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Final report

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1 Acknowledgments

The Water Apportionment Accord (WAA) Tool, with pre-season water allocation planning capabilities, has been developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) under the Australia-Pakistan Water Memorandum of Understanding in collaboration with the Ministry of Water Resources (MOWR), Indus River System Authority (IRSA), Water and Power Development Authority (WAPDA), Punjab Irrigation Department (PID), Sindh Irrigation Department (SID), Khyber Pakhtunkhwa Irrigation Department (KPID) and Balochistan Irrigation Department (BID).

The Tool is neutral, providing capability to implement the range of water allocation approaches used in Pakistan. The first prototype was developed in the latter years of the Australian Department of Foreign Affairs and Trade (DFAT) Sustainable Development Investment Portfolio (SDIP) Phase II (2016–20) project in the Indus basin Pakistan. The prototype was developed into the WAA Tool in 2020 with financial support from the Government of Australia through its Australian High Commission Islamabad and CSIRO. The current improvements and documentation are supported through a small research and development activity (WAC/2021/103) by the Australian Centre for International Agricultural Research (ACIAR).

We take this opportunity to acknowledge the support and sponsorship of this work by the Australian High Commission Islamabad. This has been critical to its success. We also thank the Pakistan Ministry of Water Resources (MoWR) for their support throughout the project. Support includes the provision of data and expertise, hosting the project team on field visits, and provision of guidance throughout the project.

We thank the Indus River System Authority (IRSA), Water and Power Development Authority (WAPDA), Sindh Irrigation Department (SID) and Punjab Irrigation Department (PID) for their provision of data, technical advice and WAA Tool review.

We would particularly like to thank and acknowledge the support and interest of the IRSA Chairman and IRSA Federal and Provincial members for the WAA Tool development.

Support from ACIAR to assist with WAA Tool reporting and training is much appreciated and gratefully acknowledged.

In conclusion, adoption of the WAA Tool provides increased transparency, coordination and equity in water allocation planning in the Indus Basin. We hope that this contributes to improved livelihoods for the peoples of the Indus Basin.

2 Executive summary

Pakistan manages the world's largest contiguous irrigation system, 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) in consultation with Water and Power Development Authority (WAPDA) and Provincial Irrigation Departments share the surface water resources of the IBIS between provinces. They distribute this resource for irrigation, urban, stock and domestic and industrial use as well as generating electricity as it travels through the system.

Broad principles on how the water resource is to be allocated are described in a 1991 Inter-Provincial Water Apportionment Accord. However, how these principles are interpreted and implemented is a detailed, complex process that is understood by only a few experts.

With an aim to capture this knowledge and in so doing provide a transparent, neutral and consistent process, CSIRO, through funding provided by the Australian Government, and in close collaboration with Pakistan water agencies, has developed the Water Apportionment Accord (WAA) Tool. This Tool replicates the 6 steps in the pre-season forecasting and subsequent 10-day allocation process of the IBIS (Figure 2.1) (Step 7 in Figure 2.1, canal command sharing, is not included in the Tool).

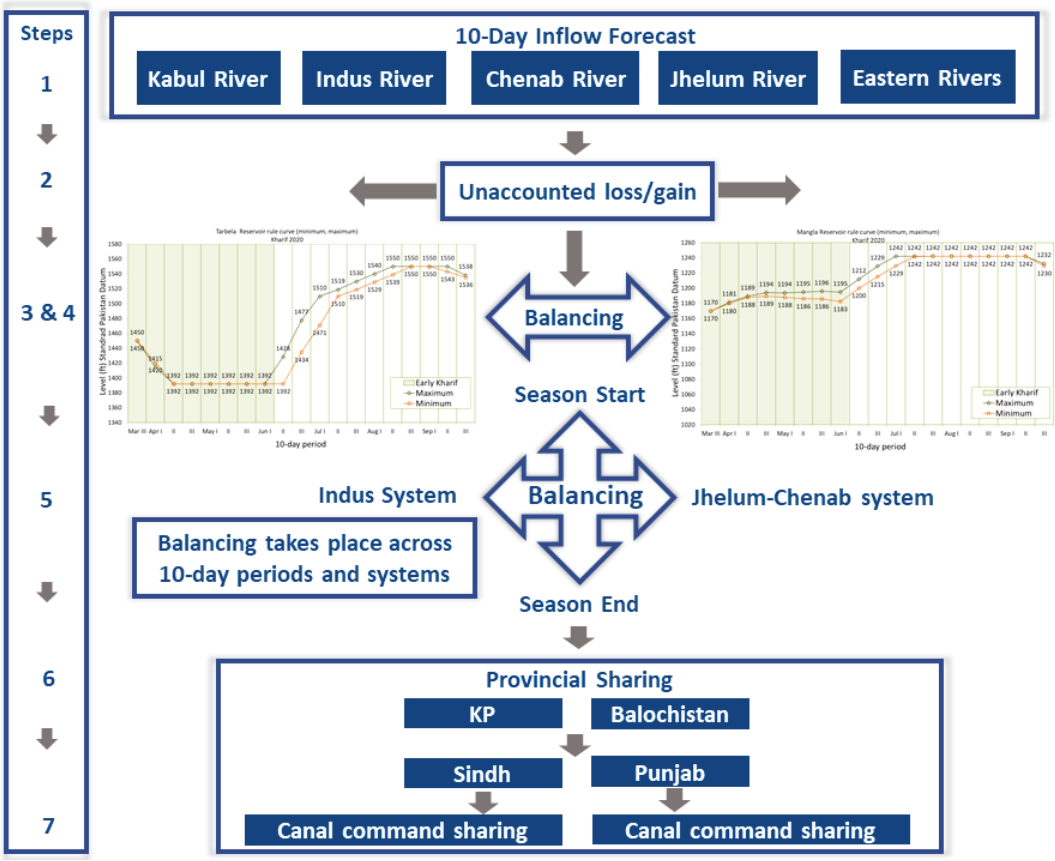

Figure 2.1 Schematic of the steps in the water resource allocation process in the IBIS

The Tool was formally handed over to IRSA, WAPDA and Provincial Irrigation Departments on 8 December 2020 (with further improvements through to the date of this report). During the handover meeting, IRSA Chairman and Provincial Members, senior representatives of WAPDA, and Provincial Irrigation Departments, highlighted the

importance of this Tool and described how its use had helped IRSA during pre-season water allocation planning for Kharif[1] 2020.

They also identified the next steps required to sustain the investment: (1) consolidating and expanding the skill base (in using the Tool and in the details of the allocation process) through continued and more intensive training of a wider audience; and (2) expanding its use to capture the mid-season allocation planning process.

Based on these specific requests and the importance of surface water allocation for irrigated agriculture and livelihood of millions of farmers across Pakistan, ACIAR has financed this small research and development activity – its objectives being to:

- consolidate the use of the WAA Tool in the seasonal planning process by providing support and further training to the current users through the next two rounds of seasonal planning (Kharif 2021 and Rabi 2021-2022)
- expand the skillbase, by using the WAA Tool as a teaching tool to train the next generation of water professionals, in partnership with Pakistani higher education/research providers. This component will extend our knowledge of the planning process and how to make the process and its outcomes understandable and accessible to a wider audience
- begin building the knowledge base to allow implementation of mid-season planning into the WAA Tool in the future. This requires understanding the current mid-season (adaptive) planning process (again undocumented and known to only a few people) sufficiently to be able to evaluate its efficacy and effectiveness compared to other methods.

Significant project outcomes include:

- publication of the WAA Tool User Guide and Reference Manual (Ahmad et al., 2022), endorsed by Pakistan water agencies as evidenced by co-authorships and Foreword by Dr Kazim Niaz, Secretary, Ministry of Water Resources
- capacity building of 35 water professionals and academic staff through a series of online and in-person workshops
- use of the Tool by IRSA and provincial irrigation departments to support 2021, 2022 and Rabi 2020–21, 2021–22 seasonal allocations
- outreach to wider audience through 4 conference presentations (including an invited presentation at the Ministry of Water Resources National Water conference in July 2022)
- developing understanding of mid-season water planning aspects through workshops and discussions.

[1] Pakistan has two distinct cropping seasons: Kharif (1 April to 30 September, wet summer) and Rabi (1 October to 31 March, dry winter)

3 Background

Pakistan operates the world's largest continuous irrigation system, the Indus Basin Irrigation System (IBIS), which supports food production, energy generation and stock, domestic and industrial supply for the nation (Briscoe et al., 2005). As shown in Figure 3.1, the IBIS is located in the lower Indus plain and spans the 4 provinces of Pakistan. This system is predominantly dependent on surface water supplies from the mountainous part of the upper Indus Basin; therefore, fair sharing of this water is critical for all provinces (Ahmad et al., 2021; Podger et al., 2021).

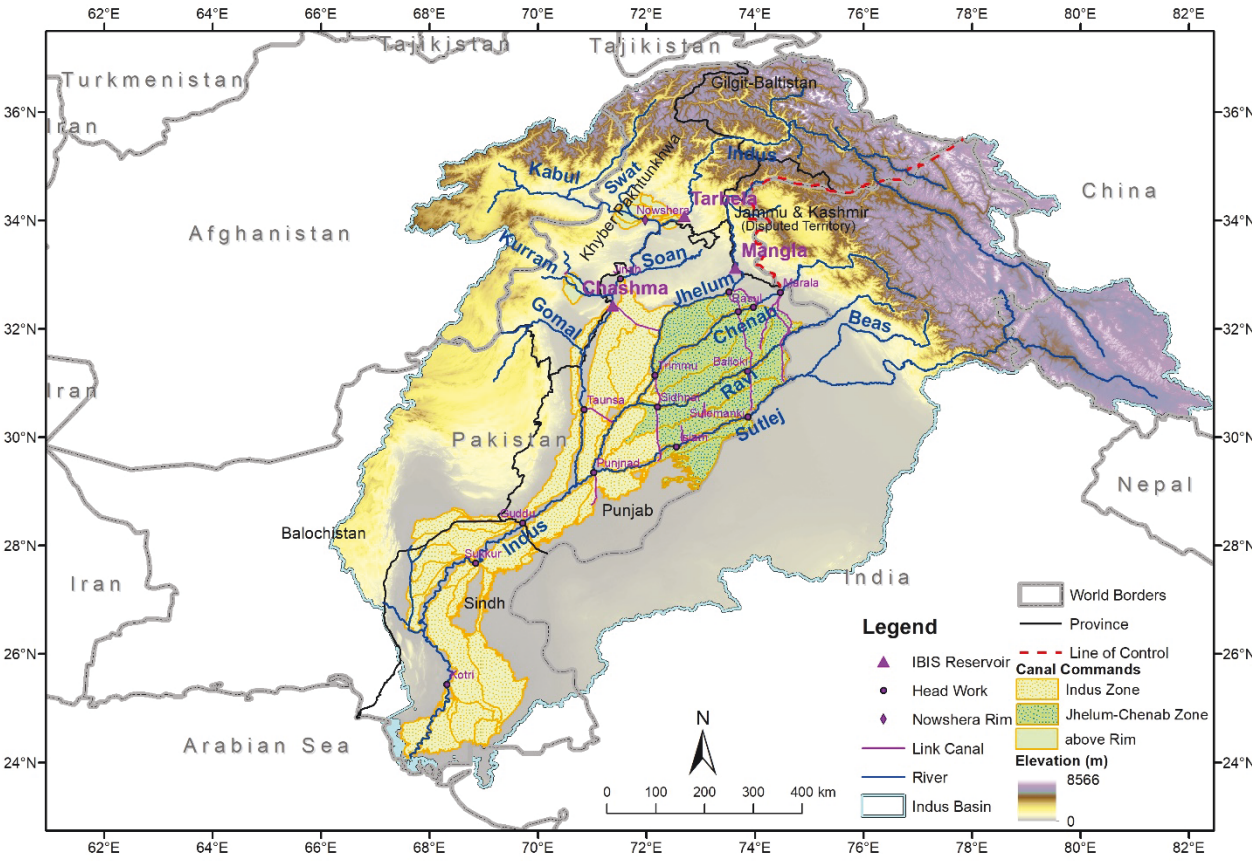

Figure 3.1 The Indus River System showing major dams, headworks, provincial boundaries, canal commands and Indus and Jhelum Chenab sub-systems (zones). Tarbela, Mangla, Marala, Nowshera, Balloki and Sulemanki are considered remote inflow measurements (rim) stations for the IBIS. IRSA makes allocation decisions within the Indus and J-C zones below the rim stations

The origins of the Indus and Sutlej rivers are from Mt Kailash in the Tibetan plateau in China. As shown in Figure 3.1, the Chenab, Jhelum, Ravi, and Beas rivers headwaters are in the Himalayas in India. The Beas flows into the Sutlej River in India and the Jhelum, Ravi and Sutlej rivers flow into the Chenab River after entering into Pakistan. The 1960 Indus Waters Treaty between India and Pakistan (United Nations, 1960) has granted full access of Ravi, Beas and Sutlej (eastern) Rivers to India and since then flows from these rivers into Pakistan have substantially reduced over time as India develops its water resources in these rivers. The Chenab and Sutlej combine at Punjnad Barrage prior to flowing into the Indus. The origins of the Kabul are in the Sanglakh range in the Hindu-Kush Mountains. The Chitral River flows from Pakistan into the Kunar River in Afghanistan which joins the Kabul River near Jalalabad. The Swat (in Pakistan) and Panjshir (in Afghanistan) rivers are also major tributaries of the Kabul that all join upstream of the Nowshera gauge. There are diversions from Tarbela into the upper Swat system via the Upper Pehur High Level Canal (UPHLC). The Kabul, Indus, Jhelum and Chenab rivers are

referred to as the **western rivers** while the Ravi, Beas and Sutlej rivers are referred to as the **eastern rivers**.

There are 6 critical headwater inflow points known as remote inflow measurements (rim) stations:

- Kabul River at Nowshera
- Indus River at Tarbela Dam
- Jhelum River at Mangla Dam
- Chenab River at Marala Barrage
- Ravi River at Balloki Barrage
- Sutlej River into Sulemanki Barrage.

Due to the structural layout of the IBIS, not all users have access to Tarbela, Chashma and Mangla supply reservoirs. There are some users who have no access to the major supply reservoirs. These users are constrained to access unregulated water from the Chenab via Marala Barrage.

A schematic diagram representing the two systems – the Indus and the Jhelum-Chenab (J-C) – of the current (as of 2020) IBIS is presented in Figure 3.2. There are 15 barrages that provide water to supply and link canals. An IBIS diagram with canal command names is provided in Appendix Figure 12.1.

On this basis the sharing process is broken up into 2 sub-systems (zones), Indus and Jhelum-Chenab (J-C) as shown in Figure 3.1 and Figure 3.2.

- The Indus system represents users who can access Tarbela and Chashma reservoirs.
- The J-C system represents users who can access Mangla reservoir and/or the Chenab River.

The J-C system flows into the Indus system at downstream of Rasul Barrage on the Jhelum River, Qadirabad Barrage on the Chenab River, Balloki Barrage on the Ravi River and Sulemanki Barrage on the Sutlej River. These are known as the RQBS barrages. IBIS canals off-taking from Rasul, Qadirabad, Balloki, Sulemanki barrages and Islam Barrage[2] are part of the Jhelum-Chenab command area and the rest of the area is under Indus command.

A schematic of the 10-day water allocation sharing across the Jhelum-Chenab and Indus systems is provided at Figure 3.3.

[2] *Islam Barrage more commonly receives water via link canal from Balloki than directly from Sulemanki of which it is downstream.*

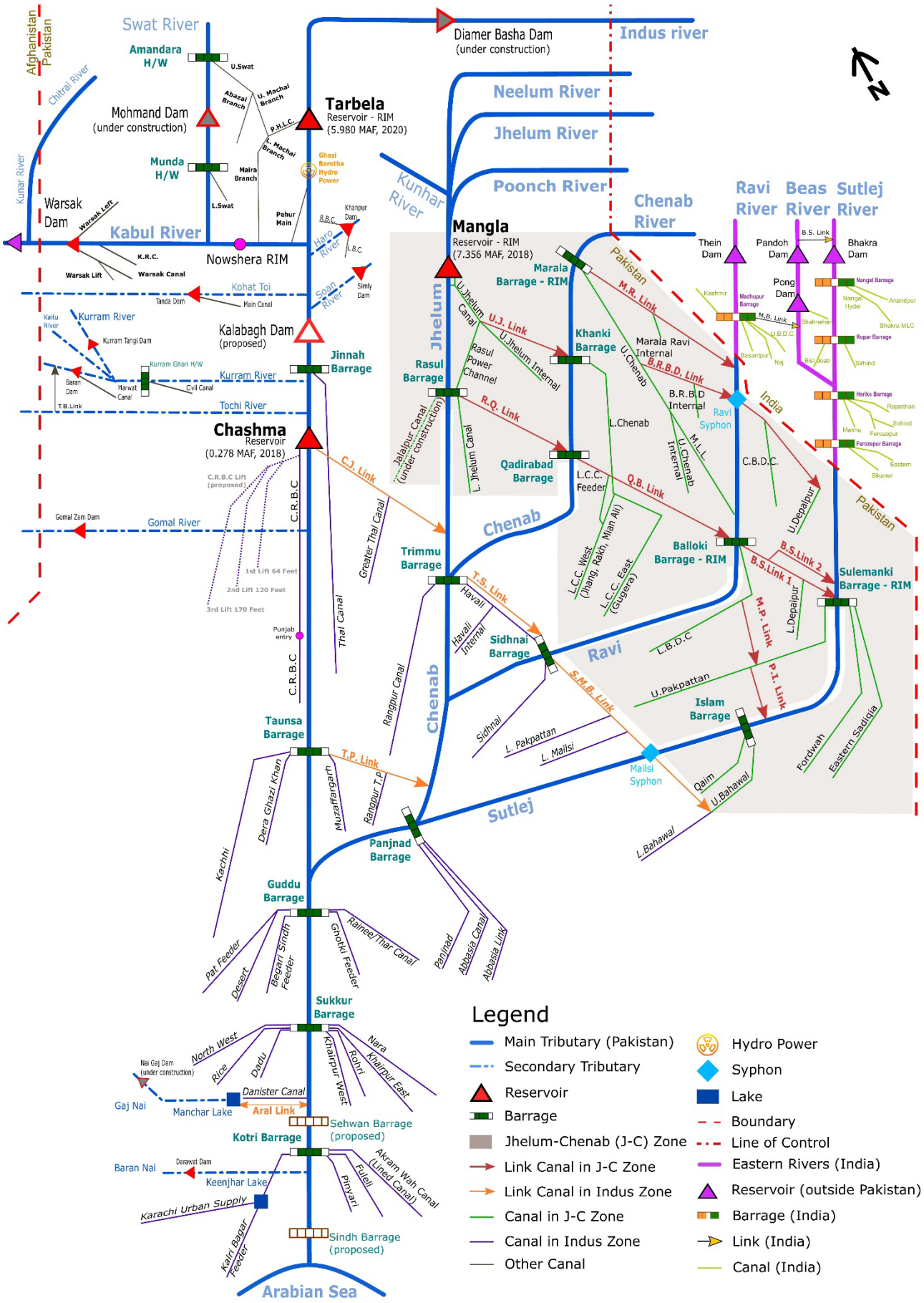

Figure 3.2 Schematic diagram of the Indus Basin Irrigation System (IBIS) with spatial demarcation of the Indus and Jhelum-Chenab (J-C) systems of the IBIS

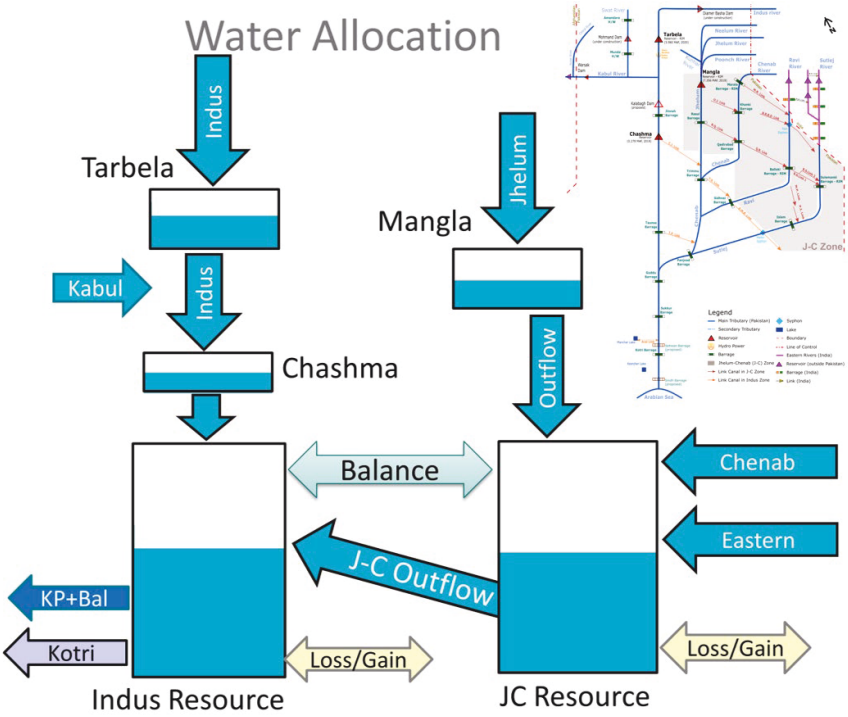

Figure 3.3 Schematic diagram of 10-day water allocation process showing how water is shared across the Indus and Jhelum-Chenab (J-C) systems. An animated version is available from https://youtu.be/9pK4LG2lYcc

4 Apportionment of the waters of the Indus River System between the provinces of Pakistan (the Accord 1991)

Inter-provincial water sharing conflicts date back to pre-partition of the Indian sub-continent in 1947 (additional background details are available in Government of Pakistan (1991); IUCN (2010); and PILDAT (2011)). However, after the final commissioning of the Tarbela Dam Project in 1977, surface water resources development almost stalled due to the non-resolution of the inter-provincial water disputes (Ministry of Water Resources Pakistan 2018). To overcome this deadlock, after a series of inter-provincial negotiations and strong political determination and leadership from provincial stakeholders, the Inter-Provincial Water Apportionment Accord (the Accord) was agreed on 16 March 1991 at Karachi.

4.1 Establishment of the Indus River System Authority

For the implementation of the Accord, the Indus River System Authority (IRSA) was established through the Pakistan Government, *IRSA Act No. XXII of 1992* (Government of Pakistan, 1992). The Act describes IRSA responsibilities of implementing the Accord

"… for regulating and monitoring the distribution of water sources of Indus River in accordance with the Water Accord amongst the Provinces." (Government of Pakistan, 1992).

The Accord itself is not an Act of Parliament but is referenced in the Act. IRSA has representation from all four provinces and the federal government. The chair of IRSA is rotated each year between each of the representatives.

4.2 The Water Apportionment Accord 1991

The Water Apportionment Accord (the Accord) contains 14 clauses ('Paragraph' in the Accord) that broadly describe how the Indus (surface) water resources are to be shared between the 4 provinces of Punjab, Sindh, Khyber Pakhtunkhwa (KP)[3] and Balochistan on a seasonal basis. A complete copy of the Accord is included at Appendix 12.2.

Principles were agreed for both the Kharif (April to September) and Rabi (October to March), with the Kharif season further sub-divided into Early Kharif (1/4 to 10/6) and Late Kharif (11/6 to 30/9).

Four Paragraphs are relevant to the sharing arrangements:

- Paragraph 2 considers accepted water distributional principles under current storage capacity (Figure 4.1)
- Paragraph 3 establishes that the authorised quotas of water for KP and Balochistan projects that were under execution at the time of the signing of the Accord be considered as existing uses (Figure 4.2)
- Paragraph 4 is used to balance river supplies above Paragraph 2 from floods and future storages (Figure 4.3)
- Paragraph 14 sub-clause b [14(b)] is used to establish the pattern of regulation based on observed average system uses for the period 1977–82 (Figure 4.4).

[3] *Previously named as North-West Frontier Province and named as such in the Accord*

2. In the light of the accepted water distributional principles the following apportionment was agreed to:

(Fig. in MAF)

PROVINCE	KHARIF	RABI	TOTAL
PUNJAB	37.07	18.87	55.94
SINDH*	33.94	14.82	48.76
N.W.F.P. (a)	3.48	2.30	5.78
(b) CIVIL CANALS**	1.80	1.20	3.00
BALOCHISTAN	2.85	1.02	3.87
	77.34 + 1.80	37.01 + 1.20	114.35 + 3.00

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi.
** Unguaged CivilCanals above the rim stations.

Figure 4.1 Para 2 from the Accord document, extract from Government of Pakistan (1991)

3. N.W.F.P/Baluchistan Projects which are under execution have been provided their authorised quota of water as existing uses.

Figure 4.2 Para 3 from the Accord document, extract from Government of Pakistan (1991)

4. Balance river supplies (including flood supplies and future storages) shall be distributed as below:

Punjab	Sindh	Balochistan	NWFP	Total
37	37	12	14	100%

Figure 4.3 Para 4 from the Accord document, extract from Government of Pakistan (1991)

14. a) The system-wise allocation will be worked out separately, on ten daily basis and will be attached with this agreement as part and parcel of it.

b) The record of actual average system uses for the period 1977-82, would form the guide line for developing a future regulation pattern. These ten daily uses would be adjusted pro-rata to correspond to the indicated seasonal allocations of the different canal systems and would form the basis for sharing shortages and surpluses on all Pakistan basis.

c) The existing reservoirs would be operated with priority for the irrigation uses of the Provinces.

d) The provinces will have the freedom within their allocations to modify system-wise and period-wise uses.

e) All efforts would be made to avoid wastages. Any surpluses may be used by another province, but this would not establish any rights to such uses.

Figure 4.4 Para 14(b) from the Accord document, extract from Government of Pakistan (1991)

The Accord does not include values for Para 14(b). Values in million acre feet (MAF) as an average of observed annual system water use volume for the period 1977–82 are given in Table 4.1. These are taken from Khan (2016). Para 14(b) values used in the WAA Tool are provided in the Note below Table 4.1.

Table 4.1 Para 14(b) average of observed annual system use for the period 1977–82 (Khan 2016). Current values are used in the WAA Tool for KP and Balochistan (see note below the table)

Province	**Kharif (MAF)**	**Rabi (MAF)**	**Total (MAF)**
Punjab	34.66	19.85	54.51
Sindh*	28.55	14.98	43.53
KP (a) (b) Civil canals**	1.80 1.75	1.27 0.73	***3.06 2.49
Balochistan	0.85	0.78	***1.63
Total (below rim stations without civil canals)	65.86	36.87	102.74
Total (below rim stations and with ungauged civil canals above rim stations)	67.61	37.60	105.23

* including already sanctioned urban and industrial uses of Metropolitan Karachi
** ungauged Civil canals above rim stations
*** current values for KP and Balochistan are listed in the following Note

Note: The WAA Tool uses the most current shares for KP and Balochistan as these reflect their current withdrawal capacity to use the water resource (this usage replicates current IRSA allocation procedure). The KP and Balochistan 10-day share constraints sum to less than their seasonal shares. Consequently, as these provinces develop their ability to consume their seasonal share, these constraints are adjusted accordingly.

The 2020–21 annual share for KP was 1.52 MAF: 0.82 MAF in Kharif and 0.70 MAF in Rabi. The 2020–21 annual share for Balochistan was 3.87 MAF: 2.85 MAF in Kharif and 1.02 MAF in Rabi.

There is scope in the WAA Tool for Punjab and Sindh to adjust the pattern of their 10-day shares provided the seasonal share total is maintained. The 10-day Para 14(b) and Para 2 share tables are provided in Appendix C of Ahmad et al. (2022a).

5 Objectives

The overarching objectives of this SRA were to:

- consolidate the use of the WAA Tool in the seasonal planning process by providing support and further training to the current users through the next two rounds of seasonal planning (Kharif 2021 and Rabi 2021-2022)
- expand the skillbase, by using the WAA Tool as a teaching tool to train the next generation of water professionals, in partnership with Pakistani higher education/research providers. This component will extend our knowledge of the planning process and how to make the process and its outcomes understandable and accessible to a wider audience
- begin building the knowledge base to allow implementation of mid-season planning into the WAA Tool in the future. This requires understanding the current mid-season (adaptive) planning process (again undocumented and known to only a few people) sufficiently to be able to evaluate its efficacy and effectiveness compared to other methods.

6 Methodology

In determining an appropriate approach, we started with identifying practical 'success' measures and then addressed how they could be most efficiently achieved. The 3 measures were:

- the Tool continued to out-perform the previous manual method, as assessed by the agencies themselves
- the agencies acquired proficiency in using the WAA Tool to support their seasonal allocation planning process and expressed confidence in their ability to undertake subsequent planning rounds with minimal support from the Australian team
- trainees/water professionals from the Federal and provincial water agencies, and research and educational institutes reported improved understanding of the allocation planning process.

Achieving success in these measures required building and then managing knowledge of the water allocation planning process, targeted capacity building exercises, and ensuring diversity and social inclusivity in all activities. These are elaborated below.

Knowledge Management

- documenting comparison of Tool performance compared to that of manual system (ref Appendix Section 12.3)
- documenting the detailed water allocation process in the WAA Tool User Guide and Reference Manual. To meet the requirements of different audiences, that document is divided into 3 parts:
    - Part I describes the principles on which the WAA Tool is built. It is written as a high level overview on the Accord and its principles and its usage for senior water managers and Accord policy makers. It does not contain implementation details (i.e. methods, equations, assumptions)
    - Part II is a User Guide. It steps through the Tool user interface which has been constructed to mimic the logical implementation sequence and provides details on rationales for Tool design choices
    - Part III is a Reference Manual that documents the details of the implementation. It contains all the equations that sit underneath each step in the allocation process.
- knowledge transfer to the broader scientific/technical community through submission of papers and accompanying scientific presentations
- initial consultations with IRSA, SID and PID to understand and draft a working paper on their current practice for mid-season planning.

Capacity building

- through regular informal technical advice on the water allocation aspects and Tool use (separately for IRSA, SID, PID, MoWR, WAPDA, KPID)
- formal online and in-person workshops
- Using the Tool as a platform to discuss critical water allocation aspects and technical advice to improve allocation aspects (this resulted in additional work – not initially planned)
- Consultations to understand the mid-season water allocation aspects.

GEDSI

- Targeted effort to involve female water professionals in the capacity building workshops
- Reinforced the importance of being GEDSI aware when setting up meetings and when considering the impacts of water planning decisions on different groups in society.

7 Achievements against activities and outputs/milestones

Objective 1: To consolidate the use of the WAA Tool in the seasonal planning process by providing support and further training to the current users through the next two rounds of seasonal planning (Kharif 2021 and Rabi 2021–22)

Table 7.1 Key activities to achieve Objective 1. This table incorporates changes required to respond to impacts of covid on travel

no.	activity	outputs/ milestones	completion date	comments
1.1	Kharif 2021 Pre-season water planning	Technical training sessions for IRSA, WAPDA and SID	March-April 2021	Release of WAA Tool version: 4.3.0 (Kharif 2021); online technical sessions
1.2	Rabi 2021-22 Pre-season water Planning	Technical training workshop for IRSA, WAPDA, SID, PID , KPID	September-October 2021	Release of WAA Tool version: 4.5.17 (Rabi 2021-22); online due to COVID-19
1.3	Kharif 2022 Pre-season water planning	Technical training workshop for IRSA, WAPDA, SID, PID [separate session for KPID in March and JS MoWR in April]	March-April 2022	Release of WAA Tool version: 4.6.10 (Kharif 2022); online due to COVID-19
1.4	Rabi 2022-23 planning	Technical sessions with IRSA during September 2022 visit to Pakistan	September 2022	Launch of WAA Tool User Guide and Reference Manual with Dr Neil Lazarow/ACIAR Water Program Manager in Islamabad & in-person technical session
1.5	National capacity building workshops in Karachi, Islamabad and Lahore	1) workshops in Karachi for SID, BID and MUET; 2) Islamabad (KPID and PCRWR), and 3) Lahore (PID, WAPDA)	Nov-Dec 2022	Provincial Minister and Secretary Sindh Irrigation attended part of the training workshop in Karachi. Meetings with Federal Secretary and Joint Secretary Ministry of Water Resources in Islamabad

Objective 2: To expand the skillbase, by using the WAA Tool as a teaching tool to train the next generation of water professionals, in partnership with Pakistani higher education/research providers

This component was designed to extend our knowledge of the planning process and how to make the process and its outcomes understandable and accessible to a wider audience. Despite the very low number of female professionals in the Federal and provincial water agencies, agencies were requested to ensure they were given the opportunity to attend workshops/meetings. As a result, almost all meetings/workshops had female participants. All training workshops included female trainers.

Table 7.2 Key activities to achieve Objective 2. This table incorporates changes required to respond to impacts of covid on travel

no.	activity	outputs/ milestones	completion date	comments
2.1	Kharif 2021 Pre-season water planning	Technical training sessions for IRSA, WAPDA and SID	March-April 2021	5 participants
2.2	Rabi 2021-22 Pre-season water Planning	Technical training workshop for IRSA, WAPDA, SID, PID, KPID	September-October 2021	30 participants (28 M + 2 F)

no.	activity	outputs/ milestones	completion date	comments
2.3	Kharif 2022 Pre-season water planning	Technical training workshop for IRSA, WAPDA, SID, PID [separate session for KPID in March and JS MoWR in April]	March-April 2022	16 participants
2.4	Rabi 2022-23 planning	Technical sessions with IRSA during September 2022 visit to Pakistan	September 2022	3 participants
2.5	National capacity building workshops in Karachi, Islamabad and Lahore	1) workshops in Karachi for SID, BID and MUET; 2) Islamabad (KPID and PCRWR), and 3) Lahore (PID, WAPDA)	Nov-Dec 2022	1) 24 participants (22 M + 2 F) 2) 8 participants (8 M) 3) 16 participants (14 M+ 2 F)

Objective 3: To begin building the knowledge base to allow implementation of mid-season planning into the WAA Tool in the future

This required understanding the current mid-season (adaptive) planning process (again undocumented and known to only a few people) sufficiently to be able to evaluate its efficacy and effectiveness compared to other methods.

Table 7.3 Key activities to achieve Objective 3. This table reflects changes made to the original schedule due to the impacts of covid on timing of travel

no.	activity	outputs/ milestones	completion date	comments
2.1	Consultations with SID, IRSA and PID	Draft working paper on mid-season water allocation approach/s	December 2022	Slightly different approaches used by IRSA, SID and PID were captured, in draft form, requiring further discussion with each agency, separately and together (planned for May 2023)
2.2	IRSA visit to Canberra	review and feedback on draft working papers and discussions for the design of WAC/2022/152 project	March 2023	Trip report prepared by IRSA team, including press release (see Appendix Section 12.6.6)

8 Key results and discussion

To achieve the SRA objectives, as much as possible, we followed an agile, user-centred design approach. This required regular interaction with stakeholders, flexibility in solutions (practical and satisfactory, not necessarily optimal), and including opportunities to reflect and allow for potential resets. We found this very important when transfer of knowledge was paramount, ensuring concepts and implementation steps were fully grasped.

This SRA largely focussed on three broad initiatives: knowledge management, capacity building and GEDSI.

Knowledge Management

1) Measuring Tool performance

To ensure adoption, demonstrating that the Tool outperformed the manual system was important. This was tested and reported in Appendix G of Ahmad et al. (2022a) and reproduced here in Appendix Section 12.4. The Tool performed better at balancing shortfalls between Indus and J-C systems and at equalising shortages across 10-day periods.

2) WAA Report

The Knowledge Management initiative achieved several significant outcomes as part of the Water Allocation Assessment (WAA) Report (Ahmad et al. 2022a) focussing on pre-season water allocation planning aspects. The report was successfully launched in September 2022, marking a crucial milestone in the project's timeline. To ensure widespread accessibility, a digital copy of the report was made available on the IRSA website[4], CSIRO Research Publications Repository[5] and ResearchGate[6]. In addition, to engage directly with stakeholders, 75 hard copies of the report were distributed during capacity building workshops.

3) Technical papers and presentations:

In addition to dissemination of knowledge and finding through the WAA Tool report (Ahmad et al. 2022), the team has shared their knowledge and experience through various technical papers and presentations. This includes four invited presentations (as highlighted in section 11.2), providing valuable insights to key audiences. Moreover, two presentations (Ahmad et al. 2023, Perraud et al. 2023) were made at 25th International Congress on Modelling and Simulation (MODSIM), Darwin, NT, Australia, 9-14 July 2023 to share this knowledge with scientists and international audiences.

4) Working paper on mid-season planning aspects

As the pre-season water allocation decision making is based on forecasted flows, the actual operations can (and usually do) differ from the pre-season water allocation plans. With the aim to encapsulate the knowledge on the current practices of IRSA and provincial stakeholders, the project team initiated initial interactions with IRSA, PID, and SID, resulting in the drafting of a working paper on mid-season water allocations. This is helping stakeholders to understand the similarities and differences in operational decision making practices among these stakeholders.

[4] http://pakirsa.gov.pk/Projects.aspx

[5] https://doi.org/10.25919/2ren-4m80

[6] https://www.researchgate.net/publication/355442566_Bringing_transparency_and_consistency_to_Pakistan's_seasonal_water_planning_decisions_1991_inter-provincial_Water_Apportionment_Accord_WAA_Tool_User_Guide_and_Reference_Manual_Second_edition#fullTextFileContent

In addition, this paper has served as a guide to scope the need for a follow-on ACIAR project on climate resilient and adaptive water allocation under 1991 Inter-provincial Water Apportionment Accord in Pakistan (WAC/2022/152).

Capacity building

To consolidate the use of the WAA Tool in the seasonal planning process and expand the skillbase, the team conducted a combination of informal on-the-job training sessions and formal training workshops (Sections 7 and 9). As a result, over 35 water professionals from IRSA, WAPDA, PCRWR, PID, SID, KPID, BID and MUET were trained.

We have noticed a significant improvement in the skill base, particularly among IRSA, SID and PID staff, in the use of WAA Tool. This improvement is evident from their active support in conducting some of the training sessions during the Nov-Dec 2022 training workshops held in Karachi, Islamabad, and Lahore.

In addition, three of the IRSA technical staff, including director operations, visited Canberra in March 2023 to discuss the mid-season planning aspects. During this visit, they also gained exposure to the water allocation process in the Murray-Darling Basin Australia, through their interactions with MDBA and NSW-DPI experts.

Gender

While undertaking knowledge management and capacity building activities, we specifically encouraged and ensured the participation of female water staff from CSIRO and partner organisations. The CSIRO team was 50% female staff. From Pakistani partners, we involved and built the capacity of 4 female water professionals in capacity building activities (2 PID, 1 SID, 1 WAPDA). Although this number may seem very small, considering the scarcity of female professional staff in Pakistani water agencies (perhaps less than 0.01%), this represents a genuine effort to build diversity and inclusion into the program.

9 Impacts

9.1 Scientific impacts – now and in 5 years

The scientific impacts of the project include:

- Translation of complex water allocation rules and manual decision-making processes into robust and scientifically defendable water sharing principles and irrigation demand patterns, now captured in the WAA Tool, developed with state-of-the-art technologies and practices
- This tool is now embedded[7] in the Indus River System Authority (IRSA) and used by them and provincial irrigation agencies to inform their Pre-season water allocation planning and national scale policy decisions (Newspaper coverage: Section 9.4.2, #7–#13)
- Provision of scientific information and assistance in understanding the impact of alternate pre-season water allocation forecasts and different sharing methods (Para 14(b), Para 2 and 3 Tier approach) on pre-season provincial water shares
- Publication of WAA Tool user manual and reference guide (Ahmad et al. 2022). This document has 3 parts**:**
  - **Part I** describes the Water Apportionment Accord, and the water sharing principles and practices that it embodies. The Accord is a critically important document as it describes how water is to be shared between provinces. It is the foundation for implementation of water sharing. However, due to its brevity, it is open to interpretation. The intent of this Part is to document the Accord and its principles and usage, as clearly as possible, without the detail of its implementation (e.g. methods, equations, assumptions). The audience is high-level senior managers, policymakers and planners
  - **Part II** is a Guide for users of the WAA Tool. It steps through the Tool user interface, which has been constructed to mimic the logical implementation sequence. This Part contains screen shots of the Tool to assist. It can be used for training in the use of the WAA Tool
  - **Part III** is a Reference Manual that documents the details of the implementation. It assumes familiarity with mathematical notation and includes >100 equations that encode the calculations. It has been prepared for use by the Pakistan government agencies engaged in water allocation, and any others who are interested in the details of the formulation of the Accord in practice.

"… the automation of key parts of the seasonal water planning procedure has brought much-needed innovation and modernization to the planning process."

(extract from Dr Niaz, Secretary Ministry of Water Resources, Foreword, Appendix Section 12.3.2)

9.2 Capacity impacts – now and in 5 years

This project has resulted in enhanced understanding on the implementation aspects of the1991 Water Apportionment Accord. Prior to this collaboration, understanding of the seasonal water allocation process was limited to a few experts.

[7] https://epaper.dawn.com/DetailImage.php?StoryImage=15_09_2022_003_006

The Australian team worked closely with local (Pakistani) experts to build mutual understanding of the water sharing principles and irrigation demand patterns, now captured in the WAA Tool, developed with state-of-the-art technologies and practices.

"It was now the Tool of choice of Pakistani water agencies and was being actively employed to aid in informed decision making ……"

(extract from IRSA press release (Section 9.4.1, #1, June 2023)

Developing an animation of the schematic diagram of how water is shared between the Indus and J-C systems (Figure 3.3) has proved to be an extremely valuable communication medium as it demonstrates, more clearly than words, the process, and works for multiple audiences.

In addition to training ~35 officials from MoWR, IRSA, WAPDA, PCRWR and provincial irrigation departments, we have provided training to staff from the U.S.-Pakistan Center for Advanced Studies in Water (USPCAS-W) which will help/translate water allocation and planning principles and practices into capacity building of next generation water scientists.

Emphasis on inclusion of women professionals in project activities, especially in training workshops, has raised awareness of the importance of diversity and inclusion within the agencies.

9.3 Community impacts – now and in 5 years

The importance of irrigated agriculture to the Pakistan economy is exemplified by the fact that irrigated agriculture supplies more than 90% of agricultural production and the agriculture sector accounts for ~23% of the GDP and employs ~37% of the labour force (GoP 2022). Approximately 65% of the total population of Pakistan resides in rural areas and their livelihoods are dependent directly or indirectly on agriculture. Presently, 90% of Pakistani farmers (7.4 million) own less than 12.5 acres of land (5 Ha) and are categorised as smallholder farmers.

Any improvement in agricultural water management resulting from improved water allocation decision making at the planning and policy levels will directly benefit farming and the wider communities in Pakistan.

9.3.1 Economic impacts

The Pakistan GDP is ~$348 bn (in 2021, World Bank data[8]) with agriculture making up ~23% (GoP 2022). We have been unable to find a separate GDP figure for the irrigation sector, but the bulk of the agricultural output is from irrigation. Employment in agriculture is ~37% of Pakistan's total employment, highlighting the critical role that irrigation plays in supporting livelihoods and food security. As the population grows and climate change forecast is for a drier future climate, efficiencies in water allocation are required.

Through use of the WAA Tool, the project has been able to provide evidence of how better strategies (e.g. for operating major storages) can result in additional pre-seasonal water allocations for all provinces. For example, IRSA's independent comparison of WAA Tool vs their manual calculations (undertaken for the WAA Tool Handover, Appendix Section 12.4) showed that WAA Tool's calculation resulted in almost 0.8 MAF (1.2%) in Kharif and 0.20 MAF (1%) more water being available for allocation (than as calculated manually). This confirmed that using the Tool results in more equitable and efficient water allocation (press release: https://nation.com.pk/09-Dec-2020/waa-tool-formally-handed-over-to-irsa), and provided a strong basis for exploring alternate water allocation

[8] GDP (current US$) - Pakistan | Data (worldbank.org)

strategies. In terms of monetary value, 1 MAF of water is worth roughly $US1.0 bn (Muhammad 2023).

This functionality can be used to consider how alternate strategies for major storage operations can reduce downstream flooding. Individual extreme events such as the flooding of 2010 can be worth billions of dollars: the World Bank and ADB (2011) estimate that the 2010 floods, the worst since 1929, cost the economy about $US11 bn, with the cost of recovery estimated at ~$US9 bn – and of course much of the cost (uncosted) was in lives, not dollars.

9.3.2 Social impacts

The social grouping/community of relevance for this SRA was the water professionals with whom we collaborated. While the ultimate impacts of improved water allocation planning will be widely felt at multiple community levels, this SRA has contributed to enhancing the social relations between Federal and provincial water agency professionals. It has achieved this through demonstrating behaviours that value balanced, open and transparent discussions, and treating all views as equal, valid and valued. The result is a Tool that is neutral (i.e. it does not favour one view/method over another) and demonstrates what can be achieved through working together.

"The Tool … has also improved the confidence, and trust amongst the federating units / stakeholders, in terms of the transparency of water availability and its regulation/distribution."

(extract from Dr Niaz, Secretary Ministry of Water Resources, Foreword page v, Ahmad et al. 2022)

9.3.3 Environmental impacts

Allocating environmental water to maintain the Lower Indus and its delta is becoming increasingly urgent, and additionally, water demand for Karachi is expected to grow considerably. While the 1991 Inter-Provincial Accord recognises the importance of below Kotri escape to sea to check sea water intrusion (Para 7), there is no agreed below Kotri allocation.

The Indus Delta is a significant environmental asset that sits below Kotri Barrage in Sindh province (Young et al. 2019). There is a large local population reliant on the estuary below Kotri for clean water and food (Figure 9.1). Additionally, it is anticipated that climate change in Pakistan will have a significant impact on the health of the Indus River and its Delta (Salik et al. 2016, Kirby and Ahmad 2022a).

Figure 9.1 The Indus Delta (left); women harvesting food (right). Images from https://blog.flyinglabs.org/2022/11/01/assessing-mangrove-forests-in-pakistans-indus-delta/, https://phys.org/news/2015-01-karachi-defensive-mangrove-barrier-triple.html, BBC UK

A nominal target of 10 MAF (~391 cubic metres/sec) is suggested by the Sindh province. This target is often met during flooding periods, whereas the environmental requirement

would be throughout the year. We have not found any studies that describe the below Kotri environmental assets and their water requirements. A common practice is to prioritise water for agriculture and cities, before water for the environment.

The Accord (Para 7) also recognises the need for more research and studies to define realistic targets for flows below Kotri Barrage. To cater for these research needs and support policy makers, special options have been created in the WAA Tool to allow users to define a 10-day environmental flow pattern (for below Kotri) and then evaluate its impact (in terms of reduction) on provincial water shares.

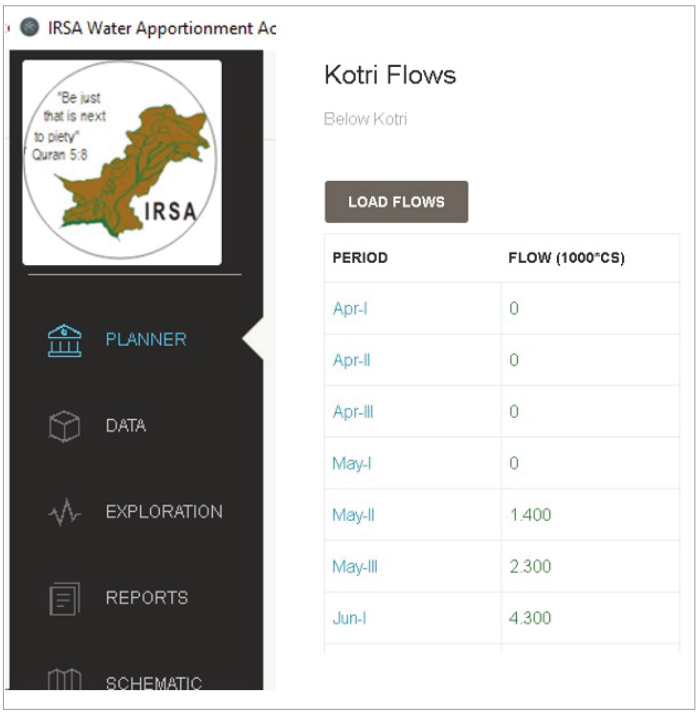

Figure 9.2 WAA Tool form for entering a 10-day flow pattern for below Kotri. This example is for the early Kharif period.

This functionality, and the importance of environmental flows below Kotri Barrage, were recently shared with an international audience (Perraud et al. 2023).

9.4 Communication and dissemination activities

In addition to planned activities (e.g. workshops, meetings), the project received a significant amount of coverage via Pakistan agency-initiated press releases which were picked up in local newspapers and local TV news. Dissemination to a wider audience was via invited presentations and papers/presentations at conferences. Lists of these activities are provided here and highlights provided in appendices.

9.4.1 IRSA Press releases

1. Australian High Commissioner and ACIAR Country Manager visit to IRSA (9 June 2023)
   http://pakirsa.gov.pk/Doc/Press_Release_AHC.pdf
2. IRSA Technical visit team to Australia regarding further development of Water Apportionment Accord (WAA) Tool (24 March 2023)
   http://pakirsa.gov.pk/Doc/Press_Release_WAA_Tool_March_2023.pdf

3. Training workshops on Water Apportionment Accord (WAA) Tool (CSIRO-IRSA Pre-season Water Planning WAA Tool Workshops in Karachi, Islamabad and Lahore) (10 December 2022) http://pakirsa.gov.pk/Doc/IRSA-Press-Release-December.pdf
4. WAA Tool User Guide and Technical Manual Launch (September 2022) http://pakirsa.gov.pk/Doc/IRSA-Press-Release.pdf
5. Photographs http://pakirsa.gov.pk/ToolHandover.aspx

9.4.2 Newspaper coverage

6. Australian HC, IRSA chief discuss water-related issues (11 June 2023) https://www.brecorder.com/news/40247095/australian-hc-irsa-chief-discuss-water-related-issues
7. Pakistan gets automated tool for water distribution tool for water distribution (15 September 2022) https://tribune.com.pk/story/2376781/pakistan-gets-automated-tool-for-water-distribution
8. New system to determine provinces' water share. The Indus River System Authority (IRSA) will switch over from a manual system to an automated one from the coming Rabi season (15 September 2022) https://www.thenews.com.pk/print/991333-new-system-to-determine-provinces-water-share
9. Govt to adopt new water data tool, ditches old manual system (15 September 2022) https://epaper.dawn.com/DetailImage.php?StoryImage=15_09_2022_003_006
10. Pakistan develops automatic tool for water distribution (16 September 2022) https://www.techjuice.pk/pakistan-develops-automatic-tool-for-water-distribution/
11. IRSA meets to discuss WAA Tool, proposes further development (14 September 2022) https://www.urdupoint.com/en/pakistan/irsa-meets-to-discuss-waa-tool-proposes-furt-1562825.html
12. Pakistan gets Australia-made system to determine provinces water shares (15 September 2022) https://propakistani.pk/2022/09/15/pakistan-gets-australia-made-system-to-determine-provinces-water-shares/
13. Pakistan is equipped with an automated system to distribute water (15 September 2022) https://netmag.pk/pakistan-is-equipped-with-an-automated-system-to-distribute-water/

9.4.3 Social media

14. Tweet from Minister for Irrigation Sindh province, 29 November 2022

15. Australian High Commission Facebook post

9.4.4 Presentations

The project team were invited to present on the project – its progress and impact – on several occasions. These are listed here and some highlights are provided in Section 12.5:

16. IRSA's presentation to Australian Head of Mission – June 2023 (Section 12.5.1)
17. Australia-Pakistan Joint Advisory Committee meeting, 30 June 2022 (ref Ahmad 2022a) (Section 12.5.2)

18. Launch of WAA Tool report (with forewords from HOM-AHC and Secretary MoWR) September 2022 (Section 12.5.3)

9.4.5 Workshops

Communicating and disseminating the technical aspects of water allocation and how they are captured in the WAA Tool was mainly through the conduct of workshops, six of which were held during the project life. These are listed here and highlights provided in Section 12.6:

19. Kharif 2021 water planning (software: WAA Tool version 4.3.0) (Section 12.6.1)
20. Rabi 2021–22 water planning (software: WAA Tool version 4.5.17) (Section 12.6.2)
21. Kharif 2022 water planning (software: WAA Tool version: 4.6.10) (Section 12.6.3)
22. Rabi 2022–23 water planning (software: WAA Tool version 4.6.10 (Section 12.6.4)
23. Three Capacity building workshops on pre-season water planning– November and December 2022 (Section 12.6.5)
24. Kharif 2023 pre-seasonal water planning, March 2023, held in Australia (Section 12.6.6).

Workshops 1-4 were held online.

Workshops 5 were held in Karachi, Islamabad and Lahore and were attended by a mix of very senior and next generation water professionals and researchers. In addition, the Sindh Provincial Irrigation Minister and Irrigation Department Secretary joined the Karachi workshop for part of the morning. IRSA staff ran parts of these meetings, presenting on the technical aspects of the process and how to use the Tool.

9.4.6 Conferences

25. Ministry of Water Resources workshop on National Water Policy, Islamabad, July 2022 (ref Kirby and Ahmad 2022b)
26. 2nd Pakistan Water Week, October 2022 (ref Ahmad 2022b)
27. International Congress on Modelling and Simulation (MODSIM2023), Darwin, Australia, July 2023 (refs Ahmad et al. 2023, Perraud et al. 2023)

10 Conclusions and recommendations

The ACIAR funding of this initiative supported the full adoption of the Tool and expanded the skillbase, both in the use of the Tool and in the principles and practice of water allocation planning in Pakistan more generally. More people understand the complete pre-season water allocation process (than restricted to only a few experts). The development of the Reference Manual and User Guide is also a valuable teaching aid for students and early career water professionals.

It allowed the project team to continue its engagement in Pakistan's water planning dialogue, providing a two-way learning and knowledge transfer bridge between both countries – imparting learnings from Australia's water reform journey on the importance of collaboration, co-design and genuine stakeholder engagement; and in exchange learnings from Pakistan on conducting Federal/provincial negotiations, and the benefits of having documented principles.

10.1 Conclusions

The project successfully achieved its objectives to consolidate the use of the WAA Tool in the seasonal planning process and, in so doing, increase the pool of people with deep knowledge of the analyses and rationales informing the current process.

The IBIS is a highly complex system and water allocation decisions are extremely important for national/provincial economies and livelihood of millions of farmers. Understanding how those water allocation decisions are made, and the data used to inform those decisions, sufficiently to be able to translate the process into software was an ambitious goal.

The Tool provides a 'common language' for discussing and debating the water allocation planning process – this proved important as it flushed out assumptions and presumptions and required participating actors to agree on the language used, and the meaning of terms. Encoding the steps in the WAA Tool provided a vehicle for doing and achieving this.

In addition to this, it was important that the Tool be neutral (i.e. all approaches treated equally and captured equally in the Tool). This not only avoided being prescriptive on the approach to adopt, it also allowed for quick and easy comparison of the outcomes from using the different implementation approaches used in Pakistan. This allowed all parties to better understand each other's approaches.

Learning evolved at all levels and was captured in minor updates to the pre-season water allocation planning WAA Tool during the life of the project. This was an iterative process – each technical session revealed more details of the intricacies of the allocation process and the Tool was revisited many times to ensure that nuances were not missed and that there was agreement before moving on. While this took time and was a slow and steady process, it provided opportunity and a relatively safe space to consider changes in allocation practices.

The SRA project provided the opportunity to devote attention to capacity building around the water allocation planning process itself; and the pre-season planning implementation in the Tool. It also provided the space to have discussions about features that needed more attention in the pre-season planning process (e.g. how best to deal with unaccounted gains and losses, and the quality and management of flow data) and to start the discussions on what happens mid-season and whether and how it might be incorporated into the WAA Tool.

In conclusion, having an agreed small number of tightly targeted activities allowed us to maintain important connections and momentum, and manage expectations as the Pakistani members of the team continued to build their internal collaborations, expertise

and knowledge base. The Pakistan water agencies are looking forward to working together to improve the pre-season planning WAA Tool and incorporate mid-season planning into it.

10.2 Recommendations

The collaborative and co-design approach adopted by the project team has worked well. Lessons include:

- **Consultation is critical**. Some key steps that the project team found worked well included: identify where you can help; form key collaborations; get high level buy-in; co-design activities; build relationships and capacity; demonstrate usefulness; and put maximum effort into adoption and endorsement.
- **Co-development and long-term engagements** are critical to develop trust and achieve desired outcomes.
- **Commitment** was required to respond to partners needs and requests – i.e. renegotiate contracted deliverables if they become out of step, reshape activities and timelines to maximise true partnering.
- **Be as flexible as possible in scheduling and planning of activities.** Water professionals are in demand within their organisations and have peak busy periods. Being aware of these constraints and looking for maximum efficiency and minimum disruption in terms of investment of their time and resources is well received and appreciated. This may require travelling at what may be considered inconvenient times to the project team.
- **Be adaptive**. Adopt an adaptive approach to changing priorities; perceived needs may differ from immediate needs; Keep it simple and focussed, responding to critical needs.
- **Be patient.** Some things take time, e.g. getting agreements to operate, building a trusted relationship, understanding the problem space, proving relevance and building capacity.

The pre-season planning WAA Tool is now embedded within Pakistani water agencies and there is a request to improve its implementation and extend it to include mid-season planning. To date, capacity building efforts have focussed on the planning process itself and how to use the Tool. Attention needs now to be given to building local expertise in maintenance of the code base and ultimately the skills to extend and update the Tool itself.

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11.2 List of publications produced by the project

Video animation

1. Schematic diagram of 10-day water allocation process showing how water is shared across the J-C and Indus systems. An animated version is available from https://youtu.be/9pK4LG2IYcc

Research reports

2. Ahmad MD, Yu Y, Cuddy SM, Perraud JM, Podger G, Freebairn A, Seaton S, Shah SMMA, Rana MKI, Khero ZI, Bodla H, Farooq M, Khan MA, Khan TA (2022a) Bringing transparency and consistency to Pakistan's seasonal water planning decisions: 1991 inter-provincial Water Apportionment Accord (WAA) Tool User Guide and Reference Manual. Second edition. CSIRO, Australia. 94 pages. https://doi.org/10.25919/2ren-4m80
3. Ahmad MD, Rana K, Akhtar MS, Anjum MA, Cuddy SM, Khan A, Khan MA, Khan TA, Khero ZI, Riaz M, Tatar ZR (2022b) Mid-season inter-provincial water allocation planning processes in Pakistan. Working paper. CSIRO, Australia. 14pp (submitted to ACIAR 23/12/2022)

Invited presentations

4. Ahmad MD (2022a) Supporting Inter-Provincial Water Allocation Decision Making in Pakistan (ACIAR SRA: WAC/2021/103). Australia-Pakistan Water MoU, Joint Advisory Committee (JAC) meeting, Ministry of Water Resources, Islamabad. 30 June 2022
5. Ahmad MD (2022b) Water Apportionment Accord (WAA) Tool providing transparency and consistency in water allocation planning. Invited presentation at Thematic Session 6: Is Transparency the Key to Resolve Interprovincial Water Disputes? The Role of Water-Energy-Food Ecosystem (WEFE) Nexus for a Climate Resilient Pakistan. *2nd Pakistan Water Week, International Conference - Serena Hotel, Islamabad.* Pakistan Water Week 24–28 October 2022
6. Ahmad MD (2022c) Water management in the Indus river basin: Challenges and opportunities for Pakistan. Guest lecture (online) at Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan. 6 April 2022
7. Kirby M, Ahmad MD (2022b) Pakistan Water Futures. Keynote presentation delivered at Ministry of Water Resources workshop on National Water Policy, 2018: Implementation framework, Government of Islamic Republic of Pakistan. 21 July 2022

Conference papers

8. Ahmad MD, Cuddy SM, Podger GM, Yu Y and Perraud J-M (2023) Water allocation planning in the Indus Basin Irrigation System in Pakistan: Using scientific tools to build trust between stakeholders. Paper and presentation at: MODSIM2023 international Modelling and Simulation Congress, 9–14 July 2023, Darwin, Australia. https://doi.org/10.36334/modsim.2023.ahmad252
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12 Appendixes

12.1 Appendix 1: Details of canal command in the IBIS

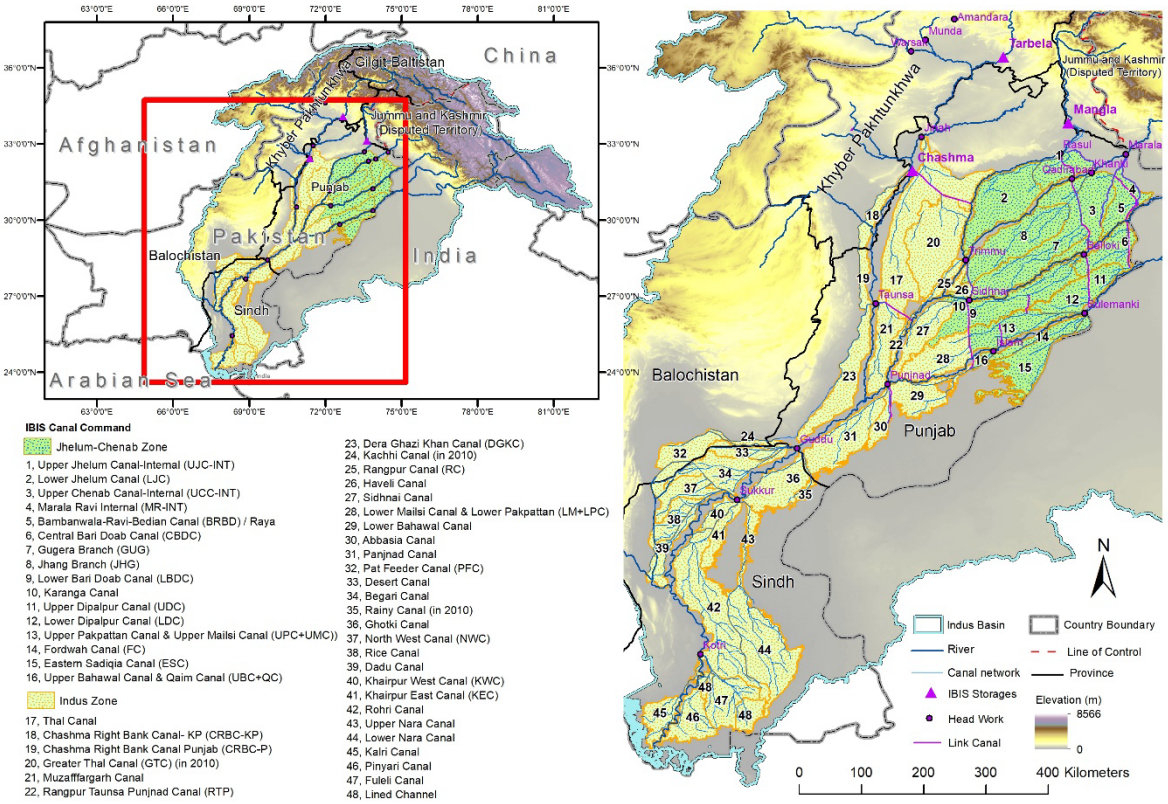


Figure 12.1 The main irrigated region of the Indus Basin Irrigation System (IBIS) in Pakistan, showing the major dams, link canals and the canal commands according to the IRSA management zones. Source: Ahmad et al. (2021)

12.2 Appendix 2: Water Apportionment Accord, extract from Government of Pakistan (1991)

APPORTIONMENT OF THE WATERS OF THE INDUS RIVER SYSTEM BETWEEN THE PROVINCES OF PAKISTAN

As a follow-up to the meeting of the Chief Ministers at Lahore on March 3, 1991, a meeting of the representatives of the four provinces was held at Lahore on March 04, 1991. Another meeting was held at Karachi on March 16, 1991. The list of participants is attached.

The participants agreed on the following points:–

1. There was an agreement that the issue relating to Apportionment of the Waters of the Indus River System should be settled as quickly as possible,

2. In the light of the accepted water distributional principles the following apportionment was agreed to:

(Fig. in MAF)

PROVINCE	KHARIF	RABI	TOTAL
PUNJAB	37.07	18.87	55.94
SINDH*	33.94	14.82	48.76
N.W.F.P. (a)	3.48	2.30	5.78
(b) CIVIL CANALS**	1.80	1.20	3.00
BALOCHISTAN	2.85	1.02	3.87
	77.34	37.01	114.35
	+	+	+
	1.80	1.20	3.00

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi.
** Unguaged CivilCanals above the rim stations.

1

3. N.W.F.P/Baluchistan Projects which are under execution have been provided their authorised quota of water as existing uses.

4. Balance river supplies (including flood supplies and future storages) shall be distributed as below:

Punjab	Sindh	Balochistan	NWFP	Total
37	37	12	14	100%

5. Industrial and Urban Water supplies for Metropolitan city, for which there were sanctioned allocations will be accorded priority.

6. The need for storages, wherever feasible on the Indus and other rivers was admitted and recognised by the participants for planned future agricultural development.

7. The need for certain minimum escapage to sea, below Kotri, to check sea instrusion was recognised. Sindh held the view, that the optimum level was 10 M.A.F., which was discussed at length, while other studies indicated lower/higher figures. It was, therefore, decided that further studies would be undertaken to establish the minimal escapage needs down stream Kotri.

8. There would be no restrictions on the Provinces to undertake new projects within their agreed shares.

9. No restrictions are placed on small schemes not exceeding 5000 acres above elevation of 1200 ft. SPD.

10. No restrictions are placed on developing irrigation uses in the Kurram/ Gomal/Kohat basins, so long as these do not adversely affect the existing uses on these rivers.

11. There are no restrictions on Baluchistan, to develop the water resources of the Indus right bank tributaries, flowing through its areas.

12. The requirements of LBOD will be met out of the flood supplies in accordance with the agreed sharing formula.

13. For the implementation of this accord, the need to establish an Indus River System Authority was recognised and accepted. It would have headquarters at Lahore and would have representation from all the four provinces.

14. a) The system-wise allocation will be worked out separately, on ten daily basis and will be attached with this agreement as part and parcel of it.

b) The record of actual average system uses for the period 1977-82, would form the guide line for developing a future regulation pattern. These ten daily uses would be adjusted pro-rata to correspond to the indicated seasonal allocations of the different canal systems and would form the basis for sharing shortages and surpluses on all Pakistan basis.

c) The existing reservoirs would be operated with priority for the irrigation uses of the Provinces.

d) The provinces will have the freedom within their allocations to modify system-wise and period-wise uses.

e) All efforts would be made to avoid wastages. Any surpluses may be used by another province, but this would not establish any rights to such uses.

C.M. Punjab
Ghulam Hyder Wyne

C.M. Sindh
Jam Sadiq Ali

C.M. NWFP
Mir Afzal Khan

C.M. Baluchistan
Mir Taj Mohammad Jamali

Shah Mehmood Qureshi
Minister Finance

Muzaffar Hussain
Minister Law

Mohsin Ali Khan
Minister Finance

Mir Zulfiqar Ali Magsi
Minister Home

Mazhar Ali
Adviser

Mohammad Ali Baloch
A.C.S (I&P)/Advisor

Khalid Aziz
A.C.S.(P & D)

Mohammad Amin
Secretary (I&P)

12.3 Appendix 3: Extracts from WAA Tool User Guide and Reference Manual (Ahmad et al. 2022a)

12.3.1 Executive Summary

EXECUTIVE SUMMARY

Pakistan manages the world's largest contiguous irrigation system, 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) in consultation with Water and Power Development Authority (WAPDA) and Provincial Irrigation Departments share the surface water resources of the IBIS between provinces. They distribute this resource for irrigation, urban, stock and domestic and industrial use as well as generating electricity as it travels through the system.

Broad principles on how the water resource is to be allocated is described in a 1991 Inter-Provincial Water Apportionment Accord. However, how these principles are interpreted and implemented is a detailed, complex process that is understood by only a few experts.

With an aim to capture this knowledge and in so doing provide a transparent, neutral and consistent process, CSIRO, through funding provided by the Australian Government, and in close collaboration with Pakistan water agencies, has developed the Water Apportionment Accord (WAA) Tool. This Tool replicates the 6 steps in the pre-season forecasting and subsequent 10-day allocation process of the IBIS (Figure 1) (canal command sharing is not included).

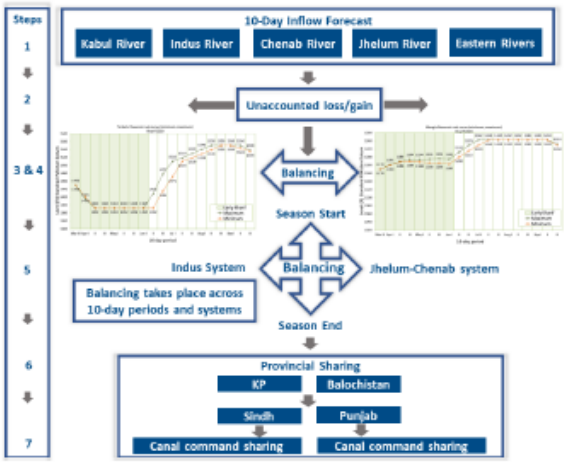


Figure 1 Schematic of the 6 steps in the water resource allocation process in the IBIS

A high-level description of these steps – forecasting inflows to the IBIS and unaccounted losses/gains (steps 1 and 2), setting reservoir level targets (steps 3 and 4), and then balancing resources between the Jhelum-Chenab and Indus system (Step 5) and balancing and sharing shortages between provinces (step 6) – is provided in Part I of this report; how those steps are implemented in the WAA Tool is described in Part II; and implementation methods (equations, etc) are detailed in Part III.

As would be expected, each of these steps is very complex, as are the dependencies between the steps. Capturing their essence in code (and in text as in this report) would not have been possible without the cooperation and collaboration of the Federal and Provincial water agencies. Building the Tool together has allowed for robust debate about the methods used and how they are implemented. As a result, the Tool includes multiple ways of implementing the steps, allowing for compare and contrast between the results from using different methods. The Tool now provides a 'user-friendly common language' for describing and modelling the water allocation process in the IBIS, supporting exploration and 'what-if' analyses.

The Tool was formally handed over to IRSA, WAPDA and Provincial Irrigation Departments on 8th December 2020 (with further improvements through to the date of this report). During the handover meeting, IRSA Chairman and Provincial Members, senior representatives of WAPDA, and Provincial Irrigation Departments, highlighted the importance of this Tool and described how its use had helped IRSA during Kharif 2020 and Rabi 2020–21 seasonal allocations.

They also identified the next steps required to sustain the investment: (1) consolidating and expanding the skill base (in using the Tool and in the details of the allocation process) through continued and more intensive training of a wider audience; and (2) expanding its use to capture the mid-season allocation planning process.

12.3.2 Forewords

Both Pakistan and Australia are countries with complex irrigation systems, operate under federated governance, and are grappling with climate change. These similarities have severed as the foundation for strong and productive cooperation on water management.

Since the 1980s our two countries have been sharing respective successes and lessons learned. The Australia-Pakistan Water Management Memorandum of Understanding provides a framework for collaboration. Various activities have been implemented through our development investments. These include the installation of flood warning systems in Gilgit Baltistan, and scholarships to talented conservationists. In addition, Australian Centre for International Agricultural Research (ACIAR) is helping farmers across Balochistan, Sindh and Punjab harness groundwater resources and increase crop yield by using technologies that monitor moisture and salinity.

In the face of unpredictable climate patterns, novel approaches are needed. It is more important than ever to convert research into technologies that can manage uncertainty. As Australia's own experience shows, balancing finite water between competing environmental, social and economic interests is not possible without evidence-based water allocation. Ultimately, we cannot manage what we do not measure. This is where Australia's premier scientific organisation, Commonwealth Scientific and Industrial Research Organisation (CSIRO), has been pivotal – at home and abroad.

Over the course of almost a decade, CSIRO has worked closely with federal and provincial water agencies in Pakistan. These efforts have resulted in the digitalisation of previously manually calculated water allocations. In particular, I am heartened to see the progression of the Water Apportionment Accord (WAA) Tool from its prototype stages, to a point where it has been handed over to the Pakistan Government and become the software of choice for seasonal water planning. This comprehensive report offers a single source of reference on the WAA Tool.

On behalf of the Australian Government, I congratulate the authors for their rigorous and impressive work. ACIAR and Department of Foreign Affairs and Trade (DFAT) have been pleased to support CSIRO in its endeavours in Pakistan.

Development assistance is only one facet of Australia's engagement in Pakistan. There is no limit to the partnerships that can form organically from knowledge exchange. So, let us all look for opportunities to continue the spirit of partnership on water management.

His Excellency, Bryce Hutchesson
Charge d'Affaires
Australian High Commission Pakistan
March 2022

Waters of the Indus System of rivers have been shared amongst the four provinces, in accordance with the water apportionment stipulated in the WAA-1991. The detailed processes involved in the distribution of the apportioned waters require precision, which is achieved through analytical and statistical techniques, manually adopted by IRSA and requiring a lot of time and effort. Para 2.9 of the National Water Policy, 2018 (NWP) envisages an upgradation of water sector information systems for improved asset management as well as evidence and data-driven decision-making. Similarly, Para 22.1 of the Policy calls for improvement in national information base by developing a national planning database to support an integrated information system, in order to enable the planning and development of water and other related resources on a sustainable basis. In view of the dicta of the Policy, Ministry of Water Resources took the initiative for establishing a collaborative engagement with the Australian Government, with a view to automate and simulate the seasonal planning process, along with the water forecast, determination of gains and losses to be used in water allocation and distribution, and the water allocation and distribution in the Indus River System. This was on the pattern of eWater Source modelling framework – Australia's national hydrological modelling platform. Water Wing of the Ministry of Water Resources facilitated joint stakeholder efforts for Commonwealth Scientific and Industrial Research Organization (CSIRO) to develop a keen understanding of the planning, operations and water distribution principles in the Indus Basin.

From many conversations over several planning sessions, the CSIRO distilled and documented the process and translated it using WRM and irrigation management concepts into mathematical formulations. An effort has been made to test and refine the process through detailed checking and cross-checking with the manual methods being used. While CSIRO has designed and then coded the Tool using modern software practices and interface style, they have respected our manual processes and preferences and tried, as far as possible, to replicate the way we do the planning and reporting of outcomes. The Tool even includes the ability to generate Rabi and Kharif Year Books, very similar to those produced manually. This joint and iterative collaboration between CSIRO and our water agency staff has been important because the automation of key parts of the seasonal water planning procedure has brought much-needed innovation and modernization to the planning process.

During March 2022, the Tool has facilitated IRSA in its seasonal water anticipation / forecasting to an extent that just the press of a button enables IRSA to explore different scenarios of water availability for its better understanding and, accordingly, its distribution and regulation, in accordance with the Water Apportionment Accord 1991. The Tool has not only provided IRSA with quick access to probable scenarios of water planning but has also improved the confidence, and trust amongst the federating units / stakeholders, in terms of the transparency of water availability and its regulation/distribution. In addition to the documentation of the process (included in this report), CSIRO has prepared extensive training material and run many on-the-job training workshops. This material can be useful for educational institutions in their training of the next generation of water professionals in Pakistan.

We are truly appreciative of the support of Australian Government, through its Department of Foreign Affairs and Trade (DFAT), CSIRO and now Australian Centre for International Agricultural Research (ACIAR), for their investment in this landmark initiative. In fact, this initiative would not have reached its result-oriented maturity had the above not supported it endlessly. We are also indebted to all the stakeholders who have contributed to the development and testing of the Tool. We are looking forward to continuing this work with CSIRO, Australian Government and ACIAR. We are pleased to be co-authors of this report.

Dr. Kazim Niaz
Secretary
Ministry of Water Resources

12.4 Appendix 4: Comparison of performance of WAA Tool with WAPDA and IRSA spreadsheets

(Extract from Appendix G, Ahmad et al. 2022a)

The WAA Tool probability tables were compared against WAPDA probability tables generated for multiple year and the difference was within 10 cu ft/sec.

Throughout the development of WAA Tool development, comparisons were also made against IRSA spreadsheets for 2 years 2019-20 and 2020-21.

For Kharif 2019 forecast, the calculation method for columns in the spreadsheets were verified for all 10-day periods. The summary of 10-day values was also compared against all published sheets and storage graphs (IRSA file: Final Criteria Kharif 2019.xls). The shortages between Indus and J-C system in the Basin report (Indus River System Authority, 2018[21]) and as calculated in the WAA Tool were equal.

The WAA tool performed **better at balancing shortfalls between Indus and J-C systems**. The Tool gets this balance exactly correct while the manual spreadsheet process balances within 1% (Figure G.1). The WAA Tool performed **better at equalising shortages across 10-day periods**. Where storage and inflows were sufficient, the WAA Tool gets 10-day shortages equal while the manual process varies by up to 8% (Figure G.1). The WAA tool did not equalise shortages in the September drawdown as this was not possible with the forecast inflows. It did ensure balancing of shortages between systems and achieved better equalisation between the second (II) and third (III) 10-day period in September.

Overall the Tool had less below Kotri flows and allocated slightly more water.

The WAA tool uses mathematical equations and optimisation techniques to ensure exact matches. Spreadsheet operators are constrained to doing this via a manual process which is difficult and laborious. This constrains the operators from achieving exact solutions.

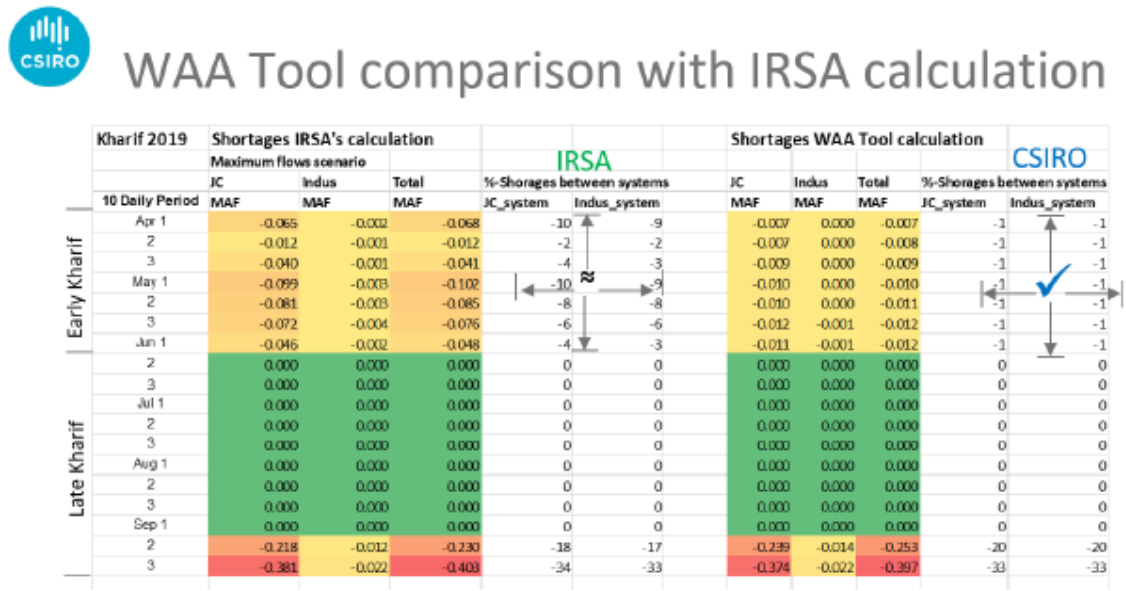


Figure G.1 Comparison of WAA Tool results with IRSA 2019 Kharif spreadsheet

[21] IRSA 2018. Anticipated Water Availability (Final) Kharif 2018. Annexure-I

A similar comparison was performed by IRSA for the WAA Tool Handover project using the WAA Tool for Kharif 2020 (Figure G.2) and Rabi 2020–21 seasonal water planning. For these seasons, Tools calculation were almost 0.8 MAF (1.2%) in Kharif and 0.20 MAF (1%) more than manual calculations, confirming Tool results are more equitable and efficient[22].

WAA- TOOL (CSIRO- Australia)

This letter is to advise that IRSA has calculated the forthcoming season Water Distribution Criteria by using the Water Apportionment Accord Tool WAA-Tool developed by CSIRO Australia in collaboration with MoWR, IRSA, WAPDA & Provincial Stakeholders. Recently the new version 4.1 of this tool was tested by CSIRO and IRSA and shared by CSIRO (https://www.dropbox.com/s/hctxonub2wk58jy/WAA_tool_V4.1_Pakistan.zip?dl=0) to all stakeholders for their evaluation.

2. It is notedthat while using the CSIRO WAA-Tool, larger and more equitable supplies can be distributed amongst the Provinces as the Tool is more efficient than manual calculations. The tool achieved this by replicating flow forecast probabilities at RIM stations and associated inflows, balancing between J-C and Indus zones on a 10-day basis while meeting various reservoir filling and emptyingcriteria. A comparison in this regard is providedbelow:-

Sr#	Provinces	IRSA Likely Kharif (MAF)			CSIRO TOOL Likely Kharif (MAF)			Difference		
		Early	Late	Total	Early	Late	Total	Early	Late	Total
1	Punjab	11.359	23.518	34.877	11.737	23.600	35.337	0.378	0.082	0.460
2	Sindh	7.418	24.516	31.934	7.681	24.594	32.275	0.263	0.078	0.341
	Total	18.777	48.034	66.811	19.418	48.194	67.612	0.641	0.160	0.801

3. Approximately 0.8 Million Acre Feet (MAF) more water can be distributed between stakeholders, wherebyadditional 0.46 MAF & 0.341 MAF would be respectively available for Punjab and

is a crucial period for the sowing of Kharif Crops in the Provinces. There will be associated benefits in agricultural production.

4. In this regard the calculation methodology used to arrive at the above calculations are also appended for your review.

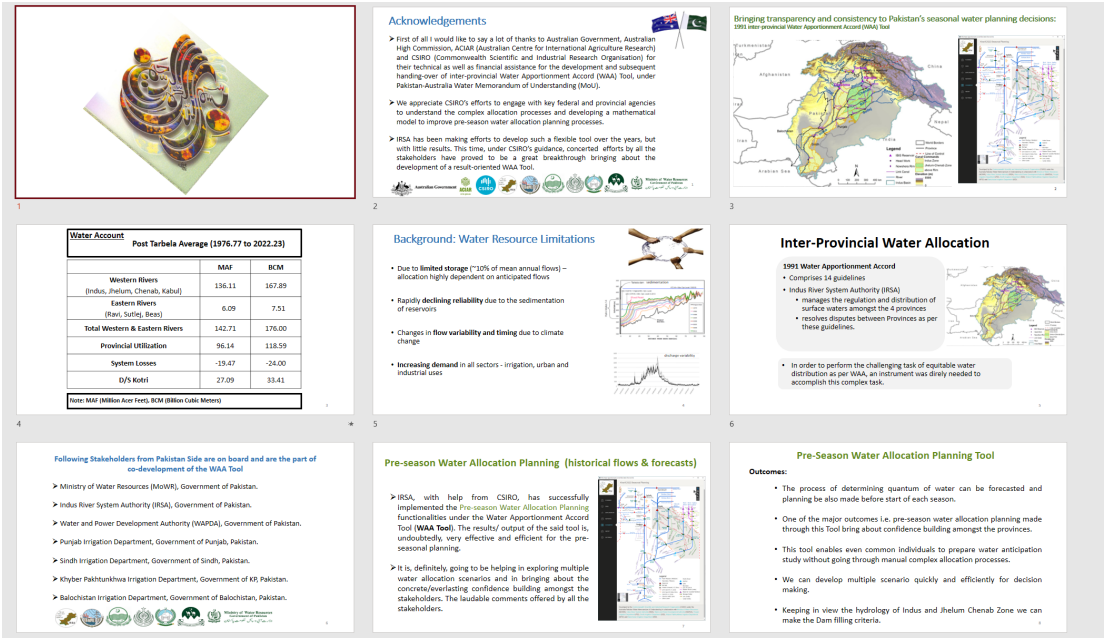
5. It is therefore requested that you kindly review the Tool and the attached sheets and submit your comments in this regard, if any. In recognition of the transparent & efficient distribution of water by the tool IRSA may adopt the Water Distribution Criteria as developed by using WAA-Tool (CSIRO) for Kharif 2020

Figure G.2 Comparison of WAA Tool results with IRSA 2020 Kharif manual spreadsheet calculation (extract from IRSA Letter No: CE(O)/IRSA/299/2124-34 – dated 31 March 2020)

[22] https://nation.com.pk/09-Dec-2020/waa-tool-formally-handed-over-to-irsa

12.5 Appendix 5: Presentation highlights

12.5.1 IRSA's presentation to Australian Head of Mission – June 2023



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Water Account Post Tarbela Average (1976.77 to 2022.23)		
	MAF	BCM
Western Rivers (Indus, Jhelum, Chenab, Kabul)	136.11	167.89
Eastern Rivers (Ravi, Sutlej, Beas)	6.09	7.51
Total Western & Eastern Rivers	142.71	176.00
Provincial Utilization	96.14	118.59
System Losses	-19.47	-24.00
D/S Kotri	27.09	33.41

Note: MAF (Million Acer Feet), BCM (Billion Cubic Meters)

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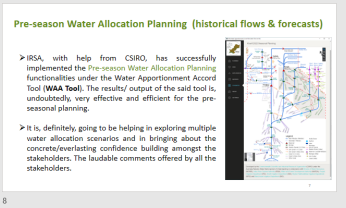

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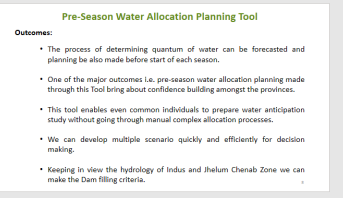

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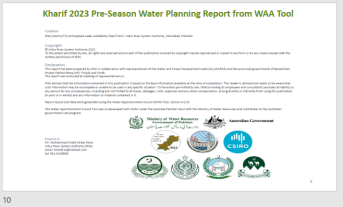

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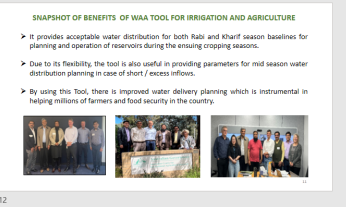

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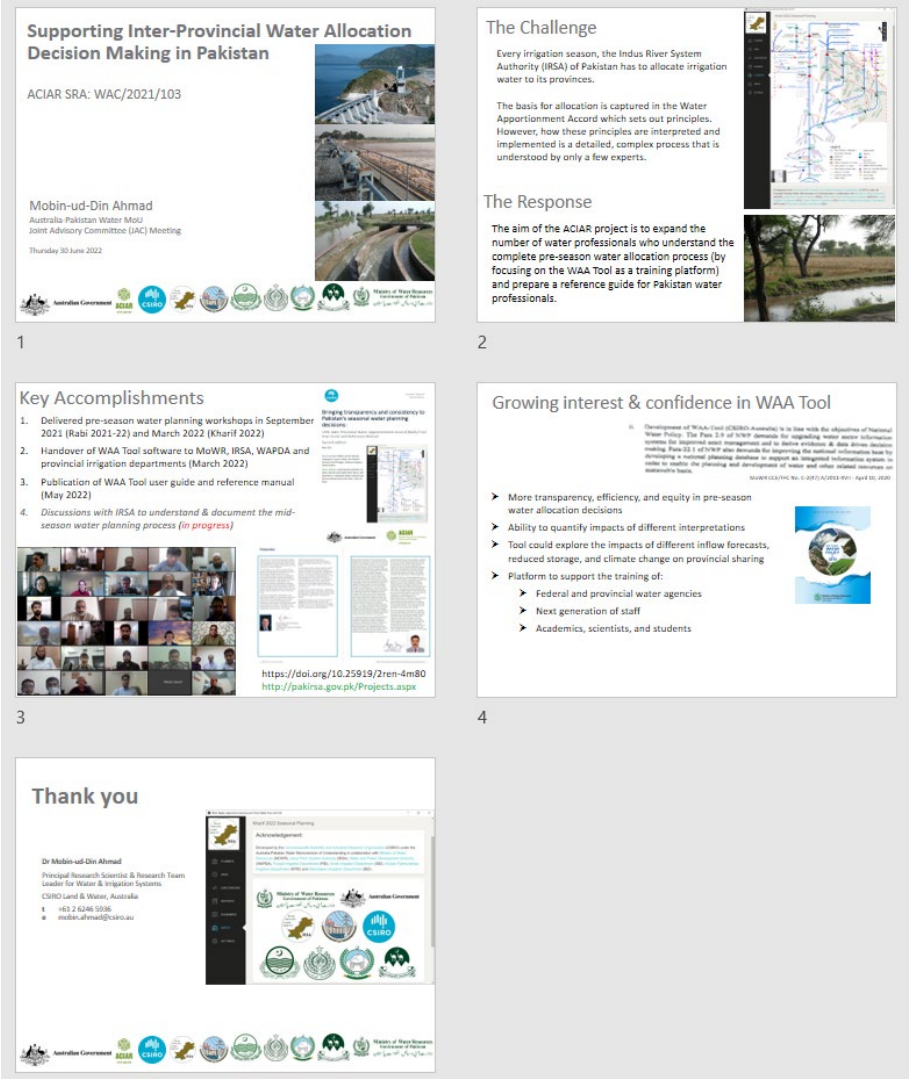
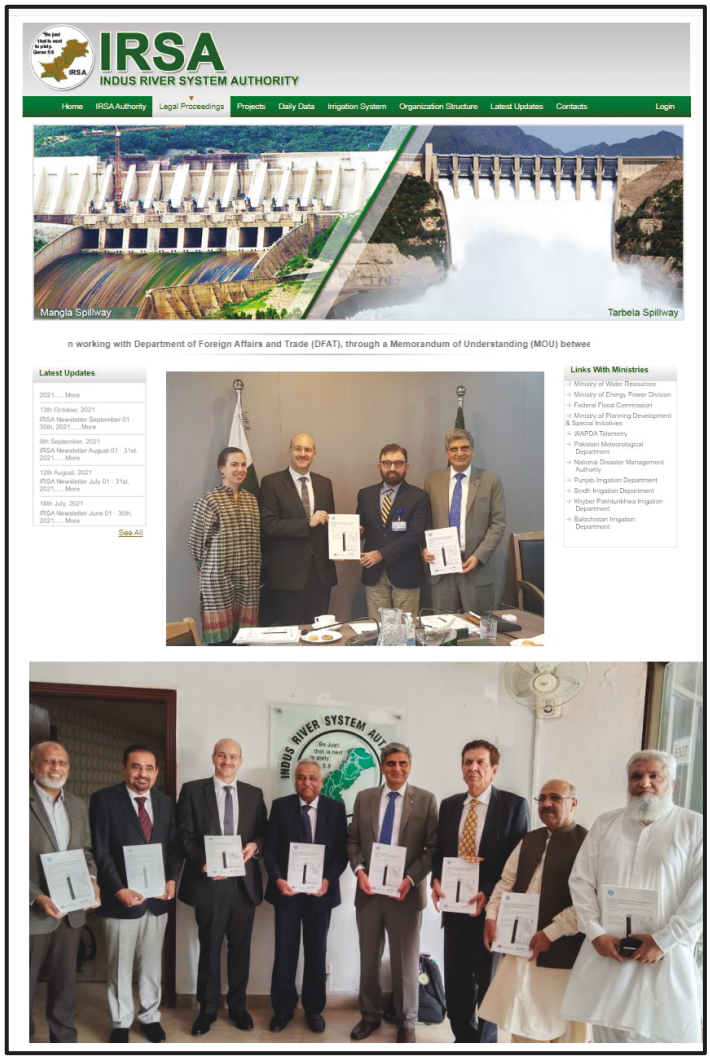
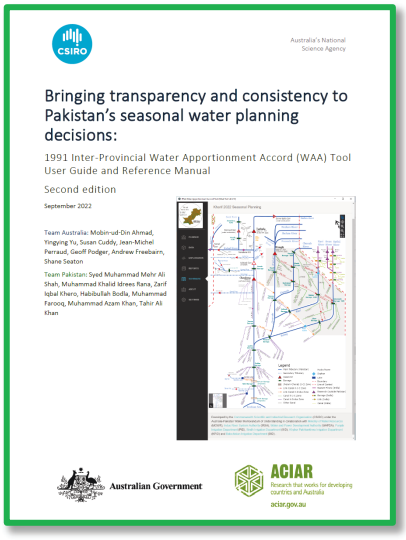
12.5.2 Australia-Pakistan Joint Advisory Committee meeting, 30 June 2022



12.5.3 Launch of WAA Tool report (with forewords from HOM-AHC and Secretary MoWR) September 2022





https://doi.org/10.25919/2ren-4m80

http://pakirsa.gov.pk/Projects.aspx

12.6 Appendix 6: Workshop highlights

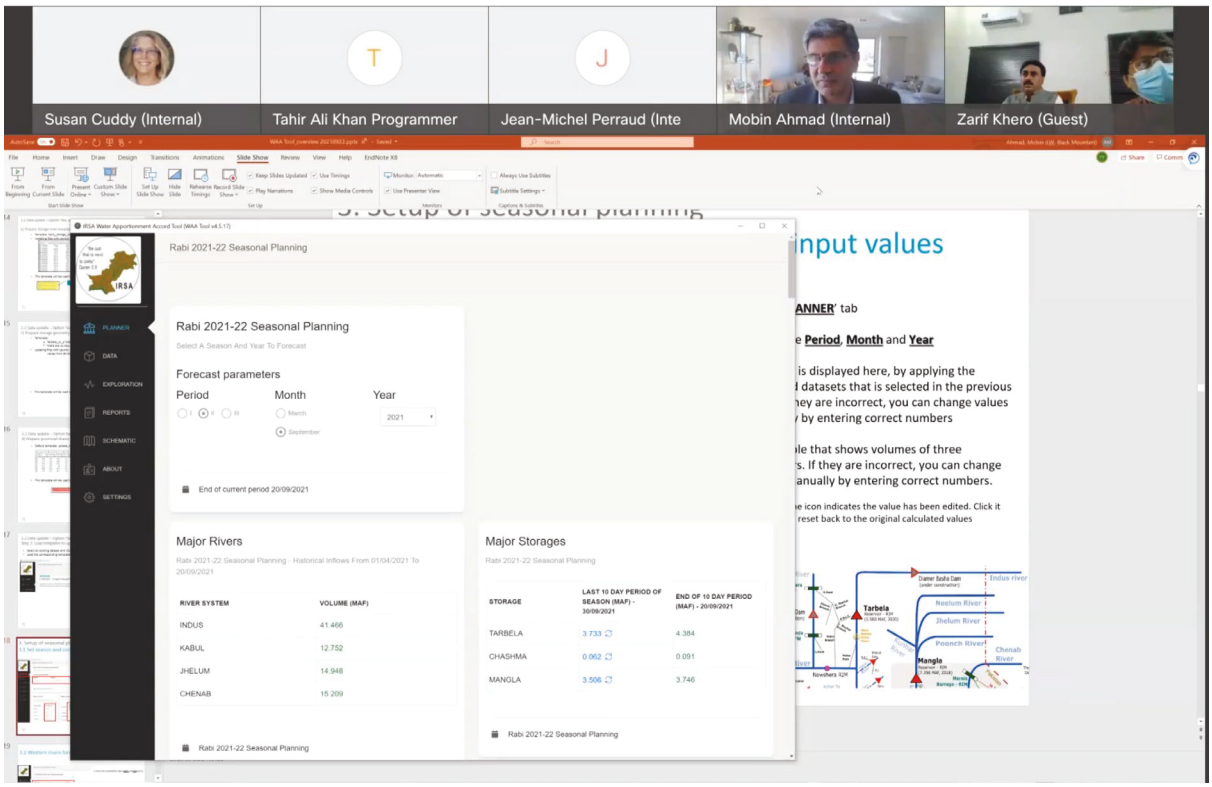
12.6.1 Kharif 2021 water planning (software: WAA Tool version 4.3.0)

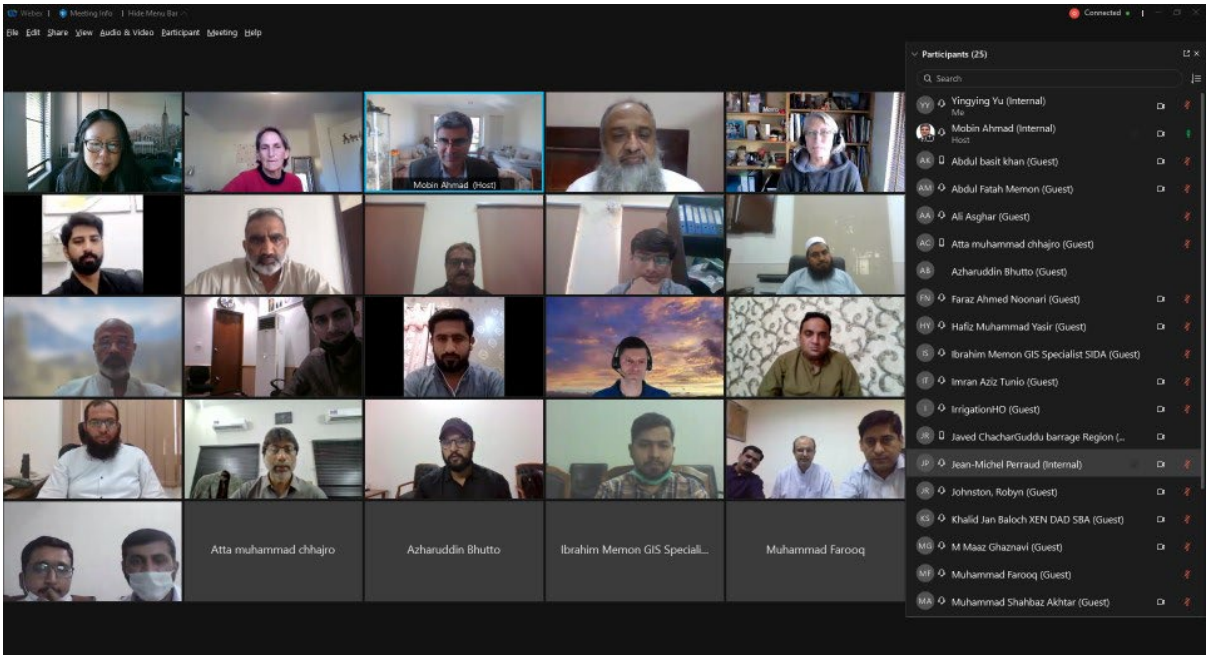
During the contract negotiation period, to ensure the continuity of engagements, CSIRO (Mobin Ahmad) conducted a series of informal (separate) skype training sessions for WAPDA (Muhammad Farooq), Sindh Irrigation Department (Zarif Khero) and IRSA (Tahir Ali Khan, Azam Khan and Khalid Rana) in March 2021

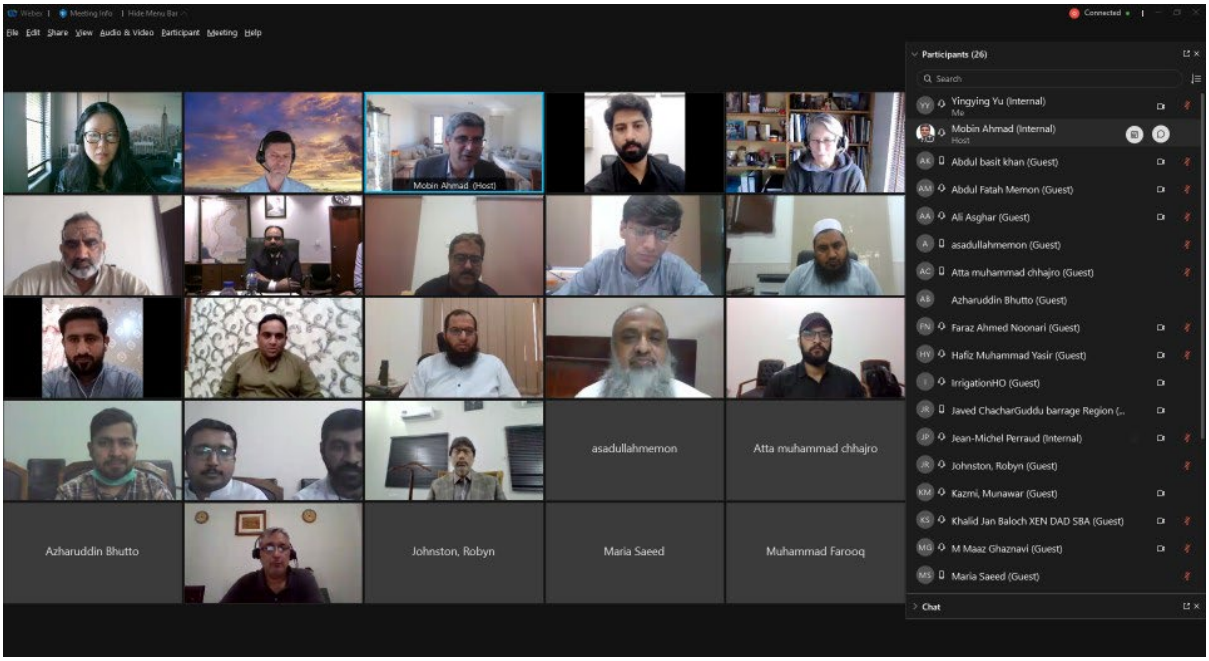
12.6.2 Rabi 2021–22 water planning (software: WAA Tool version 4.5.17)

A formal (online) training workshop was arranged, and was attended by ~30 participants from key federal (IRSA, WAPDA) and provincial (SID, PID and KPID) water agencies. The Minister and Secretary Sindh Irrigation departments attended part of this workshop.

LinkedIn post: https://www.linkedin.com/posts/mobin-ud-din-ahmad-b160a712_rabi-2021-22-training-workshop-activity-6857192968827338752-ZfAl?utm_source=share&utm_medium=member_desktop




Participants (25)
Search
Yingying Yu (Internal)
Mobin Ahmad (Internal)
Abdul basit khan (Guest)
Abdul Fatah Memon (Guest)
Ali Asghar (Guest)
Atta muhammad chhajro (Guest)
Azharuddin Bhutto (Guest)
Faraz Ahmed Noonari (Guest)
Hafiz Muhammad Yasir (Guest)
Ibrahim Memon GIS Specialist SIDA (Guest)
Imran Aziz Tunio (Guest)
IrrigationHO (Guest)
Javed ChacharGuddu barrage Region (...
Jean-Michel Perraud (Internal)
Johnston, Robyn (Guest)
Khalid Jan Baloch XEN DAD SBA (Guest)
M Maaz Ghaznavi (Guest)
Muhammad Farooq (Guest)
Muhammad Shahbaz Akhtar (Guest)
Mobin Ahmad (Host)
Atta muhammad chhajro
Azharuddin Bhutto
Ibrahim Memon GIS Speciali...
Muhammad Farooq


Participants (26)
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Yingying Yu (Internal)
Mobin Ahmad (Internal)
Abdul basit khan (Guest)
Abdul Fatah Memon (Guest)
Ali Asghar (Guest)
asadullahmemon (Guest)
Atta muhammad chhajro (Guest)
Azharuddin Bhutto (Guest)
Faraz Ahmed Noonari (Guest)
Hafiz Muhammad Yasir (Guest)
IrrigationHO (Guest)
Javed ChacharGuddu barrage Region (...
Jean-Michel Perraud (Internal)
Johnston, Robyn (Guest)
Kazmi, Munawar (Guest)
Khalid Jan Baloch XEN DAD SBA (Guest)
M Maaz Ghaznavi (Guest)
Maria Saeed (Guest)
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Mobin Ahmad (Host)
asadullahmemon
Atta muhammad chhajro
Azharuddin Bhutto
Johnston, Robyn
Maria Saeed
Muhammad Farooq

12.6.3 Kharif 2022 water planning (software: WAA Tool version: 4.6.10)

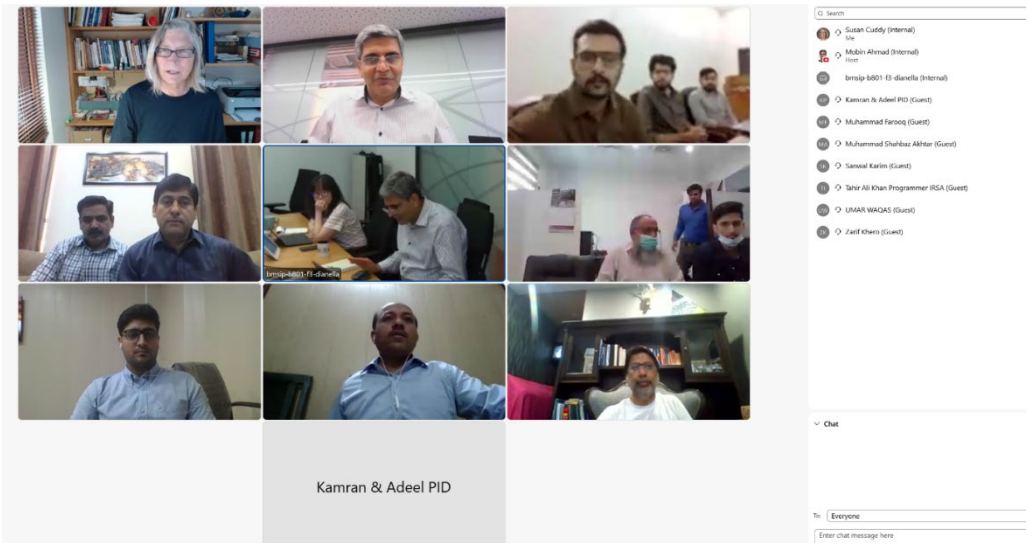
Training sessions

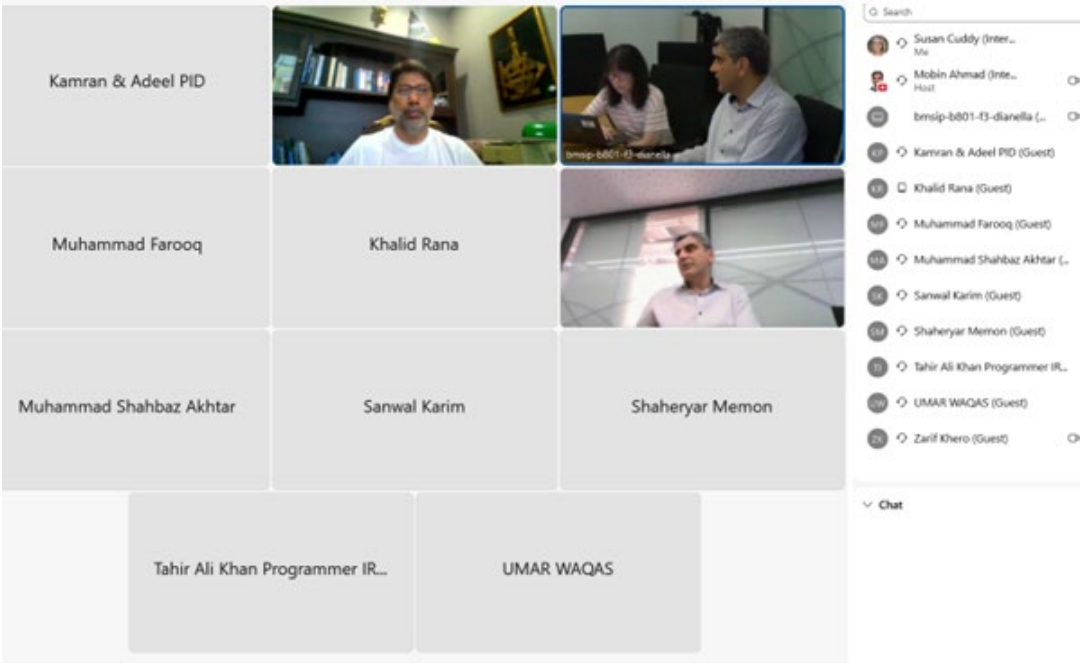
I. Session for IRSA, WAPDA, SID and PID on 21 March 2022

Despite unexpected public holidays in Islamabad (announced on Friday 18th March 2022), this workshop was attended by about 14 officials from (IRSA, WAPDA, SID, and PID), including IRSA Director Operations, SID Chief Engineer, and Director Regulation). During the workshop session, we noted that everyone had a good grip of the Tool, and we worked through (hands-on) exploring different pre-seasonal water planning steps (storage filling and release targets, sharing arrangements, safety criteria, etc). All participants expressed their approval of the Tool, their gratitude to the Australian government, and acknowledged the role that the Tool is playing in supporting their pre-seasonal water allocation decision-making processes.

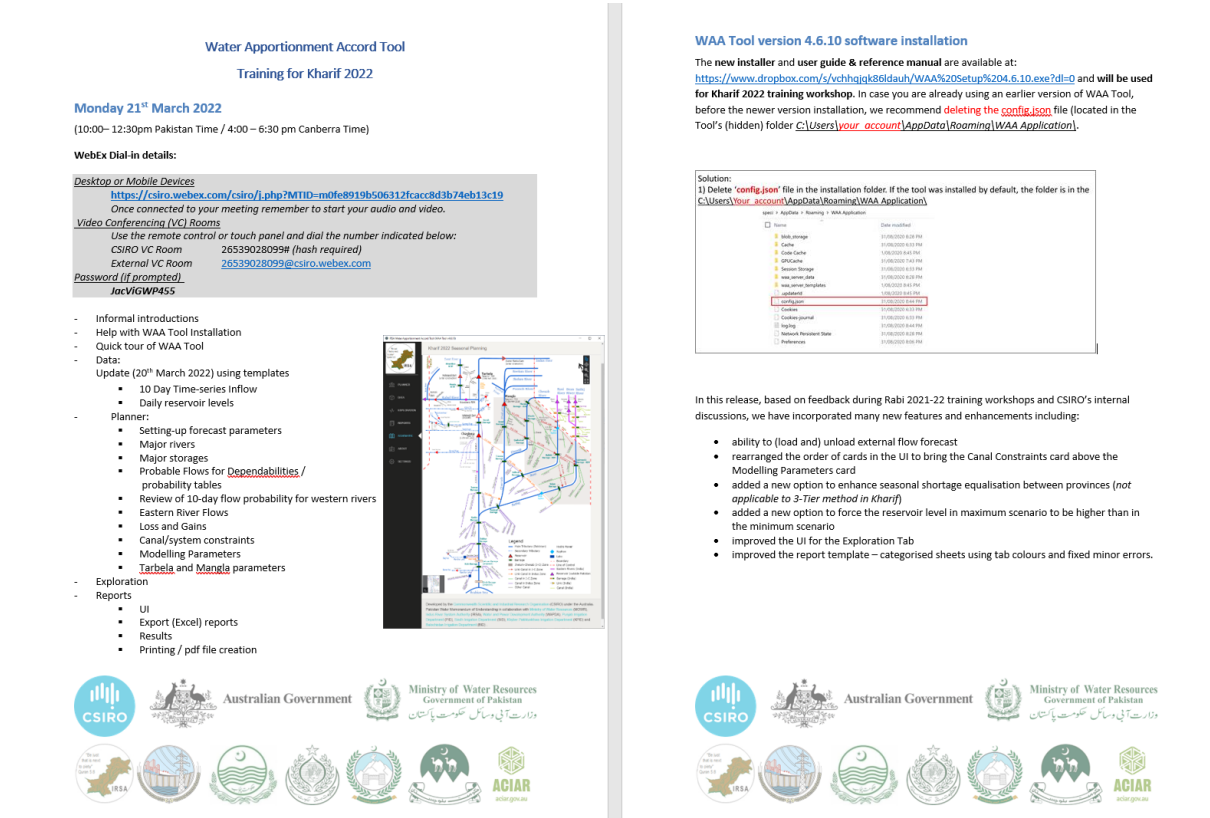
II. Session for KPID on 22 March 2022 (as KPID colleague was unable to join 21 March 2022 session)

III. Session for Joint (JS) Secretary MoWR on Sunday 17 April 2022 (as specifically requested by the JS MoWR)





Training material



Water Apportionment Accord Tool

Training for Kharif 2022

Monday 21st March 2022

(10:00– 12:30pm Pakistan Time / 4:00 – 6:30 pm Canberra Time)

WebEx Dial-in details:

Desktop or Mobile Devices
https://csiro.webex.com/csiro/j.php?MTID=m0fe8919b506312fcacc8d3b74eb13c19
Once connected to your meeting remember to start your audio and video.
Video Conferencing (VC) Rooms
Use the remote control or touch panel and dial the number indicated below:
CSIRO VC Room 26539028099# *(hash required)*
External VC Room 26539028099@csiro.webex.com
Password (if prompted)
JacViGWP455

- Informal introductions
- Help with WAA Tool Installation
- Quick tour of WAA Tool
- Data:
  Update (20th March 2022) using templates
  - 10 Day Time-series Inflow
  - Daily reservoir levels
- Planner:
  - Setting-up forecast parameters
  - Major rivers
  - Major storages
  - Probable Flows for Dependabilities / probability tables
  - Review of 10-day flow probability for western rivers
  - Eastern River Flows
  - Loss and Gains
  - Canal/system constraints
  - Modelling Parameters
  - Tarbela and Mangla parameters
- Exploration
- Reports
  - UI
  - Export (Excel) reports
  - Results
  - Printing / pdf file creation

Australian Government

Ministry of Water Resources Government of Pakistan

وزارت آبی وسائل حکومت پاکستان

ACIAR

WAA Tool version 4.6.10 software installation

The **new installer** and **user guide & reference manual** are available at:
https://www.dropbox.com/s/vchhqjqk86ldauh/WAA%20Setup%204.6.10.exe?dl=0 and **will be used for Kharif 2022 training workshop**. In case you are already using an earlier version of WAA Tool, before the newer version installation, we recommend deleting the config.json file (located in the Tool's (hidden) folder C:\Users*your_account*\AppData\Roaming\WAA Application\).

Solution:
1) Delete '**config.json**' file in the installation folder. If the tool was installed by default, the folder is in the C:\Users\Your_account\AppData\Roaming\WAA Application\

In this release, based on feedback during Rabi 2021-22 training workshops and CSIRO's internal discussions, we have incorporated many new features and enhancements including:

- ability to (load and) unload external flow forecast
- rearranged the order of cards in the UI to bring the Canal Constraints card above the Modelling Parameters card
- added a new option to enhance seasonal shortage equalisation between provinces (*not applicable to 3-Tier method in Kharif*)
- added a new option to force the reservoir level in maximum scenario to be higher than in the minimum scenario
- improved the UI for the Exploration Tab
- improved the report template – categorised sheets using tab colours and fixed minor errors.

12.6.4 Rabi 2022–23 water planning (software: WAA Tool version 4.6.10

Informal sessions were arranged as per request from IRSA, WAPDA and Sindh irrigation departments [no formal training was organised because of major flooding in Pakistan].

12.6.5 Capacity building workshops on pre-season water planning– November and December 2022

Sessions

Training on the use of the Tool for Kharif and Rabi planning was conducted for key federal and provincial water agencies and universities in Karachi, Islamabad and Lahore:

IV. Karachi workshop: 24 participants from IRSA, SID, BID, Mehran University of Engineering and Technology
V. Islamabad workshop: 8 participants IRSA, KPID, PCRWR
VI. Lahore workshop: 16 participants IRSA, WAPDA, PID

IRSA Press release December 2022

Press Release
Indus River System Authority (IRSA)
Training Workshops on Water Apportionment Accord (WAA) Tool

IRSA HQs, Islamabad, the 10th of December, 2022

Pakistan operates the world's largest continuous irrigation system, the Indus Basin Irrigation System (IBIS), which supports food production and produces cheap hydel energy for the domestic and industrial supply. IBIS spans all the 4 provinces of Pakistan. The River Indus catchment area (about 1,165,000 Km^2) falls in 4 countries, including: Pakistan; India; Afghanistan and China. This system, which is under increasing pressure from population growth and climate change, provides water, energy and food security for the whole nation. Since 1993, water resources of the Indus River System are being shared among four provinces of Pakistan according to the Water Apportionment Accord (WAA) 1991 by the Indus River System Authority (IRSA). The WAA 1991 describes the broad water-sharing principles but not the precise mechanism / steps of how these principles are to be executed. There are 6 distinct steps in the water allocation process which are performed in a systematic and orderly manner. The process is a complex set of procedures which takes considerable time and person hours to fully accomplish at the start of each cropping season. For different scenarios, the process is oftenly repeated adding even much more time and efforts on the part of IRSA technical personnel. Although common computer software like MS Excel is used as a tool to carry out the different steps but the whole process is disjointed and not automated.

2. Through a joint collaborative historic effort - conducted under the Australia-Pakistan Memorandum of Understanding (MoU) on water management - by Pakistani and Australian Governments through the Pakistan Ministry of Water Resources (MoWR), IRSA, WAPDA, Provincial Irrigation Departments (PIDs) and Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Water Apportionment Accord (WAA) Tool was developed over a 4-year period from 2018 to 2022. The pre-season planning prototype was developed into the WAA Tool in 2020 with financial support from the Government of Australia through its Australian High Commission in Islamabad and CSIRO. The recent improvements and documentation were supported through a small research and development activity by the Australian Centre for International Agricultural Research (ACIAR). The basic aims of the software Tool are to: -

- capture undocumented pre-season planning procedures in a repeatable process;
- provide transparency and consistency in seasonal water allocation planning processes;
- enable more equitable and efficient sharing of water resources;
- provide capability to explore alternate system operational scenarios / rules.

3. The Tool has been in operation since December 2020 by the stakeholders in Pakistan, being the Tool of choice, and have been actively employed to aid in informed decision making for advance seasonal planning, operation of reservoir and river network and distribution of the water resources of the Indus River System between the provinces as per policies of WAA 1991. Before its formal operationalization, the Tool was successfully tested and used for Kharif 2020 and Rabi 2020-21 pre-season planning. Tool assessments matched almost exactly with the assessments of IRSA with more accurate assessment of provincial shares.

4. The Tool captures the complete 10-day pre-season allocation processes as implemented by IRSA. The Tool forecasts Rim-Station inflows, accounts for losses / gains in the Jhelum-Chenab and Indus Zones based on the previous years reported data and decisions taken by Advisory

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Committee, operates the reservoirs on set rules, allocates shares to the provinces using different sharing options and allows for any excess water to be released downstream of Kotri Barrage. It follows the same statistical and analytical techniques as manually adopted by IRSA. The Tool also allows for the use of externally prepared flow forecasts for any/all of the Rim-Stations. With this ease of fast computing, the Tool has the capacity to calculate and present different system operational scenarios, which previously consumed considerable effort and time.

5. During the utilization of the software Tool, IRSA and the stakeholders identified the next steps required to sustain the investment: (1) consolidating and expanding the skill base (in using the Tool and in the details of the allocation process) through continued and more intensive training of a wider audience; and (2) expanding its use to capture the mid-season allocation planning process.

6. The Tool has been designed to run at start of Kharif and Rabi seasons for advance system planning by inputting the actual hydrological parameters ending March or September. However, during actual operation of the system, it is often required to revise the system operational parameters due to changed inflows, storages, demands, etc. This is known as Mid-Seasonal review of IRSA which is regularly carried out during the season if forecasted parameters differ significantly as compared to actual ones. CSIRO held separate meetings with SID, IRSA and PID to understand how they are doing mid-season planning, to assist with a future possible project development on this aspect.

7. Due to the importance of the training component, CSIRO Experts, namely, Dr. Mobin-ud-Din Ahmad as Team Leader and Ms Susan Cuddy as Senior Scientist, along with assistance rendered by technical personnel of IRSA, conducted a series of technical training workshops from 29th November to 8th December 2022. The first workshop was conducted for the lower riparian stakeholders of Sindh and Balochistan at Karachi on 29th and 30th November 2022, attended by concerned technical personnel of Sindh and Balochistan Irrigation Departments and Mehran University of Engineering and Technology (MUET). CSIRO Experts very much appreciated the enthusiasm and proactive interest of the lower riparian stakeholders, especially Sindh Irrigation Department (SID), during the Tool development period and the training sessions also. The attendees were initially introduced to the basic objectives and later run through the different system planning steps of the Tool in an interactive hands-on practice session with open discussion and queries in-between and afterwards.

8. In the second training workshop on 5th December at IRSA HQ Islamabad, technical personnel of IRSA, Khyber Pakhtunkhwa Irrigation Department (KPID) and Pakistan Council of Research in Water Resources (PCRWR) were likewise informed about the different aspects of the Tool and trained with hands-on practice lessons. CSIRO Experts said that the cooperation and technical advice rendered by the IRSA Members and Operation Section personnel during the development phase was indeed commendable and pivotal for comprehension of the complex system operational steps and procedures, which were then translated and coded into the Tool for efficient and time-saving automated operations.

9. On the next day on 6th December, 2022, the CSIRO Team formally met with IRSA Members and technical personnel to discuss about IRSA's proposed improvements in the Tool. CSIRO Experts also briefed the Authority about the progress and positive outcome of the on-going training workshops.

10. All IRSA Members appreciated the effort and collaboration of CSIRO through the Australian Government with the Pakistani stakeholders during the development of the software Tool and stressed upon the need to improve it as per realistic requirements of the users to make it more adaptable and robust to the system operational requirements of IRSA. They said that as water distribution is a very critical and sensitive issue, the introduction of a common analytical and

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presentation framework, in the form of the latest version of the WAA Tool, enables greater clarity and transparency in the complex water planning processes and promotes inter-provincial harmony. Chief Engineering Advisor MoWR informed that effective implementation of the WAA 1991 was a major objective of the National Water Policy (NWP) 2018 and the inducting of the Tool to aid in regular system operations is an important step towards achieving the said NWP 2018 objective. It was also unanimously agreed that for the continued development / updating of the Tool, a local scientific software engineer would be preferable. In order to support CSIRO in further development of the Tool, ways and means would be explored and identified by MoWR, IRSA and CSIRO, including identification and engagement of interested local and international donors for financial assistance of CSIRO. To discuss the prospective developmental aspects of the Tool and other related matters, the CSIRO Experts met with Mr. Hasan Nasir Jamy, Secretary MoWR, and Mr. Syed Muhammad Mehar Ali Shah, Joint Secretary MoWR, on the same day in a conducive and cooperative environment. During this meeting, to further enhance consistency and transparency in water allocation planning, CSIRO Experts recommended a greater focus on improving river flow data for better accounting of loss/gain assessment. One improvement would be through automating river flow and withdrawals data collection at key gauging locations, including the possibility of establishment of a new gauging station at or near the border of Punjab and Sindh provinces with the consent of stakeholders.

11. The third and last training workshop was conducted in Lahore on 8th December for Punjab Irrigation Department (PID) and WAPDA. It was encouraging that senior officials from WAPDA and IRSA Members and IRSA Director Operations attended the workshop. Training at this workshop was largely conducted by IRSA personnel, with support from CSIRO Experts.

First Training workshop in Karachi, Nov 29-30, 2022.

CSIRO Expert with Sindh Provincial Irrigation Minister, Secretary and Chief Engineer of Sindh Irrigation Department during the first training workshop, Nov 29-30, 2022 at Karachi.

Second Training workshop at IRSA HQs, Islamabad on Dec 5, 2022

Dr. Mobin-ud-Din Ahmad, Team Leader CSIRO imparting training at IRSA HQs, Islamabad on Dec 5, 2022

Group Photo of CSIRO Experts with IRSA Members and technical personnel on Dec 6, 2022 at IRSA HQs, Islamabad

CSIRO Experts meeting IRSA Members on Dec 6, 2022 at IRSA HQs, Islamabad.

The 3rd and last training workshop on Dec 8, 2022 in Lahore.

Group Photo of Third Training workshop participants in Lahore on Dec 8, 2022

END.

12.6.6 Kharif 2023 pre-seasonal water planning, March 2023, held in Australia

- Informal guidance to IRSA, Punjab and WAPDA on Kharif 2023 planning.
- Arranged meeting with Murray-Darling Basin Authority to share stories of Basin planning and approaches
- Discussed what changes are required to the existing pre-season planning implementation in the WAA Tool to support mid-season planning implementation
- Develop of standalone WAA Tool scenario comparison tool to provide for easy check of differences in inputs and outputs

Invited participation to IRSA technical committee meeting 24 March 2023

INDUS RIVER SYSTEM AUTHORITY

Government of Pakistan
35-Mauve Area, G-10/4
Islamabad

Tel: 051-9108022
Fax: 051-9108007

No: IRSA/CE(O)/108/1729-38
Dated: March 21, 2023

Through UMS/ Fax

1. **The Director (IWT&R)**
Irrigation Department
Government of the Punjab
Lahore.

2. **The Director (Regulation)**
Irrigation Department
Government of Sindh
Karachi.

3. **The Director**
Design & Hydrology / S.E (HQs)
Irrigation & Power Department
Government of KP
Peshawar.

4. **Superintending Engineer**
Pat feeder Canal & Drainage
Circle, Dera Murad Jamali
Government of Balochistan
DMJ Balochistan.

5. **The Chief Engineer (H&WM)**
WAPDA, Wapda House, Lahore.

Subject: **IRSA TECHNICAL COMMITTEE MEETING TO BE HELD ON MARCH 24, 2023 (FRIDAY) FOR KHARIF SEASON 2023**

I am directed to state that IRSA Technical Committee meeting (Physical & Online) will be held on **March 24, 2023 (Friday)** at **10:30 Hrs**, under the Chairmanship of Director (Operation) IRSA, in the Committee Room of IRSA HQs, 35-Mauve Area, G-10/4, Islamabad. The agenda of the meeting shall be as follows:-

i. Finalization of the draft Anticipated Water Availability for Kharif 2023 for the IRSA Advisory Committee;
ii. Any other item with the permission of the Chair.

2. The draft Anticipated Criteria for Kharif Season 2023 will be worked out/developed by using the Water Apportionment Accord (WAA) Tool prepared by CSIRO in collaboration with IRSA, WAPDA & all Stakeholders. The IRSA's Working Paper will be distributed in the meeting.

3. You are requested to kindly attend the meeting personally or online. For online details and technical assistance regarding WAA Tool kindly contact **Mr. Tahir Ali Khan, Programmer, IRSA Contact # 0345-5142845.**

21/03/2023
(Jalil Ahmed Soomro)
Senior Engineer (Operation), IRSA

Copy for information:
1. Chairman / All IRSA Members, Islamabad.
2. Dr. Mobin-ud-Din Ahmed, Principal Research Scientist, CSIRO, Project Leader, Canberra, Australia.
3. Mr. Zeeshan Riaz Tarar, Programmer IRSA, Islamabad *(to record minutes of meeting)*
4. Mr. Tahir Ali Khan, Programmer, IRSA, Islamabad.
5. Caretaker, IRSA, Islamabad *(for necessary arrangements)*
6. P.A to Director (Operation), IRSA, Islamabad.