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ROLE OF DIGITAL TECHNOLOGY IN RESOLVING THE LONG-LASTING DISPUTES (A Case Study of Evaluation of Losses B/W Taunsa – Guddu Reach using ADCP)

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ABSTRACT

Pakistan manages the world's largest contiguous irrigation system, i.e., the Indus Basin Irrigation System (IBIS). This system, which is under increasing pressure from population growth and climate change, provides water, energy and food security for the nation. Indus River System Authority (IRSA) has its role to regulate and monitor the distribution of water sources of Indus Rivers in accordance with the Accord amongst the Provinces and to provide matters connected therewith. In this context, IRSA in consultation with Water and Power Development Authority (WAPDA) and Provincial Irrigation Departments (PIDs) distributes the surface water resources of the IBIS between the provinces on seasonal basis.

Forecasting inflows to the IBIS and unaccounted losses/gains, setting reservoir level targets, and then balancing resources between the Jhelum-Chenab and Indus Systems and balancing and sharing shortages between provinces, is a cumbersome task. Each of these steps is very complex and has dependence between with each other. As per TORs, each province carries out forecasting of inflows and accordingly work-out losses / gains using historical data along with probability curves seasonally updated by WAPDA. The same is presented in IRSA Technical Committee (ITC) for deliberations between the provincial technical members. As a result, IRSA Technical Committee report is presented in IRSA Advisory Committee (IAC) for finalization of seasonal forecast including losses / gains in Jhelum-Chenab (JC) and Indus Systems. In the last technical committee meeting held on 26.09.2022 for Rabi 2022-23 wherein dispute arose between provinces in calculating the losses in Indus and JC Zone. Sindh has assumed more losses as compared to losses worked out by Punjab (10% v/s 0 % by Punjab). These losses have been assumed by provinces based on historical data without any logical reasoning. These losses were presented in IRSA Advisory Committee meeting and after detailed deliberations between the IRSA members. The same were approved with majority of votes rather on technical grounds / reasoning.

Acoustic Doppler Current profiler (ADCP) measures water currents with sound, using a principle of sound waves called the Doppler effect. It works by transmitting "pings" of sound at a constant frequency into the water and calculate velocity of

water moving around it. With measurement of section profile and velocity, ADCP directly provides the discharge at particular section after applying certain corrections.

In this regard, a comprehensive exercise was conducted during February 20-24, 2023 to measure the losses / gains in Taunsa – Guddu reach to address the concerns of IRSA by measuring the outflows at Taunsa and the inflows at Chachran (Bainazair Bridge on Indus) keeping in view the lag time along the riverine distance of 200 KM. A digital equipment ADCP has been used to measure the flows after applying all the corrections. Thus, very interesting results were obtained wherein it was found that losses between Taunsa and Guddu reach comes out 8-9% as compared to 21-23% reported by Sindh Irrigation Department. In short, Sindh is reporting 17-18 % excess losses.

Before, this WCAP consultants had conducted the whole exercise using Price -A Current meter manually, which is a cumbersome and time consuming exercise and they have provided gate opening formulas for determining the flows and losses accordingly. PID has also been using ADCP for measurement of flows at all main / branch canals off-taking from Punjab Barrages since 2018. This technology will also be helpful in installation of Telemetry System being installed by WAPDA for IRSA.

Key Words: ADCP, IRSA, Losses / Gains, Taunsa & Guddu

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INTRODUCTION

Pakistan is a country built around the waters of the Indus River Basin. Punjab Irrigation System is one of the largest gravity flow network in the world. In Pakistan, both the federal and provincial governments have important and complementary roles in water development and management. The federal government plays a major role in developing and managing large infrastructure and in administering the 1991 Indus Water Accord that defines how water is shared among the provinces.

IRSA is responsible for finalizing the water availability scenarios and seasonal planning of water resources in the Indus Basin River System (IBRS). The provincial shares as per Water Apportionment Accord 1991 are determined keeping in view the water availability, storage in the reservoirs and system losses. Punjab and Sind irrigation departments make their own assessment of water availability and their share, similar to IRSA's procedure and discuss their forecast in Technical Advisory Committee meeting where the water availability and seasonal planning are finalized. In this process the losses factor is most critical one which need to take carefully. In the current practice IRSA and other province take historical losses which does not make any sense due to different hydrological phenomena. In this Punjab stance is to take actual measurement in JC and Indus zone for the consideration of losses. Therefore, in this case study latest technology has been adopted for reach wise losses.

The hydroacoustic instruments is widely use to directly measure discharge in medium to shallow rivers and canals has been around for more than two decades. In the past, this technology was developed from instrumentation originally designed for oceanographic applications. Specialized software and floating platforms have extended the usability of these instruments in open channels; however, there were limitations caused by instruments operating at a single frequency that reduced the dynamic measurement range of the instrument. A recent advance in commercial microelectronics has greatly increased the capability of these devices intended for discharge measurements, including the ability to operate at multiple frequencies.

ADCP has become a popular instrument for measuring water velocity and discharge in rivers and streams due to its ability to collect data quickly and accurately across the entire cross-section of the river or stream.(Cook et al.,) Several studies have been conducted to evaluate the accuracy and reliability of ADCP discharge measurements.

Obtaining uninterrupted measurements of river discharge is extremely crucial for effective water resource management. This data is essential as it provides the necessary information and calibration for hydraulic and hydrological models. In the last decade, several methods have been introduced for real-time monitoring of

river discharge using either image-based or acoustic-based techniques (Hoitink et al., 2009).With the advancements, the acoustic Doppler current profiler (ADCP) has undergone significant advancements from being an experimental tool that could measure velocity and estimate discharge in deep water, to becoming a widely used instrument for measuring water velocity and discharge in streams with varying depths, including shallow streams (Mueller et al., 2009). This has greatly reduced the time required for making these measurements and has allowed for more detailed and precise analysis of water flow (Mueller et al., 2007).Thoms and DeJager (2015) stated that ADCP measurements were compared to traditional current meter measurements in two rivers in South Africa. The results showed that ADCP measurements were more accurate and efficient than current meter measurements, with a higher measurement resolution and the ability to measure discharge in a shorter amount of time.

PROBLEM STATEMENT:

In a meeting with Additional Chief Secretary (ACS) Irrigation, the IRSA's concern of increasing losses in Taunsa-Guddu reach during the month for February came under discussion. Appreciating the concern of IRSA, PID Punjab pointed out that the successive increase in losses under the circumstances when off-taking canals off-taking from Taunsa and Panjand are closed due to Annual Closure, is resulting only due to some misreporting of flows at Guddu Barrage. Punjab was asked to verify the releases from Taunsa Barrage and Panjnad, frequently through actual measurements under intimation to IRSA and Irrigation Department Sindh. ACS Irrigation directed the concerned staff to carry out actual flow measurements at control points relating to loss/gain assessment in all important river reaches and confirm the Discharge Tables of the canals off-taking from the barrages. He also emphasized to engage IWMI as already agreed by all stake holders for carrying out independent monitoring and measurements in Taunsa- Guddu reach.

Therefore, in the views of the above issues PID focal person along with his team and IRSA member visited the barrages from Taunsa to Benazir Shaheed Bridge on Indus River near Chachran Sharif.

METHODOLOGY:

Each year, at start of the season seasonal forecasts of water availability are made based on reservoir storage levels and expected inflows. These forecasts are then used for making specific canal allocations (i.e., season entitlements) based on their shares according to the country's 1991 Water Apportionment Accord. The canals' total allocations in MAF and entitlements for 10-day flows in cusecs are specified at the beginning of each season. Actual deliveries are recorded over the period of the irrigation season. The methodology of seasonal forecast is shown in the figure1.

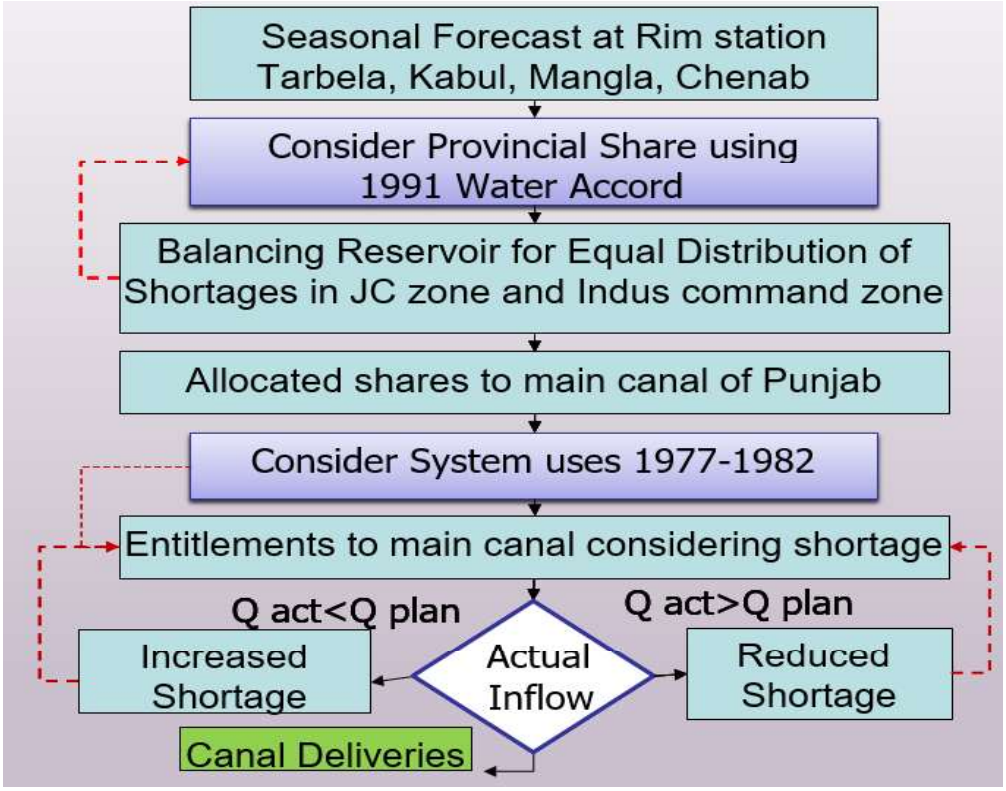


Figure 3: Seasonal Planning procedure

In the seasonal losses are major factor which need to be determine on actual measurement rather than historical using. In this regard Acoustic Doppler Current Profilers (ADCP) measurement tool was selected for actual measurement in the river reach. Data processing was carried out using the WinRiver II software package provided by the ADCP manufacturer. The software was used to process raw ADCP data into velocity profiles and calculate discharge using the standard QRev algorithm. The point velocity measurements obtained with the current meter were used to calibrate ADCP measurements and reduce measurement uncertainty.

Analysis was performed to assess the losses in the river reach after actual measurement using ADCP. The accuracy of ADCP measurements was evaluated by comparing them reported discharge and estimated discharge by considering lag time.

RESULTS AND DISCUSSION

i. Taunsa Barrage Measurements

Member Balochistan IRSA and Punjab PMIU team headed by Dr. Muhammad Riaz, reached Taunsa Barrage on 20-02-2023 in the afternoon. Inflow

and outflow were reported as 50028 cusecs and 46028 cusecs respectively (which were the same as reported in the morning gauges of 20-02-2023). After studying gauges and discharges recorded in the log book and reconnaissance of the river reach, a site downstream of barrage was selected for river flow measurements by ADCP in front of RD. 28+000-29+000 of Magassan Branch running parallel along left bank of Indus river. All the river water released from Taunsa Barrage was passing through a single creek at this location which was considered suitable for river flow measurements by ADCP. Assistant Director Monitoring carried out measurements themselves at this location in four transects after performing necessary requisite compass and moving bed loop correction tests. Measurement of river discharge at this location (RD-28+000-29+000) by ADCP was carried out in physical presence of visiting team. Average of the four transects came out as 46471 cusecs. The measured discharge found comparable with the reported discharge of 46028 cusecs.

Reported inflow and outflow at Taunsa Barrage on 21-02-2023 were 50600 cusecs and 44600 cusecs respectively. DG Khan canal was opened for 2000 cusecs in addition of TP Link which was reportedly running with 4000 cusecs. Log book of the barrage showing gauges, gate openings and discharges was studied. Gate openings and river gauges were verified before start of physical measurements. River discharge downstream of Taunsa Barrage was again measured by the same ADCP on 21-02-2023 in presence of the visiting team at the same location (RD-28-29). Measured discharge was found 46348 cusecs against reported discharge of 44600 cusecs which was 3.9 % above the reported one.

ii. Panjnad Barrage

After visiting Taunsa Barrage, team moved to Panjand Barrage for camping there to accomplish measurements at Benazir Shaheed Bridge site located on Indus river, 220 km downstream of Taunsa Barrage. On 22-02-2023, the Team visited Panjand Barrage in company of concerned operational and project staff. Executive Engineer briefed about the history, salient features and the major interventions/modifications made under the ADB financed “Rehabilitation & Upgrading Panjnad Barrage” project. PID’s SCADA Engineer briefed about SCADA installations and operations in control room. He informed that installation works have been completed and the installed systems for real time flow monitoring and piezometer observations are in testing and commissioning phase.

Team also met with Chief Engineer Irrigation Bahawalpur Zone in his office. Water availability and its distribution among the provinces came under general discussion. He apprised about the shortage being faced and managed in Bahawalpur zone due to limited availability of water in Sidhnai-Mailisi-Bahawal (SMB) Link canal and at Panjnad Barrage during Rabi 2022-23. He appreciated

the flow measurements scheduled at Benazir Shaheed bridge and assured full logistic and manpower support as and when required to carry out discharge measurements. Desert Branch off-taking from Lower Bahawal canal and its system were also visited while going back to Panjand Barrage.

iii. Benazir Shaheed Bridge on Indus River near Chachran Sharif

Benazir Shaheed Bridge is located on Indus River near Chachran Sharif and is at a riverine distance of about 220 km from Taunsa Barrage and 110 km from Guddu Barrage. The distances were determined from the Google map using riverine route by. This is the last one operational road Bridge on Indus river in Punjab territory. This observation site was carefully chosen for having a fair assessment of gains/losses in Taunsa-Guddu reach which has been a matter of serious concern for IRSA. Measurement's site was selected at a distance of 500 feet downstream of the bridge, where the river section was found straight, stable and uniform. After performance of necessary requisite Compass and moving bed tests, river flow measurements were taken by ADCP on 23-02-2023 & 24-02-2023 corresponding to measurements taken at Taunsa Barrage on 20 -02-2023 and 21 -02-2023 with three days' lag time based on average velocity of 2.37 ft/sec between Taunsa Barrage and Benazir Shaheed Bridge. Measured discharges (average of transects at this location) for 23-02-2023 and 24-02-2023 were found 43900 cusecs and 43700 cusecs respectively. Comparison of reported and measured flows at Taunsa and measured flows at Benazir Shaheed Bridge is given as follows:

Table 1:Discharge measurement using ADCP at chachran bridge on 24.03.2023

Tr.#		Edge Distance		#Ens.	MBT Corrected Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
000	R	2	2	370	2876	34506	5677	0.247	-0.636	43059	1300	12501	11:22	11:26	5.16	3.44	0	0
001	L	2	2	436	2741	35903	5956	0.283	2.08	44602	1318	12867	11:26	11:32	4.89	3.47	0	0
002	R	2	2	334	2861	34795	5718	0.353	-1.13	43373	1298	12346	11:32	11:36	5.65	3.51	0	0
Mean		2	2	380	2826	35068	5784	0.294	0.106	43678	1305	12571	**Total**	00:13	5.23	3.48	0	0
SDev		0	0	52	74.3	738	151	0.054	1.73	816	11.3	267.8			0.38	0.04		
SD/M		0.00	0.00	0.14	0.03	0.02	0.03	0.18	16.33	0.02	0.01	0.02			0.07	0.01		

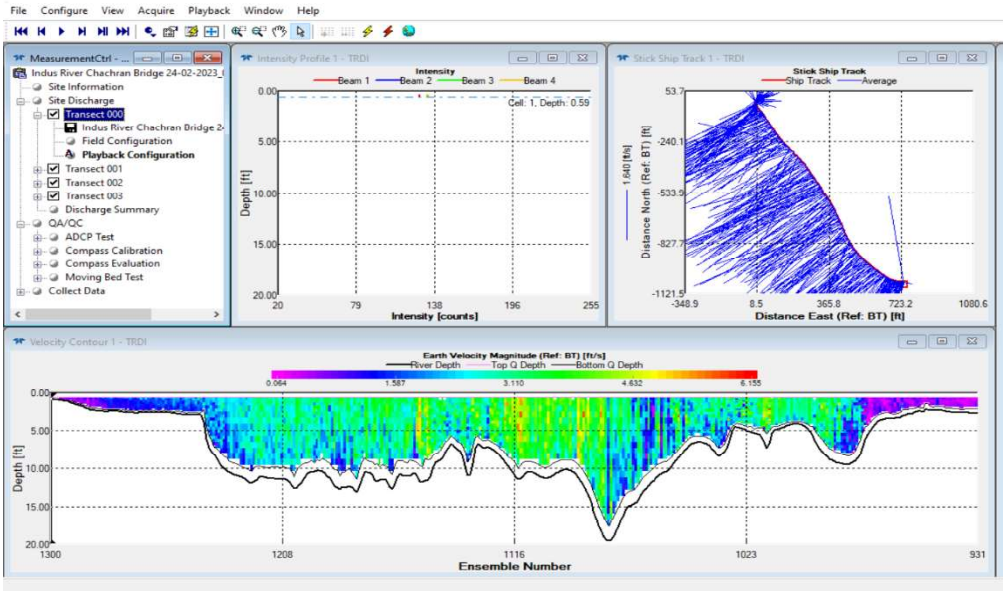


Figure 4: River Profile in ADCP at chachran bridge durin discharge measurement on 24.02.2023

(Discharges in cusecs)

Table 2: Overall summary of discharge measurement using ADCP at different location

Taunsa Barrage (D/S)				**Benazir Shaheed Bridge (D/S)**		**Loss in Taunsa-Benazir Shaheed Bridge reach**	
Date	Reported Discharge	Measured Discharge	Diff.	Date	Measured Discharge.	Discharge	%
Feb. 20, 2023	46028	46471	443 (1 %)	Feb. 23, 2023	43900	2571	5.53
Feb.21, 2023	44600	46300	1700 (3.8%)	Feb. 24, 2023	43700	2600	5.61

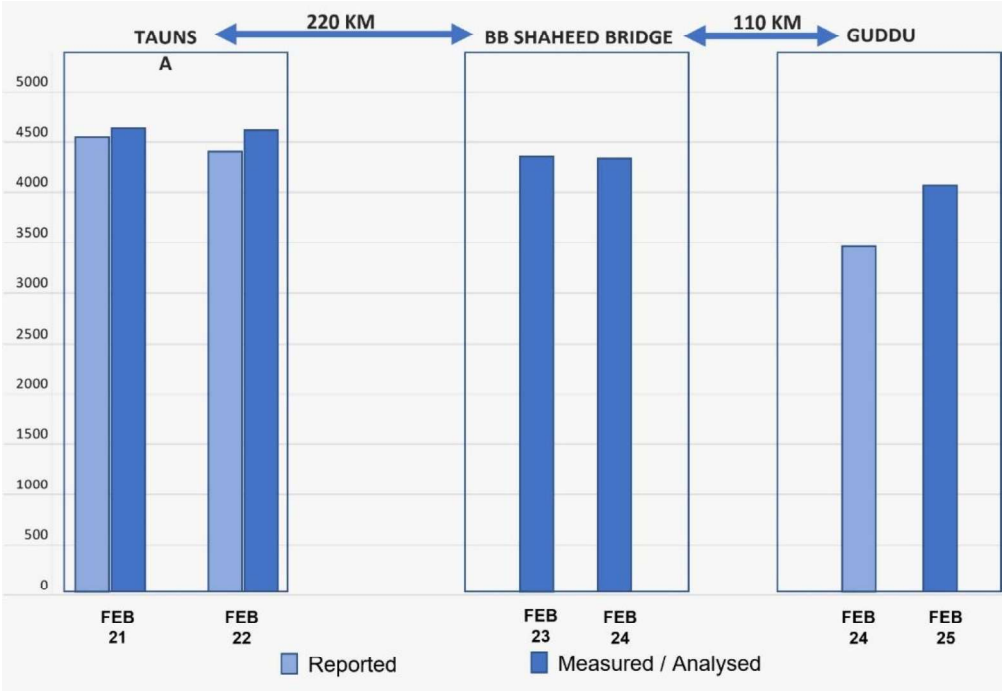


Figure 5: Reported and measure discharge analysis

The above figure comprehensive exercise was conducted during February 20-24, 2023 to measure the losses / gains in Taunsa – Guddu reach. Lag time also considered along 200 km riverine between outflows at Taunsa and the inflows at Chachran (Bainazair Bridge on Indus). It was found that losses between Taunsa and Guddu reach comes out 8-9% as compared to 21-23% reported by Sindh Irrigation Department.In short, SID is reporting 17-18 % excess losses.

Recommendation:

The case studies presented above indicate the River Surveyor is highly accurate when

comparing reported discharge measurements

i. IRSA must consider actual reach loss based on actual measurement in JC and Indus zone reaches using ADCP

ii. Before, this equipment, WCAP consultants had conducted the whole exercise using Price -A Current meter manually, which is a cumbersome and time consuming exercise and they have provided gate opening formulas for determining the flows and losses accordingly.

iii. PID has also been using ADCP for measurement of flows at all main / branch canals off-taking from Punjab Barrages since 2018.

iv. This technology will also be helpful in installation of Telemetry System being installed by WAPDA for IRSA.

v. WAPDA must install telemetry at an earliest and use fixed ADCP on all off taking channels to use

vi. WAPDA also hire consultant for carryout observation /coefficient for remainimg19 sites.

Reference:

Hoitink, Buschman, & Vermeulen. (2009). Continuous measurements of discharge from a horizontal acoustic Doppler current profiler in a tidal river. *Water resources research, 45*(11).

Klema, Pirzado, Venayagamoorthy, & Gates. (2020). Analysis of acoustic Doppler current profiler mean velocity measurements in shallow flows. *Flow Measurement and Instrumentation, 74*, 101755.

Mueller, Wagner, Rehmel, Oberg, & Rainville. (2009). *Measuring discharge with acoustic Doppler current profilers from a moving boat*: US Department of the Interior, US Geological Survey Reston, Virginia (EUA).

Mueller, Wagner, & Winkler. (2007). Best practices for measuring discharge with Acoustic Doppler Current Profilers. In: USGS Publications.