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Innovative Methods of Monitoring and Regulating River Water between Dams: A Noble Solution for Interstate Water Distribution

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Abstract: India is a federation with distinct regions and complex water problems. India's internal borders however reflect the vagaries of history and political compromise and bare little relation to the natural contours of the river basins. The same can be said for virtually every other nation in the world. India is facing serious inter-state water distribution crisis leading to interstate disputes which further leads to violence and political disorder in the country. The fault lies in the present system of water distribution between states or union territories. In this paper, we have proposed a semi-automatic water distribution system and innovative methods of monitoring and regulating river water between dams. We use automatic water level sensors to monitor the water levels in different dams instead of existing manual water level measuring scales. Measuring the water levels alone is not the solution; we propose a system which makes use of satellite images of the agricultural lands, thermal satellite images of the crop lands and weather reports by the meterological department to analyse the scenario and regulate the water between dams unlike the present manual system. Our system is semi-automatic - meaning human intervention is possible at any level of the system in case of system failure or system upgrade. Also we make use of a data acquisition and web-server (national server) to store data of each and every dam to provide proof or transparency in case of water sharing and a central decision logic which will behave accordingly as programmed. A particular signal will be sent wirelessly to each and every gate of the dams to regulate water. Also, the basic idea behind this paper is to virtually connect all the existing dams in India through a network and have a central server (star topology) and respective state or district servers, interconnected in a full mesh topology.

Keywords: Semi-automatic water distribution system, automatic water level sensors, satellite images, data acquisition, web-server, central server, star topology, full mesh topology.

I. INTRODUCTION

A dam is a barrier that impounds surface level water or underground streams. Reservoirs created by dams not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use, aqua-cultural and navigability. Hydropower is often used in conjunction with dams to generate electricity. India is a country with seven major rivers along with its numerous tributaries. They can be divided as:

a. Rivers flowing into the Bay of Bengal
b. Rivers flowing into the Arabian Sea
c. Rivers flowing into the inner part of India

Figure 1 shows the rivers of India. [1] There are several dams built on these rivers and their tributaries. A single river flows through multiple states and dams are built on its way to block the river flow and store water. For example, the river Kaveri originates in the Western Ghats of Karnataka and flows through Tamil Nadu, Kerala, and Pondicherry.[2] Karnataka has built various dams on the Kaveri river basin and this would be a cause of concern and dispute between Karnataka and the other three entities because, if and only if Karnataka regulates water to these states, the dams built in these states will receive water as they are built sequentially and the water has to pass through the dams built in Karnataka to reach the other two states and Union Territory of Pondicherry before reaching the Bay of Bengal. Figure 2 shows Kaveri river basin. In this paper, we propose a probable solution for inter-state water distribution by using technologies that are currently available. The present methods of monitoring and regulating river water between dams are the cause for major inter-state disputes. In our system or model, we use automatic water level sensors to monitor the water levels in various dams instead of manual water level measuring scales. Apart from this we also propose a system which uses satellite images of agricultural lands, thermal satellite images of irrigated crop lands and weather reports by the meteorological department to analyse the scenario and to

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regulate water between dams in a scientific and logical manner which will ensure peace. The main aim of this paper is to connect all the dams virtually in a network and acquire data from each dam and store it in a national server from which data can be retrieved and sent to the central decision logic to produce command codes to get desired outputs which in this case is opening and closing of dam gates. Also, our model is semi-automatic at each and every block to enable human intervention in case of system failure, system update or to abide by the directions given by the executive, legislative or judiciary.

This paper plays an important role in proposal of innovative methods of water distribution. As India's first Prime Minister, Jawaharlal Nehru said, "Dams are the temples of modern India".

Figure 1 Rivers in India

Figure 2 the Kaveri river basin

II. METHODOLOGY

A. System design and Working

Figure 3 shows monitoring and transmission system of Dam_1, Dam_2, Dam_3,......, Dam_n. It consists of input parameters block, digitization and transmission block and an antenna for wireless transmission of digital data to the central decision logic. Each dam on the river system consists of the above blocks. Figure 4 shows monitoring and transmission system in general. Where there are k=1, 2, 3,....., N number of dams. Figure 5 shows input parameters of each dam.

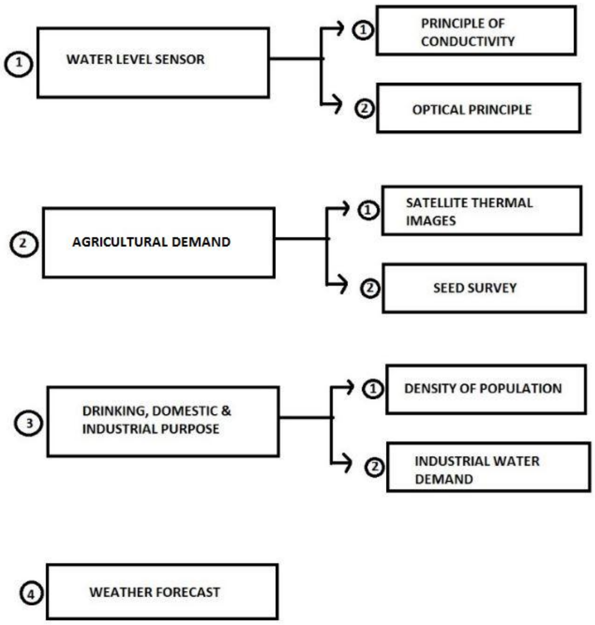

Figure 5 Input Parameters of each Dam

Each dam will have an automatic level sensor to measure the water level of each dam in cusecs. (10^6 cusec= 1 TMC) [3] We can employ two types of water level sensors:

a. Water level sensors working on the principle of conductivity [4]:
   Figure 6 shows an array of water level sensors, which detect the levels of water based on the principal of conductivity. When sensor 1 is submerged under water and sensors 2, 3, 4 and 5 are not submerged under water, the circuit of sensor 1 is closed, as water is a good conductor of electricity and water level corresponding to sensor 1 is noted and is sent to the digitization and transmission unit. Similarly, when the water level increases, and say sensors 1, 2 and 3 are submerged in water, the circuits of sensors 1, 2 and 3 are closed and value corresponding to sensor 3 is recorded. The circuits of sensors 4 and 5 still remain open.
b. Water level sensor working based on the optical principal [5]:
   Figure 7 shows optical water level sensor. It consists of a perforated float guide pipe submerged in water. A float is placed at the water level surface inside the float guide pipe.

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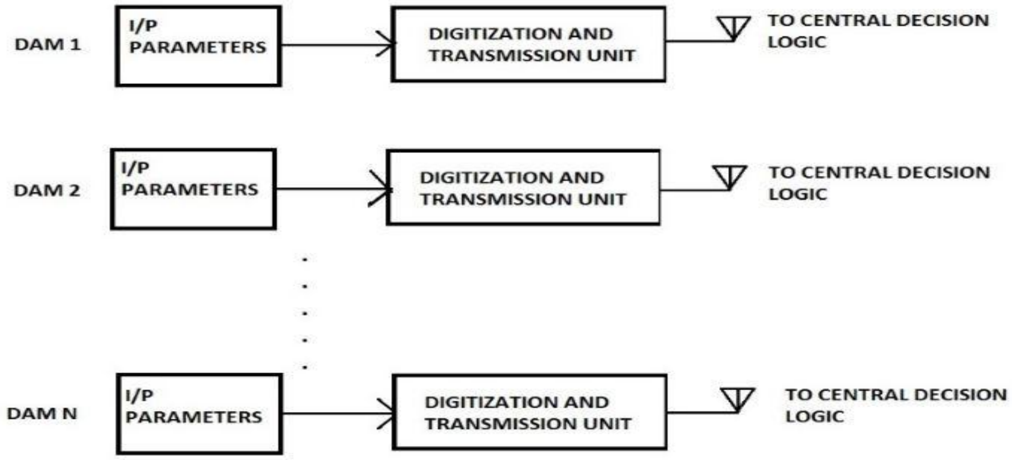

Figure 3 Monitoring and Transmission System

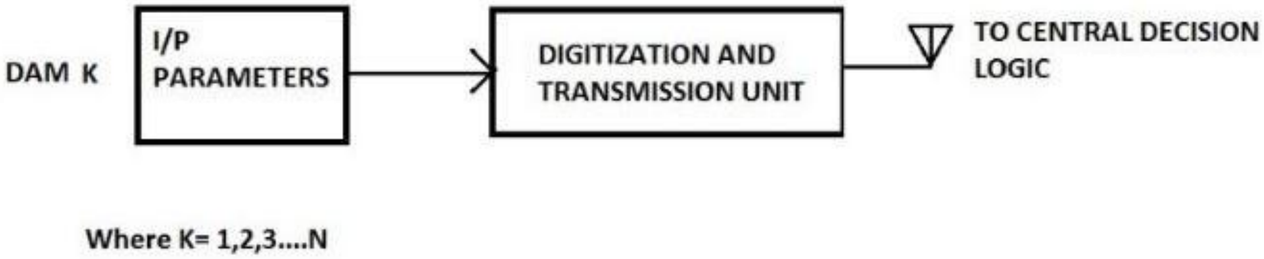

Figure 4 General Monitoring and Transmission System

The float guide pipe prevents it from floating off outside the sensor detection range. The bottom of the pipe is partially closed to make the float stable while taking measurements. Holes are made in the pipe, so that maximum amount of water can enter inside the float guide pipe. The length of the float guide pipe varies according to the dimensions of the dam and measurement range. An LED source generates input light rays which fall on the float surface. The surface of the float is made up of reflecting material. The reflected rays from the float are detected by LDRs connected in series. Thus, the sensor network incorporated in the design help in measuring the time taken by the signal generated by the source (LED) to reach the detection point.

$PD = t_{ref} - t_{measured}$, where
PD = Path Difference
t_{ref} = time taken by the reference signal
$t_{measured}$ = time taken by measured signal

The variation in voltage obtained across LDRs determines the path difference in the proposed design.
The second part of the input parameter block is agricultural demand. Water demand for the agricultural purpose is determined by 2 parameters:
a. Satellite thermal images:
Figure 8 shows water content of crop fields with thermal imaging. [6] Blue, green and red pixels represent plants with sufficient, average and low water concentrations respectively. Like many organisms, plants require water for survival. In addition to water being used in essential biochemical processes; water is the “means of transportation” for nutrients from the soil to every part of the plant. Water enters the plant through the roots, travels through the main stalk and the branches, eventually reaching the leaves. From there, through the leaf pores known as stomata, it is released into the atmosphere. This process is known as transpiration. All the biological processes taking place inside the plant produce heat. The transpiring water captures the heat and removes it from the plant when it transpires through the leaves. When the water is insufficient and the plant is under stress, it cannot lose heat fast enough through transpiration fast enough and as a result the temperature of the plant increases. This increase in temperature can be detected with remote sensing by using parts of the spectrum that are sensitive to heat.

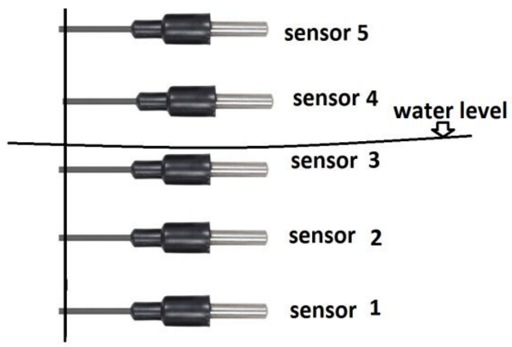

Figure 6 Array of water level sensors

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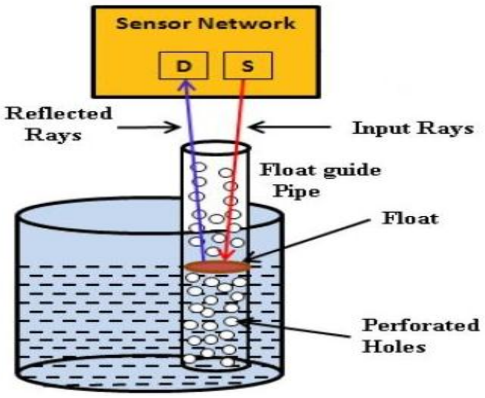
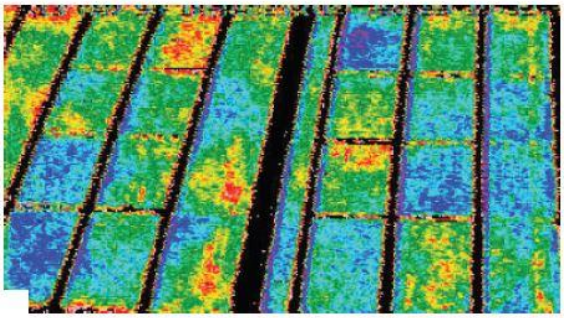


Figure 7 Optical Water Level Sensors

b. Seed survey:
A seed survey is done in every district/ taluk of a particular state. The seed survey is an indicator of agricultural activity in a particular district or state and it can define the water demand or required amount of water to irrigate these crops. A bar code can be placed on each of the seed bags to systematically track the seed demand in particular regions of the country, which is also one of the parameters for water demands for agricultural activities.


Water content of crop fields with thermal imaging. Blue, green and red pixels represent plants with sufficient, average and low water concentration.
Figure 8 Water Content of Crop Fields detected using Thermal Imaging

The third part of the input parameter block is water for drinking, domestic and industrial purposes.

a. Density of population:
The demand for water in a particular region depends on the population density in that region. Higher the population density, higher is the water demand. Water is essential for drinking, domestic and recreational purposes. So the demand for water increases with increase in population density.

b. Industrial water demand:
Water is the most essential entity for industrial activities, construction and MNCs. A country's GDP is decided by its agricultural and industrial activities. Hence water has to be provided to these entities as per demand.

The fourth input parameter is weather forecast. By utilizing the weather predictions provided by the meteorological department, one can make predictions of rainfall, temperature, humidity, possibility of flood, drought, etc., and can action be taken accordingly.
Figure 9 shows the block diagram of digitization and transmission unit. The input parameters are fed to the digitization and transmission unit.

The digitization unit consists of an analog to digital converter (ADC). An ADC consists of sampling and quantization unit. ADC unit is used to convert analog input signal to digital signal for wireless transmission over the channel. [7]

Digital communication is preferred over analog communication because of the following reason:

- Long distance transmission
- Data encryption
- Can be noise immune: without deterioration of signal during transmission and read/write cycle
- Digital hardware is flexible in implementation
- Low power consumption

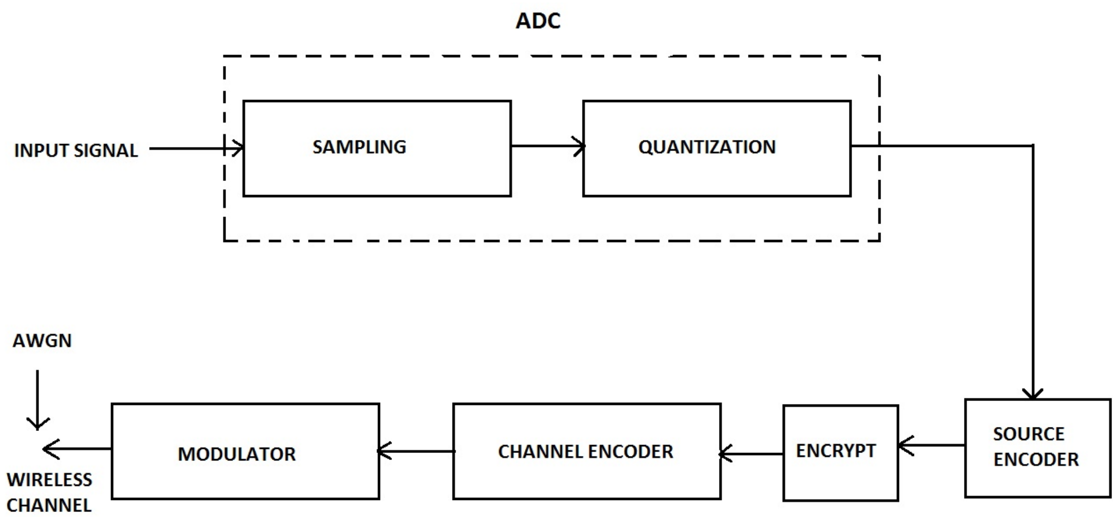


Figure 9 Block diagram of digitization and transmission unit

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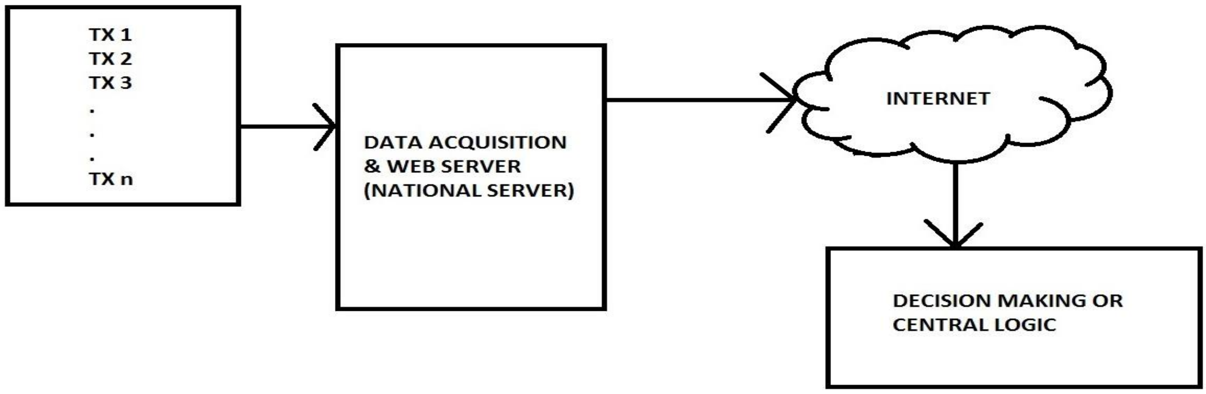

Figure 10 Data Acquisition Unit and Web Server

The output of ADC unit is fed to the source encoder for source encoding. The main aim of source coding is to remove the redundancy in the transmitting information, so that bandwidth required for transmission is minimised. Based on the probability of symbol, code word is assigned. Higher the probability, shorter is the code word. Now the digital data is encrypted using encryption block of the digitization and transmission unit. Encryption is the most effective way to achieve data security.

To read an encrypted file, one must have access to secret key/ password that enables to decrypt it. Unencrypted data is called plain text; encrypted data is referred to as cipher text. [8] The purpose of encryption is to ensure that only somebody who is authorised to access data will be able to read it using the decryption. Now the encrypted data is channel encoded by the channel encoder block. Error control is accomplished by the channel coding operation that consists of systematically adding extra bits to the output of the source encoder. These extra bits do not convey any information but helps the receiver to detect and/or correct some of the errors in the information bearing bits. There are two methods of channel encoding:

- Block coding: The encoder takes a block of ‘k’ information bits from the source encoder and adds ‘r’ error control bits, where ‘r’ is dependent on ‘k’ and error control capabilities desired.
- Convolution coding: The information bearing message stream is encoded in a continuous fashion by continuously interleaving information bits and error control bits.

Now after channel encoding, the digital stream is modulated by modulator block. The modulator converts input bit stream into an electrical waveform suitable for transmission over the communication channel. Modulator can be effectively used to minimize the effects of channel noise, to-match the frequency spectrum of transmitted signal with channel characteristics, provide the capability to multiplex many signals. The modulator output of each dam is now send to the data acquisition and web server (national server) wirelessly using an antenna. The data acquisition unit and web server is as shown in figure 10.

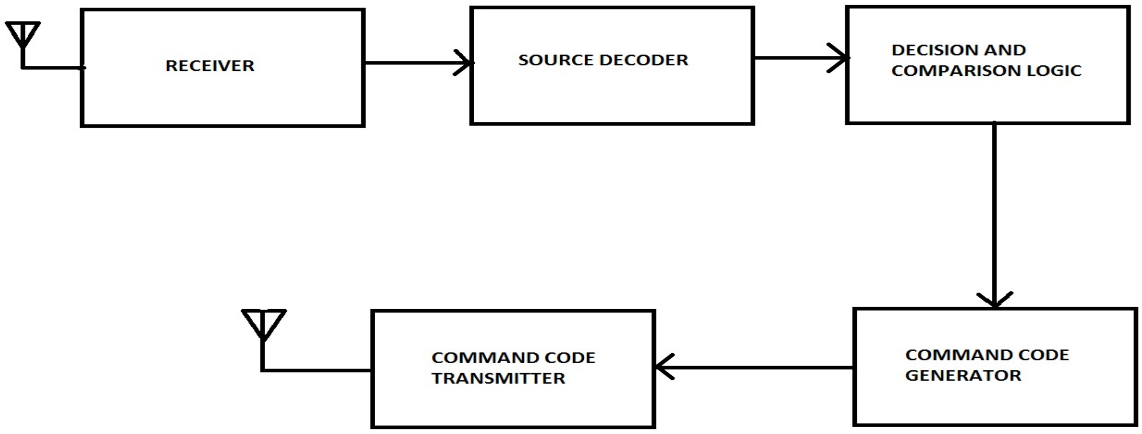

Figure 11 Central decision Logic

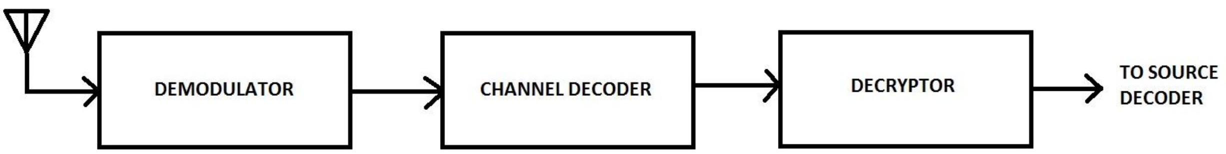

Figure 13 General receiver unit

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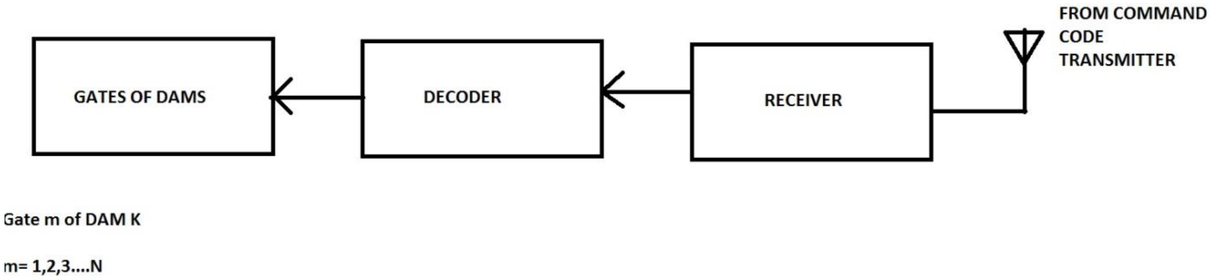

Figure 14 receiving unit placed at the dams

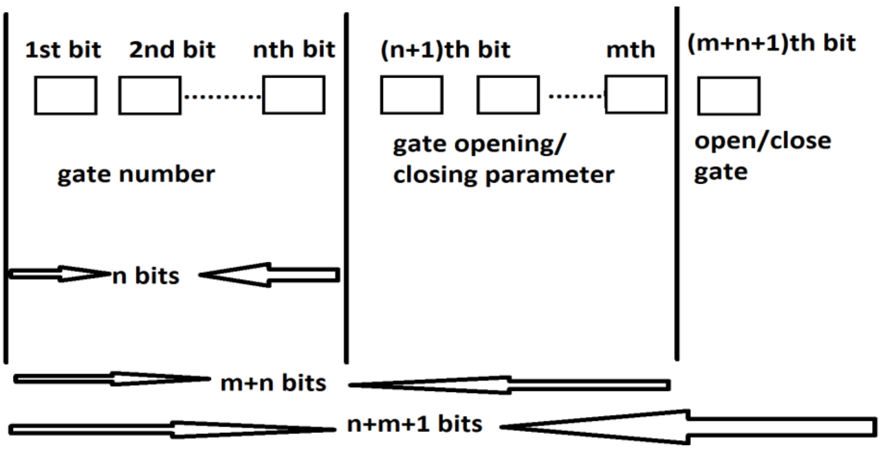

Figure 15 Decoded Signal

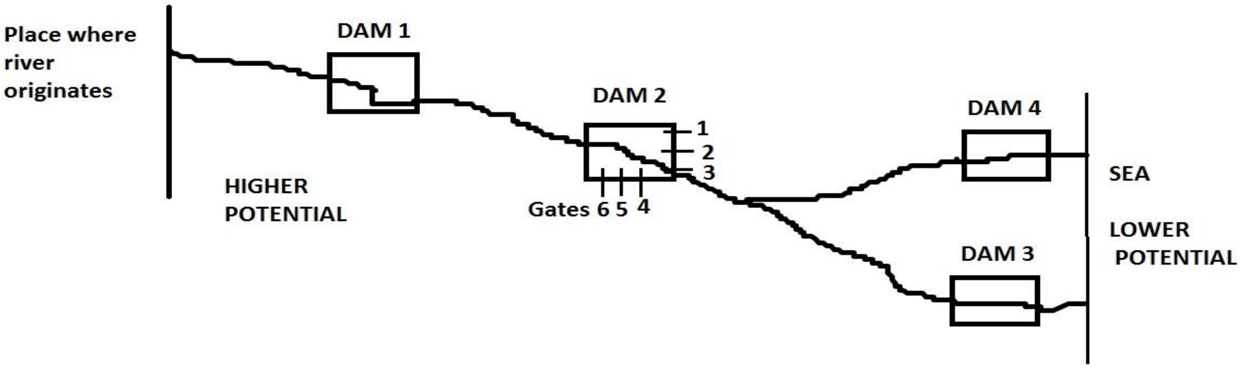

Figure 16 One-river system

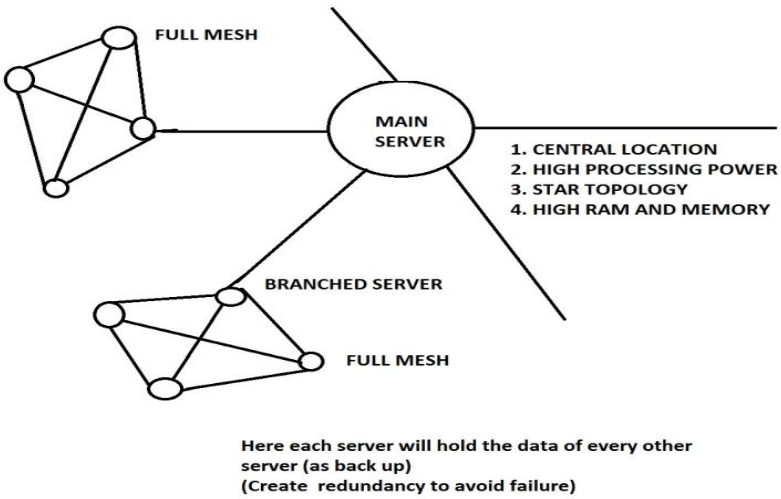

Figure 12 Network topology of the proposed system

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Here a national server is deployed for storing all the data coming from the transmission unit of each and every dam. The data can be retrieved from the cloud when required to make decisions and take actions, which is done by the decision making or central logic. Figure 11 shows the block diagram of the central decision logic. The signal which has to be manipulated is received by the receiver of the central decision logic unit wirelessly using an antenna. The signal is source decoded and is processed and a command code is generated and transmitted to the receiver of the output unit using an antenna. The central decision logic unit must be very powerful to handle huge databases, as India has more than thousand dams. It should have a very large RAM and ROM unit. Parallel processors can also be used to increase the speed of processing. Figure 12 shows the network topology of the proposed system. It consists of a powerful central or main server connected in a star topology to its branch servers. The features of the central servers are as follows:

- Centrally located
- High processing power
- It should have star topology
- High RAM and memory

The branch servers are connected in full mesh and each server will contain the information of all other connected servers, also called cloning. [9] This is done to create redundancy to avoid failure during breakdown of any server in the mesh. Here transmission unit of each dam is connected to the central unit.

Figure 13 shows the general receiver unit. It consists of a channel demodulator, channel decoder, decryption unit. This is done to demodulate, channel decode and decrypt the signal which was previously modulated, channel encoded, encrypted and source encoded. It performs the reverse process of the transmission unit. The output of the receiver is fed to the source decoder of the output unit as shown in figure 14. Here the encoded data is decoded and is sent to the gates of dams to take the following actions:

- Opening of gates
- Closing of gates

The decoded signal is as shown in figure 15. Here the first 'n' bits determine the gate number of a particular dam. The $n+1^{th}$ bit, $n+2^{nd}$ bit, ..., m^{th} bit determine the height/depth by which the gates must be opened or closed and the $n+m+1^{th}$ bit determines whether to close or open gate. These bits are concatenated to form a bit stream of n+m+1 bits. For example, consider the code "01111"

Where dam_1 has 4 gates:

- 00- Gate 1
- 01- Gate 2
- 10- Gate 3
- 11- Gate 4

And, third and fourth bit represent:

- 00- open/close by 1 feet
- 01- open/close by 2 feet
- 10- open/close by 3 feet
- 11- open/close by 4 feet

The fifth bit:

- 0- close gate
- 1- open gate

B. One-River System

Figure 16 shows an example one-river system. The following conditions may arise:

- $Dam_1 > Dam_2$ and Dam_2 requires water

Solution: open gates of Dam1

Similarly, $Dam_2 > Dam_4$ and Dam_4 requires water

Solution: open the gates corresponding to Dam_4 (i.e. open only gate 1, 2 and 3)

Say, gate 1, 2, 3 feed Dam_4 and gates 4, 5, 6 feed Dam_3

Similarly, $Dam_2 > Dam_3$ and Dam_3 needs water

Solution: open gates 4, 5 and 6.

- Dam (in upper potential) < Dam (in lower potential)

Solution: presently nothing can be done and would require high pressure system to release dam to release water from Dam (low) to Dam (high). Plan in such a way before releasing water to Dam (low), Dam (high) has sufficient water at present and decide the future using weather reports.

- Dam(k) ~ Dam(k+l)

k= 1, 2, 3,......

l= 1, 2, 3,.......

and both dams have sufficient water

Solution: No action

- Dam(k) ~ Dam(k+l)

k= 1, 2, 3,......

l= 1, 2, 3,.......

And both dams have insufficient water

Solution: Decide according to parameters other than water level of dams, as described in figure 5.

C. Multi-River System

Figure 17 shows a multi-river system. The basic idea here is to connect near-by river systems via artificial canals. This is done because, when a region/dam has flooding water and other regions/dams of another river have drought/dried up, these canals can be used to share water. But the problem with creating artificial canals is that it may require deforestation to build theses canals which disturbs the ecosystem and wildlife thereby affecting Mother Nature. This can be done by proper planning such that there is sustainable development and no devastating effects on the environment and nature.

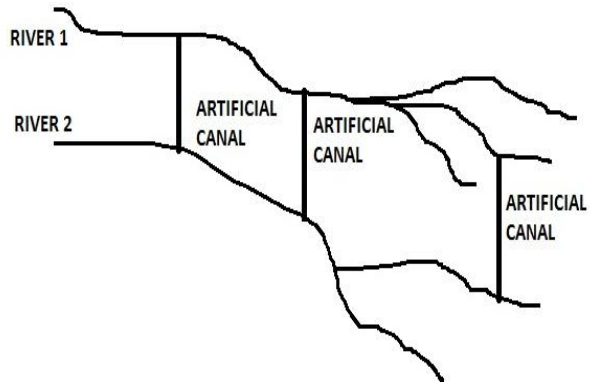

Figure 17 Multi-River System

D. Maintenance and New Planning Commission

It is not enough if we make a proposal of such system and make everything automatic. There should be well educated, well trained and skilled workers for maintenance of this system and a new planning commission must be established. Since India is a huge and populous country with various topology, diversity and varying weather. So, human force is very important at each level of operation of this system that we have proposed.

Also people of a particular state may go to courts, appealing that the decision made by the system is false or outdated or presently not feasible. So, human intervention is necessary to respect the decision taken by the judiciary, executive and legislative.

So, the system is proposed to be semi-automatic. Also, dams may block rivers, but rivers are property of the nation. Therefore, water must be shared in a fair, noble and non-partial manner.

III.FINDINGS

Comparison between present river monitoring system and regulation and water monitoring and regulating system using the model proposed in this paper is as shown in Table 1. Figure 18 and figure 19 shows the news paper articles dated 18th October, 2016 (Tuesday). A high powered technical committee formed by the Supreme Court to make ground analysis in Kaveri basin states.

The headline reads “Panel wants Cauvery supply to farmers modernised”. It pointed out that the infrastructure to deliver water to the farmers was a century old with very low conveyance efficiency which needs to be modernised for optimal use of scarce water.

The committee headed by the chairman of the Central Water Commission and comprising representatives from Karnataka, Tamil Nadu, Pondicherry and Kerala, concluded that the water application techniques are outdated and unscientific and the value of water was not realized.

Also according to figure 18, newpaper article, “crops on 1.88 lakh acres have wilted in state’s Cauvery basin: expert panel”. Also the highlights of the report state the following:

- In distress years, water must be shared proportionately.
- Ground water available in Cauvery basin in Karnataka and Tamil Nadu at 1000 feet depth.
- Large number of suicides reported in the district of Mandya.
- A number of tanks have dried up or have low storage.
- Latest technology must be installed to measure inflow of water into reservoirs.
- Crop alignment and crop diversification must be practiced.

Parameter being compared	Existing method of manual water distribution	Automated method of water distribution
Measuring water level	Manual	Automatic
Opening of gates	Human intervention	Semi-automatic
Parameters taken into consideration for monitoring and regulating	Water level and weather forecast	• Water level • Weather forecast • Satellite images • Drinking domestic and industrial demands • Seed survey
Network topology	Dams on different rivers or same river are not virtually connected in a network	All the dams in India are virtually connected in to a central/main server of star topology and branched servers with full mesh topology
Transparency of the system	This method is not transparent and can be easily manipulated	The data is stored in the server and any authorised person can access the data as proof or transparency
Is it questionable in the Court of law	Yes, but evidences are not sufficient	Yes, with ample evidence
Central planning commission	No	Yes, for a systematic and peaceful sharing of water
Formation of multi river system	No	Yes, by building artificial canals between two river systems in such a way the nature is not affected

Table 1 Comparison between Existing method of manual water distribution and automated method of water distribution

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Crops on 1.88L acres have wilted in State's Cauvery basin: expert panel

Ajith Athrady

NEW DELHI: Highlighting the severity of water crises in the Cauvery basin areas, a high-level panel has said that crop sown on 1.88 lakh acres in Karnataka have withered away due to shortage of water.

The panel headed by Central Water Commission chairman (CWC) G S Jha in its report submitted to the Supreme Court on Monday said Karnataka has sown 6.15 lakh acres under the command areas of the Kabini, Hemavathy, Harangi and KRS and about 1.88 lakh acres have withered away.

The team which toured Karnataka and Tamil Nadu following the direction of the Supreme Court said that in Karnataka it is a mix of paddy, maize, sugarcane and ragi whereas in Tamil Nadu it is Samba paddy, turmeric and sugarcane.

"In Karnataka, the survived crops are of mid growth stage, requiring limited period of watering and may require only three to four waterings/ irrigation to survive the crops which are in pre-wilting stage," said the report.

In the current year, Tamil Nadu had only single Samba crop in the command area of the Mettur reservoir to be cultivated on 12 lakh acres for which the government is expected to provide water.

The report observed that the allocation of assessed 740 tmcft of water has been made by the Cauvery Water Disputes Tribunal among all the riparian states considering the flows at 50% dependability. This implies that on an average, every two years out of four years are likely to be low flow years, the report.

In this September 25, 2016 photograph, a farmer in Gubbi taluk, Tumakuru district shows the ragi crop that has withered away as water release was stopped from the Hemavathy dam. DH PHOTO

Water requirement

The total water requirements of Karnataka up to the end of May 2017 including irrigation, drinking water and evaporation (6 tmcft) are 65.48 tmcft while the availability up to the end of May 2017 is 89.16 tmcft. The total water requirement of Tamil Nadu will be 163 tmcft (irrigation of 12 lakh acres, drinking, evaporation and releasing three tmcft to Puducherry) against the expected availability of 143.18 tmcft up to the end of May 2017, the report stated.

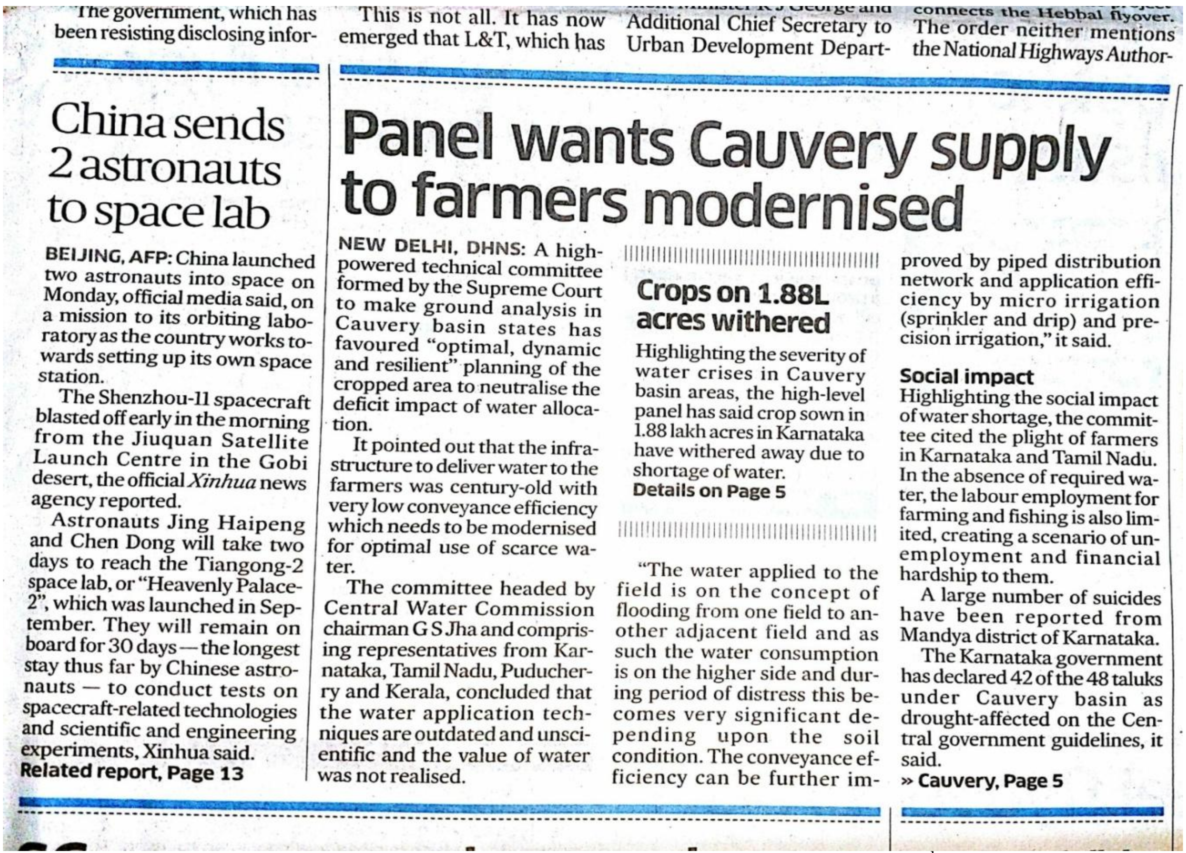
Inflow into Karnataka reservoirs are 49.76% of the normal flows as on October 13 after taking into consideration the average inflow in the last 29 years. Flow at Biligundlu (water release point from Karnataka to Tamil Nadu) is 40.75% of the normal flows as on October 12. (This means the flow at Biligundlu was 58.37 tmcft as on October 13 against the scheduled flows of 143.23 tmcft in a normal year).

DH News Service

Highlights of the report

- In distress year, water should be shared proportionately.
- Ground water available in Cauvery basin in Karnataka and Tamil Nadu at 1,000 feet depth.
- Large number of suicides reported in Mandya district.
- A number of tanks have dried up or have low storage.
- Digging borewell for growing sugarcane should be discourage.
- Efficient use of water (drip irrigation, sprinkler irrigation) should be encouraged.
- Latest technology should be installed to measure inflow of water into reservoirs.
- Crop alignment and crop diversification need to be practiced.

Figure 18 "Crops on 1.88 lakh acres have wilted in the State's Cauvery basin: expert panel" (Deccan Herald dated 18th October, 2016 Tuesday)



Panel wants Cauvery supply to farmers modernised

NEW DELHI, DHNS: A high-powered technical committee formed by the Supreme Court to make ground analysis in Cauvery basin states has favoured "optimal, dynamic and resilient" planning of the cropped area to neutralise the deficit impact of water allocation.

It pointed out that the infrastructure to deliver water to the farmers was century-old with very low conveyance efficiency which needs to be modernised for optimal use of scarce water.

The committee headed by Central Water Commission chairman G S Jha and comprising representatives from Karnataka, Tamil Nadu, Puducherry and Kerala, concluded that the water application techniques are outdated and unscientific and the value of water was not realised.

"The water applied to the field is on the concept of flooding from one field to another adjacent field and as such the water consumption is on the higher side and during period of distress this becomes very significant depending upon the soil condition. The conveyance efficiency can be further improved by piped distribution network and application efficiency by micro irrigation (sprinkler and drip) and precision irrigation," it said.

Crops on 1.88L acres withered

Highlighting the severity of water crises in Cauvery basin areas, the high-level panel has said crop sown in 1.88 lakh acres in Karnataka have withered away due to shortage of water.

Details on Page 5

Social impact

Highlighting the social impact of water shortage, the committee cited the plight of farmers in Karnataka and Tamil Nadu. In the absence of required water, the labour employment for farming and fishing is also limited, creating a scenario of unemployment and financial hardship to them.

A large number of suicides have been reported from Mandya district of Karnataka.

The Karnataka government has declared 42 of the 48 taluks under Cauvery basin as drought-affected on the Central government guidelines, it said.

» **Cauvery, Page 5**

China sends 2 astronauts to space lab

BEIJING, AFP: China launched two astronauts into space on Monday, official media said, on a mission to its orbiting laboratory as the country works towards setting up its own space station.

The Shenzhou-11 spacecraft blasted off early in the morning from the Jiuquan Satellite Launch Centre in the Gobi desert, the official *Xinhua* news agency reported.

Astronauts Jing Haipeng and Chen Dong will take two days to reach the Tiangong-2 space lab, or "Heavenly Palace-2", which was launched in September. They will remain on board for 30 days — the longest stay thus far by Chinese astronauts — to conduct tests on spacecraft-related technologies and scientific and engineering experiments, Xinhua said.

Related report, Page 13

Figure 19 "Panel wants Cauvery supply to farmer modernized" (Deccan Herald dated 18th October, 2016 Tuesday)

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IV. CONCLUSION

In this paper we have proposed innovative methods of monitoring and regulating river water between dams. It is essential to deploy a river water management system like the one proposed in this paper for systematic, non-partial, and peaceful sharing of river water. In the present scenario where there is dispute in the matter of regulating water between states/union territories, a well planned, sophisticated and a noble solution for the same must be framed. This paper can be debated upon and a formal solution should be obtained. We may be divided by language, region and creed but we must stand united as Indians.

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