

IMPROVING IRRIGATION PRACTICE AND TECHNOLOGY FOR A WATER-SECURE AND CLIMATE-RESILIENT SYSTEM: THE CASE OF STA. MARIA; RIVER IRRIGATION SYSTEM

AMÉLIORATION DES PRATIQUES ET TECHNOLOGIES D'IRRIGATION POUR LA SÉCURITÉ HYDRIQUE ET LA RÉSILIENCE CLIMATIQUE: LE CAS DU SYSTÈME D'IRRIGATION DE LA RIVIÈRE STA. MARIA

Mona Liza F. and Delos Reyes¹

ABSTRACT

Modern technology and innovative water management solutions such as micro irrigation, precision irrigation, and deficit irrigation present means to address water scarcity, increase water use efficiency, and improve climate change adaptation. However, their objectives and operational requirements do not always align well with the system designs, traditional irrigation practices and local preferences. Making modern technology and solutions work in older or traditional irrigation systems require critical stocktaking of current situations in terms of existing technology and practices, irrigation goals and philosophies, preferences, operation and management skills set, and incentives vis-à-vis achievement, potentials, and prospects.

This paper presents the results of a case study that examined the irrigation physical structure, operation and management, irrigation goals, technology used, natural physical environment and institutional settings, issues and challenges, and potentials from the technocrats' and farmers' perspectives to identify appropriate irrigation water management and technology options and mechanisms for their sustainable adoption by farmers. The case study used focus group discussions (FGD), logic design analysis, and pragmatic adoption of Mapping System Services for Canal Operation Technique (MASSCOTE) methodology to gather information and assess potential improvement in technology, farmers' knowledge and management skills at the system and on-farm levels.

The study found that the farmers have good appreciation of the issues, constraints and potentials of their irrigation system and openly talked about their proposed solutions and course of actions during their formal meetings. They are responsive to technical advisory, planning their cropping schedules and method of water distribution accordingly and flexible to any adjustments necessary based on real-time weather and water supply situations. They are receptive to alternate wetting and drying (AWD) as water-saving technology and to development of supplemental irrigation using groundwater as water supplies from the dams are limited. The results of the study indicated a logical inconsistency with the rotational irrigation or AWD practices and presence of unauthorized ungated direct offtakes. These offtakes were either deemed necessary for easy access of irrigation water or just tolerated by some farmers to maintain social cohesion. A list of technology and management options was identified based on farmers' feedback and system analysis. A capacity enhancement program for farmer-irrigators with emphasis on coherent combinations of irrigation objectives and flow control structures and a decision-support system for planning cropping calendar and water delivery to specific turnout service areas are proposed.

Keywords: Irrigation practice and technology; River irrigation system; Water management solutions; Alternate wetting and drying(AWD); System analysis.

¹ Institute of Agriculture and Biosystem Engineering, College of Engineering and Agro-industrial Technology, University of the Philippines Los Baños, Philippines, Email: mfdelosreyes@up.edu.ph

RÉSUMÉ

Les technologies modernes et les solutions innovantes de gestion de l'eau, telles que la micro-irrigation, l'irrigation de précision et l'irrigation déficitaire, offrent des moyens de remédier à la pénurie d'eau, d'accroître l'efficacité d'utilisation de l'eau et d'améliorer l'adaptation au changement climatique. Toutefois, leurs objectifs et leurs exigences opérationnelles ne s'accordent pas toujours avec la conception des systèmes, les pratiques d'irrigation traditionnelles et les préférences locales. Pour rendre ces technologies et solutions efficaces dans des systèmes d'irrigation anciens ou traditionnels, il faut dresser un bilan critique de la situation actuelle au regard des technologies et pratiques existantes, des objectifs et philosophies d'irrigation, des préférences, des compétences en matière d'exploitation et de gestion, ainsi que des incitations, par rapport aux réalisations, aux potentialités et aux perspectives.

Cet article présente les résultats d'une étude de cas qui a examiné les infrastructures physiques d'irrigation, l'exploitation et la gestion, les objectifs d'irrigation, les technologies utilisées, l'environnement physique naturel et le cadre institutionnel, les problèmes et défis, ainsi que les potentialités perçues par les techniciens et les agriculteurs, afin de déterminer des options et des mécanismes appropriés de gestion de l'eau d'irrigation et de technologie permettant leur adoption durable par les agriculteurs. L'étude de cas a eu recours à des discussions de groupe (FGD), à une analyse de conception logique et à une adaptation pragmatique de la méthodologie Mapping System Services for Canal Operation Technique (MASSCOTE) pour recueillir des informations et évaluer les améliorations possibles des technologies, des connaissances des agriculteurs et des compétences de gestion aux échelles du système et de l'exploitation.

L'étude a montré que les agriculteurs ont une bonne compréhension des problèmes, des contraintes et des potentialités de leur système d'irrigation et qu'ils ont discuté ouvertement des solutions et des mesures qu'ils proposent lors de leurs réunions formelles. Ils sont réceptifs aux conseils techniques, planifient en conséquence leurs calendriers culturels et leur méthode de distribution de l'eau, et s'adaptent avec souplesse aux ajustements nécessaires en fonction des conditions météorologiques et de l'approvisionnement en eau en temps réel. Ils sont favorables à l'alternance d'humidification et d'assèchement (AWD) comme technologie d'économie d'eau, ainsi qu'au développement d'une irrigation d'appoint utilisant les eaux souterraines, les apports des barrages étant limités. Les résultats ont mis en évidence une incohérence logique entre les pratiques d'irrigation en rotation ou d'AWD et la présence de prises directes non autorisées et dépourvues de vannes. Ces prises étaient soit jugées nécessaires pour faciliter l'accès à l'eau d'irrigation, soit simplement tolérées par certains agriculteurs afin de préserver la cohésion sociale. Une liste d'options technologiques et de gestion a été établie à partir des observations des agriculteurs et de l'analyse du système. Il est proposé de mettre en place un programme de renforcement des capacités destiné aux agriculteurs-irrigants, mettant l'accent sur des combinaisons cohérentes d'objectifs d'irrigation et d'ouvrages de régulation des débits, ainsi qu'un système d'aide à la décision pour planifier le calendrier culturel et la distribution de l'eau à des zones de desserte précises.

Mots clés : Pratiques et technologies d'irrigation; Système d'irrigation de la rivière; Solutions de gestion de l'eau; Alternance d'humidification et d'assèchement (AWD); System analysis.

INTRODUCTION

Irrigation has been considered a precondition of increased crop production. It has been a key strategy by the Government to achieve broad societal objectives of self-sufficiency in rice, the staple food of Filipinos, rural development, improved nutrition, increased farmers' income, and climate resiliency of the agricultural sector. However, achieving these irrigation goals are hindered by several issues such as rapid deterioration of physical structures, diminishing reliable supply, and hydrologic extremes (droughts and floods) associated with climate change, among others. Such issues led to consistent gap between irrigation service area and irrigated area and lower-than-projected cropping intensity and crop yield.

The National Irrigation Administration, the country's lead irrigation agency, has been conducting rehabilitation, improvement, headwork protection and retrofitting work in publicly owned and funded national irrigation systems (NIS) to address the abovementioned issues. It started irrigation modernization initiatives such as dam gates automation, telemetry for rainfall and river flow monitoring, solar-power irrigation systems with pipe network, and farm geographic information system in selected national irrigation systems (NIS). It promoted alternate wetting and drying (AWD) as a water-saving technology, crop diversification to cope with limited water supply during the dry seasons, and adjustment of cropping calendar to better aligned with prevailing climate. In addition, it is continuing its effort of strengthening the capacity of its irrigators' association for operation and management of irrigation systems, self-governance, and institutional sustainability. Further, it has been providing technical and material support to many farmers'-owned-and-operated communal irrigation systems (CIS).

Although the consistent gap between the service areas and irrigated areas remains, an apparent gain of these continuing efforts is indicated by the gradually narrowing of this gap. Based on irrigation statistics in NIA Annual Report for recent years, the national average percentage of the operated and managed (O&M) NIS service area served for the 2020-2024 period ranged from 76-83%. Its corresponding seasonal values increased to 82% and 80% for the wet and dry cropping seasons, respectively, from their 76% and 73% levels during the preceding five-year period. In the case of NIA-assisted CIS, the national average percentage of the operated and managed (O&M) irrigation service area served for the 2020-2024 period ranged from 63-71%. Similarly, the seasonal values increased to 69% and 61% for the wet and dry cropping seasons, respectively, from their 62% and 58% levels for the 2015-2019 period. Closing this gap is one of the major objectives of irrigation system improvement and modernization because it is directly equated to volumes of crop production and farmers' income.

Irrigation improvement and modernization projects are almost always associated with upgrading of the physical components and installation or adoption of advanced irrigation technology for greater control of water flows, precise water application, or efficient water use. These objectives and operational requirements do not always align with the irrigation objectives and capacity of farmer-irrigators, design and operation of existing irrigation systems, traditional management practices, or local preferences.

This paper examines the irrigation physical structure and technology used, irrigation practices and objectives, natural environment and institutional settings, issues and challenges, and potentials of a case study system to identify appropriate irrigation water management and technology options and mechanisms for their sustainable adoption by farmers.

MATERIALS AND METHODS

The case study system is the Sta. Maria River Irrigation System (RIS), a small-scale national irrigation system serving about 1,012 ha of rice fields and 917 farmers in the towns of Sta. Maria and Mabitac in Laguna. It is about 50 km to the West-Northwest from the country's capital city, Manila.

The general information on Sta. Maria RIS, water supply, system design philosophy and objectives, irrigation practices and technology used was collected from records and documents of relevant offices and published literature and validated through interviews, focus group discussion (FGD) with the irrigators association, system walkthrough with the concerned field personnel, and field measurements. The case study used logic design analysis, and pragmatic adoption of Mapping System Services for Canal Operation Technique (MASSCOTE) methodology to assess potential improvement in technology, irrigation and water management practices, farmers' knowledge and management skills at the system and on-farm levels.



Figure 1. Bagumbayan Dam intake gates of Sta. Maria RIS

RESULTS AND DISCUSSION

System design and objectives

The common goal of the NIA and SANTAMASI for the Sta. Maria RIS is the delivery of sufficient water to the whole service area for optimum crop growth for the two cropping seasons. The NIA system operation and management, rehabilitation and modernization works were aimed at closing the gap between the service area and actual area irrigated for each cropping season. Similarly, the SANTAMASI carried out their canal and canal flow control structure maintenance and operation and water distribution responsibilities with the goal of sufficiently irrigating each management units or turnout service areas (TSA) in both cropping seasons to maximize their harvest.

The information gleaned from project documents, interview, and review of the NIA design guidelines showed the following on the design philosophy and system objectives: rice monoculture; productive irrigation or provision of water for optimum plant growth; dry season as the design main irrigation season; equitable supply per ha and flexible supply; imposed allocation to management units; and upstream control of water.

Meanwhile, the SANTAMASI's statement of vision, mission, and objectives are displayed at its office translate to a prospect of a strong organization with members united and active in the pursuit of prosperous lives for all and contributing to community building. Its mission is to provide its members with the services necessary to uplift their livelihood and standard of living through farming, provide good education to each members family, and develop the community. Its objectives include expanding the knowledge of each member and the organization on modern farming technology; to maintain its goals and aspirations by enforcing policies and rules for orderly and productive irrigation service; and support its members to maintain a stable farming job and higher income.

System features

Sta. Maria RIS is a gravity type, canal irrigation scheme with a run-off-the-river dam diverting water from the Sta. Maria River, which eventually drains in the Laguna Lake, the biggest lake in the country. The dam, which is in Bagumbayan, has a design diversion capacity of $2.1 \text{ m}^3\text{s}^{-1}$ and has a drainage area upstream of approximately 20 km^2 . Sta Maria RIS has a secondary water diversion structure, the Mata check gate. Its canal network is hierarchical with two main canals and seven laterals. The total length of the main and lateral canals are about 14 km and 16 km, respectively. The Sta Maria RIS first started in-operation in 1961. Other pertinent system features is shown in Table 1. It is under the modified irrigation management transfer (IMT) contract between NIA and SANTAMASI. Under the IMT contract, the O&M and management of dams and the maintenance of main canals and flow control structures over PhP50,000 are responsibilities of the NIA while the management and maintenance canal network and flow control structures costing below PhP50,000 are responsibilities of the SANTAMASI.

Table 1. System features pertinent to design and operation

Characteristics ¹	Original	Changes
Approved diversion rate, l s ⁻¹	2,100	--
Service area, ha	2,500	1,012
Source of water supply	River	+ creeks, spring, 3 SPIS, checkgate
Water supply at the source		
Wet season	Limited	Surplus - sufficient
Dry season	Limited	Sufficient - shortage
Diversion dam	ROR dam	+ protection walls
Dam intake gates operation	Vertical, manual	Vertical, electromechanical
Dam sluice gates operation	Vertical, manual	Vertical, electromechanical
System water use	Rice irrigation	+ few orchards, fish culture & livestock
No. of management unit	28	---
Share of irrigation supply	Equitable supply to area	---
Gate setting at the tertiary offtakes	Possible at fixed time	---
Water allocation to tertiary unit	Imposed	---
Controlled variable	Discharge	---
Offtakes/turnouts along main System	Orifice with spindle-type vertical gates	+ ungated orifices, weirs
Measurement structures	Parshall, cutthroat flumes, staff gauge	+ automatic water level and rainfall recorder at dam site
Water level regulators along main system	Spindle type vertical gates	---
Freedom and precision of control of structures at the main system	Gradual	+ On/off, Stepwise, Fixed
Flow control at main system	Upstream control	---
Access/manipulation of structures	Manual, in-situ	Manual, in-situ
Immediate storage	None	---
Drainage system	Natural	---
Water reuse structure	None	10
Conjunctive use	None	Moderate
Canal materials	unlined	+ concrete lined

--- (none) + (added)

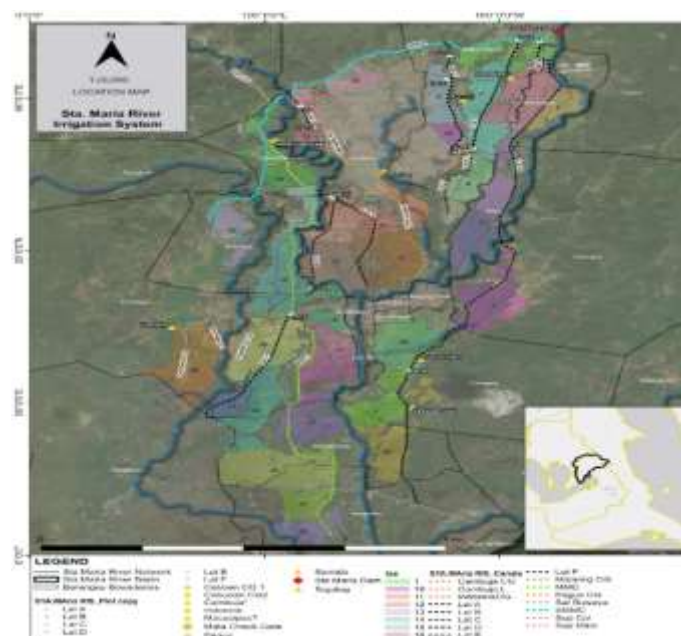
Logical Coherence of System Design

The results of categorization of the overall system objectives, operational objectives of the main system, and flow control methods based on the system design framework of Ankum (2001) indicate that the present Sta. Maria RIS was designed for rice monoculture and for 'productive irrigation' during the dry season based on 'equitable supply per hectare'. The operational objective is 'imposed allocation' to tertiary units by 'adjustable flow' and with 'rotational flow' through the main system or major conveyance canals. The flow control method employed is upstream control.

The productive irrigation aims to provide water for optimum crop growth. This objective in Sta. Maria RIS is evident by the fact that crop water requirement during periods of favourable climatic conditions to rice production was the foremost consideration in determining the capacities of canals and flow

From the perspective of the logic design framework, there was coherence among the design philosophy, objectives, and flow control method in the design of the case Sta. Maria RIS. However, with limited dry season flows, especially during period of prolonged drought, the run-off-the-river (ROR) dam would not be coherent to the system objective of “productive irrigation objective during dry season” since available water supply for irrigation can become less reliable and ROR has no storage capacity. In addition, the presence of open direct turnouts along the main canals compromised the rotational flow objective.

The service areas of Sta. Maria RIS is divided into 28 turnout service areas (TSA) or management units, each of which is managed by its elected farmer leader. The wet cropping season is from April to July and dry cropping season is from December to March. The start of cropping season is adjusted based on weather forecast and advisory on possible occurrence of El Niño-induced drought or worsen monsoon season due to La Niña phenomenon.



The cropping schedules for each irrigation zone follow a system-wide water distribution plan agreed upon by the system officials and SANTAMASI. Staggered start of farming by TSA is implemented. It starts from downstream to upstream TSA during the dry cropping season and from upstream to downstream during the wet season. In general, continuous irrigation during the wet season and irrigation rotation by lateral of TSA during the dry season are practiced. The irrigation water is conveyed from the source to the farmers' field through a network of canals by gravity flow and the irrigation method employed is flooding.

The Sta. Maria RIS is under the modified irrigation management transfer (IMT) contract between NIA and SANTAMASI since 2000. Under the IMT contract, the O&M and management of dams and the maintenance of main canals and flow control structures over Php50,000 are responsibilities of the NIA while the management and maintenance canal network and flow control structures costing below Php50,000 are responsibilities of the SANTAMASI.

System Performance

For Sta Maria RIS, the average percentage of the operated and managed (O&M) irrigation service area served for the 2020-2024 period ranged from 87-99% with 93% and 92% average values for the wet and dry cropping seasons, respectively (Figure 3). SANTAMASI attributed the gap between service area and irrigated area to water supply shortage, El Niño-induced drought, damaged and leaky canals, non-functional and missing flow control structures, inundation of downstream service areas, and flow distribution issues. Figure 4 shows the relatively water supply conditions across the Balanac RIS service area.

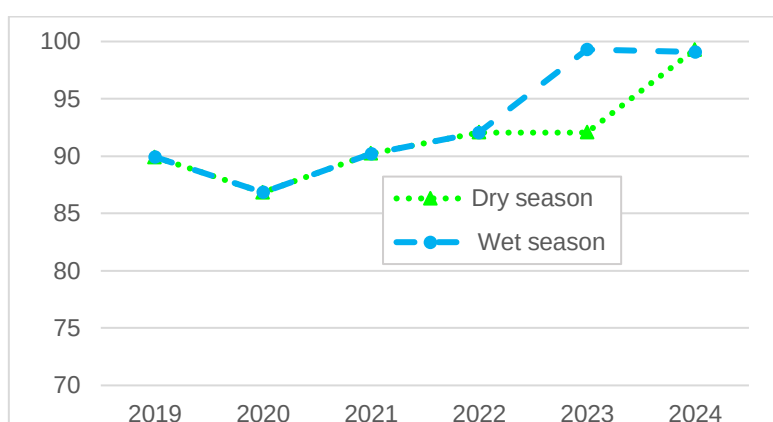


Figure 3. Percentage of irrigated service area

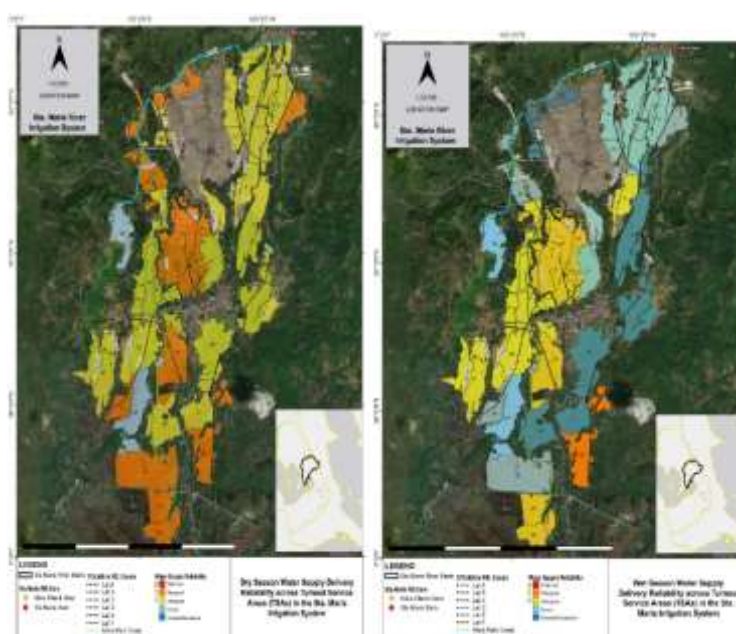


Figure 4. Relative water supply conditions in the different management units

State and capacity of physical structure

The results of the rapid appraisal of the Sta. Maria RIS present capacity and the required capacity to perform its basic functions of conveyance, diversion, division, water level regulation, flow measurement, sediment control, storage, and discharge transfer, among others, suggested that the irrigation system has either reduced or inherently limited capacity to perform these functions or satisfy the present demands (Table 2). The systems' low capacity was mainly attributed to damaged or missing gates (Table 3), heavy siltation, insufficient flow control and measurement structures; eroded canals, low main farm ditch density, and lack/inadequate spill points and drainage system.

Table 2. Functional capacity of the irrigation systems

Functional Capacity	Capacity aspect	Actual VS Required
Diversion (Dam)	Minimal head; ogee type; vertical lift screw type stem; electromechanical intake and sluice gate operation	<
Diversion (canal structures)	Many dilapidated, dysfunctional checks and turnouts; highly sensitive check (undershot)	<
Storage (canal structures)	No online mini reservoir; big canals	<
Conveyance	Substantial leaks due to ungated turnouts and direct offtakes	<
Sediment control	No sediment control along canal network; soil/rock materials falling from the adjacent road/lot	<
Water level control	Some dysfunctional checks and makeshift stoplogs	<
Flow measurement	No flow measurement done	<
Safety	No escape way of surplus flows	<
Communication	Use of mobile phones	=
Water reuse	10 drainage water reuse	<
Transport/access	With access road	=

Table 3. Population and type of flow control structures

Structure	SMMC	Lateral A	MMC	Total	Functional (Good condition)	Functional (Damaged)	Non-functional
TO-Check combo	9	7	10	26	15	9	2
TO, CHO	11	6	11	28	20	5	3
TO, vertical gate	6	24	7	37	26	9	2
TO, stop log	0	4	9	13	10	2	1
Check, vertical gate	5	6	13	24	17	5	2
Check, stop log	7	8	8	23	16	4	3
Direct offtakes	9	26	25	60	55	2	3
Parshall flume	2	2	2	6	6	0	0
Weir (measurement)	2	0	0	2	2	0	0
Supply canal	2	0	0	2	2	0	0

Drainage culvert	2	2	3	7	7	0	0
Road crossing	2	2	2	6	6	0	0

Desired improvements

Lining canals with concrete was most desired improvement work, followed by repair or installation of new gates, canal clearing and desilting and construction of reservoir. Lined canal is associated with faster water flows, reduced conveyance losses, and minimal maintenance requirement, hence the high demand for it. The preference for additional gates or flow control structures reflects the desire to have better control of water. Similarly, wish for reservoir-type dam convey the desire to a reliable water supply.

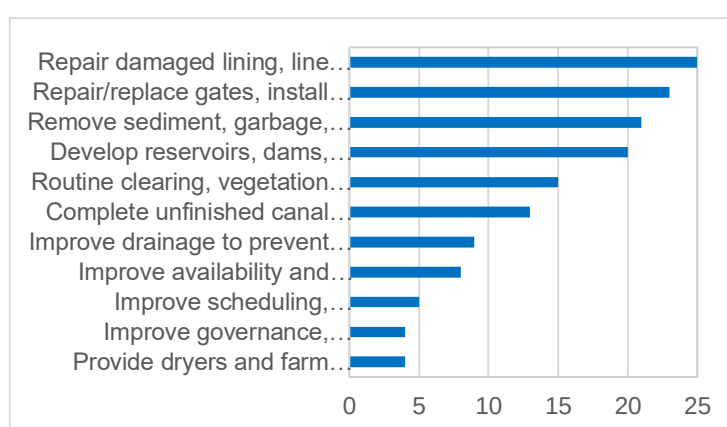


Figure 5. Desired irrigation improvement of SANTAMASI

Irrigation technology and practices improvement

The results of the study showed specific irrigation issues and improvement needs of Sta. Maria RIS which include the inconsistency of irrigation technology to the design philosophy or system objective and operational objective. The ROR dam, which does not have storage capacity, is not consistent with the productive irrigation objective, which requires timely delivery of the right amount of water for optimum plant growth. Similarly, the use of ungated direct offtakes or turnouts does not align with rotational irrigation. The assessment of the capacity of irrigation system to accomplish its different functions led to identification of required operation and management improvements. An FGD targeting relevant aspects or specific areas of concern of irrigation and drainage will point towards different improvement options.

Field measurements and use of computer-based models to generate relevant data input for planning irrigation system improvements. While this was done for the case study system, it was not included in this paper.

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