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Review on Techniques and Approaches for Performance Assessment and Indicators for Water Use Systems

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A B S T R A C T

This review synthesizes findings from 94 scholarly works to explore established techniques and strategies for evaluating the performance of water use systems (WUS). It particularly examines the frequency of application and geographic distribution of these assessment methods. The analysis indicates that Geographical Information Systems (GIS) combined with remote sensing (RS), along with traditional field-based experiments, are the most prevalent approaches. While some studies exclusively utilize one method, others adopt a hybrid model that integrates both. Notably, GIS and RS technologies have achieved broader adoption in developed regions; however, their use is progressively expanding across Africa, where such tools may prove highly beneficial due to the continent's economic constraints and unique water management challenges. The review further observes a pattern: studies that incorporate socio-economic metrics—such as increases in agricultural yield and financial returns—tend to report more favorable outcomes. In contrast, those relying heavily on technical indicators, such as irrigation system efficiency or pumping performance, often produce more variable results. These discrepancies underscore the importance of careful interpretation when comparing system performances across different contexts. The review also discusses implications for policymaking and highlights key areas requiring further research. To enhance clarity and consistency across stakeholders, the adoption of a standardized terminology set is strongly advocated.

Keywords: performance assessment; indicators; remote sensing; water resources management; efficiency

Introduction

Enhancing the effectiveness of urban and agricultural water systems is a critical response to the increasing strain on global water resources. Performance evaluation plays a central role in this regard, as it broadly encompasses the measurement of how efficiently resources are utilized and how well system processes achieve intended goals (Bos et al., 1994). However, the definition and interpretation of "efficiency" remain contentious and continue to evolve (Boelens & Vos, 2012; Haie, 2008; Lankford, 2012; Pereira, Oweis, & Zairi, 2002; Perry, 2007, 2008, 2011).

Water use systems (WUS) are commonly evaluated using specific metrics known as performance indicators. These indicators serve to measure both the effectiveness and efficiency of various activities, enabling comparisons across different time periods and locations (Nudurupati, Bititci, Kumar, & Chan, 2011). Beyond quantification, indicators also serve as communication tools—simplifying complex datasets into clear, interpretable figures for decision-makers, enabling the identification of trends, and fulfilling global reporting commitments (Bastiaanssen et al., 2001; Brown et al., 2015; Ermini, Ataoui, & Qeraxhiu, 2015; UN-Water, 2006; Bos, Burton, & Molden, 2005).

Extensive studies have been conducted to analyze the performance of WUS, primarily to inform system managers and stakeholders about operational status, and to recommend improvements based on observed outcomes. These assessments have facilitated better diagnosis and system comprehension among engineers, policymakers, researchers, and users alike (Ahmad, Turral, & Nazeer, 2009; Dejen, Schultz, & Hayde, 2012; García-Bolaños et al., 2011; Van Halsema et al., 2011). Moreover, comparative evaluations—both within and across systems—have allowed stakeholders to benchmark performance levels (Borgia, García-Bolaños, & Mateos, 2012; Kazbekov et al., 2009), and determine whether implemented interventions have achieved their objectives, thus guiding future investments and strategy adjustments (Merchán et al., 2015; Yilmaz & Harmancioglu, 2012; Zwart & Leclert, 2010).

Such performance assessments have been approached from diverse stakeholder viewpoints, including researchers, donors, local farmers, irrigation managers, and government authorities (Carr, Blöschl, & Loucks, 2012; Chandran & Ambili, 2016). These assessments are typically implemented through conventional field measurements (e.g., Andrés & Cuchí, 2014; Dejen et al., 2012; Gomo et al., 2014a; Mondal & Saleh, 2003; Singh et al., 2006), emerging remote sensing and GIS techniques (Ahmad et al., 2009; Jiang et al., 2015; Lorite et al., 2012), or an integration of both (Ahadi et al., 2013; Ahmed et al., 2010). These performance indicators have seen wide application across multiple continents: in African countries (Ahmad et al., 2018; Al Zayed et al., 2015), Asian contexts (Chandran & Ambili, 2016; Rowshon et al., 2014), European settings (Andrés & Cuchí, 2014; Gadanakis et al., 2015; Merchán et al., 2015), the Middle East (Yigezu et al., 2013), North America (Haie & Keller, 2012; Lecina et al., 2011), and South America (Ahadi et al., 2013).

While prior reviews have examined performance indicators, this study offers a deeper and more expansive analysis of the global patterns in the adoption and application of these tools for assessing WUS. To accomplish this, the review evaluated a broad range of literature and methodologies utilized in the measurement of performance across various water systems.

Performance assessment (PA) and indicators

At its core, performance assessment (PA) refers to the systematic evaluation of how efficiently resources are utilized and how effectively desired outcomes are achieved within a system (Bos et al., 1994). Despite its widespread use, the concept of efficiency remains subject to varied interpretations and ongoing scholarly debate (Boelens & Vos, 2012; Haie, 2008; Lankford, 2012; Pereira et al., 2002; Perry, 2007, 2008, 2011). Given the dynamic nature and complexity of water resource systems, there is a growing need for frameworks that can capture system behavior through quantifiable parameters, often derived from field data or simulation models. These parameters serve as reference points for evaluating system performance, identifying inefficiencies, and tracking progress over time. Thus, PA is a critical component of broader performance management frameworks, offering stakeholders—such as utility managers, farmers, and policy actors—insight into system operations, challenges, and potential improvements (Bos et al., 2005).

According to ISO (2007), an indicator is defined as a parameter—or a value derived from a parameter—that conveys information with broader relevance than its immediate context. Performance indicators, therefore, are essential tools that help quantify the success or shortcomings of specific actions, especially in terms of operational efficiency and goal achievement (Nudurupati et al., 2011). As outlined by Alegre et al. (20060, cited in Vieira et al., 2008), performance indicators (PIs) provide a measurable means of evaluating how well a water utility delivers its services, encompassing both effectiveness (i.e., achievement of objectives) and efficiency (i.e., optimal use of resources). These indicators are often expressed as ratios, which may involve comparable units (e.g., percentages) or differing units (e.g., cost per cubic meter).

Various classifications and frameworks for irrigation performance indicators have been proposed. Rao (1993) summarized the extensive range of metrics suggested by scholars for evaluating irrigation systems, while Kloezen and Garcés-Restrepo (1998) organized these into categories addressing hydrological, agronomic, economic, financial, and environmental dimensions. Bos et al. (1994) offered a widely adopted classification that segments indicators into those related to water supply efficiency (such as conveyance efficiency), agricultural productivity, and socio-economic and environmental impacts. Additionally, Bos (1997) recommended a set of indicators that assess multiple aspects—ranging from water delivery and use efficiency to maintenance, environmental sustainability, and management practices—which are especially valuable for evaluating both irrigation and drainage systems.

Indicators also play a role in simplifying the complex hydrological behavior of irrigation systems into a limited set of meaningful and interpretable figures (Bastiaanssen et al., 2001). Despite variations in terminology and data availability, a relatively consistent set of indicators is employed across different regions and system types (Vilanova et al., 2015). Nevertheless, because different stakeholders interpret performance differently, a key element of strategic system management lies in selecting appropriate indicators that reflect the priorities and expectations of users (Bos et al., 1994).

The selection of indicators also affects the outcome of performance evaluations. For example, a review by Kamwamba-Mtethiwa, Weatherhead, and Knox (2015) on small-scale pumped irrigation systems revealed that studies employing socio-economic metrics (e.g., crop yields, farmer income) tend to report positive outcomes, whereas those focusing on technical metrics (e.g., pump efficiency, water application rates) often show mixed results. These findings stress the need for cautious interpretation of comparative studies, especially when different methodologies or performance lenses are used.

In the context of domestic water systems, PA has been applied to areas such as water treatment, storage, and distribution. Vieira et al. (2008) noted that the most prominent performance indicator frameworks in this sector were developed by the International Water Association (IWA) and the World Bank. However, while most indicators target agricultural systems, only a limited number are designed to evaluate both irrigation and potable water supply systems.

Performance evaluations have been conducted at multiple levels—ranging from individual irrigation schemes to entire river basins, and even at national scales. These assessments have been used for both public and user-managed systems, and for comparing performance across different schemes globally. The multi-dimensional nature of irrigation performance means it must often be interpreted through diverse lenses—including technical, economic, and social perspectives (Carr et al., 2012; Chandran & Ambili, 2016; Dejen et al., 2012; Gomo et al., 2014; Kono et al., 2012; Kuscu et al., 2009). Importantly, performance may be perceived differently by different user groups; while farmers may see irrigation systems as beneficial, other groups—such as downstream users or environmental stakeholders—may have more critical views.

Types of performance assessment

Selecting an appropriate type of performance assessment (PA) is a crucial step in the evaluation process, as the chosen type must align closely with the underlying objectives or rationale for conducting the assessment. According to Bos, Burton, and Molden (2005), who built upon the earlier work of Small and Svendsen (1992), five principal categories of PA can be identified.

The classification includes the following:

Operational Performance Assessment, which emphasizes routine, seasonal, or periodic monitoring to evaluate how well irrigation schemes are functioning day to day.

Accountability Assessment, which measures how effectively those responsible for managing the system are fulfilling their roles and responsibilities.

Intervention Assessment, which focuses on identifying opportunities to enhance system performance, often in the context of ongoing or planned improvements.

Sustainability Assessment, which considers the long-term viability and resource use implications of system operations.

Diagnostic Assessment, which is employed to investigate the root causes of performance deficiencies with the aim of proposing targeted corrective actions.

Internal or external assessment

Performance assessments may be categorized as either internal or external, depending on the scope of analysis. Internal assessments focus on a single irrigation scheme, evaluating it against its own operational goals and standards (e.g., Kuscu, Eren, & Demir, 2009). In contrast, external assessments involve comparative analyses across multiple schemes, often benchmarking one system against others to draw broader conclusions (e.g., Dejen et al., 2012). Establishing whether the assessment is internal or external is a crucial early step, as it directly shapes the selection of indicators and the evaluation criteria to be applied (Bos, Burton, & Molden, 2005). Specifically, internally focused assessments are typically guided by scheme-specific objectives, while external assessments are more likely to rely on regionally or internationally recognized performance standards.

Numerous researchers have adopted hybrid methodologies that combine both external performance indicators—such as efficiency ratios and productivity metrics—with internal process evaluations, including assessments of irrigation timing, application durations, and water distribution patterns. These combined approaches have proven valuable in diagnosing performance issues and understanding system behavior at multiple scales (Causapé et al., 2006; Gorantiwar & Smout, 2005; Jayatillake, 2004; Sanaee-Jahromi & Feyen, 2001).

Interestingly, findings from such studies sometimes challenge conventional thinking. For instance, the introduction of more complex irrigation technologies does not always lead to improved performance outcomes. Similarly, reductions in water abstraction are not guaranteed to enhance irrigation efficiency or increase water availability for downstream users. These observations raise critical questions about assumed benefits of shifting from traditional surface irrigation methods to technologies like drip or sprinkler systems (Ahmad, Masih, & Giordano, 2014; Molle & Tanouti, 2017), underscoring the need for context-specific analysis in water management planning.

Methodological perspective of performance assessment studies

A range of methodologies has been employed in the assessment of Water Use Systems (WUS), with varying degrees of effectiveness reported across different contexts. Many performance indicators necessitate the combination of point-based measurements—such as field-level water data—with spatially extensive datasets capturing variables like crop patterns, yield distribution, and overall water usage. The advent of advanced remote sensing (RS) technologies has significantly enhanced the ability to gather such spatially explicit data. Through the use of satellite imagery, researchers can now monitor and analyze these parameters over large geographic areas, enabling more comprehensive and scalable performance evaluations.

Field measurements/conventional methods

Conventional performance assessment of irrigation systems has traditionally relied on field-based experiments to gather empirical data on water use and management practices (Andrés & Cuchí, 2014; Dejen et al., 2012; Gomo et al., 2014a; Mondal & Saleh, 2003; Singh et al., 2006). Although such studies provide valuable site-specific insights, they are often resource-intensive—requiring significant time, labor, and financial investment (Sam-Amoah & Gowing, 2001). In many developing countries, these methods remain common, with field observations of irrigation events used to evaluate operational characteristics of local schemes. However, a key limitation is that findings from these localized studies often lack broader applicability, particularly in regions with differing ecological and hydrological conditions. As a result, alternative approaches such as remote sensing have gained relevance for broader-scale assessments.

Despite the emergence of newer technologies, performance evaluation in irrigation systems still fundamentally depends on direct hydrological measurements. These typically include inflow and outflow volumes, groundwater level monitoring, and other forms of in-situ data collection (Bos et al., 2005). The computation of many performance indicators requires datasets on variables such as irrigation discharge, crop water needs, effective rainfall, evapotranspiration rates, cultivated area, cropping patterns, and yield outputs. While field experiments remain a cornerstone of irrigation assessment efforts, their limitations—especially in scalability and cost—have led researchers to increasingly integrate or complement them with more advanced, spatially distributed tools like satellite-based remote sensing (Jiang et al., 2015).

Geographical information systems (GIS)/remote sensing (RS)

Remote sensing represents a modern, wide-reaching technological advancement that enables more detailed and accurate analysis of irrigation performance than traditional field methods (Bastiaanssen & Bos, 1999; Perry, 2005). It facilitates the acquisition of near-real-time, spatially distributed data on various crop-related parameters—such as crop type, phenological stages, water availability, biomass levels, and yield uniformity—down to the level of individual plots and subplots.

Emerging evidence points to the growing reliability and adoption of GIS and remote sensing technologies in performance evaluation studies (Ahadi, Samani, & Skaggs, 2013; Ahmad et al., 2009; Akbari et al., 2007; Bastiaanssen et al., 2001; Karimi et al., 2013; Singh et al., 2006; Usman et al., 2015). These technologies have proven effective in enhancing irrigation management strategies by offering a broader, more integrated view of system performance.

However, despite their advantages, remote sensing tools remain financially and technically inaccessible to some irrigation practitioners, particularly in low-resource settings (Tarjuelo et al., 2015). Challenges such as limited financial resources and the small, fragmented nature of irrigated plots in many regions further hinder widespread adoption (Gomo et al., 2014). In contrast, developed countries have widely embraced distributed agro-hydrological modeling, incorporating remote sensing data to assess and optimize irrigation performance at scale (Jiang et al., 2015; Singh et al., 2006; Xue & Ren, 2016). Nevertheless, some developing countries have also started leveraging these technologies—for instance, Ahmad, Turral, and Nazeer (2009) successfully applied remote sensing to evaluate the functionality of large-scale irrigation schemes in Pakistan.

Conclusions

This review examines knowledge on the performance assessment of water resources systems, emphasizing the application of advanced, state-of-the-art methods and innovative techniques. It highlights the diversity in performance evaluation approaches, which vary significantly across countries, utilities, specific objectives, and the different stakeholders involved.

Findings indicate that agricultural performance assessment dominates the literature, whereas urban water system evaluations receive comparatively less attention. Additionally, assessments of municipal water systems tend to focus predominantly on management and economic aspects, often overlooking important technical factors. Irrigation performance indicators have proven highly effective for evaluating water management across multiple spatial scales—from individual fields and farms to irrigation districts and entire basins. These indicators have also been applied in controlled environments such as greenhouse horticulture. The results suggest that multi-sensor remote sensing technologies offer a valuable tool for monitoring crop water use and soil moisture at the field scale over extensive growing areas, thereby supporting operational water management decisions, especially for high-value crops.

Most performance indicators target agricultural systems, with relatively few designed to simultaneously assess both agricultural and water supply systems. Despite challenges associated with field measurements, this method remains the most widely used technique. Geographic Information Systems (GIS) and Remote Sensing (RS) technologies are primarily employed in developed countries, likely due to the technical and financial resources required for their implementation. Regarding the popularity of indicators, efficiency-related measures and water productivity rank highest, followed by indicators such as relative irrigation, adequacy, and relative water supply.

The study also reveals a significant lack of standardization in the selection and use of performance indicators. Currently, there is no universally accepted framework or set of indicators for performance assessment in water resource systems. This absence of consensus complicates comparisons across studies, as different researchers adopt varied indicators and models. It is therefore recommended that a standardized terminology and framework be developed and widely adopted to facilitate clearer communication and shared understanding among all stakeholders.

References

Ahadi, R., Samani, Z., & Skaggs, R. (2013). Evaluating on-farm irrigation efficiency across the watershed: A case study of New Mexico's Lower Rio Grande Basin. Agricultural Water Management, 124, 52–57. https://doi.org/10.1016/j.agwat.2013.03.010

Ahmad, M. D., Turral, H., & Nazeer, A. (2009). Diagnosing irrigation performance and water productivity through satellite remote sensing and secondary data in a large irrigation system of Pakistan. Agricultural Water Management, 96(4), 551–564. https://doi.org/10.1016/j.agwat.2008.09.017

Ahmad, M. T., Haie, N., Yen, H., & Tuqan, N. A. S. (2018). Sefficiency of a Water Use System: The Case of Kano River Irrigation Project, Nigeria. International Journal of Civil Engineering, 16(8), 929–939. https://doi.org/10.1007/s40999-017-0235-2

Ahmed, B. M., Tanakamaru, H., & Tada, A. (2010). Application of remote sensing for estimating crop water requirements, yield and water productivity of wheat in the Gezira Scheme. International Journal of Remote Sensing, 31(16), 4281–4294. https://doi.org/10.1080/01431160903246733

Akbari, M., Toomanian, N., Droogers, P., Bastiaanssen, W., & Gieske, A. (2007). Monitoring irrigation performance in Esfahan, Iran, using NOAA satellite imagery. Agricultural Water Management, 88(1–3), 99–109. https://doi.org/10.1016/j.agwat.2006.10.019

Al Zayed, I. S., Elagib, N. A., Ribbe, L., & Heinrich, J. (2015). Spatio-temporal performance of large-scale Gezira Irrigation Scheme, Sudan. Agricultural Systems, 133, 131–142. https://doi.org/10.1016/j.agsy.2014.10.009

Alegre, H., Melo, B. J., Cabrera, E. J., Cubillo, F., Duarte, P., Hirner, W., … Parena, R. (2006). Performance Indicators for Water Supply Services. London: IWA Publishing.

Andrés, R., & Cuchí, J. A. (2014). Analysis of sprinkler irrigation management in the LASESA district, Monegros (Spain). Agricultural Water Management, 131, 95–107. https://doi.org/10.1016/j.agwat.2013.09.016

Bastiaanssen, W. G. M., & Bos, M. G. (1999). Irrigation performance indicators based on remotely sensed data: a review of literature. Irrigation and Drainage Systems, 13(1999), 291–311. https://doi.org/10.1023/A:1006355315251

Boelens, R., & Vos, J. (2012). The danger of naturalizing water policy concepts: Water productivity and efficiency discourses from field irrigation to virtual water trade. Agricultural Water Management, 108(May), 16–26. https://doi.org/10.1016/j.agwat.2011.06.013

Borgia, C., García-Bolaños, M., & Mateos, L. (2012). Patterns of variability in large-scale irrigation schemes in Mauritania. Agricultural Water Management, 112, 1–12. https://doi.org/10.1016/j.agwat.2012.03.013

Bos, M. (1997). Performance indicators for irrigation and drainage. Irrigation and Drainage Systems, 11(2), 119–137.

Bos, M. G., Burton, M. a., & Molden, D. J. (2005). Irrigation and Drainage Performance Assessment - Practical Guidelines. https://doi.org/10.1017/CBO9781107415324.004

Bos, M., Murray-Rust, D., Merrey, DJ, Johnson, HG, & Snellen, W. (1994). Methodologies for assessing performance of irrigation and drainage management. Irrigation and Drainage Systems, 7(4), 231–261.

Bos, Marinus Gijsberthus, Burton, M. A. S., & Molden, D. J. (2005). Irrigation and drainage performance assessment: practical guidelines. (June).

Brown, C. M., Lund, J. R., Cai, X., Reed, P. M., Zagona, E. A., Ostfeld, A., … Brekke, L. (2015). The future of water resources systems analysis: Toward a scientific framework for sustainable water management. Water Resour. Res., 51, 6110–6124. https://doi.org/10.1002/2015WR017114.Received

Carr, G., Blöschl, G., & Loucks, D. P. (2012). Evaluating participation in water resource management: A review. Water Resources Research, 48(11), 1–17. https://doi.org/10.1029/2011WR011662

Causapé, J., Quílez, D., & Aragüés, R. (2006). Irrigation efficiency and quality of irrigation return flows in the Ebro River Basin: An overview. Environmental Monitoring and Assessment, 117(1–3), 451–461. https://doi.org/10.1007/s10661-006-0763-8

Chandran, K. Madhava, & Ambili, G. K. (2016). Evaluation of minor irrigation schemes using performance indicators: case studies from South India. Sustainable Water Resources Management, 2(4), 431–437. https://doi.org/10.1007/s40899-016-0074-3

Dejen, Z., Schultz, B., & Hayde, L. (2012). Comparative irrigation performance assessment in community-managed schemes in Ethiopia. African Journal of Agricultural Research, 7(35), 4956–4970. https://doi.org/10.5897/AJAR11.2135

Ermini, R., Ataoui, R., & Qeraxhiu, L. (2015). Performance indicators for water supply management. Water Science & Technology: Water Supply, 15(4), 718. https://doi.org/10.2166/ws.2015.024

Gadanakis, Y., Bennett, R., Park, J., & Areal, F. J. (2015). Improving productivity and water use efficiency: A case study of farms in England. Agricultural Water Management, 160, 22–32. https://doi.org/10.1016/j.agwat.2015.06.020

García-Bolaños, M., Borgia, C., Poblador, N., Dia, M., Seyid, O. M. V., & Mateos, L. (2011). Performance assessment of small irrigation schemes along the Mauritanian banks of the Senegal River. Agricultural Water Management, 98(7), 1141–1152. https://doi.org/10.1016/j.agwat.2011.02.008

Gomo, T., Senzanje, A., Mudhara, M., & Dhavu, K. (2014). Assessing the Performance of Smallholder Irrigation and Deriving Best Management Practices in South Africa †. 429(November 2013), 419–429.

Gorantiwar, S. D., & Smout, I. K. (2005). Performance assessment of irrigation water management of heterogeneous irrigation schemes: 1. A framework for evaluation. Irrigation and Drainage Systems, 19(1), 1–36. https://doi.org/10.1007/s10795-005-2970-9

Haie, N., & Keller, A. A. (2008). Effective efficiency as a tool for sustainable water resources management. Journal of the American Water Resources Association, 44(4), 961–968. https://doi.org/DOI 10.1111/j.1752-1688.2008.00194.x

ISO. (2007). ISO 24512 Activities relating to drinking water and wastewater services — Guidelines for the management of drinking water utilities and for the assessment of drinking water services. Retrieved July 13, 2017, from https://www.iso.org/standard/37248.html

Israelsen, O. W. (1932). Irrigation principles and practices. 472. Retrieved from http://books.google.com.co/books?id=Z19RAAAAMAAJ

Jayatillake, H. M. (2004). Application of performance assessment and benchmarking tool to help improve irrigation system performance in Sri Lanka. Irrigation and Drainage, 53(2), 185–193. https://doi.org/10.1002/ird.132

Jensen, M. E. (1966). Discussion: Irrigation Requirements of Lawns. Journal of the Irrigation and Drainage Engineering-ASCE, 92(IRI), 95–100.

Jensen, Marvin E. (2007). Beyond irrigation efficiency. Irrigation Science, 25(3), 233–245. https://doi.org/10.1007/s00271-007-0060-5

Jiang, Y., Xu, X., Huang, Q., Huo, Z., & Huang, G. (2015). Assessment of irrigation performance and water productivity in irrigated areas of the middle Heihe River basin using a distributed agro-hydrological model. Agricultural Water Management, 147, 67–81. https://doi.org/10.1016/j.agwat.2014.08.003

Kamwamba-Mtethiwa, J., Weatherhead, K., & Knox, J. (2015). Assessing performance of small-scale pemped irrigation systems in Sub Saharan Africa: Evidence from a systematic review. Irrigation and Drainage, In Press(March), 308–318.

Karimi, P., Bastiaanssen, W. G. M., Molden, D., & Cheema, M. J. M. (2013). Basin-wide water accounting based on remote sensing data: an application for the Indus Basin. Hydrology and Earth System Sciences, 17(7), 2473–2486. https://doi.org/10.5194/hess-17-2473-2013

Karimov, A., Molden, D., Khamzina, T., Platonov, A., & Ivanov, Y. (2012). A water accounting procedure to determine the water savings potential of the Fergana Valley. Agricultural Water Management, 108, 61–72. https://doi.org/10.1016/j.agwat.2011.11.010

Kazbekov, J., Abdullaev, I., Manthrithilake, H., Qureshi, A., & Jumaboev, K. (2009). Evaluating planning and delivery performance of Water User Associations (WUAs) in Osh Province, Kyrgyzstan. Agricultural Water Management, 96(8), 1259–1267. https://doi.org/10.1016/j.agwat.2009.04.002

Keller, A., Keller, J., & Seckler, D. (1996). Integrated Water Resource Systems: Theory and Policy Implications. IWMI Research Report 003 / IIMI Research Report 003, 15p. https://doi.org/10.3910/2009.004

Kloezen, W. H., & Garcés-Restrepo, C. (1998). Assessing Irrigation Performance with Comparative Indicators: The Case of the Alto Rio Lerma Irrigation District, Mexico. Sri Lanka.

Kono, S., Ounvichit, T., Ishii, A., & Satoh, M. (2012). Participatory system for water management in the Toyogawa Irrigation Project, Japan. Paddy and Water Environment, 10(1), 75–81. https://doi.org/10.1007/s10333-011-0266-2

Kuscu, H., Eren, F., & Demir, A. O. (2009). Performance assessment for irrigation water management : A case study in the Karacabey irrigation scheme in Turkey. Journal of Agricultural Research, 4(February), 124–132.

Lankford, B. (2012). Fictions, fractions, factorials and fractures; on the framing of irrigation efficiency. Agricultural Water Management, 108, 27–38. https://doi.org/10.1016/j.agwat.2011.08.010

Lecina, S., Neale, C. M. U., Merkley, G. P., & Dos Santos, C. A. C. (2011). Irrigation evaluation based on performance analysis and water accounting at the Bear River Irrigation Project (U.S.A.). Agricultural Water Management, 98(9), 1349–1363. https://doi.org/10.1016/j.agwat.2011.04.001

Lorite, I. J., García-Vila, M., Carmona, M.-A., Santos, C., & Soriano, M.-A. (2012). Assessment of the Irrigation Advisory Services' Recommendations and Farmers' Irrigation Management: A Case Study in Southern Spain. Water Resources Management, 26(8), 2397–2419. https://doi.org/10.1007/s11269-012-0023-3

Mateos, L., Lozano, D., Baghil, A. B. O., Diallo, O. A., Gómez-Macpherson, H., Comas, J., & Connor, D. (2010). Irrigation performance before and after rehabilitation of a representative, small irrigation scheme besides the Senegal River, Mauritania. Agricultural Water Management, 97(6), 901–909. https://doi.org/10.1016/j.agwat.2010.01.021

Merchán, D., Causapé, J., Abrahão, R., & García-Garizábal, I. (2015). Assessment of a newly implemented irrigated area (Lerma Basin, Spain) over a 10-year period. I: Water balances and irrigation performance. Agricultural Water Management, 158, 277–287. https://doi.org/10.1016/j.agwat.2015.04.016

Molden, D., & Sakthivadivel, R. (1999). Water Accounting to Assess Use and Productivity of Water. International Journal of Water Resources Development, 15(1–2), 55–71. https://doi.org/10.1080/07900629948934

Molle, F., & Tanouti, O. (2017). Squaring the circle: Agricultural intensification vs. water conservation in Morocco. Agricultural Water Management, 192, 170–179. https://doi.org/10.1016/j.agwat.2017.07.009

Mondal, M. S., & Saleh, A. F. M. (2003). Evaluation of some deep and shallow tubewell irrigated schemes in Bangladesh using performance indicators. Agricultural Water Management, 58(3), 193–207. https://doi.org/10.1016/S0378-3774(02)00087-2

Nudurupati, S. S., Bititci, U. S., Kumar, V., & Chan, F. T. S. (2011). State of the art literature review on performance measurement. Computers and Industrial Engineering, 60(2), 279–290. https://doi.org/10.1016/j.cie.2010.11.010

Pereira, Luis Santos, Oweis, T., & Zairi, A. (2002). Irrigation management under water scarcity. Agricultural Water Management, 57(3), 175–206. https://doi.org/10.1016/S0378-3774(02)00075-6

Perry, C., Steduto, P., Allen, R. G., & Burt, C. M. (2009). Increasing productivity in irrigated agriculture: Agronomic constraints and hydrological realities. Agricultural Water Management, 96(11), 1517–1524. https://doi.org/10.1016/j.agwat.2009.05.005

Rao, P. S. (1993). Review of Selected Literature on Indicators of Irrigation Performance. International Irrigation Management Institute (IIMI), p. 75. Colombo.

Rowshon, M. K., Mojid, M. A., Amin, M. S. M., Azwan, M., & Yazid, A. M. (2014). Improving Irrigation Water Delivery Performance of a Large-Scale Rice Irrigation Scheme. Journal of Irrigation and Drainage Engineering, 140(8), 04014027. https://doi.org/10.1061/(ASCE)IR.1943-4774.0000747

Sam-Amoah, L. K., & Gowing, J. W. (2001). Assessing the performance of irrigation schemes with minimum data on water deliveries. Irrigation and Drainage., 39(50), 31–39.

Sanaee-Jahromi, S., & Feyen, J. (2001). Spatial and temporal variability performance of the water delivery in irrigation schemes. Irrigation and Drainage Systems, 15(3), 215–233.

Singh, R., Kroes, J. G., van Dam, J. C., & Feddes, R. A. (2006). Distributed ecohydrological modelling to evaluate the performance of irrigation system in Sirsa district, India: I. Current water management and its productivity. Journal of Hydrology, 329(3–4), 692–713. https://doi.org/10.1016/j.jhydrol.2006.03.037

Usman, M., Liedl, R., & Awan, U. K. (2015). Spatio-temporal estimation of consumptive water use for assessment of irrigation system performance and management of water resources in irrigated Indus Basin, Pakistan. Journal of Hydrology, 525, 26–41. https://doi.org/10.1016/j.jhydrol.2015.03.031

Van Halsema, G.E, Lencha, B. K., Assefa, M., Hengsdijk, H., & Wesseler, J. (2011). Performance assessment of smallholder irrigation in the central rift valley of Ethiopia. Irrigation and Drainage, 60(5), 622–634. https://doi.org/10.1002/ird.613