by physico-chemical methods (Coagulation, Filtration, and Chlorination) was extremely significant. It was found that water quality improved and was under the permissible limits of National water quality standards.

Key Words: Harvested rain water, physico-chemical parameters, water quality, pollution loads

INTRODUCTION

Pakistan's population is increasing at a faster rate, current population is of 187 million which is expected to grow up to approximately 221 million by the year 2025 (Khan and Javed, 2007). So this huge increase in population posing severe effect on the water quality which is used to meet the industrial, domestic and agricultural needs (IUCN 2009). Having so much importance water is considered the essential and basic resource for humans, wildlife and environment. (Cheng and Jia, 2010). Therefore, provision of food and water for living, manufacturing, farming, amusement, shipment and commerce becomes the integral part of aquatic ecosystems. (Wei *et al*., 2009). Amount of fresh water is about 3–4% of the total water available on the earth, and 0.01% of it is available for the human use, which is very small portion of total water. (Hinrichsen and Tacio, 2002). But this small portion of water is also under the great stress which is unluckily caused by sharp population rise, urbanization and unsustainable use of water in industry and agriculture (Azizullah *et al.,* 2011).

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Rain water harvesting (RWH) systems are the best source to provide low-cost decentralized water to urban and rural households especially which are away from the safe or treated water. (Gwenzi *et al.,* 2015). In principle, the collection of rainwater is considered safe from contamination before it touches the ground as compare to the surface water in lakes and rivers, and groundwater from shallow wells. However, numerous current studies propose that rainwater can be contaminated, and consumption of untreated rain water can become a source of serious public health (Ahmed *et al.,* 2014).

For example, if untreated rainwater is consumed it makes links to bacterial diarrheas which is due to Salmonella and Campylobacter, bacterial pneumonia due to Legionella, botulism due to Clostridium, tissue helminths, and protozoal diarrheas from Giardia and Cryptosporidium (Lye, 2014). There are number of studies encountering the unreliable view that rainwater is safe for human consumption without treatment (Gwenzi *et al.,* 2015).

Clean water being a vital commodity for life and human growth is increasing its demand worldwide (Dassanayake *et al.,* 2015). Therefore to treat the available water for consumption, Coagulation/flocculation before filtration is still the major steps in conventional water treatment. Hydrolysis products from the coagulant remove suspended solids and organic matter either via charge neutralization or the incorporation of impurities into the hydroxide matrix (Ng *et al,* 2013). Disinfection of water makes it suitable to use without any risk so chemical disinfection with chlorine is a very popular means of disinfection. S. Oluka *et al.,* 2013. In a present study three stage portable water filter (Coagulation, filtration and chlorination) has been used to improve the harvested rain water quality of NUST lakes. To ensure the effectiveness, different physico – chemical and biological water quality parameters were assessed. Main objectives of the study were to assess physico - chemical and biological pollution load of NUST lakes for assessing the effectiveness of coagulation, filtration and chlorination to improve its water quality and to compare the water quality improvements before and after rainy season.

METHOD AND MATERIAL

STUDY AREA

The research was carried out on lakes of National University of Sciences and Technology Islamabad. The climate of Islamabad has a humid subtropical climate with five seasons: Winter (November–February), spring (March and April), summer (May and June), Rainy Monsoon (July and August) and autumn (September and October). The hottest month is June, where average highs routinely exceed 38 °C (100.4 °F). The wettest month is July, with heavy rainfalls and evening thunderstorms with the possibility of cloudburst and flooding. The coolest month is Januar (Climate Records: Islamabad). Diverse nature soil make up the parent material of potohar plateau in the form of loess, alluvium, colluviums and mixed by nature (Khan *et al.,* 2001). The soils of the rain fed areas are classified as silt loam, silt clay loam, and clay loam (Kazmi and Rasool 2009).

SAMPLING SITES

Composite water samples were collected from the all three lakes of NUST. It was done with seasonal variation before and after the rain (Fig. 1)

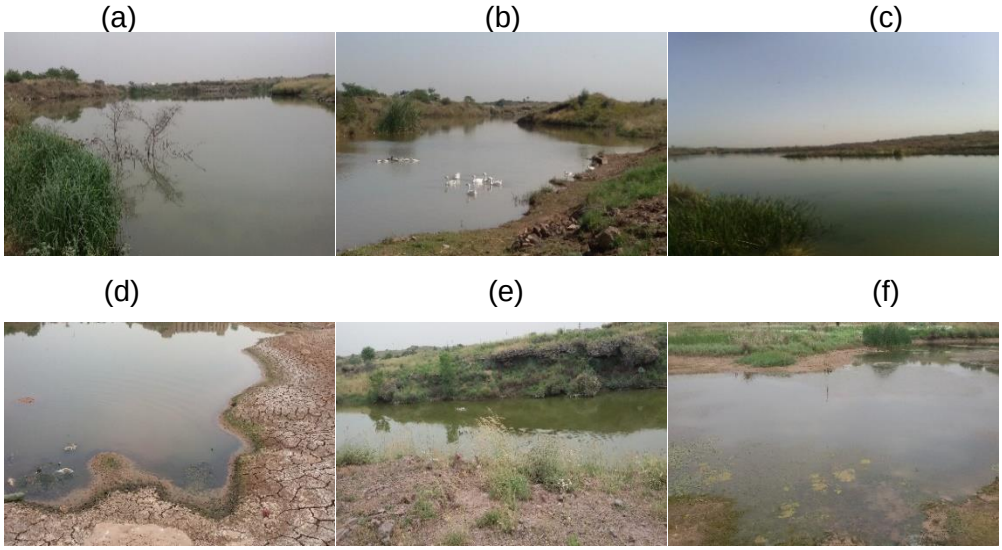


Figure 1: Study area a, b &c in wet and d, e & f in dry season

STORAGE OF SAMPLES

Samples were collected in plastic gallons. These gallons were rinsed two or three times with lake water before sample collection. All the sampling and preservation methods carried out for the quality analysis in water samples were according to Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

ANALYTICAL PROCEDURES

Water quality parameters, their units and methods of analysis are summarized in (Table.1). The temperature of water samples was measured at the sampling points by mercury thermometer. In laboratory all the samples were analyzed for different physico – chemical and biological parameters. pH, electrical conductivity (EC) and turbidity was measured by pH meter, EC and turbidity meters respectively. TDS were determined gravimetrically at 180 °C. Total hardness was measured by EDTA complexometry titration, with indicator Eriochrome Black T. Chlorides were determined by argentometric method. Total Alkalinity was measured by titration, with indicators phenolphthalein and methyl orange. Colour, phosphorus and nitrates were measured by using spectrophotometer. Total bacterial count was done by spread plate count.

Table 1: Water quality parameters associated with their abbreviations, units and analytical methods used.

Variables	**Abbreviations**	**Units**	**Analytical methods**
Temperature	Temp	°C	Thermometer
PH	pH	pH unit	pH meter
Turbidity	-	NTU	Nephlometric
Total dissolved solids	TDS	mg L^{-1}	Gravimetric
Electrical conductivity	EC	µS cm^{-1}	Electrometric
Colour	-	TPC	Spectrometer
Chloride	Cl	mg L^{-1}	Titrimetric
Total hardness	T– Hard	mg L^{-1}	Titrimetric
Alkalinity	ALKY	mg L^{-1}	Titrimetric
Phosphorus	P	mg L^{-1}	Spectrometer
Nitrates	NO_3	mg L^{-1}	Spectrometer
Total Bacterial Count	TBC	CFU/ml	SPC (Agar media)

TREATMENT METHODOLOGY

Water treatment methodology is shown in (Figure.1). Composite water samples were collected and poured into pitchers, which had sand and gravel at the top. Coagulation was done (per liter of water). After two hours water was filtered through filter cloth into a clean container. Then 3 – 4 drops of chlorine were added into per liter of water. 30 minutes were given for disinfection. Water was treated by three stage portable water filter (Coagulation, Filtration and Chlorination) by using chemical agents. Physico – chemical and biological analysis (Total Bacterial Count, Colour, Odour, Turbidity, TDS, pH, EC, Total Hardness, Chloride, Alkalinity, Phosphorous and Nitrates) of water was done before and after treatment.

Experimental Design

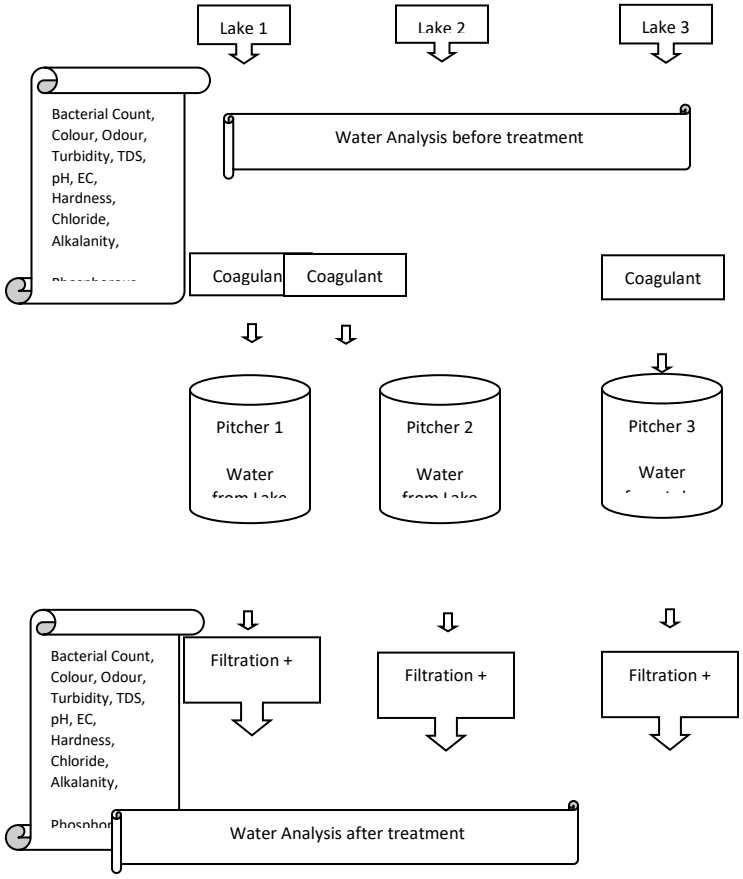


Figure 2: Experimental design for the treatment of lake water.

RESULTS

The analytical results of physico – chemical and biological water quality parameters before and after treatment were significantly different for all the three lakes (Fig. 3 & 4). Temperature of water samples ranged before treatment 21.5 C – 22.2°C. After treatment of before rain samples it was 21.5, 21.4 and 21.2 °C for lake1, 2 and 3 respectively. And after rain water samples it was 20.9, 20.8 and 21°C for Lake 1, 2 and 3 respectively (Table. 2). The temperature of water samples from all the three lakes before and after treatment was within the permissible limits of Pak- EPA. pH of water samples ranged from 7.3 - 8.5. After treatment of before rain water samples it was 7.7, 7.7 and 7.8 for Lake 1, 2 and 3 respectively. And after rain water samples it was 6.7, 7.0 and 6.9 for Lake 1, 2 and 3 respectively (Table. 2). All the water samples after treatment were within the permissible limits of Pak- EPA. Turbidity of water samples was observed in range from 14.3-60.5 NTU. After treatment of before rain water samples it was 2.74, 1.23 and 2.25 NTU for Lake 1, 2 and 3 respectively. And after rain water samples it was 1.8, 1.5 and 1.2 NTU for Lake 1, 2 and 3 respectively (Table. 2). Turbidity analysis showed

that all the water samples were in safe limits after treatment. TDS analysis showed range 125- 407 L^{-1}. After treatment of before rain water samples it was 297.5, 250 and 265 mg L^{-1} for Lake 1, 2 and 3 respectively. And after rain water samples it was 120, 88 and 104 mg L^{-1} for Lake 1, 2 and 3 respectively (Table. 2). TDS analysis showed that all the water samples after treatment were within a permissible limit. EC of water samples ranged from 229- 762 µs/cm. After treatment of before rain water samples it was 663, 516 and 562 µs/cm for Lake 1, 2 and 3 respectively. And after rain water samples it was 212, 180 and 202 for Lake 1, 2 and 3 respectively (Table. 2). It was found that EC of after rain water samples by treatment was within the permissible limits, but by treatment of before rain water samples EC was higher than permissible limits and didn't improved well after treatment. Colour of water samples ranged before treatment 35 – 147 TPC. After treatment of before rain water samples it was 5, 4 and 3 TPC for Lake 1, 2 and 3 respectively. And after rain water samples it was 3, 2.5 and 2 TPC for Lake 1, 2 and 3 respectively (Table. 2). Results showed almost clean results for colour. Hardness of water samples ranged 400 – 702 mg L^{-1}. After treatment of before rain water samples it was 415, 376 and 357 mg $L^{-1}$for Lake 1, 2 and 3 respectively. And after rain water samples it was 304, 368 and 384 mg L^{-1} for Lake 1, 2 and 3 respectively (Table. 2). Chlorides of water samples ranged before treatment 166 – 860 mg L^{-1}. After treatment of before rain water samples it was 756,512 and 501 mg L^{-1} for Lake 1, 2 and 3 respectively. And after rain water samples it was 202, 223 and 154 mg $L^{-1}$for Lake 1, 2 and 3 respectively (Table. 2). It was found that Cl of after rain water samples by treatment was within the permissible limits, but by treatment of before rain water samples Cl was higher than permissible limits and didn't improved well after treatment. Alkalinity of water samples ranged 144 – 340 mg L^{-1}. After treatment of before rain water samples it was 325, 250 and 197 mg L^{-1} for Lake 1, 2 and 3 respectively. And after rain water samples it was 148, 148 and 136 mg L^{-1} for Lake 1, 2 and 3 respectively (Table. 2). Alkalinity of all water samples was within a permissible limit. Phosphorus of water samples ranged from 1.7 – 2.38 mg L^{-1}. And nitrates of water samples ranged 3.51 – 29.08 mg L^{-1} (Table. 2). Phosphorus and nitrates both were within the permissible limits after the treatment. Bacterial count of water samples ranged 50×10^3 – 136×10^3 CFU/ml (Table. 2). After treatment of before and after rain water samples it was found that all the water samples were showing negative results for total bacterial count having no microbial colony. All the water samples were having odor which was removed by the treatment of water. Under microscope water was analyzed for the presence of algae. It was seen that algae was present in the water samples (Fig. 5).

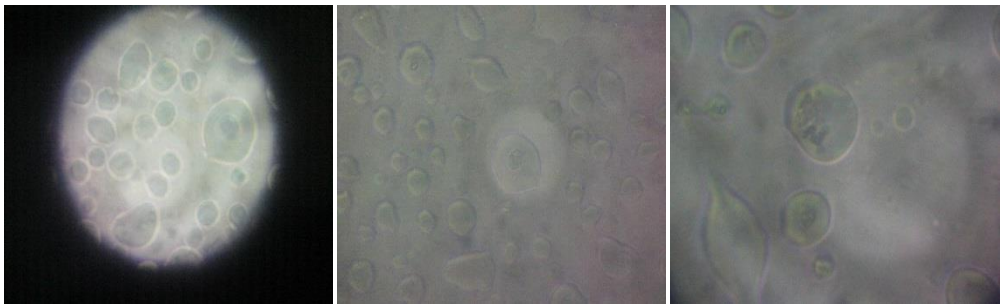


Figure 5: Microscopic view of algae present in lake water.

Table 2: Water quality parameters: Pak-EPA Standards associative with observed ranges. Source: (Pak-EPA, 2008).

Parameters	**Units**	**Pak Guideline**	**Observed Range**			
			Before Rain		**After Rain**	
			Before Treatment	After Treatment	Before Treatment	After Treatment
Temp	°C		22 – 22.5	21.2 – 21.5	21.5 – 21.8	20.8 – 21
pH	pH unit	6.5–8.5	8 – 8.5	7.7 – 7.8	7.3 – 7.6	6.7 – 7.0
Turbidity	NTU	> 5	22 – 60	1.23 – 2.74	14.3 – 25.8	1.2 – 1.8
TDS	mg L^{-1}	>1000	315 – 407	250 – 315	125 – 198	88 – 120
EC	µS cm^{-1}	400	626 – 762	516 – 663	229 – 290	202 – 212
Colour	TPC	15	71 – 147	3 – 5	35 – 56	2 – 3
Cl	mg L^{-1}	250	736 – 860	501 – 756	166 – 290	154 – 223
Total Hard	mg L^{-1}	>500	516 – 702	357 – 415	400 – 432	304 – 384
ALKY	mg L^{-1}	1000	229 – 340	197 – 325	144 – 208	136 – 148
Phosphorus	mg L^{-1}	-	1.7 – 4.5	1.007 – 1.8	1.9 – 2.3	1.1 – 1.2
Nitrates	mg L^{-1}	≥50	17.8 – 20.7	4.75 – 18.9	3.5 – 29	.63 – 1.96
TBC	CFU/ml	-	90×10^3– 136×10^3	-	50×10^3– 108×10^3	-

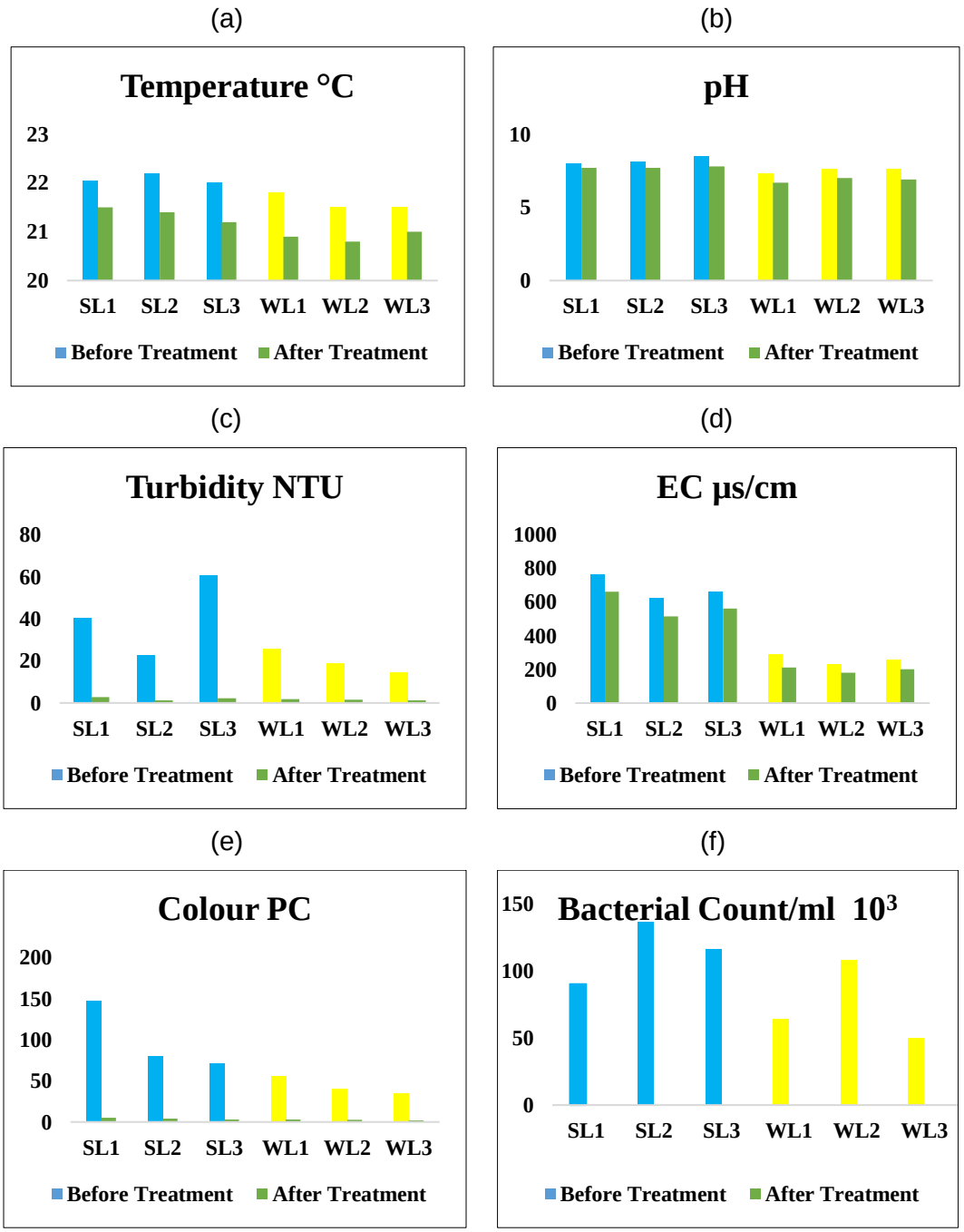


Figure 3: Comparison of mean values observed before and after the treatment for physico – chemical and biological parameters in Lake 1, 2 & 3 in summer (before rain) and winter (after rain).

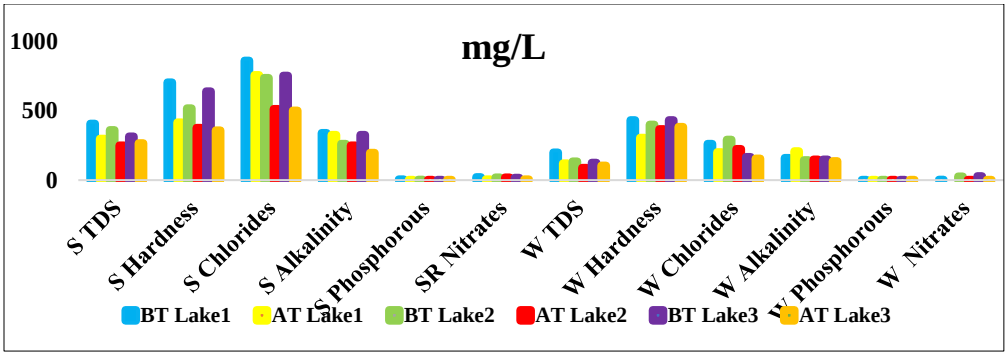


Figure 4: Comparison of mean values observed before and after the treatment for physico – chemical parameters in Lake 1, 2 & 3 in summer (before rain) and winter (after rain).

Discussion:

This study was carried out to find the effectiveness of three stage portable water filter for harvested rain water of lakes. Findings of the present study focused on water samples collected from NUST lakes for improving quality of water showed considerable variation in the physico – chemical and biological parameters of water before and after the treatment and especially in dry and wet season. These variations were due to the used coagulation, filtration and chlorination during the treatment process.

The temperature of water samples ranged from 21.5 – 22.2°C before treatment. Which improved 20.8 – 21.5 °C was within the permissible limit of Pak – EPA, this decrease in temperature was due to the use of mud pitchers for water treatment. Turbidity of lake water ranged from 1.2 – 2.7 NTU after treatment it was due to the coagulation, which can successfully remove a large amount of organic compounds, including some dissolved organic material, which is referred to as Natural Organic Matter (NOM) or Dissolved Organic Carbon (DOC). Coagulation in water treatment involves the addition of chemicals to alter the physical state of dissolved and suspended solids and facilitate their removal by sedimentation (Kimura *et al.,* 2013). As chemical products, coagulants react with the suspended and colloidal particles in the water, causing them to bind together and thus allowing for their removal in the subsequent treatment processes (Jiang and Wang, 2009).

The aggregation mechanisms through which particles and colloids are removed include a combination of charge neutralization, entrapment, adsorption and complexation with coagulant ions into insoluble masses (Ghernaout and Ghernaout, 2012). The larger particles, or floc, are heavy and quickly settle to the bottom of the water system. It can also remove suspended particles, including inorganic precipitates, such as iron. Similarly water was cleared from colour (35 – 147 TPC) and odour as well because a large amount of DOC can give water an unpleasant taste and odour, as well as colour. While coagulation can remove particles and some dissolved matter as TDS were decreased from (125 – 407) to (88 – 315) in the study but the water may still contain pathogens after the coagulation. In an international report published in 1998, it was found that

coagulation can only remove between 32 and 87 percent of bacteria. Usually, the pathogens that are removed from the water are removed because they are attached to the dissolved substances that are removed by coagulation. As an integral part of the conventional water treatment scheme, coagulation treatment has been employed to decrease turbidity and colour and to remove pathogens Verma *et al.,* 2012). Coagulation can remove efficiently the hydrophobic and high molar mass fractions of NOM (Mao *et al.,* 2013). Moreover, coagulation/flocculation processes have been intensively used for decolorizing wastewater (Verma *et al.,* 2012). Coagulation is often applied to augment biological phosphorous removal in activated sludge processes (Nguyen *et al.,* 2010). In a current study alum coagulation was proved to be efficient for removing odour, colour and turbidity and decreasing the TDS, hardness and alkalinity of water. Similarly Christopher *et al.,* 2009 optimized coagulation using aluminium sulfate for the removal of dissolved organic carbon when water quality was pH ranged (6.4 – 8), turbidity was (1.7 – 7.3), colour was in range of (16 – 54) and alkalinity was from 7 – 100. Chao et al., 2007 found that conventional water treatment system was efficient to make the water safe which was having turbidity (4.6 – 8.5), temperature (16.1 – 28.7), pH (7.98 – 8.62), alkalinity (183 – 191).

The second step in a water treatment system is filtration, which removes particulate matter from water by forcing the water to pass through porous media. As coagulation does not remove all of the viruses and bacteria in the water, it cannot produce safe drinking water. It is, however, an important primary step in the water treatment process, because coagulation removes many of the particles, such as dissolved organic carbon, that make water difficult to disinfect. Because coagulation removes some of the dissolved substances, less chlorine must be added to disinfect the water. Less chlorination was done in treatment process after coagulation and filtration, which removed bacterial contamination from 136×10^3 cfu/ml. Disinfectants could oxidize organic matter, produce disinfection by-products and increase the AOC concentration. Therefore, much attention must be paid to the removal of organic matter before disinfection in order to limit DBP formation and preserve the biostability. Moreover, high organic matter concentration results in high chlorine consumption and increased DBP formation (Christopher *et al.,* 2009).

The improving efficiency of lakes water by three stage portable water filter was successfully determined by before and after treatment analysis of water. In summer (dry) season water pollution was higher as compared to winter (wet) season. But three stage portable water filter was found efficient to improve the quality of NUST lakes. So rain water harvesting should be in practice to overcome the water shortage in areas like Islamabad, where water shortage becomes the prominent problem in summers. And there should be another path for the sewerage water to pass, to avoid the degradation of lakes water quality. And three stage portable water filter should be used which is the combination of (coagulation, filtration and chlorination) to overcome the shortage of safe water.

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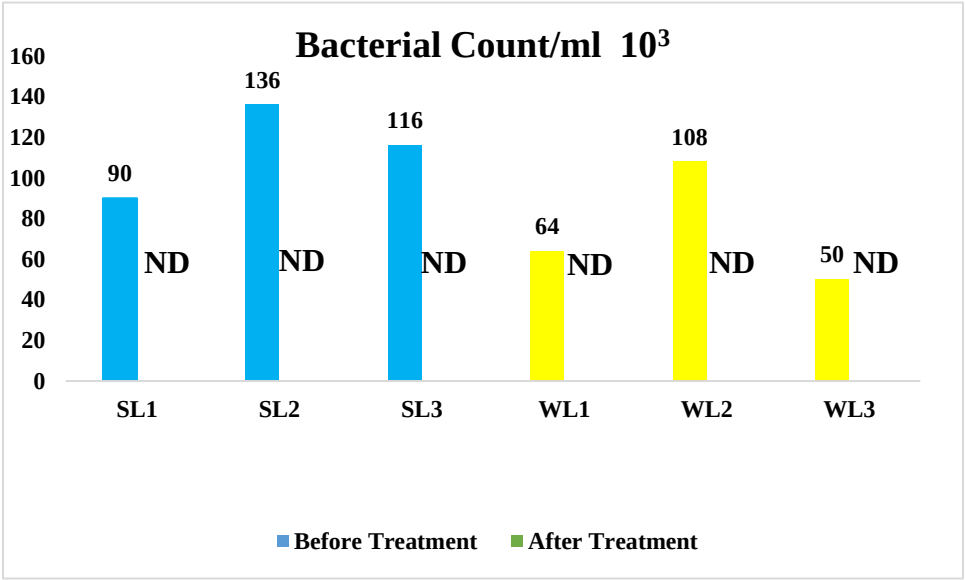
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Turning Deserts into Farmlands

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Abstract

The aim of this paper is to disseminate our research on a unique tree, which can be used to turn deserts and barren lands into evergreen resorts and farmlands. This tree has the capability to uplift deep groundwater from tens to hundreds of meters below the ground surface. It can separate salt from groundwater for onward its own use and for the use of neighboring [plant] species. We are working to develop our further understanding on this unique topic, which will provide a sustainable solution of groundwater use in deserts and salt-affected lands, and, therefore, this research can be used to sustain and secure supply chains of our future food.

Introduction

Salinity is a common environmental problem in arid and semi-arid irrigated lands as it lowers the crop yield. The problems are associated with high water tables, which are ore often caused by a lack of subsurface drainage. Poor subsurface drainage may be attributed to: (1) an insufficient transport capacity of the aquifer, and (2) a situation where water cannot exit from the aquifer, for instance, a topographical depression or when an area is enclosed by inflow boundaries such as different doabs in the Punjab (a doab is an area enclosed between two adjacent rivers, refer to Wikipedia, 2013a). The major factor in the accumulation of salt in soils is a lack of net recharge (Wikipedia, 2013b; Ritzema, 1994).

Salinization transforms fertile and productive land into barren land, and often leads to the loss of habitat and reduction of biodiversity. Salinity limits the vegetative and reproductive growth of plants by inducing severe physiological dysfunctionality and leading to widespread direct and indirect harmful effects. In saline and desert soils, the high salt concentration in the solid or liquid phase results in high osmotic pressures hindering the normal development of plants.

Prosopis cineraria (Ghaf tree) is extremely salt and drought tolerant, growing in areas with less than 75 mm annual rainfall and temperature up to 50°C. It can grow in areas up to 600 m above mean sea level, favouring habitat of sand plains and dunes. Its fruits and leaves are considered good fodder for camels, livestock and wild animals. It is a valuable shade tree in barren sandy deserts. In ancient times, people ate the young leaves and seedpods for their survival during severe droughts. The wood that it provides can be used as fuel and for construction purposes. This unique species can therefore effectively be used in salt-affected areas for soil remediation and rehabilitation.

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Ghaf tree [refer to Figure 1] can be used for sustainable crop production in water-scarce areas where it provides groundwater to crops and trees because of its distinct ability to uplift groundwater through its tap roots that reach tens of meters down into the desert subsoil. It thus also helps natural desert flora and fauna and converts desert areas into forever-green resorts. Other species benefit from the Ghaf tree, due to its natural ability to separate salt from water and to transport fresh groundwater upward into the shallow subsurface. The salt is left behind in the subsurface. This species has been proven essential for the ecology of deserts in the Arabic peninsula, from the Gulf countries to Afghanistan, Pakistan, India and elsewhere [refer to Figure 2].



Figure 1: Ghaf tree (Prosopis cineraria).

Gallacher and Hill (2005) reported from other literature that Prosopis cineraria leaves have a high transpiration rate, when we compare it with other desert species; its tap root estimates are ranged between 20 m and 60 m below the ground surface. They further reported that sudden death of large number of mature trees has been attributed to over-exploitation of the underlying water table. Using both seeds and vegetation through root suckers can reproduce Prosopis cineraria; it is often found in clusters forming small forests, which may be wholly or largely originating from a single individual by vegetative multiplication (cloning). Farmers have been growing Prosopis cineraria for centuries, a tree that has been a source for life in arid regions (Lal et al., 2008).

In spite of several such benefits, stands of this unique species are threatened due to lack of public awareness and scientific knowledge. Thus fundamental research is needed to understand its complex physical and biological processes and is the objective of this [research] project. This knowledge is essential for understanding long-term development of Prosopis forests, and, therefore, for their management and conservation.



Figure 2: The presence of Ghaf stands in a typical desert, where groundwater is very deep.

Objectives

Our aim is to ascertain the growth and salt removal mechanisms of this species in combination with the analysis of its deep root system. This helps us to achieve a better understanding of the species and its different mechanisms. Yet another objective is to increase the awareness of the international community towards several advantages of the species as well as to promote Prosopis cineraria for sustainable management of deserts and salt-affected areas. We aim to achieve the objective by disseminating our research in peer-reviewed journals, print and electronic media.

Materials and Methods

This research focusses to develop the understanding of the basic processes of tree mechanism. The 3D architecture of shallow and deep root systems, the spatial and vertical distribution of soil and groundwater salinity, the potential growth and transpiration rates of Ghaf tree are being assessed and analyzed. In this regard, sufficient funds are required to use the resources of Dubai Desert Conservation Reserve (http://www.ddcr.org/en/) and Botanic Gardens Conservation International (http://www.bgci.org) – for which research proposals are being submitted to many national and international donors/institutes. The collected

information and data will be combined with the interpretation and modelling to unveil the processes near the zone where the roots tap the groundwater. The fate of the salt left behind resulting from these mechanisms will also be determined. MATLAB-based models are being used to model and visualize the results.

Findings

Our current research shows that the unique capability of this tree to separate water from salt influences the salinity of the groundwater. Increased salinity near the roots raises the density of the groundwater. This triggers convective groundwater flows, which transport saltier water to greater depths. Such combined complex physical and biological processes seem to determine the longevity of these Prosopis stands, and need to be researched further to improve our understanding of the tree's behaviour. In the context, when huge investments are being made to convert deserts and salt affected areas into useful green areas, the promotion of Ghaf tree will play an important role in global climate change.

Research Outcome

The scientific outcome of this research will promote long-term conservation of this species in arid and semiarid environments, which it turns green without any external source of water, where it restores salt-affected lands, and where it provides an additional and sustainable source of water to crops. If we plant this species alongside the irrigated areas, this will result into reduced irrigation cost. The commercialization aspect of this research will be patented; scientific output will be published in peer-reviewed journals of high impact and presented at international conferences and forums.

We are interested to develop our further understanding on this unique topic, which will provide a sustainable solution of groundwater use in deserts and salt-affected lands, and, therefore, this research is an essential requirement to achieve this goal to sustain and secure supply chains of our future food.

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Illegal Wildlife Trade in Global and Pakistan Context

By
Dr. Abdul Aleem Chaudhry

Wildlife traditionally refers to undomesticated animal species, but has come to include all plants, fungi, and other organisms that grow or live wild in an area without being introduced by humans.

Wildlife can be found in all ecosystems. Deserts, forests, rain forests, plains, grasslands, and other areas including the most developed urban sites, all have distinct forms of wildlife. While the term in popular culture usually refers to animals that are untouched by human factors, most scientists agree that much wildlife is affected by human activities.

Humans have historically tended to separate civilization from wildlife in a number of ways including the legal, social, and moral sense. Some animals, however, have adapted to suburban environments. This includes such animals as domesticated cats, dogs, mice, and gerbils. Some religions have often declared certain animals to be sacred, and in modern times concern for the natural environment has provoked activists to protest the exploitation of wildlife for human benefit or entertainment.

The global wildlife population has decreased by 52 percent between 1970 and 2014, according to a report by the World Wildlife Fund.

Wildlife trade refers to the commerce of products that are derived from non-domesticated animals or plants usually extracted from their natural environment or raised under controlled conditions. It can involve the trade of living or dead individuals, tissues such as skins, bones or meat, or other products. Legal International wildlife trade is regulated by the United Nations' Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which currently has 170 member countries called *Parties*. Illegal wildlife trade, however, is widespread and constitutes one of the major illegal economic activities, comparable to the traffic of drugs and weapons. Wildlife trade is a serious conservation problem; it has a negative effect on the viability of many wildlife populations and is one of the major threats to the survival of vertebrate species.

Wildlife use is a general term for all uses of wildlife products, including ritual or religious uses, consumption of *bushmeat* and different forms of trade. Wildlife use is usually linked to hunting or poaching. Wildlife trade can be differentiated in legal and illegal trade, and both can have domestic (local or national) or international markets, but they might be often related with each-other.

Wildlife trade often includes the trade of living individuals of wildlife species as companion animals (pet trade) or for zoological institutions. These individuals are sometimes semi-domesticated or bred in captivity for the purpose of trade.

Reasons for Concern

Different forms of wildlife trade or use (utilization, hunting, trapping, collection or over-exploitation) are the second major threat to endangered mammals and it also ranks among the first ten threats to birds, amphibians and cycads.

Wildlife trade threatens the local ecosystem, and puts all species under additional pressure at a time when they are facing threats such as over-fishing, pollution, dredging, deforestation and other forms of habitat destruction.

Wildlife is traded alive or dead.

In the food chain, species higher up on the ladder ensure that the species below them do not become too abundant (hence controlling the population of those below them). Animals lower on the ladder are often non-carnivorous (but instead herbivorous) and control the abundance of plant species in a region. Due to the very large amounts of species that are removed from the ecosystem, it is not inconceivable that environmental problems will commence to occur (similar to i.e. overfishing that causes abundance of jellyfish to occur). In the example given it also becomes quickly clear that having the governments of countries where wildlife occurs crack down effectively on wildlife trade may, in some instances, allow these countries to save themselves a considerable amount of money.

Interpol has estimated the extent of the illegal wildlife trade between $10 billion and $20 billion per year. While the trade is a global one, with routes extending to every continent, conservationists say the problem is most acute in Southeast Asia. There, trade linkages to key markets in China, the United States, and the European Union; tax law enforcement; weak border controls; and the perception of high profit and low risk contribute to large-scale commercial wildlife trafficking. The ASEAN Wildlife Enforcement Network (ASEAN-WEN) ASEAN Wildlife Enforcement Network, supported by the U.S. Agency for International Development and external funders, is one response to the region's illegal wildlife trade networks.

In many instances, tribal people have become the victims of the fallout from poaching. With increased demand in the illegal wildlife trade, tribal/indigenous people / populations are often direct victims of the measures implemented to protect wildlife. Often reliant upon hunting for food, they are prevented from doing so, and are frequently illegally evicted from their lands following the creation of nature reserves aimed to protect animals. Tribal people are often falsely accused of contributing to the decline of species – in the case of India, for example, they bear the brunt of anti-tiger poaching measures, despite the main reason for the tiger population crash in the 20th century being due to hunting by European colonists and Indian elites. In fact, contrary to popular belief, there is strong evidence to show that they effectively regulate and manage animal populations.

Notable trade hubs of the wildlife trade include Suvarnabhumi International Airport in Bangkok, which offers smugglers direct jet service to Europe, the Middle East, North America and Africa. The Chatuchak weekend market in Bangkok is a known center of illicit wildlife trade, and the sale of lizards, primates, and other endangered species has been widely documented. Trade routes connecting in

Southeast Asia link Madagascar to the United States (for the sale of turtles, lemurs, and other primates), Cambodia to Japan (for the sale of slow lorises as pets), and the sale of many species to China.

Environmental organizations' investigations units in Vietnam are locating on the ground and online serious organized wildlife crimes and criminals. Yet little in the way of arresting, detaining, charging and prosecuting these criminals is being witnessed within Viet Nam. Two criminals from Thailand and Viet Nam and were reported to INTERPOL and the Vietnamese wildlife trade policing group in 2015. The evidence supplied was more than enough to act on. Yet both are still killing animals, dealing in wildlife parts, and smuggling illicit animal products. This is high time that ASEAN started to do their job, and destroy all ivory, rhino horn, tiger and pangolin parts held in Vietnamese vaults, as well as policing the web and ground traders. This is not on, and it must stop!

Morocco has been identified as a transit country for wildlife moving from Africa to Europe due to its porous borders with Spain. Wildlife is present in the markets as photo props, sold for decoration, used in medicinal practices, sold as pets and used to decorate shops. Large numbers of reptiles are sold in the markets, especially spur-thighed tortoises. Although leopards have most likely been extirpated from Morocco, their skins can regularly be seen sold openly as medicinal products or decoration in the markets.

Despite international and local laws designed to crack down on the trade, live animals and animal parts — often those of endangered or threatened species - are sold in open-air markets throughout Asia. The animals involved in the trade end up as trophies, or in specialty restaurants. Some are used in traditional Chinese medicine (TCM). Despite the name, elements of TCM are widely adopted throughout East and Southeast Asia, among both Chinese and non-Chinese communities.

The trade also includes demand for exotic pets, and consumption of wildlife for meat. Large volumes of fresh water tortoises and turtles, snakes, pangolins and monitor lizards are consumed as meat in Asia, including in specialty restaurants that feature wildlife as gourmet dining.

In South America

Although the volume of animals traded may be greater in Southeast Asia, animal trading in Latin America is widespread as well.

In open air Amazon markets in Iquitos and Manaus, a variety of rainforest animals are sold openly as meat, such as agoutis, peccaries, turtles, turtle eggs, walking catfish etc. In addition, many species are sold as pets. The keeping of parrots and monkeys as pets by villagers along the Amazon is commonplace. But the sale of these "companion" animals in open markets is rampant. Capturing the baby tamarins, marmosets, spider monkeys, saki monkeys etc. in order to sell them, often requires shooting the mother primate out of a treetop with her clinging child; the youngster may or may not survive the fall. With the human population increasing, such practices have a serious impact on the future prospects for many

threatened species. The United States is a popular destination for Amazonian rainforest animals. They are smuggled across borders the same way illegal drugs are - in the trunks of cars, in suitcases, in crates disguised as something else.

In Venezuela more than 400 animal species are involved in subsistence hunting, domestic and international (illegal) trade. These activities are widespread and might overlap in many regions, although they are driven by different markets and target different species.

Legal trade of wildlife has occurred for many species for a number of reasons, including commercial trade, pet trade as well as conservation attempts. Whilst most examples of legal trade of wildlife are as a result of large population numbers or pests, there is potential for the use of legal trade to reduce illegal trade threatening many species. Legalising the trade of species can allow for more regulated harvesting of animals and prevent illegal over-harvesting.

Examples of successful wildlife trade

Australia

Crocodiles

Trade of crocodiles in Australia has been largely successful. Saltwater crocodiles (*Crocodylus porosus*) and freshwater crocodiles (*Crocodylus johnstoni*) are listed under CITES Appendix II. Commercial harvesting of these crocodiles occurs in Northern Territory, Queensland and Western Australia, including harvesting from wild populations as well as approved captive breeding programs based on quotas set by the Australian government.

Legalizing trade for endangered species

The 15th Conference of the Parties of CITES was held in Doha, Qatar in March 2010.

Under the Convention on International Trade of Endangered Species (CITES), species listed under Appendix I are threatened with extinction and are prohibited for commercial trade. This rule applies to all species threatened with extinction, except in exception circumstances. Commercial trade of endangered species listed under Appendix II and III is not prohibited although Parties must provide non-detriment finding to show that the species in the wild is not being unsustainably harvested for the purpose of trade.

Illegal wildlife trade is estimated to be a multibillion-dollar business involving the unlawful harvest of and trade in live animals and plants or parts and products derived from them. Wildlife is traded as skins, leather goods or souvenirs; as food or traditional medicine; as pets, and in many other forms. Illegal wildlife trade runs the gamut from illegal logging of protected forests to supply the demand for exotic woods, to the illegal fishing of endangered marine life for food, and the poaching of elephants to supply the demand for ivory.

Illegal wildlife trade is also often unsustainable, harming wild populations of animals and plants and pushing endangered species toward extinction.

Endangered animals and plants are often the target of wildlife crime because of their rarity and increased economic value. Furthermore, illegal trade negatively impacts a country's natural resources and local communities that might otherwise benefit from tourism or legal, sustainable trade.

Thousands of wildlife species are threatened by illegal and unsustainable wildlife trade. For example, in recent months significant media attention has gone to the plight of the world's rhinoceros species, which are facing increased poaching as demand for their horns increases in Asia. In some parts of Asia, rhino horn is considered to be a powerful traditional medicine, used to treat a variety of ailments. While there is little scientific evidence to support these claims, the dramatic rise in poaching to supply this demand is pushing rhinos toward the brink of extinction.

CITES and Illegal Wildlife Trade

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has brought together 179 nations to combat the illegal and unsustainable wildlife trade through a uniform regulatory regime and increased coordination on a global scale. The U.S. Fish & Wildlife Service's (Service) Division of Management Authority and Division of Scientific Authority, as well as the Office of Law Enforcement, are primarily responsible for implementing and enforcing CITES in the United States.

1,004 rhinos were poached and killed in South Africa in 2013: 668 were killed in 2012, 341 in 2011, 333 in 2010, and 122 were killed in 2009.

The rise in poaching of rhinos is due to the high price of rhino horn on the black market. A kilogram of rhino horn is sold for up to $65,000. *(Source: Live Science, "Amid Record-Breaking Poaching, Wildlife Experts Seek to Smash a Black Market," Yahoo News, March 5, 2015.*

Price of Elephant Ivory in China in 2014: (*in* ENVIRONMENTAL THREATS)

According to reports from wildlife organization (Save the Elephants), the price for raw ivory in China in 2014 was $2,100 per kilogram. (Back in 2010, the price of the ivory was $750 per kilo).

Between 2010 and 2012, up to 33,000 elephants were poached and killed on average each year. (*Source: AFP, "Smuggled elephant ivory price triples," Yahoo News, July 3, 2014*).

Number of Elephants Killed by Poaching in 2013 (*in* ENVIRONMENTAL THREATS)

Based on statistics released by the Convention on International Trade in Endangered Species (CITES), there were at least 20,000 elephants killed worldwide by poachers in 2013 for their ivory tusks. The number of elephants killed was slightly down from the 22,000 elephants killed in 2012 and the 25,000 poached in 2011.

Price of Pangolin Scales for Sale (in ENVIRONMENTAL THREATS)

A report released by China's Public Security Bureau for Forests and the University of Oxford found that the average price for a kilogram of pangolin scales was $600. The price of a kilo of pangolin scales for sale in 2013 was twice the amount that a kilogram of scales were sold for in 2008.

According to the report, 2.59 tonnes of scales were seized in China between 2010 and 2013. The scales represented approximately 4,870 pangolins that were killed in order to produce those scales. In addition to the scales, 259 intact pangolin were seized during the time period.

One method of pangolin smuggling highlighted by the report was through the use of China's postal system. In one case discovered in November 2013, security services discovered 5 packages of pangolin scales weighing 70 kilos each being sent through the postal system. It was later discovered that up to one tonne of scales, representing 1,660 pangolins, were shipped through China's postal system by wildlife smugglers.

The pangolin is in high demand across Asia due to its use as a traditional medicine. According to the BBC, consumers roast the pangolin scales and then eat the scales with the belief that it helps detoxify the body and stimulate lactation.

Across Asia, a full pangolin for sale is available on the black market for $1,000. *(Source: Ella Davies, "'Shocking' scale of pangolin smuggling revealed," BBC Nature News, March 14, 2014)*.

The world is dealing with an unprecedented spike in illegal wildlife trade, threatening to overturn decades of conservation gains. Ivory estimated to weigh more than 23 metric tons – a figure that represents 2,500 elephants – was seized in the 13 largest seizures of illegal ivory in 2011. Poaching threatens the last of our wild tigers that number around 3,890.

Wildlife crime is a big business. Run by dangerous international networks, wildlife and animal parts are trafficked much like illegal drugs and arms. By its very nature, it is almost impossible to obtain reliable figures for the value of illegal wildlife trade. Experts at TRAFFIC, the wildlife trade monitoring network, estimate that it runs into hundreds of millions of dollars.

Some examples of illegal wildlife trade are well known, such as poaching of elephants for ivory and tigers for their skins and bones. However, countless other species are similarly overexploited, from marine turtles to timber trees. Not all wildlife trade is illegal. Wild plants and animals from tens of thousands of species are caught or harvested from the wild and then sold legitimately as food, pets, ornamental plants, leather, tourist ornaments and medicine. Wildlife trade escalates into a crisis when an increasing proportion is illegal and unsustainable – directly threatening the survival of many species in the wild.

Stamping out wildlife crime is a priority for WWF because it's the largest direct threat to the future of many of the world's most threatened species. It is second only to habitat destruction in overall threats against species survival.



Ivory for sale





Ivory and Rhino horns; The elephant ivory



Rhinos for animal collections and horns



Tiger for animal collections and body parts



Shells on display for sale



Butterflies on display for sale









Lion family: for animal collections and Body parts



Pangolins for Scales and meat



Falcons for Falconry



Wild Cats for Fur



White Rhino for animal collections and horns used as traditional medicine and Dagger handles



Indian armored Rhino for animal collections and horns



Elephant for animal collections and Ivory



Tiger for animal collections, trophy, skins and body parts



Corals for Collections



Elephant in its natural habitat

Wildlife Trade in Pakistan

Pakistan is home to some of the world's rarest plants and animals. The abundant biodiversity and ecosystems in Pakistan also provide abundant opportunities for wildlife *crime*. As a source, consumer and transit country for consignments of live animals, their parts and derivatives, Pakistan is in a strategic location with convenient pathways to smuggle by air, road and sea. *Endangered* species most commonly traded here are listed in CITES and include *Saker* and Peregrine Falcons, freshwater and marine turtles, Indian Pangolin, scorpions and several rare species of lizards.

The key drivers of this trade in Pakistan have been identified as:

1. inadequate implementation of legislation and weak penalties are ineffective deterrents for smugglers;
2. government bodies responsible for enforcing legislation often lack the equipment, technology and capacity to successfully spot smugglers, who often use calculated and sophisticated techniques;
3. concerned government agencies lack interagency coordination and cooperation,

Illegal wildlife trade is a low risk, high return crime in Pakistan. Underlining these factors, the insidious combination of *poverty*, *greed* and ***corruption*** propel this trade further.

WWF-Pakistan conducted undercover surveys, in 25 selected cities of Pakistan and assessed wild animal and bird markets, pet shops, local herbalists (Hakeem) and street vendors who sell products made-up of animal derivatives etc. The analysis of e-commerce portal including **OLX** as well as social network platform

Facebook groups and individual pages were visited to determine if an online wildlife trade existed in Pakistan. A database on wildlife seizure events reported in the media since 2007 was compiled to develop an understating about the species in the international trade demand and major destination countries.

Forty five (45) markets and 123 shops were found to be involved in the illegal wildlife trade. Twenty (25) Facebook, 65 individual pages and 12 assessed were found to be selling raptors, big cats, reptiles as well as pangolins.

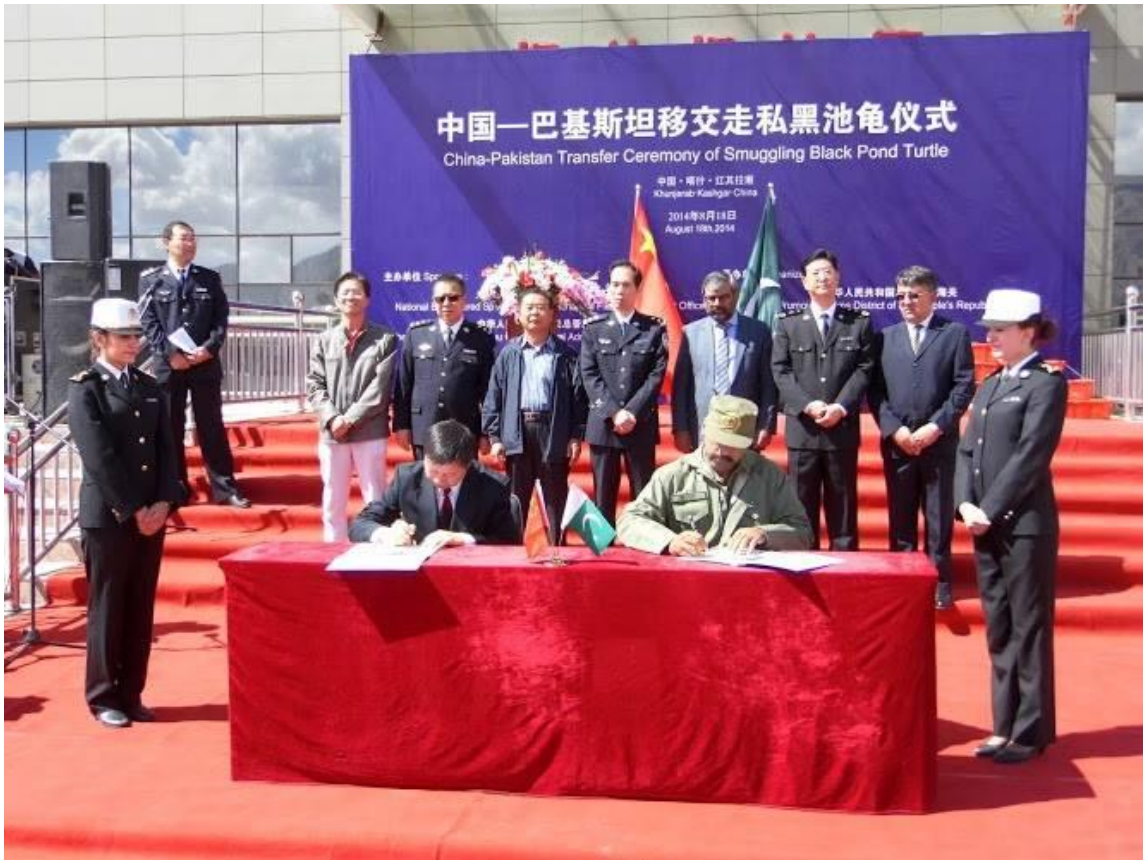
The WWF study highlighted the need of further comprehensive studies in coordination with the provincial wildlife departments to determine spatial variation/synergies in the wildlife crimes and illegal trade hotspots; Genetics studies to validate the medicinal usage of wildlife in the ointments and develop a strategy to control/regulate herbal medicinal use of wildlife derivatives.

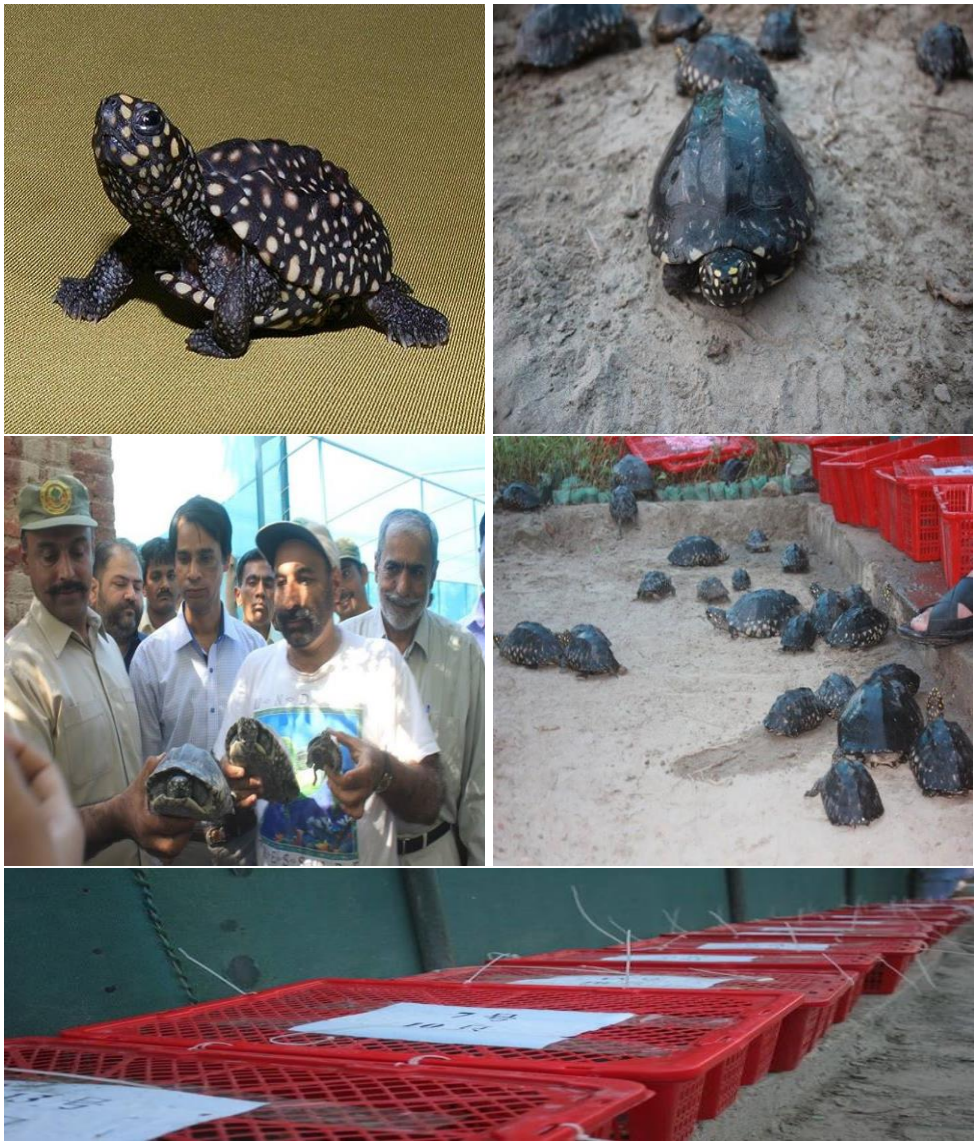
The study also highlighted the urgent need to take proactive role by the Federal Ministry of Climate Change and Pakistan Telecommunication Authority to ban/block website and social media pages which offer wildlife for sale illegally.

Illegal Trade of Fresh water Turtles with China

The Chinese authorities were instrumental in confiscating the consignment of 200 **black pond turtles** (*Geoclemys hamiltonii*), a Vulnerable species, illegally poached and smuggled from Pakistan to China in 2014.

The consignment was handed over to Pakistan Wildlife Department authorities at Khunjerab National Park (Pakistan border with China). The turtles were subsequently released in their natural habitat near Sukkur, Sindh.


中国—巴基斯坦移交走私黑池龟仪式
China-Pakistan Transfer Ceremony of Smuggling Black Pond Turtle



All eight freshwater turtle species occurring in Pakistan are listed in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices I and II and their import and export without a legal permit is prohibited. Countless species including turtles are illegally poached and exported from Pakistan to other countries especially China and East Asian countries.

Illegal trade of body parts of soft shell turtle species has been reported since year 2000. Many a consignments have been confiscated in the past by the Wildlife and Customs authorities in Sindh, Punjab and Islamabad and at Pak-China border in Soest in Gilgit Baltistan.

All of these consignments comprised withered frozen meat of turtles or body parts of soft shell species. These are used as food and in traditional medicines.

The hard shell species was however noted to be targeted in illegal trade for sale as pets for the first time.

Listing of Papers Presented at Various World Environment Day(s), Commemorated by Pakistan Engineering Congress

Sr. No.	Title of Paper	Name of Author
	2007 – Climate Change:	
1.	Engineering options for Managing and Mitigating Climate Change	Safia Shafiq
2.	An overview of Glacier Depletion in Tibetan	Rehmatullah Jilani
3.	Plateau Climate Change and Sustainable Development	Dr. Qamar-uz-Zaman Chaudhry
4.	Glaciers- The Barometer of Climate Change	Rakhshan Roohi Arshad Ashraf Rozina Naz
5.	Climate Change and Tree-limit status: A case study based on comparison between an optimistic scenario for European mountains and a pessimistic on for Pakistan	Amin U Khan
6.	Adapting to Risks of Climate Change	Shafqat Masood
7.	Impact of Temperature Gradient With Time & Its Variation With reference To Change Of state	Engr. Shaukat Ali Awan
	2008 – Kick the Habit, Towards a Low Carbon Economy:	
8.	Clean Development Mechanism	Muhammad Ashraf
9.	Hydel Power Generation: A Low Carbon Prospect For Prosperous Pakistan	Dr. Allah Baksh Sufi, A. Dastgir and Zahid ul Haq
10.	Re-Utilization of Solid Waste Carbon Saves Economy	Muhammad Khalid Iqbal, Tahira Shafiq & Khursheed Ahmad
11.	Low Carbon Economy – A Pakistan Perspective	Muhammad Daniel Saeed Pirzada
12.	Isotipic and Chemical Characterization of Coal from Selective areas of Pakistan	A .Mashiatullah, T. Javed, R. M. Qureshi, Z. Shah, Z. Latif and Habib-ur-Rehman
13.	ENERCON and Low Carbon Economy	Asif Masood

2009 – Your Planet Needs You-Unite to Combat Climate Change:

14.	Social and Economic Benefits of Weather, Climate and Water Services	Dr. Qamar-uz-Zaman Chaudhry
15.	Influence of Climate Change on Upper Indus River Flows	Danial Hashmi and Dr. Muhammad Siddique
16.	Vehicular Emissions and their Impacts on Human Health in Karachi – A Case Study	Muhammad Ashiq, Ambreen Kanwal and Said Rehman
17.	Emission Inventory of Lahore – 2007	B.M. Ghauri and A.N. Khan
18.	Accountability of Chemical Industries Towards Sustainable Development	S.E Benjamin
19.	Environmental Issues Related to Water Resources Development and Integrated Water Resource Management in Pakistan	Dr. Muhammad Nawaz Bhutta
20.	E-Waste : An Impending Challenge	Muhammad Daniel Saeed Pirzada and Farkhanda Nahid Pirzada
21.	Unsafe Drinking Water and Health Hazards	Sabir Ali Bhatti and Zia Mustafa
22.	Environmental Management for Menace of Water Logging of Chashma Jhelum Link Canal in Thal Desert Area – A Case Study	Dr. Allah Bakhsh Sufi, Syed Javed Sultan and Atia Dastagir
23.	Impact of Western Economic Policies on the Planet [With Special Reference to Pakistan]	Dr. Zafar Altaf
24.	Drinking Water Quality Berween Source and Point – of – Use in Satellite Town Rawalpindi – A Case Study	Shaukat Farooq, Imran Hashmi and Sara Qaisar
25.	Drinking Water Quality in Rawalpindi / Islamabad and Adjoining Areas in 2008	Jamal a. Nasir, Birjees Mazhar Qazi, M. Salman and Alam Khatoon
26.	An Overview of Ploye thylene Terephthalate Recycling in Pakistan	Dr. Zahiruddin Khan
27.	Poverty alleviation – a Challenge for Pakistan	Shahida Saleem

2010 – Bio-Diversity Connecting with Nature – Many Species, One Planet, One Future

28.	Deforestation – A Trample on the Moonscapes	Engr. Usman-e-Ghani
29.	River Ravi Potential, Pollution and Solutions; An Overview	Abdullah Yasar Fawad Ali Fateha Arshad Amna Iqbal Zainab Razi
30.	Wetlands in Pakistan: What is happening to them?	Dr. Abdul Aleem Chaudhry
31.	Promoting Better Management Practices An Initiative of WWF – Pakistan to reduce the ecological footprint of thirsty crops	Hammad Naqi Khan Arif H. Makhdum Zernash jamil Asad Imran A.Rasheed Bhutto Lal Khan Babar
32.	Botanical Diversity in Pakistan; Past, Present and Future	Muhammad Ibrar Shinwari, Maryum Ibrar Shinwari
33.	Biodiversity – A stavle Ecosystem (A Review)	Dr. Zaheer-ud-Din Khan
34.	Biodiversity and Economic Growth	Shahida Saleem
35.	Climate Change Threats to Biodiversity in Pakistan	Dr. M. Mohsin Iqbal Arshad Ahmad Khan
36.	Future of your Fuel Tank!!!	Umarah Mubeen Zia-ul-Islam Dr. Mian Wajahat Hussain Dr. Kauser Abdullah Malik
37.	Effect on Carbon Nitrogen Ratio, Ammonia Nitrogen in food waste composting using different techniques	Muhammad Khalid Iqbal, Tahira Shafiq Sameer Ahmed Khurshied Ahmed
38.	State of Forests in Sindh as well as the Economic benefits flowing out of it	Muhammad Sadiq Mughal

2011 – Forests-Nature at Your Services

39.	Forest and Climate Change	Dr. Abdul Aleem Chaudhry
40.	"Moringa: A Miracle Plant of Agro-Forestry and Southern Punjab, Pakistan	Prof. Dr. M. Ashfaq, Shahzad M. Basra and Umair Ashfaq
41.	Medicinal Plant Resources for Economic Development of Rural Community in Mankial, District Swat	Iftikhar Ahmad, Prof. Dr. Nowshad Khan and Fouzia Anjum
42.	Growth and Metal Accumulation in Various Tree Species in Response to Urban Waste Water Irrigation	Muhammad Ayyoub Tanvir Dr. M. Tahir Siddiqui and Zafar Hussain
43.	Significance of Forests in Islam	Engr. Mumtaz Hussain
44.	Creating Forests Resources in Thal Desert for Combating Land Degradation	Raja Attaullah Khan
45.	An Overview of Forests in Pakistan	Engr. Saeed Iqbal Bhatti

2012 – Green Economy-Does it Include You

46.	Making Agricultural Economy Green: Reducing Carbon Emissions Through Improved Irrigation Management	Dr. Asad Sarwar Qureshi
47.	Participatory Irrigation Management and its Role in Green Economy	Ch. Karamat Ali and M. Rizwan Aslam
48.	Policies for Improving Water Governance for Better Livelihoods – Managing Water for Green Economy and Green Growth – South Asia Perspective	Sardar Muhammad Tariq
49.	Short Rotation Energy Plantations	Major (Retd.) Shahnawaz Badar, Dr. Muhammad Afzal and Iftikhar-ul-Hassan Farooqi
50.	Water Shortage and Vegetation	Dr. Muhammad Afzal and Iftikhar-ul-Hassan Farooqi

51.	Construction of Large and Medium Dams for Sustainable Irrigated Agriculture and Environmental Protection	Irshad Ahmad, Dr. Allah Bakhsh Sufi, Shahid Hamid and Wassay Gulrez
52.	Energy from Municipal Solid Waste in the form of Solid Waste Briquettes	Dr. Rai Niaz Ahmad, Muhammad Azhar Ali, Abdul Nasir and Altaf Hussain
53.	Desertification Control for Improvement of Environment and Sustainable Land Use of Cholistan Desert – Pakisan	Muhammad Akram and Zamir Ahmed Somro
54.	Management of Agriculture Resources in Changing Environment Prospects	Dr. Allah Bakhsh Sufi and Talib Hussain
55.	Water as Crucial and Probably Agriculture's	Lubna N. Bukhari and Zeeshan A. Bhutta
	2013 - Think-Eat-Save	
56.	A Review of Global Food Security: Production, Wastage, Shortage and Solutions	Ms. Asifa Alam, Dr. Engr. Abdullah Yasar, Dr. Amtul Bari Tabinda
57.	Population Explosion and Food Waste	Mrs. Shahida Saleem
58.	Food Security Challenges in Pakistan and Strategies to Overcome	Mr. Muhammad Zubair, Mr. Mumtaz Shah, Mr. Kashif Bashir
59.	Natural Solution to Water Pollution of River Ravi	Mr. Sohail Ali Naqvi, Mr. Ali Hasnain Sayed
60.	Global Food Loss and Waste Within Food Supply Chain (Causes and Preventions with Special Reference to Pakistan)	Ms. Tayyaba Rizvi, Dr. Riffat Saqlain, Mr. Qamber Raza
61.	Transforming Food Waste into a Valuable Resource Through Anaerobic co-digestion	Mr. Muzammil Anjum, Dr. Azeem Khalid, Mr. Tariq Mahmood
62.	Prospects and Perspectives of Precision Agriculture in Pakistan	Chaudhary Muhammad Ashraf, Hafiz Qaisar Yasin
63.	Future Food Challenges for Pakistan – Pothwar as Impending Resource for Food Security	Dr. Ghulam Nabi, Mr. Muhammad Ashraf, Mr. Muhammad Masood

64.	Impact of Water Resources Management on Agriculture and Environment with Dungi Dam in Pothwar Area	Engr. Muhammad Saeed Arain, Engr. Syed Javed Sultan, Engr. Muhammad Mumtaz
	2014 – Effects of Climate Change on small Island Developing States (SIDS) and its Mitigation	
65.	Mitigation of Adverse Impacts of Climate Change in Small Islands Developing States	Dr. Muhammad Afzal Chaudhry
66.	A Review of SIDS: Characteristics, Effect of Climate Change and its Mitigation	Sidra Siddique, Asifa Alam, Dr. Engr. Abdullah Yasar, Dr. Amtul Bari Tabinda
67.	Environmental Change Detection of Urban Land cover, Agriculture, Forest and Sea Surface Temperatures Using Satellite Data	Dr. Badar Ghauri
68.	Effects of Climate Change on small Island Developing States (SIDS) and their Mitigation	Engr. Riaz Nazir Tarar
69.	Disaster Vulnerability, Risk Reduction and Mitigation in Small Island Developing States	Saba Dar, Ali Hasnain Sayed, Sohail Ali Naqvi
70.	Vulnerability of Small Island developing States to Climate Change	M. Aia ur Rehman Hashmi, M. Munir Sheikh, M. Mohsin Iqbal, Ghazanfar Ali, Arshad M. Khan
71.	Climate Change Effects on Small Island Developing States Biodiversity and Related Issues	Dr. Abdul aleem Chaudhry
72.	Small Island States of Indian Ocean and Impacts of Climate Change and its Mitigation	Attia Dastgir, Engr. Ishteqaq Ahmad, Dr. Muhammad Fayyaz Ahmad
73.	Environmental Ethics (A Prologue to Sustenance from Air to Oceans and from Islands to Mainlands)	Engr. Usman-e-Ghani
	2015 – Water and Sustainable Development	
74.	Managing food security Through Adaptation to Climate Change in Pakistan: An Overview	Iqra Saleem, Tahreema Farooq, Dr. Abdullah Yasar, Dr. Amtul Bari Tabinda

75.	Impacts of Rapid Urbanization on Air Quality and Temperature Variations in Developing Countries – An Overview	Dr. Abdullah Yasar Dr. Amtul Bari Tabinda Maham Sajid Hina Gul
76.	Extending Future Water Availability for Human Consumption Through salvage	Riaz Nazir Tarar
77.	Control of Environmental Issues by Safe Usage of Drainage Effluent for Growing of Crops	Engr. Muhammad Saeed, Engr. Munawar Ahmad, Engr. Asim Saeed Malik
78.	Study on Impact of Atmospheric Acidification on Carbon Sequestration of Forest Soil Ecology and its recovery by Calcium-Magnesium (CA-MG) Liming Technique	Muhammad Mansha Syed Hussain H. Rizvi
79.	Water Scarcity; Population Growth and Poverty	Mrs. Shahida Saleem
80.	Water Consumption – An Alarming Situation	Ms. Sara Ephraim
81.	The More Money You Have the More waste You Produce	Dr. Muhammad Anwar Baig
82.	Seven Billion Dreams and One Planet, Consume with Care	Dr. Muhammad Afzal Chaudhry
83.	Spatio Temporal Impact of Tidal Inundation in Indus Deltaic Creek System	Ibrahim Zia Dr. Naeem Ahmad Syed Mrs. Hina Zafar
84.	Seven Billion Dreams, One Planet, Consume with care: Ecosystems and Their Services	Dr. Abdul Aleem Chaudhry
85.	A Revoew pm Sustainable Consumption and Production to Prevent Resources Exploitation in order to Save our Planet	Asifa Alam Sidra Siddique Dr. Amtul Bari Tabinda Dr. Engr. Abdullah Yasar
86.	Ground Water – A natural Resource Under Serious Threat	Ghuam Zakir Hassan Sial Ghulam Shabir Faiz Raza Hassan Saleem Akhtar