

CO-CREATING A REMOTE SENSING–BASED DIGITAL TOOL FOR IRRIGATION PERFORMANCE MONITORING: THE CASE OF THE OFFICE DU NIGER IN MALI

CO-CRÉATION D'UN OUTIL NUMÉRIQUE BASÉ SUR LA TÉLÉDÉTECTION POUR LE SUIVI DES PERFORMANCES D'IRRIGATION : LE CAS DE L'OFFICE DU NIGER AU MALI

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ABSTRACT

Irrigation authorities in the Sahel are under growing pressure to do more with less water, yet most operational monitoring systems remain volumetric and report agricultural performance only indirectly. The Office du Niger (ON) in Mali manages one of West Africa's largest irrigation schemes, equipping approximately 142,000 ha of smallholder rice and private sugar production. Its existing system monitors irrigation deliveries but does not relate this directly to crop yields and actual water demands, while field data collection is increasingly constrained by security conditions. This paper describes the co-creation of IPON (Irrigation Performante de l'Office du Niger), a remote sensing–based digital tool co-created by the Office du Niger, the International Water Management Institute and eLEAF between 2021 and 2025. Rather than delivering a pre-built product, the partners invested in a structured listening phase: information needs at various management levels were diagnosed against existing reporting workflows, and irrigation performance indicators were selected with end-users. IPON combines Water Productivity through Open access of Remotely sensed derived data (WaPOR) layers on actual and reference evapotranspiration, net primary production, and rainfall with measured irrigation deliveries to compute eleven irrigation performance indicators at the zones and tertiary scales from 2018 onwards, presented through a Tableau Public dashboard maintained by ON staff. The paper documents the indicators against the information needs they address, and the co-creation steps that secured institutional ownership. An independent post-launch evaluation surveying thirteen ON technical staff found that all respondents had used IPON and 61.5% judged that it fully or largely meets the analytical needs of the seasonal report, with an overall utility rating of 3.46 out of 5. The case shows that for large publicly managed schemes, sequencing trust-building before tool-building is as decisive as the underlying remote sensing technology.

Keywords : Irrigation performance; co-creation; remote sensing; WaPOR; water productivity; Office du Niger; Mali; decision-support tool; institutional ownership; Tableau.

RESUME

Les autorités chargées de l'irrigation au Sahel subissent une pression croissante pour produire davantage avec moins d'eau, alors que la plupart des systèmes de suivi opérationnels restent volumétriques et ne rendent compte des performances agricoles que de manière indirecte. L'Office du Niger (ON) au Mali gère l'un des plus grands réseaux d'irrigation de l'Afrique occidentale, alimentant

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environ 142 000 ha de rizières tenues par de petits exploitants et de cultures sucrières privées. Son système actuel surveille les apports d'eau d'irrigation, mais ne les relie pas directement aux rendements des cultures et aux besoins réels en eau, tandis que la collecte de données sur le terrain est de plus en plus entravée par les conditions de sécurité. Cet article décrit la co-crédation d'IPON (Irrigation Performante de l'Office du Niger), un outil numérique basé sur la télédétection, développé conjointement par l'Office du Niger, l'Institut international de gestion de l'eau et eLEAF entre 2021 et 2025.

Plutôt que de fournir un produit préfabriqué, les partenaires ont investi dans une phase d'écoute structurée : les besoins en informations aux différents niveaux de gestion ont été analysés par rapport aux plans de travail de rapport existants, et les indicateurs de performance d'irrigation ont été sélectionnés en collaboration avec les utilisateurs finaux. L'IPON ajoute les couches «Water Productivity through Open access of Remotely sensed derived data» (WaPOR) sur l'évapotranspiration réelle et de référence, la production primaire nette et les précipitations avec les débits d'irrigation mesurés afin de calculer onze indicateurs de performance de l'irrigation à l'échelle des zones et à l'échelle tertiaire à partir de 2018, présentés via un tableau de bord de Tableau Public géré par le personnel de l'ON. Cet article présente les indicateurs en fonction des besoins d'information auxquels ils répondent, ainsi que les étapes de co-crédation qui ont permis d'assurer l'appropriation institutionnelle. Une évaluation indépendante menée après le lancement auprès de treize membres du personnel technique des ON a révélé que tous les personnes interrogées avaient utilisé l'IPON et que 61,5% d'entre eux ont estimé qu'il répondait pleinement ou en grande partie aux besoins analytiques du rapport saisonnier, avec une note globale d'utilité de 3,46 sur 5. Cette étude de cas montre que, pour les grands périmètres gérés par le secteur public, il est tout aussi déterminant de privilégier l'instauration d'un climat de confiance avant la mise au point de l'outil que la technologie de télédétection sous-jacente.

Mots-clés : Performance de l'irrigation; Co-crédation; Télédétection; WaPOR; Productivité de l'eau; Office du Niger; Mali; Outil d'aide à la décision; Appropriation institutionnelle; Tableau.

1. INTRODUCTION

Climate variability and growing food demand have intensified the pressure on large publicly managed irrigation schemes across the Sahel (FEWS NET, 2023; FAO, 2016). In response, irrigation authorities are increasingly expected not only to account for the volumes of water they divert from rivers, but to demonstrate the agricultural performance achieved with that water (Molden et al., 2010; Bos et al., 2005). This shift, from volumetric tracking to performance-oriented governance, requires new categories of information that are difficult to collect through conventional field-based monitoring alone, particularly in operating contexts where access to the perimeter is constrained by insecurity.

Remote sensing has emerged as a practical answer. The WaPOR (Water Productivity through Open access of Remotely sensed derived data) database developed by the Food and Agriculture Organization of the United Nations (FAO) provides open-access satellite layers on actual evapotranspiration and interception (AETI), net primary production (NPP), reference evapotranspiration (RET) and precipitation (PCP) at spatial resolutions appropriate for irrigation management (FAO, 2020). Combined with in-situ records of irrigation deliveries, these layers support the routine computation of a range of irrigation performance indicators.

The technical feasibility of such tools, however, is no longer the main constraint. Across Africa, many satellite-based decision-support systems have been deployed but few survive beyond their funding cycle, because they are insufficiently embedded in the workflows of the institutions expected to operate them. The challenge has therefore moved from data availability towards the institutional and procedural design of the tools themselves.

This paper documents the co-creation of IPON (Irrigation Performante de l'Office du Niger), a remote sensing-based irrigation performance monitoring tool developed with the Office du Niger (ON) in Mali and the International Water Management Institute (IWMI). Launched operationally in September 2025, IPON now informs seasonal reporting, rehabilitation prioritisation, irrigation planning, and the monitoring of water use beyond official scheme boundaries. The paper has two objectives: to describe the WaPOR

co-creation process (Adamseged et al., 2026) that allowed ON to take full ownership of the platform, and to set the eleven irrigation performance indicators implemented in IPON against the information needs they address, so that other irrigation authorities can use the indicator-needs mapping as a starting point for their own co-creation dialogues.

2. STUDY AREA AND METHODS

2.1 *The Office du Niger*

The Office du Niger is a state-owned irrigation authority that manages a centrally operated gravity-fed scheme in the inland delta of the Niger River, in the Ségou region of central Mali. The scheme currently equips approximately 142,000 ha and supports the livelihoods of close to 90,000 farming households (Office du Niger, internal records, 2024). Rice produced by smallholders dominates the cropped area, complemented by a sugar concession and seasonal off-rice vegetables. Rice is cultivated in two seasons each year — a wet season, when rainfall supplements irrigation deliveries, and a dry season, when the crop depends almost entirely on water diverted from the Niger River. River discharge during the dry season is, however, insufficient to divert sufficient water to irrigate the full perimeter, so only a reduced share of the equipped area can be cultivated in that second cycle. Water is diverted at the Markala barrage on the Niger River and distributed to seven management zones — Niono, Molodo, Kouroumari, Macina, Kolongo, M'Bewani and N'Débougou — and from there to the 54 tertiary distribution units, the *casiers*, that constitute a group of fields served by an outlet in the irrigation distributary.

2.2 *The co-creation approach*

IPON was co-created under the second phase of FAO's WaPOR programme, funded by the Directorate-General for International Cooperation (DGIS) of the Netherlands. Where the first phase focused on producing the underlying satellite data, the second phase deliberately shifted toward translating data into co-created operational tools owned by national institutions. The co-creation aimed at delivering need-based, context-relevant and user-friendly tools to foster ownership and wider adoption (Adamseged et al., 2026). The methodology adopted for IPON departed from a classical 'technology delivery' model. Instead, the partners — the IWMI, the technology provider eLEAF, FAO, and the Office du Niger — followed a five-step co-creation pathway that placed institutional listening before software development (Adamseged et al., 2026; Zwart et al., 2026).

The five-step co-creation sequence applied to IPON — institutional anchoring of an internal technical committee, joint diagnostic of information gaps, co-design, and iterative handover — operationalizes the irrigation Operator of the Future's (iOF) (World Bank, 2023) facilitated, problem-centred self-assessment approach by ensuring indicator selection is driven by the institutional decisions operators are already required to make rather than by data availability, thereby securing the ownership that the iOF framework identifies as a precondition for sustained performance-oriented management (Adamseged et al. 2026).

2.3 *Data sources and indicator computation*

IPON combines two complementary data streams. Satellite-derived layers are drawn from FAO's WaPOR database, specifically actual evapotranspiration and interception (AETI), net primary production (NPP), reference evapotranspiration (RET) and precipitation (PCP), at decadal and seasonal time steps. In-situ data on irrigation water deliveries to the zones and *casiers* are obtained from the Office du Niger's monitoring records. Cropped area information is derived from supervised classification of Sentinel satellite imagery on Google Earth Engine (GEE), twice a year corresponding to the dry (Dec-May) and wet (May-Dec) agricultural seasons in Mali.

The indicators are computed for each *casier* and aggregated to zone and scheme level. The time series runs from 2018 onwards, allowing inter-annual comparisons across at least eight cropping seasons for both rice and sugar cane. Computations follow the definitions established by Bos et al. (2005) for relative

irrigation supply and relative water supply, by Molden et al. (2010) for water productivity, and by FAO (2020) for the WaPOR-derived biomass and water consumption variables.

2.4 Tool architecture

The IPON application is built on the IPADT (Irrigation Performance Assessment Decision-support Tool) shell as a configurable framework for irrigation performance monitoring. For the Office du Niger, the shell was parameterised with the scheme's casier boundaries, the eleven retained indicators and a Tableau dashboard layer that exposes the results in tables, time-series graphs and casier-level performance maps. A set of Python scripts downloads the WaPOR data layers, integrates them with the in-situ irrigation deliveries and generates the aggregated input files that feed the Tableau Public dashboard. The tool is available offline only. The same IPADT shell can be re-parameterised for other irrigation schemes, which is the basis for the transferability discussed in Section 4.

3. RESULTS

3.1 The co-creation process

Step 1 — Initial exchange and exposure (2021–2022). First contacts between IWMI and the Office du Niger took place during a WaPOR launch event in Bamako in 2021. Subsequent technical exchanges and training sessions introduced ON staff to the WaPOR data and the kind of indicators it could support. No commitment to a tool was made at this stage; the purpose was to establish whether the data could answer questions ON managers were actually asking.

Step 2 — Institutional anchoring (early 2023). In early 2023, the Office du Niger formally established an internal technical committee dedicated to the initiative. The committee, rather than a single focal point, became the counterpart for the development team. This step was decisive in subsequent ownership: from this point onward, the project belonged to a body inside the ON rather than to an external agreement.

Step 3 — Joint diagnostic of information needs (2023). A structured diagnostic was carried out to identify where the existing seasonal reporting system fell short of the analytical needs of ON management. The diagnostic combined a documentary review of seasonal reports, semi-structured interviews with staff of the Office du Niger across various management levels.

Step 4 — Co-design and concept formalisation (July 2023). A two-day co-design workshop in Ségou translated the diagnostic into a concrete tool concept: which indicators, computed at which spatial unit, presented in which visualisations, accessed by which user profiles. A formal memorandum of understanding between IWMI and the Office du Niger was signed only after this workshop, reflecting the principle that the working relationship should precede administrative formalities.

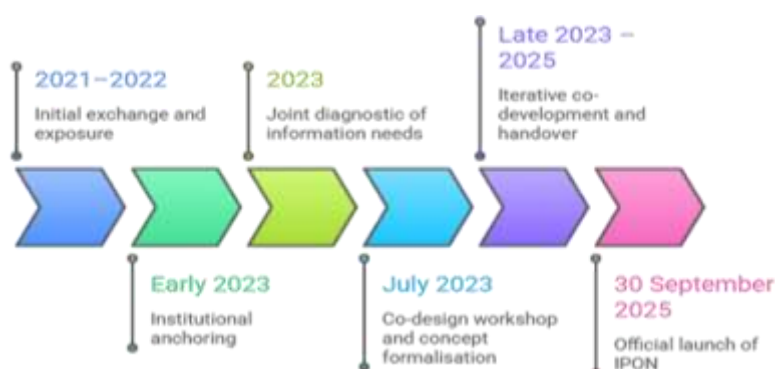


Figure 1. IPON co-creation steps between 2021 and 2025.

Step 5 — Iterative co-development and handover (late 2023 – 2025). From late 2023, IWMI, eLEAF and the ON technical committee co-developed the tool through repeated feedback loops. A beta version was integrated into actual ON workflows for testing before being finalised. The interface was translated into French as a non-negotiable condition for routine use by ON staff. The Office du Niger chose the name IPON for the platform. Capacity building covered not only end-user training but also the maintenance and seasonal update of the platform, so that ON technicians could operate it independently. IPON was officially launched on 30 September 2025 and has since been updated independently by the Office du Niger.

3.2 The IPON interface, and the indicator set and information needs it addresses

The eleven IPON indicators — spanning water productivity, relative irrigation supply, crop water deficit, irrigation uniformity and off-perimeter water use — were mapped many-to-many against documented user needs across the organizational, user-level and scheme-level performance layers of the iOF pyramid, providing the multi-dimensional evidence base that the toolkit prescribes as the foundation for moving from rapid performance assessment to strategic planning and targeted action plans (Zwart et al., 2026; World Bank, 2023).

Table 1 maps each documented user need (mapped under step 3 of the process) expressed by Office du Niger staff — from fee collection and dry-season planning to monitoring of off-perimeter cultivation and rehabilitation prioritisation — against the eleven indicators implemented in IPON. The mapping is intentionally many-to-many: most needs are informed by a combination of indicators rather than a single metric, and most indicators contribute to more than one decision. This design reflects the way ON managers actually reason about scheme performance, which rarely follows the boundaries of any individual indicator.

Table 2 sets out what each indicator measures and the data inputs on which it relies; read with Table 1, it documents the analytical chain from managerial question through to the satellite layers and in-situ records that feed each indicator. This mapping is the principal product of the diagnostic phase: it disciplined indicator selection by institutional decisions rather than data availability and is the starting point we recommend to other irrigation authorities considering a comparable tool.

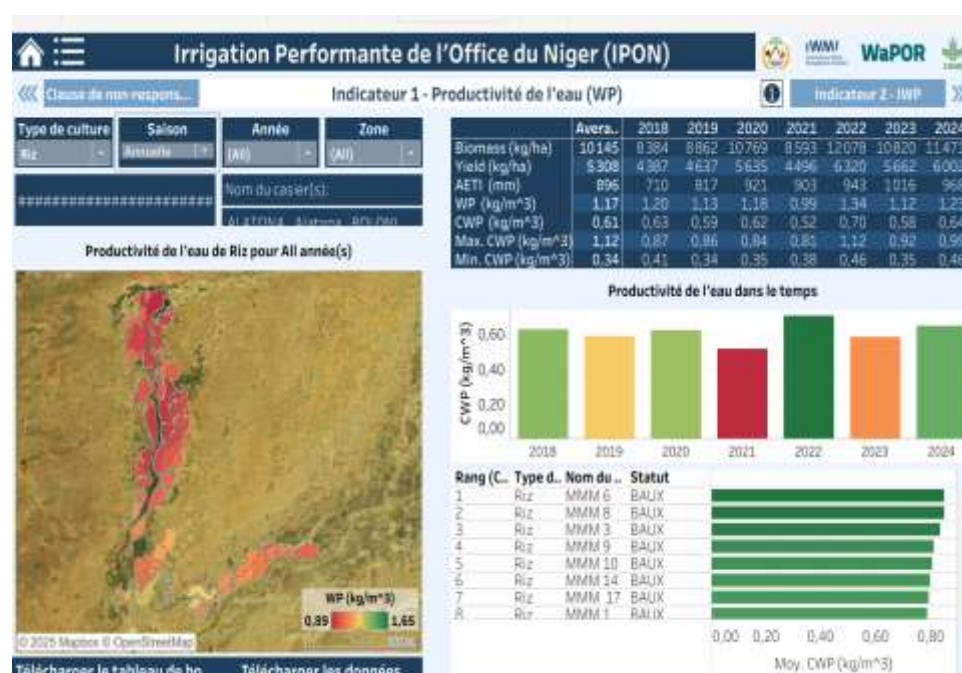


Figure 2. Interface of the IPON dashboard

Table 1. User information needs and the irrigation performance indicators addressing them in IPON

Assessed user need	Irrigation performance indicators										
	WP	IWP	RIS	RWS	CWD	RWD	IU	PEA	WC	Y	TCA
Relative yield information											
Cropping area outside tertiary units											
Monitoring head/tail water use											
PRODEAU project — underperforming units and intervention monitoring											
Introduction rice intensification system											
Illegal water abstraction within tertiary unit											
Irrigation in the dry season											
Fee collection based on the scheme performance											
Reduce irrigation supply to increase water productivity											

Table 2. Irrigation performance indicators implemented in IPON and the information needs they address at the Office du Niger.

Indicator (abbreviation)	Data inputs	Spatial unit	What does it measure?
Water productivity (WP)	NPP, AETI (WaPOR)	Casier / zone	Quantifies the amount of agricultural output (crop yield) produced per unit of water used; indicates how efficiently the crop has used available water to produce yield.
Irrigation water productivity (IWP)	NPP, AETI, PCP (WaPOR); irrigation deliveries	Casier / zone	Agricultural output (crop yield) produced per unit of irrigation water applied; isolates the contribution of irrigation water (excluding rainfall) to crop production.
Crop yield (Y)	NPP (WaPOR); harvest index	Casier / zone	Agricultural production harvested per unit of land area; central to food security, resource allocation, risk management and sustainable agricultural practice.
Water consumption (WC)	AETI (WaPOR)	Casier / zone	Water moving from earth to atmosphere through evaporation and transpiration; comparing consumption before and after an event or intervention reveals changes over time.
Total cropped area (TCA)	WaPOR land use; cross-validation with ON declarations	Casier / zone	Combined area of land under cultivation (crops and orchards); a key indicator for agricultural planning, food security and environmental impact assessment.
Relative irrigation supply (IRR)	Irrigation deliveries; AETI, RET (WaPOR)	Casier / zone	Relates irrigation water supply to crop water requirements in the season, exclusive of precipitation; assesses the minor season when irrigation is the main source of supply.
Relative water supply (RWS)	Irrigation deliveries; PCP, RET (WaPOR)	Casier / zone	Ratio between total water available to the crop (irrigation + precipitation) and the crop net water requirements.
Crop water deficit (CWD)	AETI, RET (WaPOR)	Casier / zone	Difference between crop-specific potential evapotranspiration and crop-specific actual evapotranspiration; quantifies whether crop growth is optimal or suboptimal.
Relative water deficit (RWD)	AETI, RET (WaPOR)	Casier / zone	Quantifies whether crop growth has been optimal or suboptimal; provides information similar to CWD but its relative nature permits comparison amongst different crops.
Irrigation uniformity (IU)	AETI (WaPOR)	Casier / zone	Degree to which water deliveries are considered fair by all; a fundamental aspect of equitable and sustainable water management, also known as performance uniformity.
Off-perimeter water use	WaPOR AETI; scheme boundary	Scheme periphery	Visualises unofficial scheme extensions and quantifies unrecorded water abstractions; supports detection of cultivation and water use beyond the official scheme boundary.

IPON is delivered through a Tableau dashboard organised around three coordinated views that together support the seasonal performance assessment workflow of the Office du Niger. Figure 1 shows a representative screen of the interface. The central panel is a thematic map of the scheme in which each casier is symbolised by the value of the indicator selected by the user, so that the spatial pattern of performance — for example water productivity, crop water deficit or off-perimeter water use — across the seven management zones can be read at a glance. Filters along the top of the dashboard allow the user to switch indicator, season and year, and to drill from zone to individual casier without leaving the view.

The map is complemented by a tabular panel that lists the numerical values of the selected indicators for the spatial units selected on the map, supporting side-by-side comparison between casiers, and providing the figures that feed directly into the seasonal report. A graph panel completes the interface and plots the time series of the chosen indicator from 2018 onwards, so that the current season can be placed in the context of inter-annual variability and longer-term trends.

3.3 Institutional uptake and ownership outcomes

The co-creation sequence produced an institutional outcome that is at least as important as the technical deliverable. By the official launch in September 2025, the Office du Niger was already running IPON without external technical assistance. The technical committee established in 2023 had participated in every step from indicator selection and prototype review to platform configuration, and therefore understood the tool's structure, limits and update procedure. Seasonal updates are now performed by ON technicians; seasonal reports incorporating IPON outputs have been produced without requests for support from IWMI.

To assess institutional uptake after the launch, an independent evaluation of the ON seasonal reporting system was commissioned in late 2025 (Sanogo, 2026). The evaluation combined a documentary review of the existing reporting workflow with a structured survey of thirteen ON technical staff drawn from the General Directorate, technical directorates and zone management. The survey results indicate that IPON has moved beyond the project team and into the wider institution. None of the respondents reported never having used the tool; 15.4% reported using it regularly, 69.2% occasionally and 15.4% rarely.

The perceived fit with current reporting needs was likewise positive: 61.5% of respondents judged that IPON fully or largely meets the analytical needs of the seasonal report, 38.5% that it partially meets them, and none that it was inadequate, with an overall utility rating of 3.46 out of 5. The institutional audiences identified for IPON outputs span the full management hierarchy, with the technical directorates and zone managers (100%), the General Directorate (92.3%) and the operational monitoring function (92.3%) named most frequently.

Three concrete uses for IPON outputs have emerged in operational practice. Seasonal reports now include a performance section that pairs the existing hydraulic indicators with WP, IWP, WC and TCA at casier level. Rehabilitation planning has begun to use CWD and RWD maps to identify casiers where water stress co-occurs with documented infrastructure degradation, providing an evidence-based prioritisation that did not exist before. Water-use fee collection is informed by the off-perimeter water use indicator, which has revealed agricultural activity beyond the official scheme boundaries that the in-situ monitoring system could not detect. These uses confirm that IPON is being applied to questions ON managers were already asking, rather than to questions the tool happened to be able to answer.

4. DISCUSSION

4.1 Lessons learned from the Mali co-creation process

Two outcomes distinguish IPON from comparable remote sensing-based irrigation tools in the region: the Office du Niger updates and runs the platform without external support, and IPON outputs are entering operational decisions — seasonal reporting, rehabilitation prioritisation, fee collection — rather than circulating as a parallel reporting stream. Four lessons account for these outcomes. First, institutional anchoring preceded tool specification: the 2023 decision to constitute an internal technical committee, rather than nominate a single focal point, gave the development team a counterpart with a standing mandate, robust to staff rotation. Second, the diagnostic of the existing reporting system preceded indicator selection; several indicators technically computable from WaPOR were deliberately not surfaced because the diagnostic did not establish an institutional decision they would inform. Third, capacity building was layered across levels — hands-on dashboard use for zone technicians, indicator interpretation for technical directorates and the General Directorate, and seasonal update and maintenance routines for the IT team — so that no single role held the tool's continuity. Fourth,

formalisation followed substance: the memorandum of understanding was signed only after the July 2023 co-design workshop, French translation was treated as non-negotiable, and the platform's name was chosen by the Office du Niger.

For other large publicly managed irrigation systems considering a comparable digital initiative, the Mali experience suggests three sequencing rules: the diagnostic of the existing reporting system should precede indicator selection; the institutional anchor for the tool should be established before any software is specified; and the platform should be designed from the outset as a configurable shell, so the investment in data pipelines and indicator definitions can be amortised across deployments while the co-creation conversation is repeated in each new context.

4.2 From IPON to a transferable shell (IPADT)

The platform underlying IPON was deliberately developed as a generic shell, named the Irrigation Performance Assessment and Decision-support Tool (IPADT), in collaboration with eLEAF. IPADT is irrigation-system agnostic: the indicator definitions, the WaPOR data ingestion pipeline and the Tableau templates are inherited from a common backbone, while the spatial units, the integration of in-situ data sources, the language of the interface and the indicator set actually displayed are configured per deployment. IPON is therefore one configured instance of IPADT, parameterised to the Office du Niger's context and needs.

This separation between backbone and configuration is an explicit lesson from the Mali experience. It allows the technical co-creation effort in a new country to focus on the conversation that determined IPON's value in the first place — which indicators, at which spatial unit, for which institutional decision — rather than on rebuilding the data pipeline. The shell has since been used as the starting point for co-creation conversations with irrigation authorities in other WaPOR partner countries in sub-Saharan Africa and the Middle East and North Africa region. Specifically, the shell was used to develop irrigation performance assessment tools for the West Gharraf Irrigation Project in Iraq (Amdar et al., 2025), and for the schemes in the Lower Limpopo basin in Mozambique (Matheswaran et al., 2025).

5. CONCLUSIONS

The co-creation of IPON shows that a remote sensing-based decision-support tool can be embedded inside a centrally managed irrigation authority in a way that survives the project that created it. The technical deliverable is a Tableau dashboard computing eleven irrigation performance indicators at casier scale; the process deliverable is an ON technical committee that diagnosed its own analytical gaps, selected its own indicator priorities, and now operates the tool without external support. The IPADT shell makes the approach replicable in other irrigation systems, provided the co-creation sequence is repeated rather than short-circuited. For irrigation digital tools intended to outlive their funding cycle, how the tool is built is at least as consequential as what it computes.

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REFERENCES

Adamseged, M.E.; Minh, T.T.; Schmitter, P. 2026. WaPOR: Catalysing data-driven solutions through a co-creation approach. Food and Agriculture Organization of the United Nations, Rome.
<https://doi.org/10.4060/cd8567en>.

- Amdar, N.; Talal, G.; Schmitter, P.; Dembélé, M. 2025. Irrigation performance: Iraq. Colombo, Sri Lanka: International Water Management Institute (IWMI). 2p. (Water Productivity through Open access of Remotely sensed derived data [WaPOR] Tool Series). <https://hdl.handle.net/10568/177461>
- Bos, M. G., Burton, M. A., and Molden, D. J. 2005. Irrigation and Drainage Performance Assessment: Practical Guidelines. CABI Publishing, Wallingford, UK.
- FAO. 2016. [The State of Food and Agriculture: Climate Change, Agriculture and Food Security](#). Food and Agriculture Organization of the United Nations, Rome.
- FAO. 2020. [WaPOR – The FAO portal](#) to monitor water productivity through open access of remotely sensed derived data. Food and Agriculture Organization of the United Nations, Rome.
- FEWS NET. 2023. Sahel Food Security Outlook and Climate Impacts on Agriculture. Famine Early Warning Systems Network. Available at: <https://fews.net>.
- Matheswaran, K.; Vissa, D.; de Sousa, W.; Adamseged, M.; Schmitter, P.; Dembélé, M. 2025. Irrigation performance: Mozambique. Colombo, Sri Lanka: International Water /Management Institute (IWMI). 2p. (Water Productivity through Open access of Remotely sensed derived data [WaPOR] Tool Series). <https://hdl.handle.net/10568/177460>
- Molden, D., Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., and Kijne, J. 2010. [Improving agricultural water productivity: Between optimism and caution](#). Agricultural Water Management 97(4): 528–535.
- Office du Niger. 2024. Internal scheme records on equipped area, cropping pattern and farming households. Ségou, Mali: Office du Niger.
- Sanogo, K. 2026. Évaluation du système de rapportage saisonnier de l'Office du Niger (Mali). Consultancy report prepared for the International Water Management Institute, Bamako, Mali.
- Zwart, S.; Kassambara, B.; Schmitter, P.; Dembélé, M. 2025. Irrigation performance: Mali. Colombo, Sri Lanka: International Water Management Institute (IWMI). 2p. (Water Productivity through Open access of Remotely sensed derived data [WaPOR] Tool Series). <https://hdl.handle.net/10568/177463>
- Zwart, S. J., Dembélé, M., and Tall, M. 2026. Listening before building: how IWMI and Mali's Office du Niger co-designed a digital irrigation tool for long-term impact. International Water Management Institute, Accra.