ENERGY SECURITY: SOME SUGGESTIONS

SHAHBAZ KHAN, Islamabad

High-profile advisory council comprising energy professionals should be set up



UNEXPECTED ISSUES: LNG supply chain has started throwing up unique challenges including sometimes even impacting supplies from the country's own fields, photo: ROTTERS

Energy security appears to be the biggest challenge confronting the country since long. The following paragraphs are an attempt at a quick health check of Pakistan's energy supply chain and recommending the way forward.

Despite all of our cash flow issues and heavy debt, we have somehow ended up with a highly lethal energy mix which compels us to spend around $16 billion on fuel imports annually-The main reason is that during the past more than 40 years, instead of considering a long-term strategy and its execution, we have mostly reacted to crisis.

A few examples are failure to build any major dam after Tarbela Dam in 1976 and Thar coal taking decades to commence its monetisation-though its effective utilisation could substantially increase the reserve life of oil and gas.

Similarly, despite negligible progress on gas reserve replacement, we continued to use it liberally. The optimal use of indigenous resources could help in delaying the import of expensive liquefied natural gas (LNG). The replacement of oil and gas reserves requires a sustained focus on the exploration and production (E&P) activity. We instead have not been very consistent in this regard.

Hardly 35% of the country has so far been explored with the last major hydrocarbon discovery in 2002 in Tal block.

Lack of interest by most of the E&P MNCs for the past 15-20 years adds to the challenge. Pakistan has a rich past with respect to the presence of MNCs such as UTP, BP, Occidental, BHP, Tullow, OMV, Premier, BG, etc. Only a few such as MOL, PCNiC, UEP and Eni are still active in Pakistan.

In addition to E&P, the MNCs contribute to imparting modern knowledge and skills to the country's professionals who serve as employees or interact with expatriates in joint ventures and other forums like PPEPCA.

This, in conjunction with other factors, went a long way towards maintaining excellence at high levels in the E&P industry for a long time. However, the gradual exit of MNCs is causing a marked dent in the entire process.

Challenges of midstream and downstream industries have also increased with time. Unaccounted-for-gas (UFC) and associated losses stood at 358 million cubic feet per day (mmcfd) in FY19, ie equivalent to sales of a large gas field.

Similarly, the LNG supply chain, still in its infancy, has started throwing up unique challenges including sometimes even impacting supplies from our own fields.

We have not so far been able to achieve the refining capacity as per requirement, thus compelling us to meet at least 45% of requirement for petroleum products (20 million tons per year) through imports.

The transmission infrastructure for oil and petroleum products also needs augmentation. It goes without saying that the planned addition of Machike to the Taru Jabba pipeline (initially conceived in 2000) is an apt step in that direction. Appropriate solutions to indigenous crude oil transportation are required.

A number of countries having dearth of oil and gas have made huge investments in E&P abroad to augment their energy security. However, we are far behind in that direction as well as in establishing strategic underground oil and gas reserves.

The above observations indicate that at least some aspects of the country's energy supply chain need more focus.

India and Bangladesh

Both countries appear to be galloping towards their energy goals. ONGC of India has targets to double its gas production by 2040. It drills more than 500 wells a year with 50 offshore wells. Pakistan hardly drills 80 wells per year. ONGC has assets outside India in 17 countries contributing 200,000 barrels of oil equivalent per day. Oil India is active in 10 countries.

India has plans to invest $100 billion in oil and gas infrastructure by 2024. With 23 large refineries, it has refining capacity of 257 million tons per year, which generates annual revenue of $35 billion from the export of petroleum products. Also, it has three underground oil storages.

Bangladesh's gas production has gone up from 1,744 mmcfd in 2009 to 2,700 mmcfd and the aggregate supply including re-gasified LNG is 3,250 mmcfd.

It established a robust LNG supply chain in less than three years, ie two terminals each of 500 mmcfd, supply contracts and transmission capacity, while further expansion is in progress.

Bangladesh has especially done wonders in electricity generation and transmission. It increased generation capacity four times from 5,000 megawatts in 2009 to 21,000MW by 2019 and targets to reach 60,000MW by 2040.

What is to be done?

Until the above situation is dealt with in a holistic manner with a long-term plan and a dedicated team capable of supporting implementation of such a plan, "fire-fighting" may continue to consume most of our time and resources.

Therefore, a state of energy emergency is required to be declared immediately along with the constitution of a high-profile advisory council comprising world-class energy professionals (engineers, geoscientists, etc) who have managed large value chains. Some immediate tasks of the advisory council can be as follows:

First, conduct an integrated review of the oil and gas supply chain gaps, along with a concomitant study of power supply issues and options (including coal), develop remedial plans and support their implementation.

Second, make baseline capacity assessments of relevant components, including the governance and institutional framework, of supply chains and corresponding catch-up plans, and support their implementation.

Some international references such as that of Norway, South Korea, Singapore, China, etc may come in handy in this homework. Third, approach all E&P MNCs which are still in Pakistan or have left and ascertain their candid feedback with respect to what can/could retain them.

Fourth, nurture a culture of professionalism. We have no future without fulfilling this essential requirement. This requires capacity gap mapping of human capital requirements and focused capacity-building plans including opportunities for the exposure of professionals to international systems and corporate environments.

A number of countries such as Singapore, South Korea and China are examples of the progress possible in short periods by investing in human resources. Advisory councils have played a vital role in expeditious development of a number of modem economies. Therefore, there is no reason for its failure in Pakistan.

The above suggestions assume critical urgency because 64% of Pakistan's population is between 18 and 30 years of age. Also, the ratio is projected to stay the same for the next 20 years.

Therefore, it is imperative to respond to the needs of the youth bulge with the fastest possible socioeconomic development which, of course, necessitates a robust energy supply chain.

ARTIFICIAL INTELLIGENCE IN NEURAL NETWORK PROGRAMMING AND LEARNING

By

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The scope of this article is to understand Artificial intelligence its uses, applications, advantages and disadvantages in a general way from our daily life examples and basic concept of application of AI in Neural Network Programming and learning.Let us first define the terms artificial and intelligence. Artificial means any thing which is not natural and created by humans and term intelligence means the ability to understand, think and learn. When we combine these two terms together, we get artificial intelligence (AI). AI is broad area of computer sciences where we have computer machines behave like human intelligence. The main objective of AI is to mimic the human brain and ingrain intelligence in machines so that machine can act intelligently and independently same like human brain. Let's take a look on human brain before we discuss about AI. Human brain functions independently, make decisions, take input from environment and keeps on updating knowledge. Human brain functions can be segregated in different functions like communication, logical reasoning, problem solving, storing and retrieving experiences and updating memory and displaying and controlling emotions. If we just talk about communication, human brain is performing many different functions simultaneously while communication brains use subconscious memory to retrieve linguistic vocabulary and phrases and bring them to conscious memory, relate words to experiences and convert words into sounds and tempos by using vocal chords, body gesture and expression control. Now how brain knows all this, actually brain has capability to observe things using visionary organs, hearing capability, touch, taste, smell and other social and natural interactions in other words we can say we are equipped with different sensors to interact with our environment. Our brain is programmed for running our body, organs and maintaining the ability of continual understanding, thinking and learningthrough organs or sensors which create intelligence in humans. The ability of learning in humans are open ended due to its independence in inferencing from logics and exercising logical reasoning to reach to conclusions and day to day decision making which keeps on updating human intelligence and ultimately the knowledge.Intelligence is something that makes the man superior to all the other living beings on this earth. The human is made to be the most intelligent living thing to exist which can feel, sense and see things and have its own perception and views. How can we not expect it to prove its intelligence through passive ways?

Artificial intelligence is a term coined by John Mccarthy in 1955 at the Dartmouth conference and was defined by him as "the science and engineering of making intelligent machines". But how can we make machines intelligent?

To answer this question, we will have to understand the importance of decision making in our actions. We are always doing decision making, name anything you

can find that you need to make decision, in fact your life is all about decision making like what to say? What language to use? What words to select? What tone to use to utter those words? What expression to show? What gesture to display? If you deeply analyze each second of your life you will find that you are continuously in decision making state every moment. Some decisions are logical and simple programmed like mathematical calculations and other are complex and involve emotions. When we program machine in a way that it can make decisions that lays foundation stone for artificial intelligence. To better understand use of machines as intelligent tools let's discuss an example like you visit physician for some ailment or sickness, what actually medical practitioner does? Physician checks your vitals, symptoms, see test results and related that information with medicine properties and select best suited medicine and suggest medicine. What if we have programmed a machine who in a same way collects all information from patient using forms, voice recognition, sensors and then based on stored information suggests medicine? Can that machine replace the role of physician and act as an expert system? The answer is upto major extent yes, this is an example of artificial intelligence.

Now we discuss artificial intelligence in technical terms to discuss AI in more specific way. Most often the two terms artificial intelligence and machine learning are used interchangeably, but in actual they are different. Artificial intelligence is a broader term and machine learning is part of artificial intelligence. We can say all machine learning is AI but not all AI is machine learning.

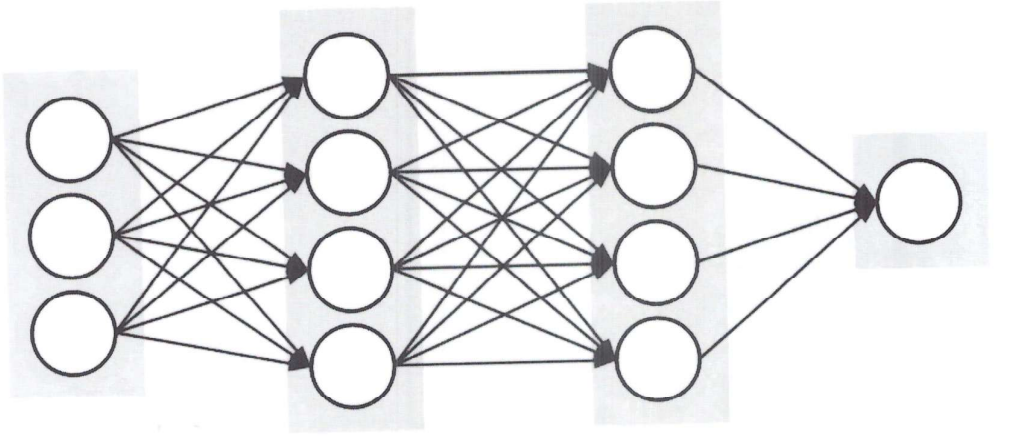
AI has many different building blocks applications which includes but not limited to:

1. **Expert Systems**(ES) –ESare systems which has capability to act as an expert. They cannot absolutely replace experts but they provide significant support to experts in their work.
2. **Natural language processing (NLP)** - NLP is a branch of AI that deals with study of how machines can understand human language. The main objective is to develop systems that can understand text and can perform translation, grammar checking, topic classification or other related operations like humans do.
3. **Speech Recognition** - Speech Recognition is a capability which enables machines or programs to understand human speech and convert that into text format and subsequently that can be used to activate commands, translations into different languages or other task as humans use their voice to perform different operations.
4. **Computer Vision**– Computer Vision is a capability of machine to visualize, interpret and understand the visual world. This is used by the machine to accurately identify, locate objects and process to react using cameras, videos etc. like humans do by using eyes.
5. **Robotics** – Although robotics and AI are not same thing but robotics can be made more intelligent using AI. AI is part of large robotic system like use of sensors, actuators and other algorithms to make robots intelligent.
6. **Automatic programming**– Automatic programming is a capability to understand the problem and convert that into logics and programs and

execute as per requirements. This enables machines to step up into solve logical reasoning not exactly but similarly like humans.

There are many other applications to support AI, we have discussed above only few of them to explain how different applications form ears, eyes and other senses for machines to interact with environment the concept is more or less like humans as they have five senses to interact with environment.

The human brain is one of the wonders of the world and human system are guided through evolution of thousand and thousands of years to learn the logics and how to analyze and conclude out of them. Human brain uses neurons to receive information from environment through sensors and form neural network and apply different algorithms to understand. Neurons interact with each other using electrical pulses or spikes and information moves back and forth for different combinations before our brain comes to a final conclusion. Human brain is very complex and is yet to be explored completely, however, Artificial Intelligence inspired by the functionality of human brain has stepped into the field of Neural Network Programming and Learning which has laid a foundation of deep learning.In neural network programming the perceptron is used to represent neuron, in other words we can say the perceptron is an artificial neuron and is a basic unit of neural network. Biological neuron in brain carries electrical spikes receives signals axons of other neurons whereas perceptron is a mathematical model of biological neuron to form neural network in AI. Now, let us discuss how neural network works in AI.Let us see how the machine will learn to compare pattern and will predict the output. The neural network consists of different layers of neurons which are the core processing units of the network. The first layer is the input layer which receives the input.To explain the input layer let us consider example of visual learning, let us see how machine takes input to learn about shape using neural network to identify basic shape. Just imagine if there are three shapes namely square, circle and triangle. Let say each shape consists of 28 X 28 pixels that mean there are 784 pixels now if machine is supposed to compare and differentiate square out of these shapes.In our case the input is 784 pixels so there 784 neurons and our input layer will consist of 784 neurons.The output layer is the layer which predicts the final output.In between there are many hidden layers which are used for the computations to reach to output.



The arrows in between neurons are called channels, each channel is assigned with some value based on some logic called as weight. Each neuron in the input layer is multiplied with weights and the sum of total associated channels is sent to neurons in hidden layer where each neuron is associated with some numeric value called as Bias which is added to the propagated value. The final value of each neuron is then passed to an activation function to determine if that particular neuron is activated or not. The Activated neurons are then transmit data to the next layer of neurons over the channels and in this manner the data is propagated through the network in hidden layers. This is called forward propagation. The neurons in output layer gets data from network with higher values and determine the output based on the values, it is more like probability analysis. The predicted output is then compared with actual output and error is determined and is sent back to the network for the network learning this is called backward propagation. This forward and backward propagation provide learning to neural network to refine the output to match the actual output.

Summing up above discussion about Artificial Intelligence, neural network programming and learning we can say these are the techniques to make machines intelligent to act as humanlike as possible. The research in this field is at very basic stage and the knowledge about human brain is incomplete so this will have to go through the stages of evolution and world will witness the wonders of Artificial Intelligence in the time to come.

DEVELOPMENT OF INNOVATIVE ROTATION PLAN ANALYSIS TOOL FOR EFFECTIVE MONITORING OF HAKRA CANAL SYSTEM, SOUTH PUNJAB-PAKISTAN

By:

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ABSTRACT

Surface water supply operations and canal operations in Pakistan are based on heuristic approaches. This heuristic management technique often depends heavily on expert human judgment. Pakistan also has one of the world's most complex supply-based irrigation networks. Water distribution within the network is challenges due to water shortages. Shortage of irrigation water is a contest normally occurs at canal tail-end user. The rotational plans only become applicable when the system is bearing the capacity constraints or shortages in water supply. To overcome these problems, Excel Based rotational plan analysis tool has been developed to evaluate the rotational programme in the canal system for effective canal monitoring system. For this study, Hakra Canal System with a command area of 1.4 million hectares has been selected. The results show that among all channels, flood channel has less DPR and on weekly basis analysis, group C channels taking 11% more share in week 2. Similarly, in week 22 only group C channels are getting their fair shares.

Keywords: Canal Management, Water Shortages, Rotational Program

1. INTRODUCTION

The Punjab irrigation system faces numerous constraints that may limit the canal operations. Ahmed, Mahmood, and Munir (2015) stated that Punjab Irrigation System is one of the world's largest systems comprising 13 barrages and 26 main canal systems and 12 link canal systems with overall length of main and branch canals of about 6,500 km, and 2,794 distributaries and minors with overall length of about 31,050 km. GINI coefficient has been widely used as an indicator for the estimation of water distribution equity. Numerous research studies such as Melkamu & Bannor 2015, Cullis and Koppen 2007, Anwar & Haq 2013 and Anwar, Bhatti & de Vries 2016, have supported its usage in this particular context.

The rotational plans are mostly applicable up till the distributaries heads. The direct offtakes of channels are always brought into rotational. Only a couple of rotational plans exist in the system in which minors have also been rotated. On the contrary, main canals, branch canals and link canals themselves are never rotated unless any one of them is being fed by a channel that is under rotation. For example, in case of Sadqia division, Sadiq Ford Feeder acts as a distributary and feeds Fordwah Branch in the Fordwah division during the Rabi season. Sadiq Ford Feeder is being rotated under the Sadqia Rabi rotational plan which consequently brings Fordwah Branch

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under rotation. Moreover, rotational plans are strict and cannot be violated. The total number of priorities in the plan would always be equal to the total number of groups or subgroups, whichever is greater. Further, the number of unique waras will also be equal to the total number of priorities. It should be noticed that a group cannot repeat itself under a specific priority rank unless all the other groups have individually acquired that position in consecutive waras. As for the wara duration is concerned, the length of wara in the Punjab irrigation system varies from 7-8 days. It may be even shorter than the aforementioned time frame, however, such instances are quite rare. Adding more, there are two seasons in a year, Kharif and Rabi. Each season comprises of approximately 24 weeks and independent rotational plan is proposed for each one. It should be noticed that ideally, the number of times a group acquires the first position in the rotational plan for the whole season should be the same for every group. The shortages should be distributed equally among all the groups.

Due to introduction of high yield seeds and the increase in cropping intensities, the colonial era water allowances are presently inadequate and hence the farmers frequently face water scarcity issues and involve in water thefts, tampering the outlets, and exchanges in warabandi (fixed turn water distribution quota) times (Awan, Anwar, Ahmad and Hafeez, 2016). Due to water security issues, water is distributed in IBIS on equity basis and for this purpose, a rotational plan is used in the irrigation canal system. Mishra et al. (2001) reported that the rotational irrigation system is a common phenomenon is South Asia to distribute water (Shende and Sachin,2006) addressing water security issues. Therefore, for efficient management to minimize the effect of shortage of water supply at the tail end of an irrigation canal, monitoring of the canal through innovative tools is a dire need. The main objective of current study is to analyses the rotational program of a canal system for effective management and monitoring.

2. METHODOLOGY

2.1 Study Area

Hakra branch canal offtakes receive irrigation water from Eastern Sadqia canal which extracts water from Sulemanki Headworks. The design discharge of Hakra Branch Canal is 2900 cusecs with total cultivable command area of 1.4 Million hectares. Length of the canal is (285433 ft) 87 km as shown in Fig-1. The Major crops grown in the command area of Hakra Branch Canal include wheat, sugarcane, rice and cotton. It has 17 distributaries which convey water from Hakra canal to the farmers' fields via a network of water courses and farm channels. Mostly in the discharge measurement has been taken at Reduced Distance (RD) 2+000 and at 285+000 tail of Hakra branch.

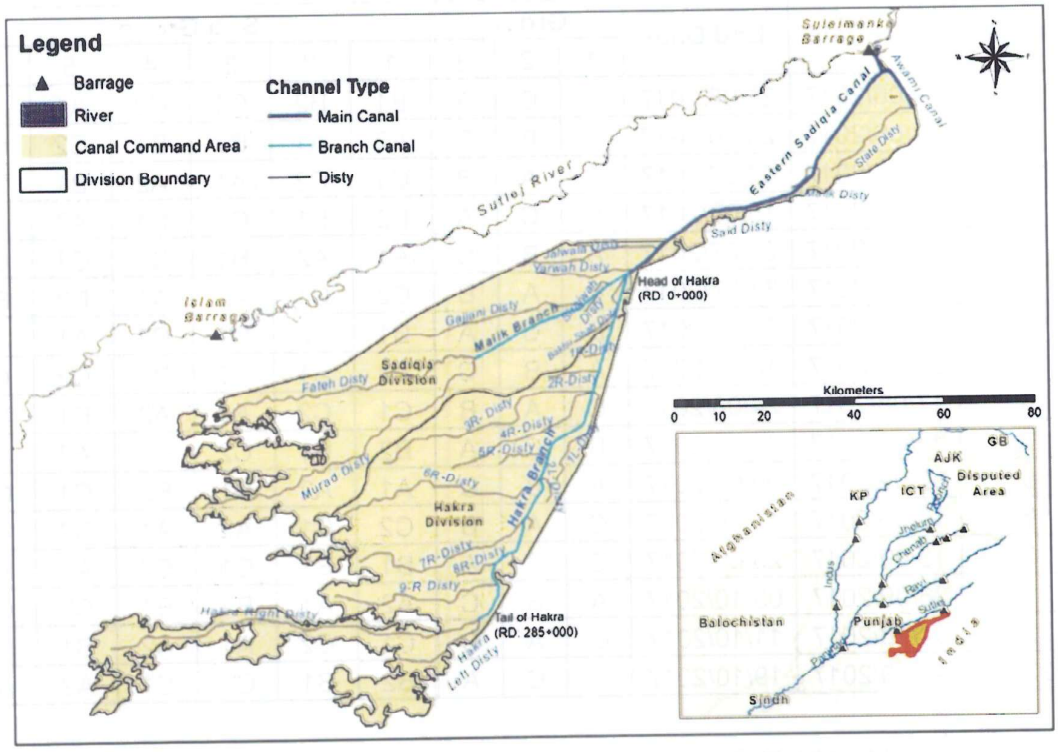


Figure-1: Study Area Map of Hakra Branch Canal Area

2.2 Data and data source

For the study purpose to evaluate the rotational program all the data given in the following table has been collected from Programme monitoring and implementation unit (PMIU) Irrigation Department;

Table-1: Data and data source

Type of Data	Source	Data Resolution
Rotational Programme	PMIU Irrigation	Seasonal
Canal discharges	PMIU Irrigation	Daily

Table-2: Rotational Program

Week No.	Start Date	End Date	Group			Sub Group					
			1	2	3	1	2	3	4	5	6
1	19/04/2017	26/04/2017	C	A	B	C2	C1	A2	A1	B2	B1
2	27/04/2017	04/05/2017	B	C	A	B1	B2	C1	C2	A1	A2
3	05/05/2017	12/05/2017	A	B	C	A2	A1	B2	B1	C2	C1
4	13/05/2017	20/05/2017	C	A	B	C1	C2	A1	A2	B1	B2
5	21/05/2017	28/05/2017	B	C	A	B2	B1	C2	C1	A2	A1
6	29/05/2017	05/06/2017	A	B	C	A1	A2	B1	B2	C1	C2
7	06/06/2017	13/06/2017	C	A	B	C2	C1	A2	A1	B2	B1

Week No.	Start Date	End Date	Group			Sub Group					
			1	2	3	1	2	3	4	5	6
8	14/06/2017	21/06/2017	B	C	A	B1	B2	C1	C2	A1	A2
9	22/06/2017	29/06/2017	A	B	C	A2	A1	B2	B1	C2	C1
10	30/06/2017	07/07/2017	C	A	B	C1	C2	A1	A2	B1	B2
11	08/07/2017	15/07/2017	B	C	A	B2	B1	C2	C1	A2	A1
12	16/07/2017	23/07/2017	A	B	C	A1	A2	B1	B2	C1	C2
13	24/07/2017	31/07/2017	C	A	B	C2	C1	A2	A1	B2	B1
14	01/08/2017	08/08/2017	B	C	A	B1	B2	C1	C2	A1	A2
15	09/08/2017	16/08/2017	A	B	C	A2	A1	B2	B1	C2	C1
16	17/08/2017	24/08/2017	C	A	B	C1	C2	A1	A2	B1	B2
17	25/08/2017	01/09/2017	B	C	A	B2	B1	C2	C1	A2	A1
18	02/09/2017	09/09/2017	A	B	C	A1	A2	B1	B2	C1	C2
19	10/09/2017	17/09/2017	C	A	B	C2	C1	A2	A1	B2	B1
20	18/09/2017	25/09/2017	B	C	A	B1	B2	C1	C2	A1	A2
21	26/09/2017	03/10/2017	A	B	C	A2	A1	B2	B1	C2	C1
22	04/10/2017	11/10/2017	C	A	B	C1	C2	A1	A2	B1	B2
23	12/10/2017	19/10/2017	B	C	A	B2	B1	C2	C1	A2	A1

3.0 DEVELOPMENT OF ROTATIONAL PLAN TOOL

A mathematical "Post-Seasonal Rotational Plan Evaluation Tool" has been developed that possess the capacity to analyses operated rotational plans. Performance indicators are used to comment on the effectiveness of an implemented seasonal rotational plan in terms of equity in water distribution and the percentage of plan being followed.

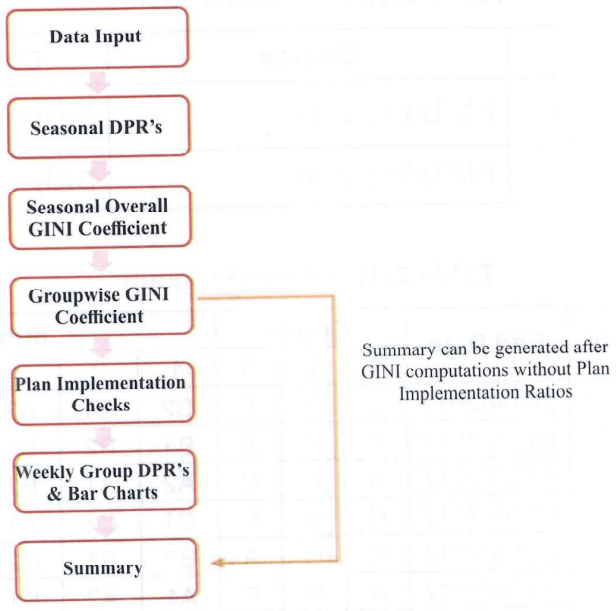


Figure 2: Methodology Flow Chart

Performance parameters in water sharing equity

Performance parameters or indicators are the measurable values that are used to assess the performance of rotational plans in terms of equity in water distribution and percentage of plan implementation. These parameters can assist in performance assessment of irrigation canals and guide water managers to take necessary operational decisions.

3.0.1 Delivery Performance Ratio (DPR)

The delivering performance ratio (DPR) is defined as the ratio of actual discharge to design discharge. If a channel is functioning at a DPR value of 1, it means that the channel is withdrawing its design share. Normally, the irrigation site staff have a cushion to operate a channel up to a DPR value of 1.2. Similarly, channels are not operated under a DPR value of 0.6 so that they are not subjected to siltation.

Where;

$$DPR = \frac{Q_A}{Q_D} \qquad \text{Eq-1}$$

DPR = Deliver performance ratio (unit less);

QA = Discharge at which the channel is being operated (cusecs);

QD = Channel design discharge (cusecs). In case of rotational plans,

QD will be the discharge of the channel that has been allocated in the rotational plan. This discharge might not be equal to the full design capacity of the channel.

3.0.2 GINI Coefficient

GINI coefficient is an indicator that can be used to quantify the equity in water distribution in the system. Its value ranges between zero (0) and one (1). Zero represents a uniform distribution of water whereas one shows fully inequitable distribution.

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n\sum_{i=1}^{n} x_i} \qquad \text{Eq-2}$$

Where; G = GINI Coefficient;

x = Seasonal average DPR of a channel;

n = Total number of channels;

i, j = Columns & rows of the matrix.

For user convenience, GINI has been reported in inverse format. This will reverse the evaluation criteria i.e., value one (1) for perfect equality and value zero (0) for inequality.

$$\text{GINI Index} = 100 - x(\%age) \qquad \text{Eq-3}$$

GINI coefficient is a function of channels DPR's and it can only be computed at the completion of the season. Computing a GINI coefficient for a specific wara or number of waras may not provide reasonable results. In case of rotational plans, GINI coefficient will indicate the extent up till which the executed rotational plan was

able to ensure the water equity among the consumers. However, it is important that this coefficient is analyzed in parallel with other performance indicators. A schematic for computing the GINI is shown in the Figure-3 below:

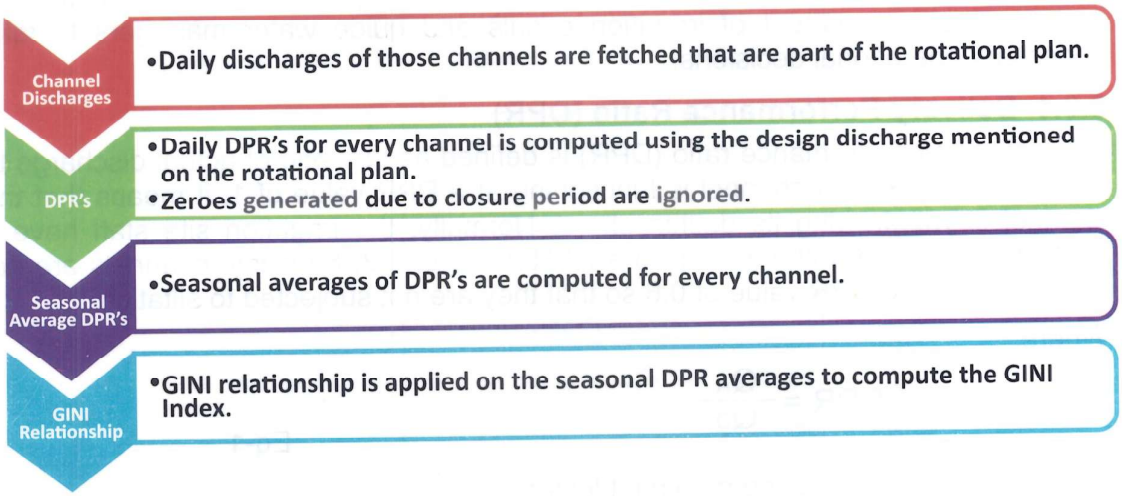


Figure-3: Schematic for computing GINI Index

3.0.3 Plan Implementation Ratio

An in-house logic has been developed to estimate the percentage of plan implementation of the executed rotational plan during a season. The logic can be implemented on individual waras as well as for the complete season. This flexibility is provided to the user so that percentage of plan implementation could be tracked for desired time window.

The logic is a function of the daily discharges of the channels and compares them to compute the implementation percentage. The user is required to input the rotational plan and define two threshold values of DPR's i.e. Upper DPR threshold and Lower DPR threshold. Currently, value of 1.2 and 0.8 have been selected. Daily discharges of the channels, which are part of the rotational plan, are taken from Irrigation Department database against the dates during which the analysis is intended. These dates can be for the complete season or any particular waras. Fetched discharges are arranged in a row wise pattern against the dates and follows the preference order that is mentioned in the rotational plan. Their corresponding daily DPR's are computed and arranged in the similar way. Once DPR values are properly ordered, maximum DPR value of each group is identified and placed against the dates in the similar row wise fashion.

It is to be noted that maximum DPR of the least priority group is of no interest for logic implementation and therefore ignored. After the processing of data, DPR of every channel is compared with the user defined thresholds and the maximum DPR of the consecutive group. Based on the comparison, the developed logic could either be true or false. This activity is continued till the intended last date of the analysis. In the end, the total instances of TRUE and FALSE decision occurrences are counted for calculating the plan implementation percentage. It is to be mentioned that the above logic is applied for all the channels on each day. The channels residing in the least priority groups, however, are not considered in the analysis and therefore

skipped. A schematic for computing the plan implementation percentage is shown in the Figure-4. During the closure period in Rabi season, plan implementation is computed by analyzing the head discharge of the parent channel. If the head discharge is null during the planned closure date, the conditions are counted as TRUE, as the channel has been closed according to the rotational plan, and vice versa.

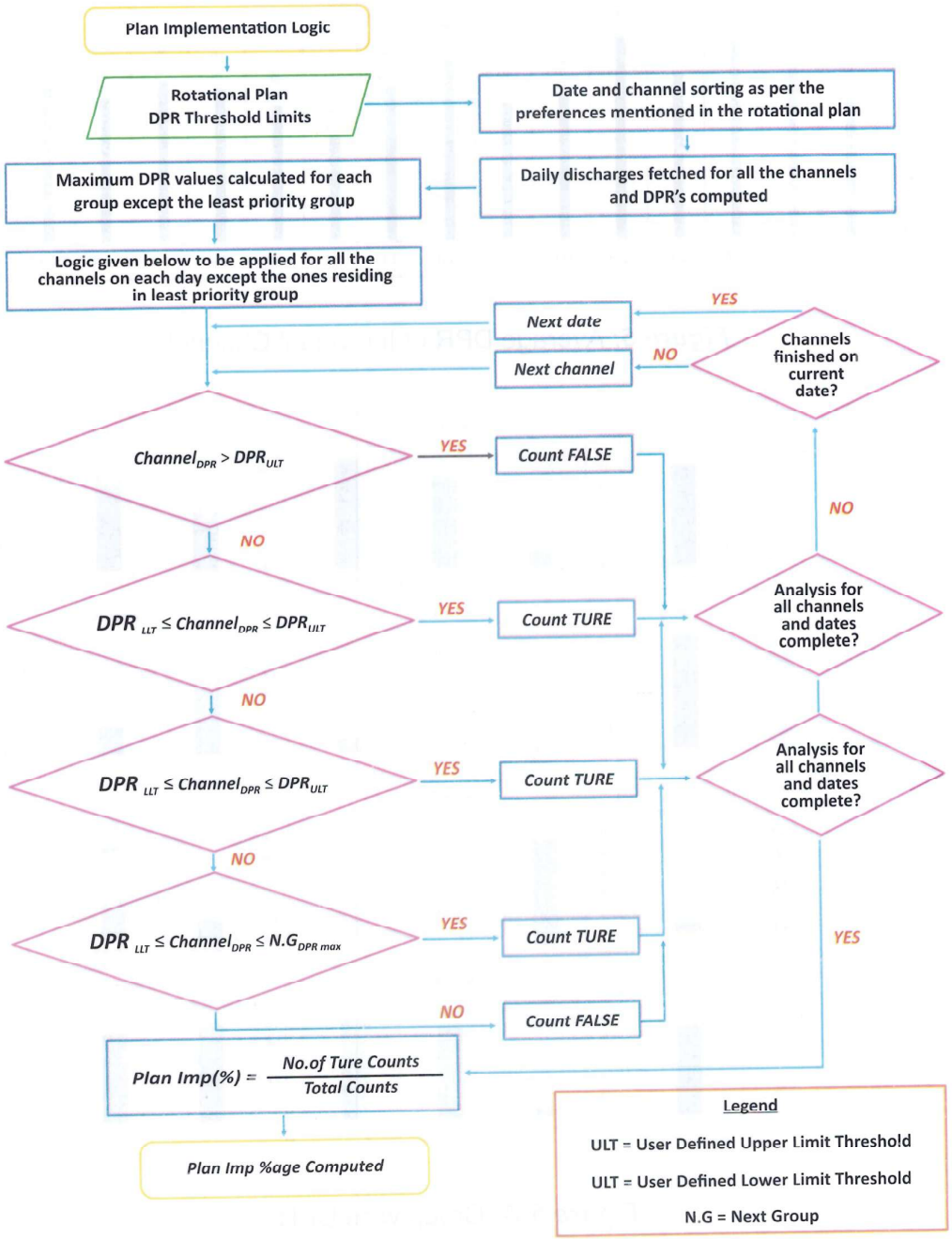


Figure-4: Schematic for computing plan implementation percentage

4.0 RESULTS AND DISCUSSION

Rotational Analysis tool for the Hakra Irrigation canal is developed. It can be seen from the figure that the rotational plan has been strictly followed. It can be seen that from the result in the week 22 only group-C is facilitated and rest of the group could not get their fair.

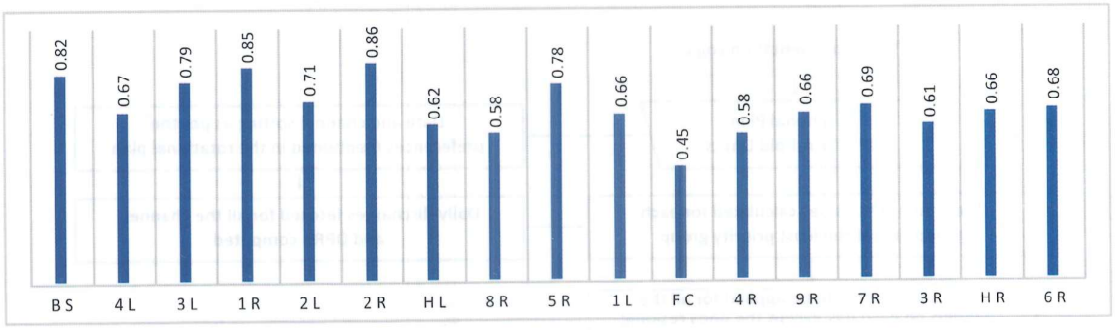


Figure-5: Average DPR of Individual Channel

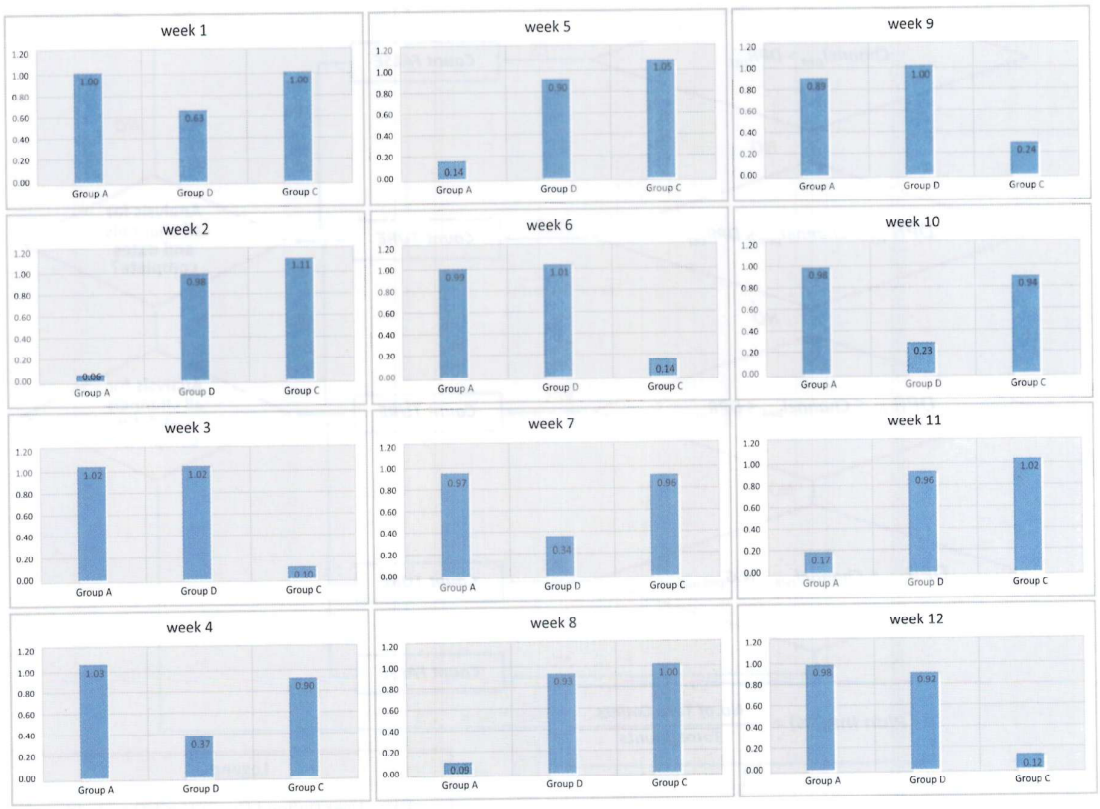


Figure-6-A: Group wise DPR

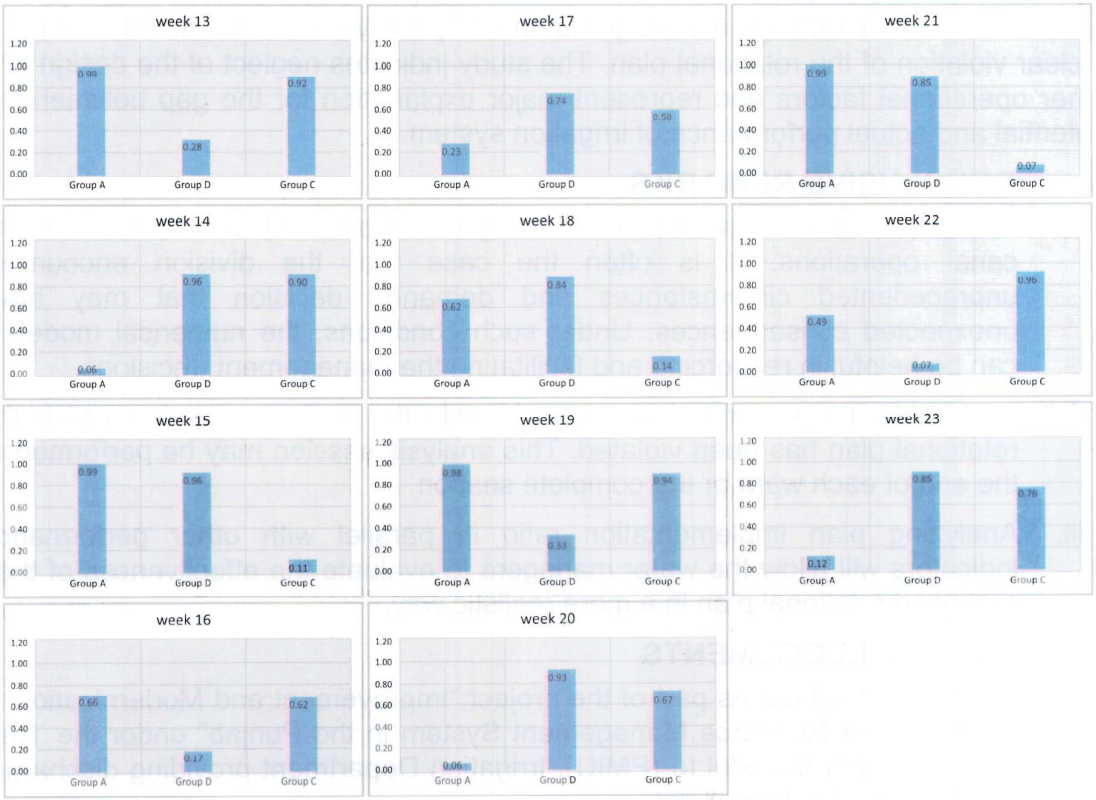


Figure-6-B: Group wise DPR

Table-3: Results Summary

Plan Implementation Statistics		Equity (GINI)
Total Checks	920	Overall GINI= 92%
True Checks	528	
False Checks	392	
Impl. Ratio logic _0	57%	Group A=97%
Impl. Ratio logic _1	82%	Group B=90%
Impl. Ratio logic _2	84%	Group C=99%

Rotational Plan is prepared at division level on seasonal basis (Rabi and Kharif) for Hakra canal division. In the rotational plan the 1st priority canals run on their design discharge with (±10% variation of the design discharge which is depicted in the results. Similarly, 2nd and 3rd priority channels in the rotational plan run as per water availability in the parent channel It can be seen from Table-3 that plan implementation percentage and GINI index are in direct relationship, however, it does not necessarily have to be directly proportional. it can be seen from Figure 6-A and Figure 6-B that among three groups, one group of the channels for rotational plan possess an average DPR greater than 80%. The average DPR as mentioned in the figure-5 vary from 0.45 to 0.86 means inequitable distribution among the canals but in the Group Wise it shows that the distribution among the group is

equitable. It was also observed that DPR in week 8 (Wara 8) the canal at 2nd priority run as 100% of their design discharge but the 1st priority canals run as 93% which is a clear violation of the rotational plan. The study indicates neglect of the design and other operational factors and represent major explanation for the gap between the potential and actual performance of irrigation system.

4. CONCLUSIVE REMARKS

i. This tool can also assist in forecasting the impacts of decisions related to canal operations. It is often the case that the division encounters unprecedented circumstances and demands decision that may have unexpected consequences. Under such conditions, the numerical modeling can be helpful in reinforcing and facilitating the management decisions.

ii. It will help the water managers to identify the instances during which the rotational plan has been violated. This analysis session may be performed at the end of each wara or the complete season

iii. Analyzing plan implementation ratio in parallel with other performance indicators will allow the water managers to evaluate the effectiveness of their proposed rotational plan in a more realistic way.

5. ACKNOWLEDGEMENTS

The study was carried out as part of the project "Improvement and Modernization of Irrigation and Water Resource Management System in the Punjab" under the Task C. Authors are highly thankful to (PMIU), Irrigation Department providing discharge, and hydraulics structural detail data.

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GROUNDWATER-FOOD SECURITY-CLIMATE CHANGE NEXUS IN PUNJAB, PAKISTAN

By

Ghulam Zakir-Hassan[1,2,3,4] Ghulam Shabir[2] and Faiz Raza Hassan[3]

Abstract

Irrigated agriculture plays a vital role in the economy of Pakistan by contributing about 90% of food production, 22% of GDP, employs about 45% of the overall labor force and generates over 60% of foreign exchange. Role of water resources has become significant which underpins the food security in the country. Indus Basin Irrigation System (IBIS) is the lifeline for economy of Pakistan and is the major pillar of food security. IBIS is one of the largest irrigation networks of the world and is confronted with multidimensional challenges out of which climate changes have attained paramount importance. The irrigation system was designed on 67% irrigation system during the 19th century while current cropping intensity has crossed the limits of 150-160% or even more. Continuous increase in population and consequently more food demands have shifted the pressure on the aquifer underlying the Indus Basin. After India, USA & China, Pakistan has become the 4th largest user of groundwater where about 40% irrigated food production is dependent on groundwater. In Punjab province, about 1.2 million tubewells are extracting about 40-45 MAF of groundwater annually. Consequently, groundwater management has confronted with multitude of tiny users in Pakistan. Climatic changes have made the availability and reliability of surface water a question mark. Resultantly pressure on groundwater is increasing and water levels are dropping abruptly taking this resource beyond the bound of rural poor farmers. Intrusion of saline water into fresh aquifer, secondary salinity and sea water intrusion are the major threats for groundwater quality. About 3000 piezometers have been installed to monitor the groundwater behavior (levels and quality) in the Punjab province. Research study carried out in Lower Bari Doab Canal (LBDC) has indicated that by falling of water table from 40 to 70 ft. the cost of pumping per acre-feet of groundwater has increased by 125%. Similarly has been observed that in many urban areas groundwater is depleting at an annual alarming rate of 2.54 ft., (Lahore city) and the water table in sweet water zones in rural areas (Vehari District) has gone beyond 70-90 ft. Human activities like increasing cropping intensities, unplanned over pumpage, lack of awareness/capacity, use of chemicals in agriculture/food production, industrialization, urbanization, solid waste landfills, domestic effluents, lack of legal and regulatory framework etc. are the major threats to sustainable use of groundwater for food security. Climatic changes are posing severe adverse impacts

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on the sustainable use of groundwater which is putting the food security under threat. Global warming, rising sea levels, glacier melting, unprecedented rainfall, prolonged droughts and floods are the consequences of changing climate which are affecting directly or indirectly the groundwater resources in the aquifer underlying the Indus Basin.

Key Words: Groundwater, food security, climate change, aquifer, Punjab, Pakistan

1. Introduction

World population is expected to increase by 45% in the next thirty years. Groundwater is the world's most extracted raw material with withdrawal rates currently in the estimated range of 982 km^3/year. Out of total earth's water, 99 % is unusable for human beings while only 1 % is usable. Out of this usable (1%), 99% comes from groundwater while nearly 1 % world's groundwater is fresh and is accessible for consumption. Pakistan is 4th largest user of groundwater after India, USA and China. Pakistan is blessed with a plenty of water resources including a large groundwater reservoir underlying the Indus Basin. The extent of this large and highly transmissive aquifer is about 297,200 km^2 with a length of 1,900 km, but this natural resource is under serious threats and need immediate measures for its sustainable utilization. In Pakistan, over 90% drinking water and 100% industrial water comes from groundwater. Groundwater has helped in increasing cropping intensity from 60% in 1947 to 150% or even more in 2015. In Pakistan, current per capita water availability (1200 m^3/person) is low, which puts us in the category of a high water stress countries on the globe. UNESCO has predicted that by 2020 water shortage will be a serious worldwide problem. Without improved efficiencies, agricultural water consumption is expected to increase by about 20% globally by 2050 **WWAP (2012).** Groundwater quality depends on the climatic parameters, nature of the surface flow, topography, extent of seepage and irrigation with amendment practices. Groundwater in the Indus basin contributes around 35% to the total water available for agriculture and water quality of the 60 percent area is marginal to brackish **World Bank (1997)** and **Ahmad and Rashida (2001**).

Pakistan is the 8th largest food producing country and economy heavily relies on agriculture sector which accounts for a quarter of its GDP and employs two-fifths of total labor force. The agriculture mainly depends on the Indus River System (IRS) for 90% of its irrigation needs, which is also a source of generation of about 30% energy of the country. Pakistan's agricultural performance is closely linked with the supply of irrigation water. This natural resource is being utilized for drinking, agricultural, industrial, livestock, commercial and other uses and is continuously under threat. The other most obvious uses of water for people are drinking, cooking, bathing, cleaning, and for some watering family food plots.. Irrigated agriculture contributes over 90% of Pakistan's food production. Agriculture sector generates over 60% of foreign exchange. It is the second largest sector, accounting for over 22% of GDP, and remains by and far the largest employer, absorbing 45% of the country's total labor force. Around 63% of country's population living in rural areas is indirectly or directly linked with this sector for their livelihood. While on the other, it is a large market for industrial products such as fertilizer, pesticides, tractors and agricultural implements. According to **Kaldor (1978)** two-sector model, agricultural and industrial sectors supply inputs to each other and provide market for their outputs but differ in

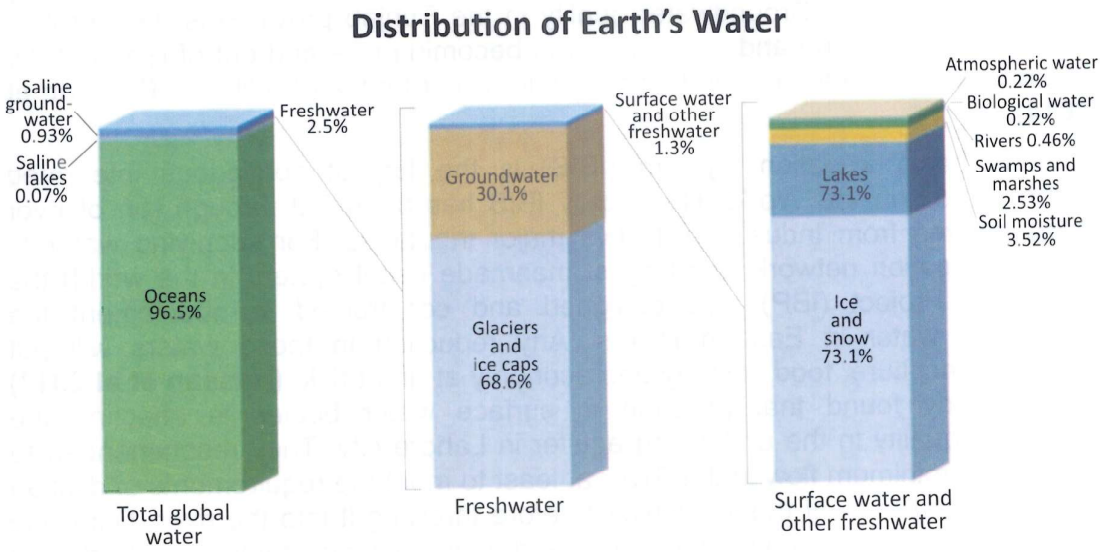
a number of ways. The agricultural sector has disguised unemployment and produces consumer goods for competitive markets, while industrial sector produces investment goods which are sold in imperfectly competitive markets at mark-up prices. According to **Duranton (1998),** in order to transform from agriculture sector to industrial sector a significant increase in the agricultural sector productivity is necessary. On the demand-side, the growth in agricultural production increases agricultural income which leads to increase in the demand for industrial products; whereas on the supply side, the increase in the agricultural productivity shifts human resources from the agricultural to the industrial sector **Jorgenson (1967)**. **Chebbi (2010)** evaluated the role of agriculture in economic growth and dealings with other sectors. Johansen's multivariate approach has been used to study the co-integration with the other sectors in its country economy and he deeply analyzed how to overcome the problems of spurious regression.

Annual groundwater pumpage has increased from 4 billion m^3 in 1959 to around 60 billion m^3 in 1999-2000. About 79 % area in Punjab and 28% area in Sindh provinces has fresh groundwater suitable for agriculture **Afzal (1999) and Bhutta (1999).** In Punjab province about 40-50% crop water requirements are being met from groundwater through about 1.2 million tubewells installed by a multitude of tinny farmers in rural areas. Groundwater quality in the Punjab province is deteriorating with the passage of time and sweet water is becoming rare and out of reach of the common farmers who are dependent on groundwater for their livelihood. **(Hassan et al, 2014).**

The Indus basin Irrigation System (IBIS) is the largest contiguous integrated irrigation system in the World. Historically IBIS has been fed through run of river supplies derived from Indus and its five major tributaries. For supplying water to Pakistan's irrigation network (the largest manmade canal system in the world) the Indus Basin Project (IBP) was designed and constructed to supplement the deficiency of water in Eastern Rivers. Any reduction in those waters will put Pakistan's agriculture, food security and economy at great risk. (**Hassan et al 2013)** during a study found that pollution in surface water bodies is affecting the groundwater quality in the underlying aquifer in Lahore city. They recommended to allow/arrange minimum flow in the River at least to meet the requirements of dilution of pollutants and to treat the wastewater before throwing it into the river. Domestic and industrial effluents contain organic and inorganic pollutants, which deeply percolate to groundwater. Flow in Ravi River especially during the winter is remarkably insufficient to dilute and wash off wastewater pollution **(Hassan et al, 2016).** Major part of Pakistan's canal irrigation network lies in Punjab Province. This network was started to be constructed by British during early nineteen century. The continuous expansion of the irrigation system over the past century significantly altered the hydrological balance of the Indus River Basin (IRB) in Pakistan **(Hassan and Bhutta, 1996).** This also posed severe impacts on aquifer equilibrium. From the above discussion it has been concluded that economy of Pakistan is agri-based for which water resources are required on sustainable basis to feed the ever increasing population of the country.

Groundwater is the world's most extracted raw material with withdrawal rates currently in the estimated range of 982 km3/year. About 60% of groundwater withdrawn worldwide is used for agriculture; the rest is almost equally divided

between the domestic and industrial sectors. 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. About 38% of irrigated lands in the world are equipped for irrigation with groundwater. Out of total earth's water, 99 % is unusable for human beings while only 1 % is usable. Out of this usable (1%), 99% comes from groundwater while nearly 1 % world's groundwater is fresh and is accessible for consumption. In Pakistan, current per capita water availability (1200 m3/person) is low, which puts us in the category of a high water stress countries on the globe. Pakistan is blessed with a plenty of water resources including a large groundwater reservoir underlying the Indus Basin. The extent of this large and highly transmissive aquifer is about 297,200 km2 with a length of 1,900 km, but these natural resources is under serious threats and need immediate measures for its sustainable utilization. Globally, total freshwater withdrawals are believed to have increased by about 1% per year between 1987 and 2000, based on data obtained from FAO: AQUASTAT.UNESCO has predicted that by 2020 water shortage will be a serious worldwide problem. Without improved efficiencies, agricultural water consumption is expected to increase by about 20% globally by 2050 **WWAP (2012)**. Global distribution of water resources is shown in Figure 1.



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the Worls's Fresh Water Resources.

Figure 1: Water Distribution in the world

Global estimates show that approximately 4430 km^3 of fresh water resources are abstracted annually, of which 70% are used in agriculture, 25% in industry and 5% in household **(Kinzelbach et al., 2003)** as depicted in Figure 2.

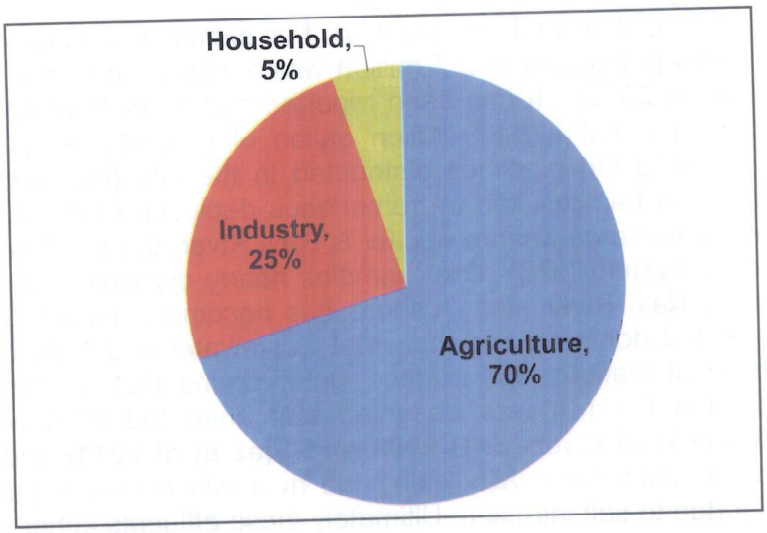


Figure 2: Major global groundwater consumers

An assured supply of water has, therefore, been the prime concern of all societies. In our own time the increasing stress on capacities of water systems has led to a growing realization that it is only through a scientific approach to their management that we can hope to sustain the quality and regular availability of this basic human requirement. The need for appropriate integrated studies in developing countries is the most important in view of an increasing population, widespread aridity and scarcity of fiscal resources and vagaries of hydro-meteorological conditions. Groundwater, surface water and land comprise a complex interlocked system and they must be considered and managed in their totality towards making the most optimal use of this precious resource. Groundwater resources are now being increasingly tapped to meet societal needs on account of their possible availability in the vicinity of the consumer. However, it is important to recognize that although groundwater has ubiquitous occurrence and vast magnitude, its potential as a perennial source is subject to wide spatial-temporal variations. With the advent of remote sensing and sophisticated data processing techniques, the speed and scale of investigations of visible resources such as land and surface water have greatly improved. Since last many years, rapid increase in population and urban sprawling has resulted in over extraction of groundwater especially in the urban areas to meet with human demands due to which underground water table is depleting at alarming rates. Urban sprawl is to be the fastest growing threat to local environment and quality of life. As urban areas expand, environmental problems like losing green space, groundwater recharge area, and degradation of natural ecosystem and deterioration of water resources are increased. The impact on groundwater quality from urban sprawl is attributed by the combined effect of population and land use change. Substances which contaminate groundwater are dived into two basic categories, one which occur naturally and other substances that are produced or introduced by man's activities **(Mahmood 2013)**. The un-planned pumpage of groundwater is also causing salt-water intrusion into fresh groundwater due to which sweet groundwater resource is becoming scare. This needs formulation of long term policy framework and comprehensive planning to guard against fast depleting ground water resources. Pressure of aquifer is increasing with the rapid increase in

population, industrialization and urbanization. For example, according to the 1981 census, Lahore has population of 2.7 million which increased to 6.4 million in1998 **(Faiza & Tabassum 2009).** It has been reported that more than 480 WASA tube wells are extracting about 478.67 Million gallon of groundwater per day and is supplied through 7700 km pipelines distributed in the city **(Hussain and Sultan 2013).** This situation has resulted in tremendous depletion of groundwater levels. The only source to recharge Lahore aquifer is Ravi River, the smallest eastern river of the Indus River System (IRS) which remains nearly dry except during monsoon season. However, Ravi River along Lahore has become a sullage carrier due to disposal of untreated domestic and industrial wastewater and effluents. There are over dozen disposal stations and surface water drains that discharge untreated wastewater into the River. It was observed that untreated wastewater is being discharged into the Ravi River **(EPD 2008 and Ejaz et al 2011)** and it is causing deterioration of groundwater quality along the river which may impact the overall quality of aquifer due to salt intrusion. Ultimately these effluents either leach down to aquifer or are used for irrigation in the downstream areas which cause severe health concern.

Over exploitation of groundwater poses serious consequences on our infrastructural network in addition to other socio environmental concerns. Land subsidence is the lowering of the land-surface elevation from changes that take place underground. Common causes of land subsidence from human activity are excess pumping water, oil, and gas from underground reservoirs; dissolution of limestone aquifers (sinkholes), collapse of underground mines; drainage of organic soils; and initial wetting of dry soils (hydro-compaction). In areas where climate change results in less precipitation and reduced surface-water supplies, communities will pump more ground water. Also, increased demands on ground-water supplies cause more land subsidence in areas already subsiding and new subsidence in areas where subsidence has not yet occurred. In the future, however, increasing population may result in subsidence problems in metropolitan areas where damage from subsidence will be great. Land subsidence causes many problems including: (1) changes in elevation and slope of streams, canals, and drains; (2) damage to bridges, roads, railroads, storm drains, sanitary sewers, canals, and levees; (3) damage to private and public buildings; and (4) failure of well casings from forces generated by compaction of fine-grained materials in aquifer systems. As such, over exploitation of groundwater reservoir is a serious hazard for economy of a country. Human activities like increasing urbanization, use of chemicals in agriculture/food production, industrialization, acidic rains due to air pollution, domestic waste, solid waste landfills, increasing cropping intensities, unplanned over pumpage etc are the major threats to groundwater which are deteriorating its quality and quantity at very alarming rates. At the same time water availability in Pakistan has become severe and severe with the passage of time while water demand is increasing tremendously. This situation has put the country among the water scare countries. Per capita water availability and its reduction trends are shown in Figure-3.

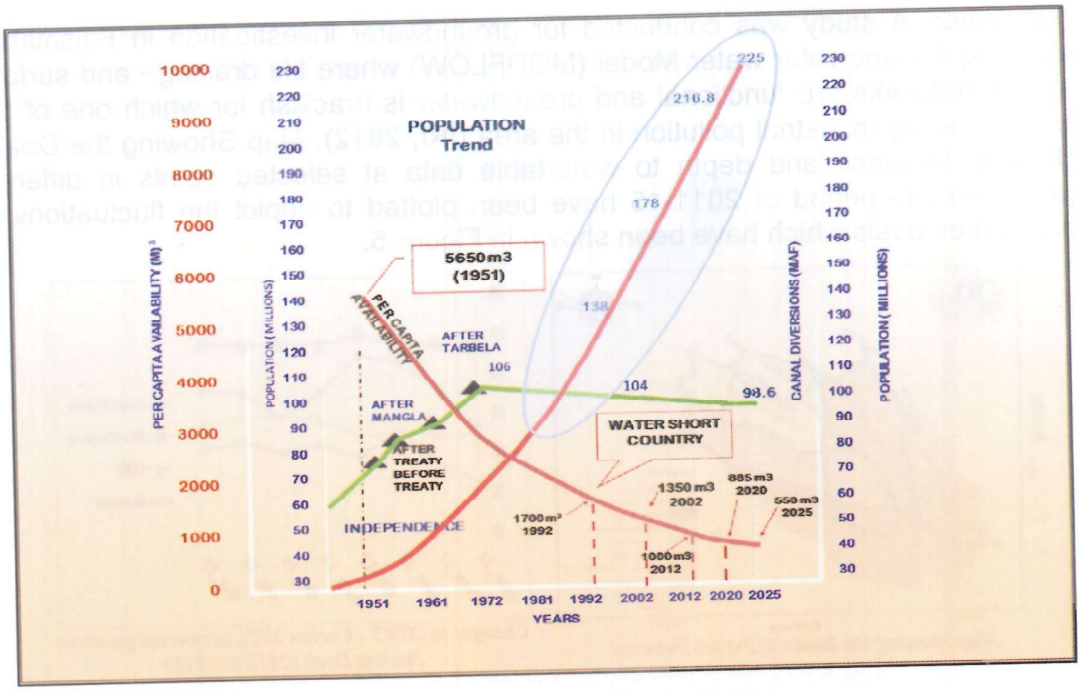
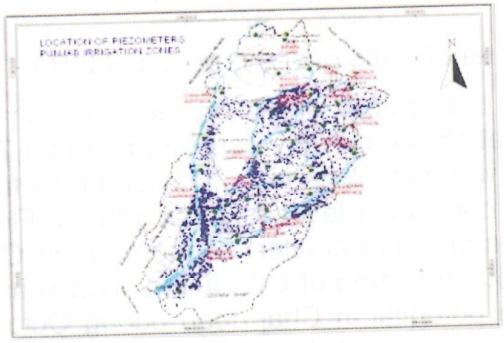


Figure-3: Water Availability in Pakistan

2. Experimental layout and data analysis

Keeping in view the significance of groundwater in the national GDP and ever increasing pumpage of groundwater, the Punjab Irrigation Department is monitoring the groundwater in the province. For monitoring of groundwater round about 3000 piezometers have been installed at different location scattered in canal commanded areas in the whole province as depicted in Figure-4.

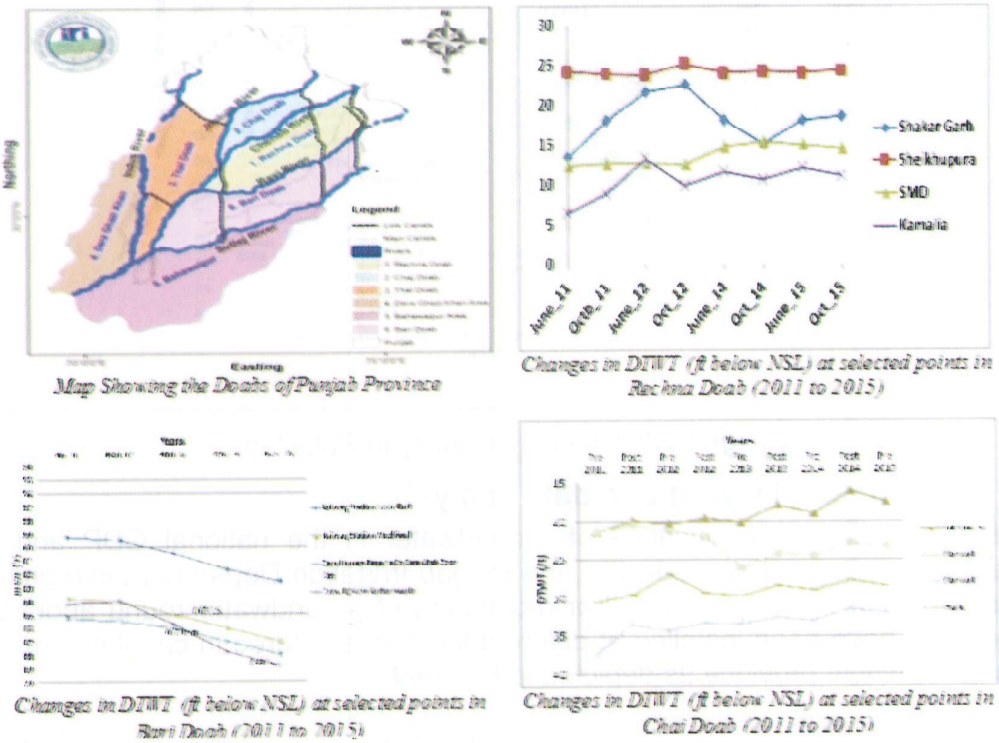


Sr. No.	GW Monitoring Units	Total No of Piezometers	Area (km^2)
1.	Bahawalpur	607	23100
2.	DG Khan	464	12138
3.	Faisalabad	559	15626
4.	Lahore	320	18195
5.	Multan	587	22735
6.	Sargodha	421	10814
7.	Thal	248	13929
	Total	3206	116537

Figure-4: Piezometer for groundwater monitoring in Punjab Province

Groundwater levels have been measured using water level indicator from the piezometers biannually (pre-monsoon and post-monsoon). The observed data have been analyzed to visualize the aquifer behavior in the study area. **(IRI, 2009) and (IRI, 2013)** conducted a field survey and investigation study by installation of sixty exploratory boreholes in the field at various critical sites in Punjab to explorer the groundwater quality and soil stratification to observe the impact of surface drains and other potential threats for groundwater. Wherein it was observed that surface water bodies especially drains are playing a vital role in contamination of

groundwater. A study was conducted for groundwater investigation in Faisalabad area using Groundwater water Model (MODFLOW) where tile drainage and surface drainage networks are functional and groundwater is brackish for which one of the causes is heavy industrial pollution in the area **(IRI, 2012)**. Map Showing the Doabs of Punjab Province and depth to watertable data at selected points in different Doabs over the period of 2011-15 have been plotted to depict the fluctuations of groundwater levels which have been shown in Figure-5.



Map Showing the Doabs of Punjab Province

Changes in DTWT (ft below NSL) at selected points in Rechna Doab (2011 to 2015)

Changes in DTWT (ft below NSL) at selected points in Bari Doab (2011 to 2015)

Changes in DTWT (ft below NSL) at selected points in Chaj Doab (2011 to 2015)

Figure-5: DTWT at selected points in different Doabs over the period of 2011-15

In Chaj Doab (bounded by Chenab River on the south-east and Jhelum River on the north-west) groundwater deeper than 20 feet showed nearly constant rise of 1.7 to 2.2 feet per year. During years 2011-2015, water levels in the Chaj Doab rose from 0.3 to 2.6 ft per year with average 0.9 ft. Groundwater level is in rising trend. Flood water contributes significantly towards recharging the aquifer average rise in Chaj doab during flood 2014 is 0.77 ft/season. Total recharge of GW during flood season 2014 in Chaj Doab is 1.20 MAF. Recharge potential in Chaj doab during October 2010 and June 2012 were found out as 4.32 and 4.675 MAF respectively **IRI (2016).** The area under depth to watertable more than 30 feet was 95 Km^2 in pre-monsoon 2011 which decreased to 30 Km^2 in post-monsoon 2011 and it further decreased to 2.65 Km^2 in post-monsoon 2015 in Chaj Doab area as shown in Figure-6.

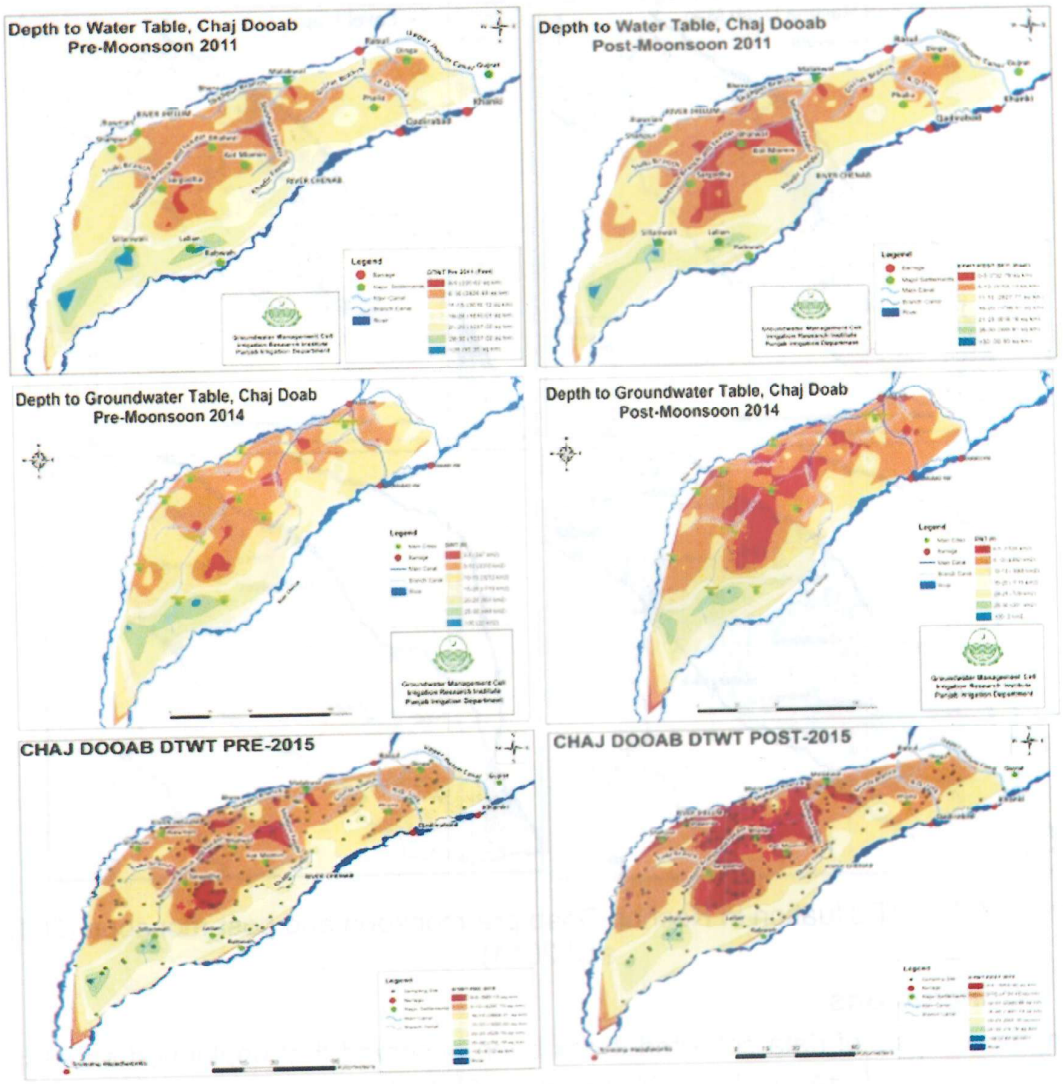


Figure-6: DTWT situation in Chaj Doab pre-monsoon and post-monsson (2011, 2014 and 2015)

Groundwater levels are falling at an average rate of 1-2 ft/year in some areas of Rechna Doab (bounded by two rivers, on the south and east by the Ravi River while on the North and West by the Chenab River) is showing in figure 7. Recharge potential in Rechna doab during October 2010 and June 2012 were found out as 15.80 and 16.381MAF respectively. Flood water contributes significantly towards recharging the aquifer average rise in Rechna doab during flood 2014 is 2.57 ft/season. Total recharge of GW during flood season 2014 in Rechna Doab is 1.90 MAF **IRI (2015).** Research study carried out in Lower Bari Doab Canal (LBDC) has indicated that by increase of depth to water table from 40 ft. to 70ft the cost of pumping per acre-feet has increased 125% as showing Figure-7.

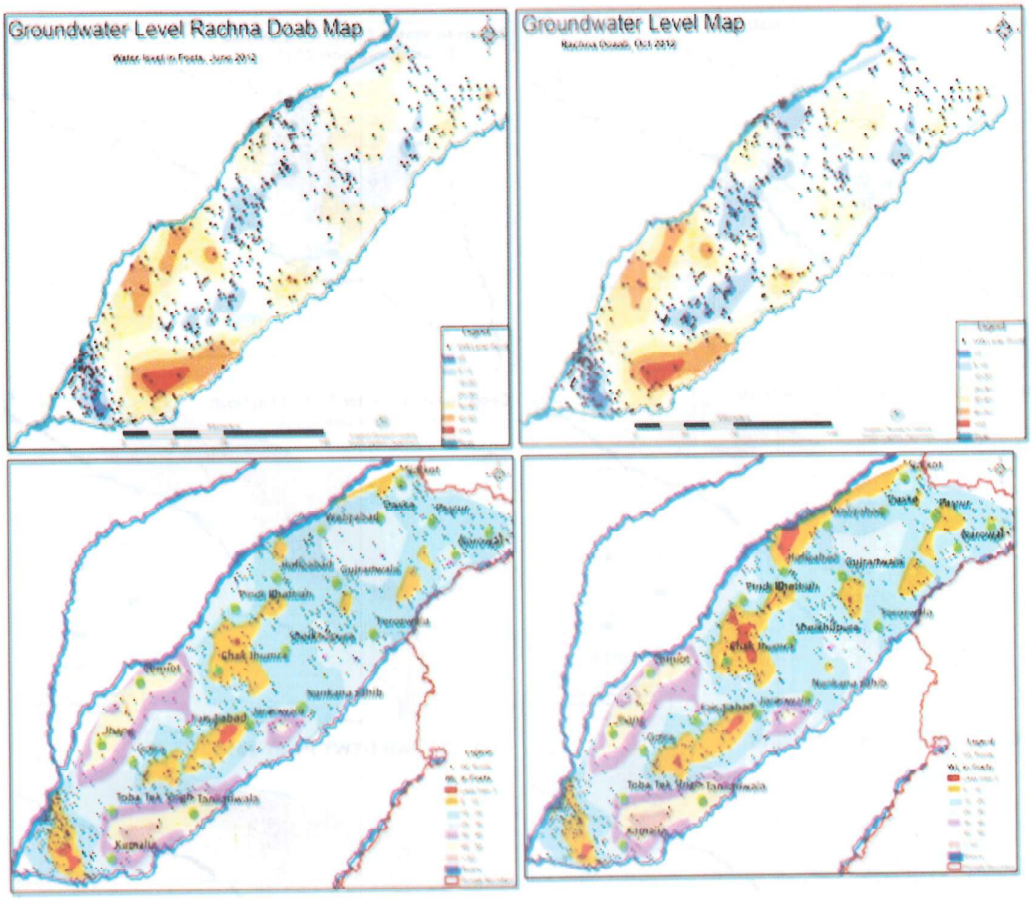


Figure-7: DTWT situation in Rechna Doab pre-monsoon and post-monsoon (2012 and 2014)

3. Conclusions

From the analysis of data collected it has been observed that unplanned excessive pumpage, lack of awareness and capacity of stakeholders, lack of regulatory framework and spatial/temporal uncertainty in surface water availability due to climatic changes (droughts and floods) are the major challenges for groundwater management in Punjab. In Chaj Doab the watertable are showing rising trends with an average rate of 0.9 ft/year and quality is deteriorating with the passage of time. In the Rechna Doab area it is been observed the average groundwater depletion rate is 1-2ft/year and over exploitation in certain areas is causing intermixing of fresh and saline water leading to overall deterioration of groundwater quality. Groundwater in Bari doab is under the worst conditions where water table has gone below 50-60 ft in certain areas and cost of pumpage has increased more than 100 times. In urban areas due to increase in population and reduction in recharge due to infrastructural development, groundwater in under tremendous pressure. For instance, in Lahore city (provincial capital) groundwater has fallen even more than 100 ft below the natural surface and average annual rate of groundwater depletion is 2.54 ft. In irrigated agriculture scenario, direct energy intensity has risen 80% (from 1 to 1.8 MJ per kg of crop produced) in Punjab province during the period from 1995 to 2010. Use of groundwater in irrigated agriculture consumes 30 times more energy as

compared to surface water. It has been found that flood water plays a significant role in recharging the aquifer. For example during flood 2014, 2.57 ft rise in water table has been observed in Rechna doab.

4. Recommendations

Management of groundwater can be accomplished by adopting suitable measures both on demand as well as on supply sides. Some measures for groundwater management are:-

- Creating additional surface storages, improving canal operations for timely deliveries, improving application and delivery efficiencies to reduce the pressure on groundwater, increasing the water productivity are the best management options.
- Rainwater harvesting for on-farm use and groundwater recharge particularly in south Punjab is recommended.
- Aquifer recharge using flood water by flood plain management and building retention reservoirs along rivers.
- Domestic, agricultural and industrial effluents must be treated, recycled and used. It will avoid groundwater pollution as well.
- Legislation for regulating the groundwater abstraction and IWRM are direly needed for development, utilization and protection of groundwater resources.
- Awareness raising and capacity building of stakeholders about groundwater management must be ensured
- The capacity of groundwater institutions be developed to perform key functions of planning, research and providing information/technical support at regional level as well as local level.
- Adopting the drought-tolerant and low delta crops where water is scarce or unreliable
- Subsidy on SMART energy tubewells and water use and defining groundwater entitlements.

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TELEMEDICINE IN PAKISTAN: A TOOL FOR A PROGRESS TOWARDS RURAL HEALTH CARE DELIVERY – A QUALITATIVE STUDY USING THEMATIC ANALYSIS

By

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Health care delivery in Pakistan is a challenging practice since independence. Despite of multiple health care programs launched by different governments, still health care delivery system in Pakistan is under developing stage, especially at rural areas. The rationale of the research is to explore the factors which influence health care delivery system in rural areas of Pakistan through Telemedicine. This research also explores the factors that create hurdle in health care delivery in rural areas of Pakistan. Qualitative methodology has adopted to conduct this research and thematic analysis has applied as a tool to conduct this research through interviews of Participant. Themes generated through thematic analysis are comprised of different factors identify during research. The themes generated through the tool of thematic analysis are develop through different factors. The themes are Medical facilities are not appropriate in rural areas, Telemedicine with advance technology bridge the gap between rural patients and health care delivery system, and lack of Education, information and Technology in rural areas are main hurdle of health care delivery via Telemedicine. After obtaining the themes from thematic analysis, A health care consultation and treatment system has been designed as a theoretical model. The model signifies the possibility of advancement of telemedicine system in Pakistan through Mobile application system which will help in online consultation and treatment of rural areas patients of Pakistan with better health care services and delivery timely.

Introduction

Background of Health care in Pakistan

The health care services delivery arrangement of Pakistan is intricate in light of the fact that it incorporates health care subsystems by central government and provincial governments contending with formal and casual private area health care systems (Kurji, 2016) (Javed et al., 2018). Healthcare is deliver chiefly through vertically oversaw illness explicit instruments. The various foundations that are answerable for this include: provincial and district health divisions, parastatal associations, federal retirement aide establishments, non-government organizations (NGOs) and private sector (Akbari, 2009). Pakistan's health care sector is additionally set apart by metropolitan provincial incongruities in health care delivery and awkwardness in the health labor force, with deficient health supervisors, attendants, paramedics and talented birth chaperons in the fringe areas (Akram, 2007).

In spite of the expansion in facilities of Public health, Pakistan's populace development has produced a neglected requirement for healthcare (Shaikh, 2015). Public medical services organizations that address basic medical problems are regularly just situated in significant towns and urban areas. Because of the shortfall

of these foundations and the expense related with transportation, ruined individuals living in rural and far off territories tend to consult with the private doctors (Akram, 2007). Studies have shown that Pakistan's private sector's health care framework is outflanking the public area health care framework as far as administration quality and patient fulfillment, with 70% of the populace being served by the private health care services sector (Akbari, 2009).

There are several factors triggering health care issues in Pakistan including malnutrition, obesity, and among all is lack of health care information (Asif et al., 2020). Pakistan do not have concrete regenerative health care instructive projects focused at youthful populace. Little youngsters and young ladies are more mindful of their privileges as youth however they don't think a lot about their Reproductive Health Rights. Young people and youth face boundaries in getting to sexual and conceptive health care administrations, for example, requiring a senior relative to go with them.

Concept of Telemedicine

Telemedicine is the best approach to give better medical care offices to individuals of the oppressed unprocurable zones. As limitations on schedule and assets makes vis-à-vis conference progressively beyond a doubt won, and telemedicine can possibly create significant efficiencies in the suggestive interaction. Telemedicine is now and then utilized as an equivalent word, or is utilized in a more restricted sense to depict far off clinical administrations, like analysis and checking. At the point when provincial settings, absence of transport, an absence of versatility, diminished subsidizing, or an absence of staff limit admittance to mind, telemedicine may connect the gap (Mashima & Doarn, 2008). just as supplier distance-learning; gatherings, oversight, and introductions between specialists; online data and wellbeing information the board and medical services framework integration (Miller, 2007).

Aim of the Study

On the basis of concept of telemedicine and background of the health care in Pakistan, the aim of the study is formulated as under:

1. To explore the barriers that create hindrance in health care delivery in Pakistan
2. To explore the benefits of telemedicine in health care delivery in Pakistan.
3. To explore the limitations faced by telemedicine practices in Pakistan.

Limitations faced by Health Sector

While numerous parts of medication have needed to completely embrace telemedicine for quite a while, there are sure dangers and hindrances which bar the full mixture of telemedicine into best practice. For a beginning, it is questionable with regards to whether a professional can completely leave the "active" experience behind (Umefjord, 2007). Although it is anticipated that telemedicine will supplant numerous conferences and other wellbeing associations, it can't yet completely supplant an actual assessment, this is especially so in diagnostics, restoration or mental health (Umefjord, 2007).

The advantages presented by telemedicine challenge the standardizing methods for medical services conveyance set in both enactment and practice. Thusly, the developing unmistakable quality of telemedicine is beginning to highlight the requirement for refreshed guidelines, rules and enactment which mirror the current and future patterns of medical services practices (Shaw, 2009) (Umefjord, 2007). Telemedicine empowers ideal and adaptable consideration to patients any place they might be; albeit this is an advantage, it additionally presents dangers to security, wellbeing, clinical permitting and repayment. At the point when a clinician and patient are in various areas, it is hard to figure out which laws apply to the context (Keck & Doarn, 2014). Once medical care crosses borders distinctive state bodies are associated with request to control and keep up the degree of care that is justified to the patient or telemedicine purchaser. The way things are, telemedicine is mind boggling with many ill defined situations when incorporated particularly as it crosses borders. This viably restricts the possible advantages of telemedicine (Shaw, 2009) (Umefjord, 2007)

Benefits of Telemedicine

Telemedicine can be valuable to patients in disconnected networks and far off locales, who can get care from specialists or experts far away without the patient making a trip to visit them (Berman & Fenaughty, 2005). Recent advancements in versatile cooperation innovation can permit medical care experts in different areas to share data and examine patient issues as though they were in the equivalent place (Van't Haaff, 2009). Remote patient checking through portable innovation can diminish the requirement for outpatient visits and empower far off solution confirmation and medication organization oversight, possibly altogether decreasing the general expense of clinical care (Saylor, 2012). It might likewise be best for patients with restricted portability, for instance, patients with Parkinson's disease (Dorsey et al., 2018). Telemedicine can likewise work with clinical instruction by permitting laborers to notice specialists in their fields and offer prescribed procedures more easily (Conde et al., 2010).

Telemedicine additionally can kill the conceivable transmission of irresistible infections or parasites among patients and clinical staff (Berman & Fenaughty, 2005). This is especially an issue where MRSA is a worry. Moreover, a few patients who feel awkward in a specialist's office may improve distantly. For instance, white coat condition might be stayed away from. Patients who are home-bound and would somehow or another require a rescue vehicle to move them to a center are additionally a thought.

Pakistan health care via Telemedicine

Pakistan still has no concrete conceptive health instructive projects focused at youthful populace. Little youngsters and young ladies are more mindful of their privileges as youth however they don't think a lot about their Reproductive Health Rights. Teenagers and youth face hindrances in getting to sexual and conceptive wellbeing administrations, for example, requiring a senior relative to go with them.

In far off rural provincial regions where there is generally couple of specialists, telemedicine improves admittance to medical care, decreasing the requirement for patients or specialists to travel (Ullah et al., 2009). Telemedicine speeds up the reference cycle by lessening superfluous references, and improve the consistency

and nature of medical services. Improved contacts between the expert staff produce instructive advantages for them and lessen proficient disengagement. Telemedicine has clear benefits on account of crises in distant conditions, for example, on ships, in planes, and conceivably on the combat zone. In every one of these circumstances it is exceptionally troublesome that patients can be alluded to the specialist on schedule (Ullah et al., 2009).

The principle partners in the medical services measure are medical care consumers (patients). Consumer arranged consideration, where patients are straightforwardly associated with the cycle of care, will extraordinarily improve the medical services measure. Innovation can assume key parts in purchaser situated medical care (for instance, making data available to buyers, incorporating buyers' inclinations into HISs, distant observing, correspondence, and so on), which is concentrated in a part of clinical informatics called Consumer health Informatics (CHI) (Eysenbach, 2000).

Methodology

A Qualitative methodology has been adopted to conduct this research. Hagerty et al. (1993) model of grounded theory concept of human relatedness has been adopted for conducting research using thematic analysis technique via QSR Nvivo (version 10). For data collection in qualitative study, there are multiple methods to perform. For this research, an individual interview has been opted. Semi-structured interviews were picked as a result of tending to requests that were needed to be talked about in a meeting and it was likely not going to get another chance to meet a particular member.

Sampling used for this research is purposive sampling. The reasoning of embracing purposive sampling in this examination is to be more capable than arbitrary testing in a medical field. This research zeroed in on various health sector portion necessities.

Thematic analysis was chosen considering the way that it licenses discovering themes and sub-themes. In thematic analysis, themes can be perceived inductively and deductively (Gale et al., 2013). It is a versatile method in different exploration researches, for occasion, it incorporates legitimate techniques normal to most of subjective examination, for instance, thematic coding in grounded theory hypothesis.

Participants selected for interviews are related with health sector including, physicians, surgeons, paramedical staff, biomedical engineers ad IT experts linked with health sector. 20 interviews were conducted for this research including 15 is face to face while rest of the 05 interviews is on Skype mentioned in Table1 and 2.

Table 1: Sampling Framework

Sampling Framework based on following stake holders
Physicians
Surgeons
Paramedical staff
Biomedical Engineers
IT experts

Table 2: Interview Characteristics

Profession	Interviewee	Gender	Method
Biomedical Engineer	GM_1	Male	In person
IT expert	IGK_2	Male	In person
Biomedical Engineer	SM_3	Male	In person
Physician	MK_4	Female	In person
Biomedical Engineer	SA_5	Male	In person
Paramedical Staff	WS_6	Male	Skype
Physician	TM_7	Male	Skype
IT expert	FIS_8	Male	In person
Surgeon	RK_9	Male	In person
Biomedical Engineer	JT_10	Male	Skype
Paramedical Staff	MI_11	Female	In person
Physician	UM_12	Male	Skype
Biomedical Engineer	MAK_13	Male	In person
IT expert	DI_14	Male	In person
IT expert	BZ_15	Male	In person
Paramedical Staff	HR_16	Male	Skype
Biomedical Engineer	WA_17	Male	In person
Biomedical Engineer	IY_18	Male	In person
Paramedical Staff	FM_19	Male	In person
IT expert	AQ_20	Male	In person

Results

Theme 1: Medical facilities are not appropriate in rural areas

According to literature

Roughly 61% populace lives in provincial areas, however absence of foundation, strategic challenges and restricted freedoms for progress keep numerous specialists from rehearsing there (Ahmed & Ahmed, 2018).

According to field notes

> *"...Pakistan needs to focus for health stability in rural areas. There is hardly any advance practice for health care betterment in rural areas of Pakistan..." MAK_13*

According to literature

The Government of Pakistan is the principal in establishing healthcare services offices. The fundamental design of health services comprises of rural health zones, essential health units, tehsil settle emergency clinics, locale central command clinics and educating medical clinics (Ullah et al., 2009).

According to field notes

> *"...It's a responsibility of Government both provincial and federal to establish health care centers in rural areas with advance medical facilities to treat the patient efficiently..."SA_5*

According to literature

Pakistan is thickly populated country where larger parts of individuals are living in towns and rural communities (Ullah et al., 2009).

According to field notes

> *"...Rural population is comparatively higher than urban which is the main factor in hurdle of health care delivery..."JT_10*

Theme 2: Telemedicine with advance technology bridge the gap between rural patients and health care delivery system

According to literature

Clinical applications for cell phones have been created and broadly utilized by health experts and patients. The utilization of cell phones is standing out enough to be noticed in medical care step by step. Clinical applications make cell phones valuable devices in the act of proof based medication at the place of care, notwithstanding their utilization in portable clinical correspondence (Mosa et al., 2012).

According to field notes

> *"...Many Health apps are now playing a pivotal role in telemedicine system. Rural areas are now being facilitated in other part of the world..."FIS_ 8.*

> *"...Pakistan have enough potential to develop a Hub of customer data center that maintain medical history as well as instant OPD consultation at any part of the country..."DI_14.*

According to literature

Sickness finding applications were intended to get to analysis and therapy data in a couple of taps on a cell phone (Burdette et al., 2008).

Doctors address the essential clients and partners of telemedicine administrations and doctors' acknowledgment of telemedicine administrations is anticipated to have a critical effect on its appropriation (B.A. Ly et al., 2017)

According to field notes

> *"...Smart apps are also helpful in getting consultation of doctors outside the country in a minute without any high cost..."TM_7.*

Theme 3: lack of Education, information and Technology in rural areas are main hurdle of health care delivery via Telemedicine

According to literature

Pakistan has an intense deficiency of medical care power. Telemedicine offers a successful and reasonable answer for improving medical services results in nations like Pakistan where deficiency of assets wins and a huge extent of populace is situated in far off territories (Shaikh, 2015).

According to field notes

> *"...Rural areas require proper technology set-up and also medical forces to establish telemedicine technique at primary level..."UM_12.*

According to literature

Telemedicine framework requires assortment of medical care data from patients. Accordingly, the progression of data should be controlled and given close consideration to regarding what sort of data will be assembled, who will approach and how much (Kamal et al., 2018).

According to field notes

> *"...Proper data management of patients required to establish. Rural areas of Pakistan are still far behind in establishing patients medical history..."MI_11.*

Theoretical Model

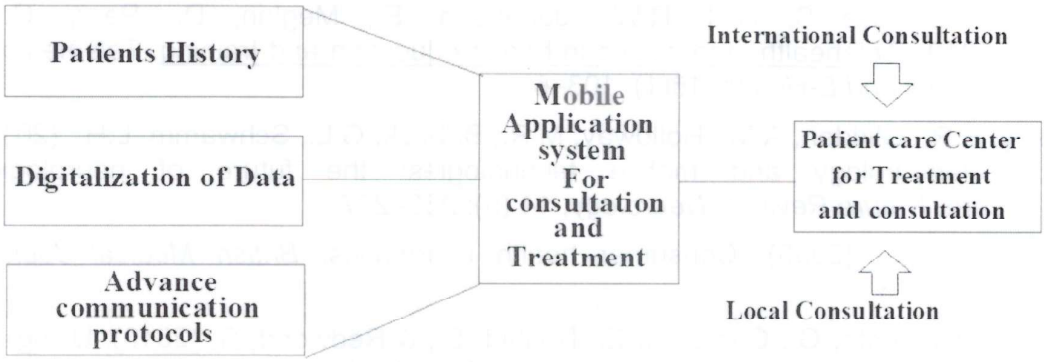


Figure-1: Health care consultation and Treatment system

Conclusion

This research extends and advances the idea of telemedicine system in Pakistan's rural areas for patient care. Through this research, patients at rural areas will get treated in small time frame and it will also reduce customer health care cost. High risk patient can be easily treated during emergency with the help of online specialist advice. Health care consultation and treatment system require digitalization of patient medical history by allotting patient number to track the history in few seconds of time for consultation and treatment. Data digitalization will also help the government to establish health card program more efficiently.

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