NILE-SEC
NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL

NBI Technical Reports: Water Resource Management Series

Guidance for Benchmarking Irrigation Performance in the Nile Basin

WRM-2022-06

EUROPEAN UNION

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Document Sheet

This Technical Report series publishes results of work that has been commissioned by the member states through the three NBI Centers (Secretariat based in Entebbe- Uganda, the Eastern Nile Technical Regional Office based in Addis Ababa - Ethiopia and the Nile Equatorial Lakes Subsidiary Action Program Coordination Unit based in Kigali - Rwanda. The content there-in has been reviewed and validated by the Member States through the Technical Advisory Committee and/or regional expert working groups appointed by the respective Technical Advisory Committees.

The purpose of the technical report series is to support informed stakeholder dialogue and decision making in order to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the shared Nile Basin water resources.

Document	
Citation	NBI Technical Reports - WRM-2022-06
Title	Guidance for Benchmarking Irrigation Performance in the Nile Basin
Series Number	Water Resources Management 2022-06
Date	September 2022
Responsible and Review	
Responsible NBI Center	Nile-Secretariat
Responsible NBI	Dr Michael Kizza
Document Review Process	Strategic Water Resources Analysis Regional Expert Working Group
Final Version endorsed	August 2022 – 30th Nile-COM Meeting (Dar es Salaam, Tanzania)
Author / Consultant	
Consultant Firm	International Water Management Institute (IWMI)
Authors	Leul Kahsay and Amare Haileslassie
Project	
Funding Source	European Union (EU) and German Federal Ministry of Economic Cooperation and Development (BMZ)
Project Name	Support to Transboundary Water Cooperation in the Nile Basin
Project Number	16.2083.0

Contents

Acronyms and Abbreviations iii
EXECUTIVE SUMMARY v
1. INTRODUCTION 1
2. LIMITATIONS AND CHALLENGES OF BENCHMARKING AND POSSIBLE SOLUTIONS 5
3. OBJECTIVES AND APPLICATION OF IRRIGATION PERFORMANCE BENCHMARKING IN NILE BASIN COUNTRIES 6
4. GUIDANCE FOR BENCHMARKING OF IRRIGATION PERFORMANCE 9
4.1. Overview 9
4.2. External Benchmarking 11
4.2.1 Scope and Salient Features of External Benchmarking 11
4.2.2 Data Processing and Analysis for External Benchmarking 14
4.3. Internal Benchmarking 16
4.3.1. Scope 16
4.3.2. Participatory Internal Benchmarking Process: Synchronizing PIM with BIP 17
4.3.3 Quality Control 20
4.3.4. Indicators for Internal Benchmarking 21
5. CONCLUSIONS AND RECOMMENDATIONS 35
References 38
Annex. REVIEW OF INTERNATIONAL AND REGIONAL EXPERIENCE ON BENCHMARKING 41
A1. Benchmarking of Agricultural Water Use and Productivity in Key Commodity Crops in the United Kingdom 41
A2. Irrigation Benchmarking Service by Government Agency in India 44
A3. Benchmarking of Australian Irrigation Water Provider Business 46
A4. Benchmarking Initiatives in the Nile Basin 47

List of Figures

Figure 1. The objective of benchmarking is continual improvement of irrigation performance through comparison with best practices........8

Figure 2. The goal of benchmarking is sustainable improvement in irrigation performance........8

Figure 3. An example of presenting trend analysis result of maize yield in Ethiopia benchmarked against yield in Egypt........16

Figure 4. Benchmarking as an integral part of the irrigation scheme management process 20

List of Tables

Table 1. An overview of the types of benchmarking proposed for the Nile Basin countries........10

Table 2. Typical indicators for external benchmarking of irrigation performance in the Nile Basin. 13

Table 3. Example illustrating the calculation of the deviation of a chosen indicator (maize crop yield) from the corresponding external benchmarking value........15

Table 4. Template for compiling the productive efficiency performance indicators for benchmarking of irrigation projects 25

Table 5. Temporal comparison of productive efficiency 26

Table 6. Template for determining major service delivery performance indicators........29

Table 7. Percentage deviation of relative water supply and usage of irrigable area........ 29

Table 8. Key economic efficiency performance indicators for benchmarking of irrigation projects.. 31

Table 9. Temporal comparison of economic efficiency 32

Table 10. Template for key environmental performance indicators...33

Table 11. Temporal comparison of environmental performance in terms of the land damage index...33

Table 12. Template for compilation of parameters for determining gender performance indicators.

....34

Acronyms and Abbreviations

ANCID	Australian National Committee on Irrigation and Drainage
AUD	Australian Dollar
BCM	Billion Cubic Meters
BIP	Benchmarking Irrigation Performance
CWP	Crop Water Productivity
FAO	
GBP	Food and Agriculture Organization of the United Nations
GIZ	Great British Pounds
	Deutsche Gesellschaft für Internationale Zusammenarbeit
Ha	Hectare
INR	Indian Rupee
IPTRID	International Programme for Technology and Research in Irrigation and Drainage
IWC	Irrigation Water Corporation
IWMI	International Water Management Institute
KPI	Key Performance Indicator

kWh	Kilowatt hour
m	Meter
Mha	Million hectares
mm	Millimeter
MoIWR	Ministry of Irrigation and Water Resources
M&E	Monitoring and Evaluation
NB	Nile Basin
NBI	Nile Basin Initiative
O&M	Operation and Maintenance
PIM	Participatory Irrigation Management
SGB	Sudan Gezira Board
UKIA	UK Irrigation Association
USD	United States Dollar
WUA	Water Users' Association

EXECUTIVE SUMMARY

Benchmarking of irrigation performance can be defined as the process of identifying the gap between the current performance of an irrigation entity and its achievable potential, and carrying out a comparative analysis to guide changes that can realize higher performance.

There is such a need to initiate benchmarking of the irrigation sector in the Nile Basin (NB) because the present and projected levels of irrigation water demand and supply indicate that a large water deficit is likely in the future. This calls for urgent and sustained efforts to improve water and agronomic management practices and technologies to enhance water-use efficiency. Promotion of good water conservation and water-use practices can substantially mitigate future water stress while increasing agricultural productivity and farm income. Accordingly, the Secretariat (Nile-Sec) of the Nile Basin Initiative (NBI) intends to support member countries by fostering a dialogue on developing options of efficient water use such as adoption of improved irrigation technologies and optimization of cropping patterns across the basin. An integral part of such an endeavor is to promote benchmarking irrigation performance (BIP) as a management tool for irrigation systems with a view to improving productivity and achieving 'more value per drop'.

This guidance document on BIP has been prepared by the International Water Management Institute (IWMI) under the auspices of Nile-Sec in support of the initiative to enhance water-use efficiency in the Nile Basin. Context-specific approaches to BIP are proposed in this document, and cost-effective benchmarking indicators and data to be collected are suggested.

Proposed Benchmarking Approaches. Two types of benchmarking have been suggested for implementation in the NB: External and internal benchmarking. The key factor determining their usage is accessibility of information on the quantity and quality of the ingredients of these approaches and the processes involved in attaining the benchmarks.

External benchmarking. With the aim of learning from others' experience, this approach assesses the performance of an irrigation entity against external benchmarks. Any country with the best irrigation performance can be used as a source of benchmark data—as long as it is available and accessible. External benchmarks can be used to continuously assess the effectiveness of irrigation policy and strategies in the Nile Basin. This approach can be implemented by national policymakers, macro-level planners, researchers and/or regional agencies. Presuming that input data can be obtained from non-confidential sources—such as published annual statistical reports and online sources—policymakers of NB countries can use external benchmarking to address the following four questions:

(i) Have institutions in the NB irrigation sector accurately pinpointed the key constraints to productivity of irrigated agriculture;
(ii) Are there any weak links in coordination among relevant sectors;
(iii) Are the ongoing or newly proposed technical and management interventions relevant, effective and efficient, taking into account local and international experiences; and
(iv) Is there a need to increase, through policy or strategy interventions, the impact of irrigation on issues such as:
    - Equity in land and water distribution;
    - Water allocation within and across sectors;
    - Maintenance and management of irrigation infrastructure;
    - Access to improved production technologies;
    - Agricultural support services;
    - Emphasis on pro-poor approaches, etc.

Internal benchmarking. This approach assesses an irrigation scheme in terms of its performance over time with reference to its achievable potential (or benchmarks). The benchmarks may be gathered or drawn from (i) the past best results of the scheme; (ii) local research findings; and/or (iii) international research results or other acceptable standards (e.g., maximum water-use efficiency, maximum crop yield, etc.) achieved in a similar environment anywhere in the world—provided that the background information is available and accessible. The party responsible for implementing internal benchmarking is normally the person at the helm of an irrigation scheme or a group of schemes under the same management. Six indicators are suggested in this document for internal benchmarking. They are used to track and adjust variables that may directly affect the productivity and sustainability of a scheme. The variables are:

(i) Cropping program (crop and variety selection, cropping pattern, cropping intensity, crop rotation, soil fertility management, crop protection, etc.);
(ii) Irrigation water management (irrigation scheduling, water-use efficiency, drainage, etc.);
(iii) Operation and maintenance (O&M) (equitable and timely water distribution, O&M fee collection, efficient and effective preventive maintenance, efficient and effective repair works, etc.); and

(iv) Irrigation support services (extension, irrigation technology, production inputs, market, etc.).

The following crucial institutional arrangements are recommended for successful implementation of BIP in the NB countries:

(i) The provincial/state government agencies tasked with irrigation development should adopt benchmarking as a management tool to improve the performance of irrigation schemes. Their national counterparts should use their supervisory role in implementing the benchmarking process;
(ii) Irrigation staff working at the grassroots level must be (a) well-trained, (b) equipped with the mandated irrigation management guidelines, and (c) supported with continuous technical backstopping to implement the whole irrigation management and BIP package rather than bits and pieces of it;
(iii) Shortcomings that could derail the participatory irrigation management (PIM) approach should be assessed and rectified. Subsequently, PIM should be integrated with benchmarking and promoted with intensive technical support to ensure that dissemination of best practices and correction of deficiencies are achieved more effectively; and
(iv) Tailor-made benchmarking tools (online, mobile applications and/or software) should be designed and disseminated with the involvement of the stakeholders. It is also important to assess the potential application of satellite-derived geospatial information for BIP in the Nile Basin.

Finally, Nile-Sec and the NB member countries should promote (i) standardization of key performance indicators (i.e., their definition, data collection methods and use) to ensure that the results of BIP are accurate and comparable; (ii) continuous awareness-raising sessions for relevant personnel on BIP synchronized with PIM; (iii) adoption of site-specific, meaningful and affordable indicators for internal and external benchmarking by member countries; (iv) national and regional workshops to enable exchange of best practices, success stories and challenges related to BIP and PIM; (v) regional cooperation to improve water-use efficiency through data sharing; and (vi) investment and incentive mechanisms to institutionalize BIP in the member countries.

1. INTRODUCTION

1.1 Definition of Benchmarking

The aim of benchmarking is to achieve continuous improvement in the performance of an irrigation entity through comparative evaluation with reference to internal and/or external standards. This concept has been defined in different ways by different authors. For instance:

- Malano and Burton (2001) define irrigation performance benchmarking as *"a systematic process for securing continual improvement through comparison with relevant and achievable internal or external norms and standards".*
- Benchmarking is management tool to identify the gap between current performance and achievable performance so that changes can be made to realize higher standards of irrigation performance (Malano et al. 2004).
- Benchmarking is a process of identifying, learning from and adapting good practices and processes to help improve irrigation performance by comparing like with like (Kahan 2010).

This guidance document adopts the definition of benchmarking as a process of identifying the gap between current and achievable performance and making a comparative analysis that can inform changes aimed at enhancing performance.

1.2 The Need for Benchmarking Irrigation Performance

The need for benchmarking of the irrigation sector in the Nile Basin (NB) arises from the likelihood of a large water deficit in future. It calls for urgent efforts to improve water and agronomic management practices and technologies to enhance water-use efficiency. Some of the key drivers of the need to institutionalize benchmarking irrigation performance (BIP) in the Nile Basin are summarized below:

(A) Need to Urgently Address Projected Water Deficit. The NB is endowed with renewable mean annual surface water (long-term average) of 92–93 billion cubic meters (BCM) (NBI 2016). There are abundant groundwater resources in 12 trans-boundary aquifers covering 4,489,458 km^2 (of which 30% are located in the Nile Basin with the water stored in fossil aquifers or a mixture of fossil and renewable recharge

[Awulachew et al. 2012]). Despite this abundance of water, the NB is on the verge of facing critical water shortages, which could be physical and/or economic, depending on the location. The 6.4 million hectares (Mha) of land irrigated in 2011 have a water requirement of the order of 84–85 BCM (Multsch et al. 2017; NBI 2016). Irrigated area in the basin is projected to increase to 10.8 Mha by 2050 if the present country-specific irrigation development trend continues (NBI 2019). This is nearly consistent with an earlier study (Multsch et al. 2017) which projected that irrigated area and annual irrigation water requirement in the NB would increase to 10.2 Mha and 123 BCM, respectively, by 2050 under a scenario of poor irrigation infrastructure. This projected water demand is more than the current annual surface water yields in the basin, and hence is likely to be a critical challenge for the NB countries. On the other hand, the potential contribution of groundwater toward bridging this anticipated water deficit is not known. Under different irrigation efficiency improvement scenarios, Multsch et al. (2017) predicted that the NB would be in a state of perpetual water deficiency of 5–29 BCM per year—the smaller figure being the projected deficit under a theoretical scenario of maximum possible efficiency, and the larger figure being a projection under more likely efficiency improvement scenarios.

In the light of such portents, there is a strong need for the NB countries to collaboratively address the projected water deficit with appropriate strategies and improved practices and technologies.

(B) Need to Improve Irrigation Productivity to Tackle Persisting Food Insecurity and Undernourishment. The average yields of most crops in the upstream NB countries are low; on average they are one-sixth to one-half of the yields in Egypt (NBI 2012). Through the period 1993–2013, this yield gap remained very wide with no sign of narrowing while 90,000 ha, or 24.3%, of the area equipped for irrigation (as of 2010) in Egypt have become salinized due to irrigation mismanagement (FAO 2016). By extension, water productivity (yield per unit of water applied) is low in all the Nile Basin countries. Through the period 1996–2005, the water footprint (volume of water used to produce a product) of cereal crops in Eastern Africa and Northern Africa was 3,746 m^3/ton and 2,811 m^3/ton, respectively, as compared to 1,926 m^3/ton and 654 m^3/ton in Southern Africa and Western Europe, respectively (Mekonnen 2011). In sum, there is much room for improvement of irrigation water productivity in the Nile Basin. Persistent low agricultural productivity coupled with the fact that 70–90% of the population is directly dependent on agricultural employment (NBI 2016) explains why food insecurity and undernourishment are high on the agenda of upstream NB countries. Low productivity could be attributed to many factors such as failure to adopt and disseminate good agricultural and water management practices. For instance, research on irrigation efficiency and investment on water-saving

interventions have been implemented far more intensively in Egypt (Allam et al. 2005; Kotb and Boissevain 2012; Swelam 2016; Multsch et al. 2017) than in the other Nile riparian countries. Egypt's initiative in this regard may in fact have been partly driven by the alarming extent of land salinized due to irrigation. However, in the other NB countries, the challenge of water-use efficiency improvement has been addressed only intermittently by a few academic and research communities with little or no participation by other key stakeholders. So, there is a need for NB countries to establish a system to synchronize the efforts of all stakeholders to identify gaps and then implement the full package of good practices on a continuous basis.

Despite a very wide productivity gap persisting for decades, there is no documented evidence in the NB countries on the practice of BIP. It would have been a logical action for policymakers in the NB countries to use local research results and regional statistics to address important questions such as:

- Why are crop yields in Egypt much better than in the other NB countries?
- What are the strengths of Egypt's irrigated agriculture and the weaknesses of other NB countries which explain this disparity in crop yields?
- Which aspects of the irrigation sector should the NB countries target in order to enhance productivity?

The absence of such initiatives implies that there is a need to spread awareness and impart training on the concepts and practices of BIP. There is a need for the NB countries to adopt systematic tools to

- track irrigation productivity and compare it with achievements in other parts of the world;
- examine the policy, technology and management aspects of their irrigation systems in relation to those of successful countries; and
- accelerate implementation of best practices.

In sum, there is a strong need for a dialogue on improving irrigation performance. The NB member countries should jointly develop options on efficient water use such as improved irrigation technologies and optimized cropping patterns across the basin. It would be important to adopt BIP as a management tool to improve productivity of irrigation schemes—to generate 'more value per drop'. This guidance document describing the concept and practices of participatory BIP has been prepared to support such initiatives in the context of the NB.

1.3 Scope and Purpose of Guidance Document

This guidance document is intended for use by irrigation sector officials, scheme managers and supervising agencies in the NB countries who might be interested in using benchmarking as a tool for improving the performance of the sector in general and individual irrigation schemes in particular.

This guidance presents applicable information on:

- the principles and practices of benchmarking in the irrigation sector;
- the process of identification of appropriate indicators, data collection, processing, and analysis; and
- application of benchmarking in a participatory irrigation management context.

This document is useful for policy-makers, planners, irrigation managers and supervising agencies of irrigation schemes in identifying performance gaps and taking up corrective measures as and when required.

1.4 Approach Followed in Preparing This Guidance Document

The preparation of this document was guided by Nile-Sec's motive of promoting water-saving measures in irrigation schemes using benchmarking as a management tool. Relevant concepts related to benchmarking as well as the modalities of their application in the management of irrigation schemes have been compiled from various sources. The benchmarking methodology and performance indicators have been adopted from a number of guidelines and reports, which are duly cited where applicable.

2. LIMITATIONS AND CHALLENGES OF BENCHMARKING AND POSSIBLE SOLUTIONS

While benchmarking can be used to improve irrigation performance, it is not easy to develop relevant and affordable indicators on all aspects of irrigation management. Besides, the difficulty of accessing data and obtaining a complete description of the processes that generate benchmark data can be major constraints to the application of external benchmarking. The solution to this challenge may be to adopt the internal benchmarking approach and use as a standard the existing best practices and upper productivity limits established by local research agencies.

Benchmarking could also be constrained by lack or inadequacy of resources (finance, expertise, technical tools, etc.). A solution to this problem would be to start small with a few key indicators selected from a long list in collaboration with stakeholders. Such chosen indicators must be meaningful and affordable to the stakeholders. This process should be guided by lessons drawn from successfully implemented benchmarking initiatives in various parts of the world. Accordingly, this guidance document presents a set of proven indicators that have already been successfully applied by practitioners. Nile Basin countries may adopt some or all of them.

Another limitation of benchmarking can be attributed to insufficient understanding of the concept in terms of how it works or the benefits it can offer. Further, this problem may become magnified due to continuous staff turnover within an irrigation scheme or institution. This challenge can be addressed through training and retraining personnel on benchmarking and ensuring that it fits in with the existing management practices. Moreover, it is necessary for benchmarking to be viewed as a vital management tool rather than a cure for all the shortcomings of an irrigation scheme. The role of benchmarking is to present a comparison of indicator values; it is up to the manager to process the data, taking into account various internal and external factors that contribute to the success or failure of an irrigation scheme. Therefore, it is imperative to ensure that benchmarking is led by the manager of a scheme or the head of the pertinent institution.

Benchmarking requires continuous endeavor given that irrigated agriculture involves many variables that change temporally in response to input supply, climate, market, etc. Any discontinuity in the benchmarking process, resulting from a lack of proper understanding of the concept, institutional instability or staff turnover, can be problematic. Therefore, irrigation managers and regulatory bodies would have to ensure that implementation of benchmarking is institutionalized firmly within the management culture of the scheme in question. This will be explained in the sections below.

Lack of participatory management can also constrain the success of benchmarking. To improve the productivity of an irrigation scheme, all individuals (men and women; farmers and employees) with a role to play in a given irrigation scheme must be involved in the whole process (Oakley 2013). Such participatory involvement will equip them to foresee how even some small errors can trigger the failure of the entire scheme. Without participatory benchmarking, it would be difficult for a manager to detect weak links in the process and take corrective measures.

Another challenge would stem from the fact that water measurement is not commonly done in most of the irrigation schemes in the NB although it is essential for water-use efficiency as well as benchmarking. Irrigation agencies of the basin countries would have to address the factors constraining measurement of water in these irrigation schemes.

3. OBJECTIVES AND APPLICATION OF IRRIGATION PERFORMANCE BENCHMARKING IN THE NILE BASIN COUNTRIES

The objective of benchmarking is to improve irrigation performance through comparison with relevant and achievable standards. It involves continuous assessment of the performance of irrigation schemes using standard indicators, and subsequently, adoption of best practices or actions to correct the deficiencies (Figure 1). As illustrated in Figure 2, benchmarking is about moving from one position to a better position (DTIC 2009).

By extension, the goal of benchmarking is to contribute to sustainable improvement in water-use efficiency and water and agricultural productivity. Sustainability of irrigation can be achieved through maximizing productivity, minimizing environmental hazards, equitable distribution of water and coverage of operation and maintenance (O&M) costs by the users. The resultant positive impact is anticipated to go beyond the directly targeted scheme.

The specific objectives of BIP are to:

- continuously collect data on the indicators selected for quantifying irrigation system performance;

- compare the indicator values with previous levels of performance, predetermined targets, and/or the performance of other reference irrigation schemes; and
- use the results thus obtained to identify and implement appropriate actions to correct performance deficiencies.

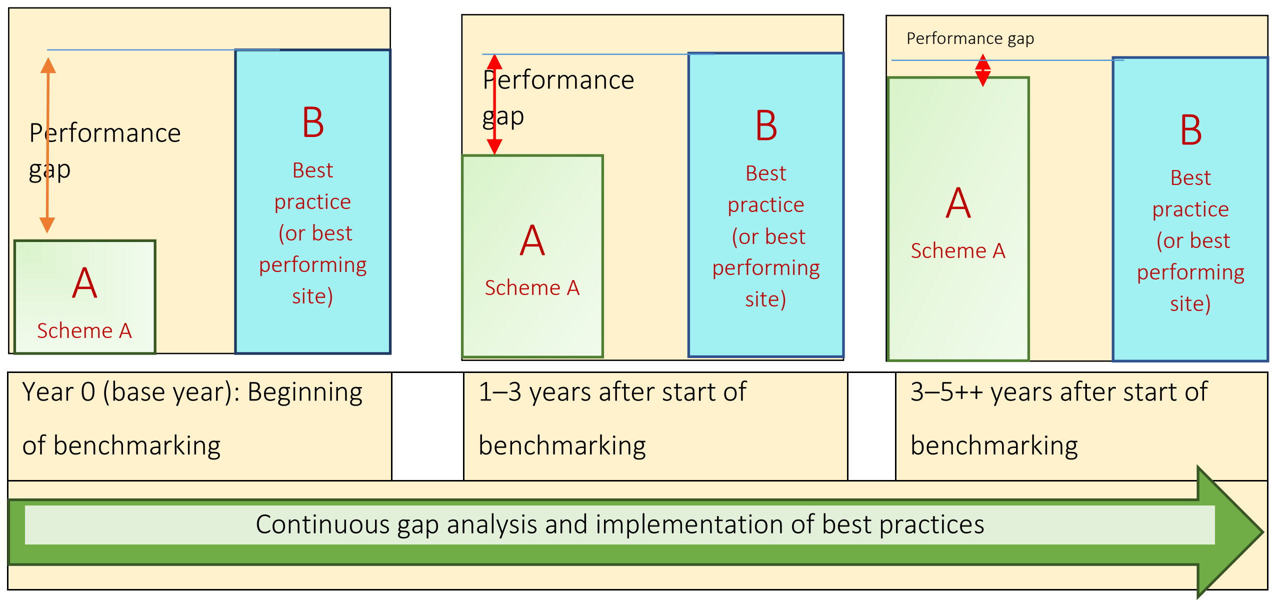

FIGURE 1. The objective of benchmarking is continual improvement of performance through comparison with best practices.

Source: Authors, based on concepts gathered from various sources.

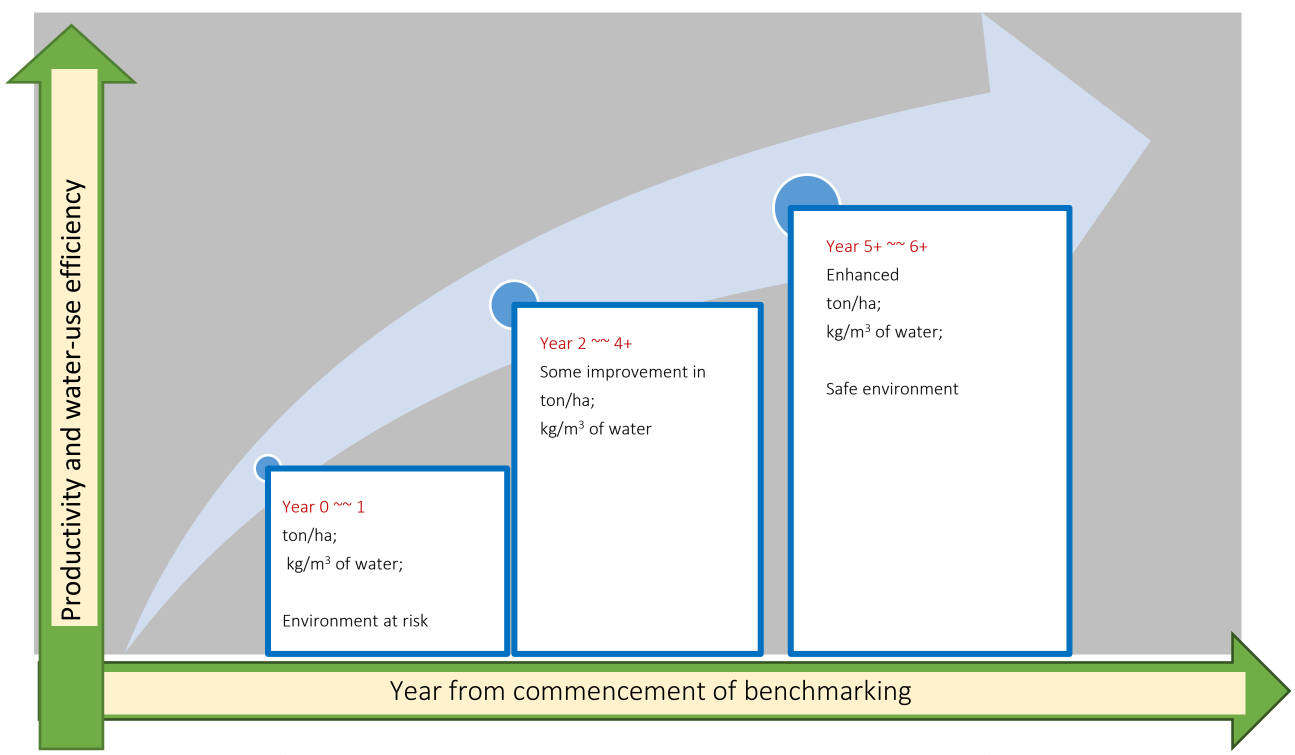

FIGURE 2. The goal of benchmarking is sustainable improvement in irrigation performance.

Source: Authors, based on concepts gathered from various sources.

4. GUIDANCE FOR BENCHMARKING OF IRRIGATION PERFORMANCE

4.1. Overview

On the basis of global and regional experiences, two types of benchmarking are suggested for implementation in the NB: External and internal benchmarking (Kahan 2010). The salient features of these two approaches are presented in Table 1 while a more detailed description is presented in subsequent sections.

External benchmarking is recommended for situations needing continuous assessment of policy and strategy in the irrigation sector and affiliated domains. It should be implemented by national policy-makers, macro-level planners, researchers and/or regional agencies. The input data and associated background information needed for external benchmarking are presumed to be obtained from non-confidential sources such as published annual statistical reports and other online sources.

The internal benchmarking approach on the other hand is suitable for assessment of the performance of an irrigation scheme by its manager, or a group of schemes managed under one-umbrella by the person at the helm.

The reference data (benchmarks) for internal benchmarking should be the past best results of the scheme or local or international research results provided that a complete description of the processes that generated the benchmark data are accessible. However, accessing performance indicator values from other countries or even other schemes within a country could be very challenging due to a number of reasons including confidentiality.

TABLE 1. An overview of the types of benchmarking proposed for the Nile Basin countries.

Type of benchmarking	Data source	Appropriate user	Sample leading questions	Possible areas of intervention
External benchmarking Objective: To assess and improve effectiveness of irrigation policy and strategy	–Annual publications of statistical agencies of NB countries –Online research results –Reports and data from line ministries, departments	–Regional agencies (e.g., Nile Basin Initiative [NBI]) –National policy-makers, macro-level planners	–Is there a need for policy or strategy intervention? –Have sector institutions accurately pinpointed the key constraints to productivity of irrigated agriculture? –Are the proposed or applied technical and management interventions relevant, effective and efficient? –What plans (five-year or annual) have been made to correct deficiencies?	Equity in land and water distribution Water allocation within and across sectors Maintenance and management of irrigation infrastructure Access to improved irrigation and production technologies Extent of agricultural support measures Extent of emphasis on pro-poor approaches Extent of coordination of relevant sectors on all aspects of irrigation
Internal benchmarking Objective: To assess and improve performance of individual irrigation schemes	–Local research results supported by full menu of interventions –Past best results of the scheme –Daily, weekly, monthly reports of the scheme (compiled by WUAs, irrigation manager, assistants)	–Water users' associations (WUAs) –Irrigation manager –Supervising agency	–What is the actual crop yield compared to the standard? –What is next year's plan to close the yield gap? –What should be done if water supply is inadequate? –What should be done to increase O&M fee collection? –What are the social or environmental problems to be addressed? –What is next year's plan to correct deficiencies?	Crop type and variety, agronomic practices Crop protection Irrigation water management O&M Extension support service Marketing support service Social and environmental issues

Source: Authors, based on concepts gathered from various sources.

4.2. External Benchmarking

4.2.1 Scope and Salient Features of External Benchmarking

External benchmarking can be employed to compare the performance of an irrigation scheme with that of other reference schemes that have similar features in terms of agroclimatic conditions, soil type, cropping patterns, irrigation practices, etc. (Malano and Burton 2001; DTIC 2009) and a reputation of being successful. However, in the NB context, application of external benchmarking for direct comparison of irrigation scheme performance may come up against the following challenges:

- It may be difficult to know which scheme is indeed successful enough to serve as a source of benchmarks unless its data has been gathered and analyzed.
- It may require consistent effort to get the consent of the personnel of a target scheme to gain access to their data over several years.
- There is no guarantee of the accuracy of benchmark data.
- There is a risk of interruption in data collection due to funding limitations or due to staff attrition at either end and/or due to other unforeseen reasons.

Such limitations make external benchmarking a less convenient method to use for identifying scheme-level performance gaps and implementing corrective measures. However, for assessing the effectiveness of irrigation sector policy and strategy, it could be of significant importance. As for ease of accessing information, external reference data on policy and strategy interventions can be obtained from non-confidential documents such as research reports, annual publications of sector institutions or the statistics agencies of NB countries. Table 2 presents the sample indicators for external benchmarking.

Potential users of external benchmarking in the NB countries would be national policy-makers, macro-level planners and researchers, who could use it to assess the performance of irrigation sector institutions with a focus on efforts to narrow gaps in yield, water productivity and water-use efficiency. The results of such assessment could then be used as inputs to compare the policies and strategies of an NB country with that of a benchmark country.

The purpose of using external benchmarks is to learn from others' experience (Malano and Burton 2001; DTIC 2009). Any country with the best irrigation performance can be used as the source of benchmark data as long as the purpose of external benchmarking is to compare and improve the effectiveness of irrigation sector policies and strategies.

Specifically, policy-makers (e.g., ministers or board of directors) and macro-level planners (such as heads of department of a ministry) could use external benchmarking for:

- Determining whether the sector institutions under scrutiny have accurately pinpointed the key constraints adversely affecting the productivity of irrigated agriculture;
- Detecting whether there are any weak links in the coordination of relevant sectors;
- Assessing whether ongoing or newly proposed technical and management interventions are relevant, effective and efficient, taking into account local and international experience; and
- Examining whether there is a need to increase the impact of irrigation (ICID 2007) through policy or strategy interventions on various issues such as:
    - Equity in land and water distribution;
    - Water allocation within and across sectors;
    - Maintenance and management of irrigation infrastructure;
    - Access to improved production technologies;
    - Agricultural support services; and
    - Emphasis on pro-poor approaches.

TABLE 2. Typical indicators for external benchmarking of irrigation performance in the Nile Basin.

	Indicator	Nile Basin country ……………	Benchmark country …..	Deviation (%)	Purpose of finding
	A	B	C	D =(B-C)/C*100	E
1	Average national yield of major irrigated crop #1				To assess the performance of national irrigation, agricultural extension and research agencies against that of the benchmark country in order to identify appropriate policies/strategies to improve the sector.
	Average national yield of major irrigated crop #2				
	Average national yield of major irrigated crop #3				
	Average national yield of major irrigated crop #4				
2	Percentage of irrigated area in relation to area equipped with infrastructure				To detect whether national agencies are constrained by (i) poor planning and design; (ii) inefficient irrigation infrastructure; (iii) poor O&M system; and (iv) to identify appropriate policies/strategies to improve the sector.
3	Area having pressurized irrigation as a proportion of the total irrigated area				To identify appropriate policies/strategies to promote the use of pressurized irrigation (i) to enhance water-use efficiency; and (ii) motivate the establishment of manufacturing companies.
4	Trend of national cropping patterns: (a) % of water-intensive crops (b) % of high-value crops (c) % of crops used as inputs in agro-processing				To identify appropriate policies/strategies to (i) replace water-intensive crops; (ii) increase production of high-value crops; and (iii) establish agro-processing plants, etc.

Source: Authors, based on concepts gathered from various sources.

4.2.2 Data Processing and Analysis for External Benchmarking

After collecting the values for the required parameters as per the template shown in Table 2, the next task would be to (i) calculate the percentage deviation of a particular parameter from the benchmark for a given number of year(s); and (ii) determine the trend of that parameter over the past 5–10 years. This case is illustrated below using maize crop yield as the key indicator (Table 3) (note: crop yield is among the few vital indicators used in benchmarking exercises because data is easily and abundantly available; it is also the most noticeable quantitative indicator that reflects the effect [or the lack] of direct and indirect interventions).

Percentage deviation is computed by subtracting the value of a chosen indicator in the study location from the benchmark value, dividing the result by the benchmark value and multiplying it by 100. For example, if the average maize yield in the area of interest in a given year was 32.9 t/ha and the benchmark yield was 78 t/ha, the deviation percentage would be: (32.9-78)/78* 100 = -57.8%. The negative sign in the result signifies that the data value is lower than the benchmark value. In this example, the average maize yield of the study area was lower than the yield of the benchmark area by 57.8% in the given year.

Trend analysis is used to identify the trend of an indicator value at a location over a period of time. This can be easily done using Microsoft Excel. Using the data shown in Table 3, the linear trend of maize yields in the study area and the reference country are computed and presented in Figure 3. This example shows that maize yield in Ethiopia was lower than that of Egypt during the period 2014–2018; and it appears that the same trend may continue in future unless corrective measures are taken. Such evidence can be helpful to Ethiopian policy-makers in revisiting relevant policies and strategies and intensifying appropriate interventions. To begin with they could launch a study to identify the causes of performance deficiencies and draw appropriate lessons. Subsequently, best practices (relating to both policy and strategy) can be sought from the benchmark country or from other sources. It is advisable to repeat the external benchmarking process year after year or at 2–3 years intervals as appropriate.

TABLE 3. Example illustrating the calculation[a] of the deviation of a chosen indicator (maize crop yield[b]) from the corresponding external benchmarking value.

	Indicator		Nile Basin country: Ethiopia	Benchmark country: Egypt	Deviation (%)	Conclusion and recommendation
	A		B	C	D = (B-C)/C*100	E
1	Average national yield of major irrigated crop #1 (e.g., maize)	Year	t/ha	t/ha		Ethiopia's maize productivity is lower than that of reference country Egypt. There is a need to design and implement corrective measures. Policy-makers should critically assess (i) the gap in irrigation sector policies and strategies; and (ii) the types and causes of challenges encountered in implementation of the existing policies and strategies. Best practices may be sought from the benchmark country or elsewhere.
		2014	34.2	77.6	-55.9	
		2015	37.3	73.5	-49.3	
		2016	36.7	76.1	-51.8	
		2017	37.4	77.9	-52.0	
		2018	32.9	78.0	-57.8	

Notes:

[a.] As per template shown in Table 2.

[b.] Source of maize yield data: FAO 2020.

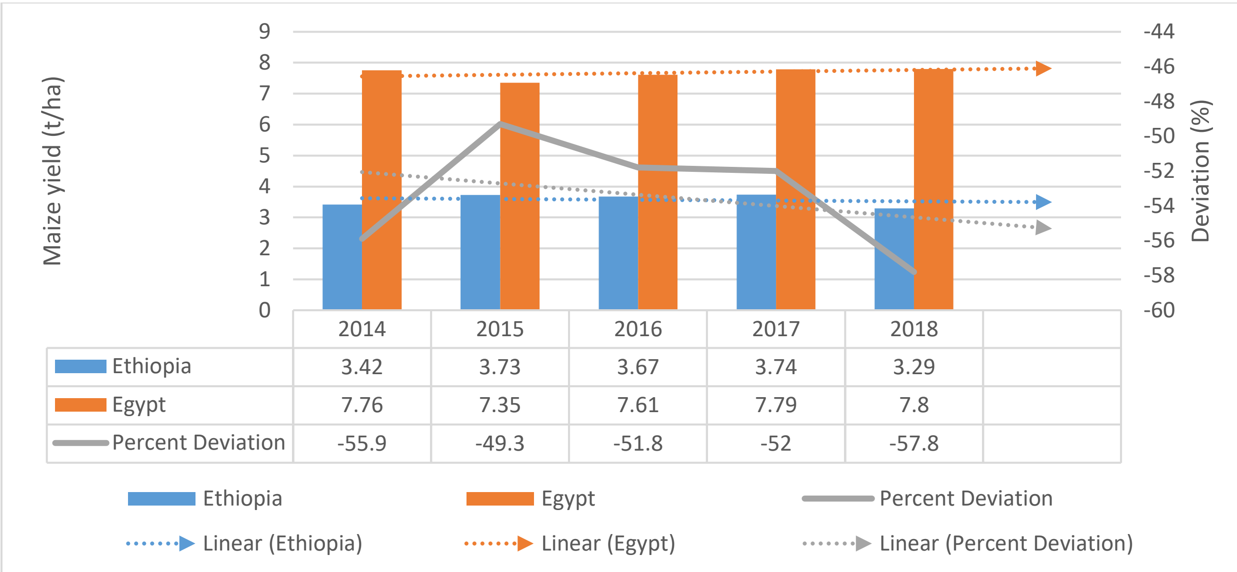

FIGURE 3. An example of presenting trend analysis result of maize yield in Ethiopia benchmarked against yield in Egypt.

4.3. Internal Benchmarking

4.3.1. Scope

Internal benchmarking studies the performance of an irrigation scheme over time and assesses it against its achievable potential (or benchmarks). The benchmarks may include (i) the past best results of the scheme; (ii) local research results; and/or (iii) international research results or other acceptable standards (e.g., maximum water-use efficiency, maximum crop yield, etc.) achieved in a similar environment anywhere in the world—provided that the background information is available and accessible. The party responsible for implementing the internal benchmarking exercise is the person at the helm of an irrigation scheme or a group of schemes under one management. For best results, it must be conducted within the context of participatory irrigation management as explained in the preceding sections. In Section 4.3.4, we suggest six indicators for internal benchmarking. They are used to track and adjust the following variables that may directly affect the productivity and sustainability of a scheme:

(i) Cropping program (crop and variety selection, cropping pattern, cropping intensity, crop rotation, soil fertility management, crop protection, etc.);

(ii) Irrigation water management (irrigation scheduling, water-use efficiency, drainage, etc.);

(iii) O&M (equitable and timely water distribution, O&M fee collection, efficient and effective preventive maintenance, efficient and effective repair works, etc.); and

(iv) Irrigation support services (extension, irrigation technology, production inputs, market, etc.).

In internal benchmarking, comparative analysis could involve the following:

(i) Comparison against an established standard or best practice (e.g., maximum crop yield, water-use efficiency, etc., recorded by local researchers or adapted from another scheme in the same country or another country);

(ii) Comparison with past results of the scheme; or

(iii) A combination of both (i) and (ii).

This guidance document recommends the third option.

4.3.2. Participatory Internal Benchmarking Process: Synchronizing PIM with BIP

As indicated above, benchmarking is required to bring about a positive change through continuous monitoring, evaluation and improvement of the performance of irrigation projects. Toward that goal, the party vested with the authority to make decisions for an irrigation scheme must take full responsibility for the process. In other words, the irrigation manager of a scheme (or the head of a supervising agency or government irrigation department) should ideally be responsible for planning and implementing productivity enhancement packages with a built-in participatory internal benchmarking system (DTIC 2009).

For a given irrigation scheme, a participatory irrigation management (PIM) process with a built-in internal benchmarking system should involve six steps, as shown in Figure 4. In steps 1–4 (which must take place before the beginning of the irrigation season) the responsible party (e.g., scheme manager or head of the supervising agency) organizes participatory performance evaluation sessions at two levels: A session involving smaller (e.g., tertiary-level) groups followed by a plenary session. The objective of these sessions is to discuss the scheme's strengths, performance deficiencies and future improvement plans. The activities to be done include the following:

(i) Initially, the responsible party prepares a preliminary discussion note (i.e., a draft performance evaluation report [with gender-disaggregated data]) and gives it to each tertiary group in advance.

(ii) Upon receiving the draft discussion note, each tertiary group convenes separately to discuss the extent and causes of the strengths and weaknesses of the scheme; and then prepares its own future action plan for improvement.

(iii) In the plenary session, all stakeholders convene to:

- discuss the type and extent of the strengths of the scheme, and devise ways to scale them up;
- examine the performance gaps in detail, and pinpoint causes and corrective measures;
- agree on the type and magnitude of interventions required for correcting deficiencies; and
- agree on draft seasonal, annual and five-year action plans for routine as well as improvement works.

(iv) Based on the results of the stakeholder evaluation sessions, the manager refines the draft seasonal, annual and five-year action plans by:

- selecting appropriate benchmarking indicators for tracking improvements in performance (explained in subsequent sections);
- setting seasonal, annual and five-year targets (equivalent to a best practice) for each indicator;
- preparing final, comprehensive and problem-specific action plans (seasonal, annual and five-year); and
- discussing the revised seasonal, annual and five-year action plans with tertiary groups and irrigators so that every stakeholder knows what the respective individual and collective responsibilities are.

Inclusive participation in these sessions (men and women; farmers and employees) makes for more rigorous pinpointing of weak links and motivates every individual to more effectively carry out routine tasks and corrective measures (Oakley 2013). Therefore, the audience for the plenary and group evaluation sessions should include every individual involved in the irrigation scheme regardless of his/her level of responsibility. Irrigators, employees and all individuals with a role to play in the irrigation scheme must be encouraged to present his/her assessment of the scheme.

During the irrigation season, as indicated in step 5 of Figure 4, the responsible party implements the planned physical works and best practices[1], and monitors progress on the predetermined performance indicators.

At the end of the irrigation season, as illustrated in step 6 of Figure 4, the responsible party analyzes the information and presents his or her findings at a joint evaluation session held with the stakeholders.

[1]. For example, best cropping pattern, best cultural practices, best irrigation water management, etc.

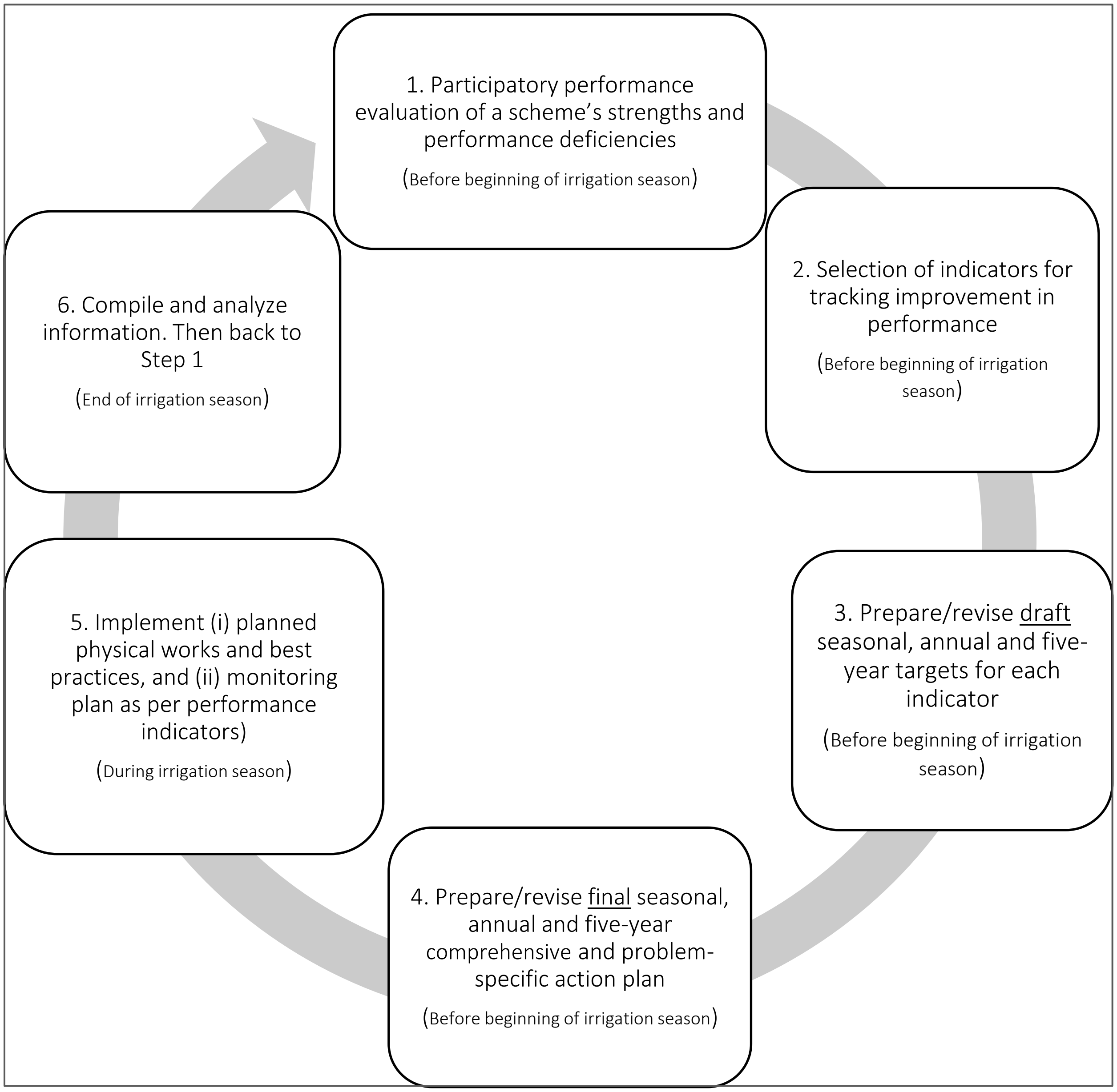

FIGURE 4. Benchmarking as an integral part of the irrigation scheme management process.

Source: Authors, based on concepts from various sources.

4.3.3 Quality Control

As benchmarking is a management tool, all stakeholders, especially management bodies and supervisors, must regularly monitor the task of data collection for timeliness, quality and completeness. This is the core part of the benchmarking exercise as it influences the type and magnitude of future improvement measures.

4.3.4. Indicators for Internal Benchmarking

As explained above, internal benchmarking involves collection of sufficient information to objectively measure the current performance gaps of an irrigation scheme. The information is then used as input to design a set of interventions for improvement. This process starts with the identification of key performance indicators, which must be site-specific (Malano and Burton 2001; Battilani et al. 2014) and targeted at addressing site-specific issues such as one or more of the following:

- Low water and land productivity that may be attributed to poor water management, poor agronomic and crop protection practices, etc.;
- Deterioration of infrastructure due to poor management;
- Land degradation attributed to poor irrigation management; and
- Lack of gender-inclusiveness resulting in unequal access to water resources and decision-making roles, etc.

Accordingly, this guidance document has adopted simple, well-defined and objective-oriented performance indicators as recommended by internationally recognized BIP guidelines (Malano and Burton 2001; Battilani et al. 2014). These indicators are categorized into five domains or key activities: service delivery, productive efficiency, economic/financial performance, environmental performance and gender-inclusiveness (van Koppen 2002). A brief explanation of these domains is presented in subsequent sections.

The IPTRID/FAO (International Programme for Technology and Research in Irrigation and Drainage/Food and Agriculture Organization of the United Nations) benchmarking guideline (Malano and Burton 2001) defines a total of 27 key performance indicators relating to: service delivery (8), productive efficiency (6), financial performance (7) and environmental performance (6). It advises that the initial costs associated with benchmarking need not be high. Accordingly, successful benchmarking practitioners in India (WRD 2009) and the United Kingdom (Knox et al. 2013) adopted 11 indicators each in their respective benchmarking processes. The International Water Management Institute (IWMI) developed gender performance indicators for irrigation to track gender inclusiveness in irrigation schemes and related policies and strategies (van Koppen 2002).

The type and number of key performance indicators used in this document are guided by existing proven practices.

A. Indicators for Productive Efficiency

There can be several objectives of benchmarking for productive efficiency depending on the interested party—farmers, regulatory agency or government. These objectives may include the following:

- To quantify variability within key agricultural production sectors and the potential environmental impact of water, fertilizer and energy use (government, regulatory agencies, farmers);
- To identify the best management practices in order to encourage the 'average' farmer to move nearer to being the best performer (farmers);
- To highlight opportunities for increasing productivity (yield quantity and quality) under similar soil, agroclimatic and economic conditions (farmers);
- To quantify the importance of water for agribusiness production and the 'added value' of water (governmental, regulatory agencies, farmers) (Knox et al. 2013).

It is apparent that timely supply of adequate irrigation water is positively correlated with crop yield. The productive efficiency performance indicator helps a project manager understand the efficiency with which available water resources are being used in crop production. However, the quantity and quality of agricultural output is governed by several other inputs as well, such as:

- Cropping program (crop/variety selection, crop rotation, cropping pattern);
- Cultural practices (land preparation, planting/transplanting, fertilizer application, cultivation, plant protection, irrigation scheduling);
- Marketing (for input/output);
- Environmental protection, etc.

Hence, details of the above-mentioned inputs used during the irrigation year (or season) must all be considered when analyzing the productive efficiency of an irrigation scheme. This requires the management team to keep a record of the timing, quality and/or quantity of all the inputs so as to identify the factors responsible for deviation from the target output. This is an important step toward identifying good practices or areas of improvement pertinent to the study scheme. Managers can also monitor the water productivity of their scheme by using the WaPOR-FAO portal[2], which provides near real-time agricultural water productivity information generated by remote sensing technologies. It allows scheme managers to pinpoint areas with good or low agricultural water productivity.

In sum, the derived value of the productive efficiency indicator would help the responsible party:

- Assess the trend in output achieved in response to continuous adoption of efficient water use and best agricultural practices;
- Quantify the value of water in agricultural production in different irrigation schemes operating under similar agroclimatic and soil conditions;
- Identify opportunities for increasing yield and quality of produce so as to become the best competitor in the market; and
- Plan and implement relevant best practices.

Two performance indicators are presented here for tracking productive efficiency, namely, output per unit irrigated area and output per unit irrigation water supply:

(i) Output per unit irrigated area. Two options are available for measuring the output per unit irrigated area.

Option 1 is agricultural output in terms of monetary units. This indicator refers to agricultural output (expressed in USD or local currency) obtained from the total irrigated area of the study scheme. This exercise requires collection of yearly/seasonal yield data and the market prices of all crops grown under the irrigation scheme. The derived value of this indicator is then compared with various reference data such as (i) the previous value achieved by the same scheme or other schemes, and/or (ii) the target value determined by the local research station or any other source such as the local agricultural extension department.

Option 2 is relative yield. This indicator is limited to comparing the actual crop yield with the potential crop yield applicable to the area. This option is more appropriate for internal benchmarking in the NB.

(ii) Output per unit irrigation water supply. This indicator describes the agricultural output (expressed in monetary units such as USD or the local currency) produced from the total irrigated area

[2] (https://wapor.apps.fao.org/home/WAPOR_2/1)

relative to the total quantity of water supplied for irrigation in a year (or season). It measures how best the available water was used for production of crops. If the derived value of this indicator deviates significantly from an acceptable standard, the management team would be required to assess the causes contributing to low productivity and propose corrective measures with an action plan.

Data Processing and Analysis for Internal Benchmarking of Productive Efficiency Indicators. The templates for compilation of values for parameters to determine productive efficiency are presented in Tables 4 and 5. The steps to be followed are:

- List the crops grown in a given season and their corresponding areas;
- Fill in the benchmark yield, which is the maximum yield achievable as per research done in the vicinity or in another country. (List the sources (citation) of the benchmark);
- At the end of the season, measure and record the average crop yields;
- Calculate the percentage deviation of the actual yield from the benchmark yield and identify the causes of the deviation if the result is negative; and
- Use Table 5 to record the annual productive efficiency result so as to compare the trend over time.

TABLE 4. Template[1] for compiling the productive efficiency performance indicators for benchmarking of irrigation projects in the Nile Basin.

Name of scheme……………………………………… Location…………………………………………………………………..Coordinates…………………………………………………

Season (from………………..to……………… year……………………. Total area (ha) equipped for irrigation……………………..

	A	B	C	D	E	F	G	H	I	J
1	Crop	Irrigated area (ha)	Yield			Unit price (USD/t)	Gross revenue (USD)	Water use		
2			Benchmark (t/ha)	Actual (t/ha)	Deviation (%)			Benchmark (m^3/ha)	Actual (m^3/ha)	Deviation (%)
3					(D3-C3)/C3*100		B3*D3*F3			(I3-H3)/H3*100
4										
5										
6										
7										
8										
9										
10										
11										
12										
13	Total									
14							Sum (m^3)	Sum(H*B)	Sum(I*B)	

16	Total actual annual value of agricultural production (USD) (total obtained in season………………… of year………………)	G13
17	Output per unit irrigated area (USD/ha)………………………….(total actual gross revenue divided by actual irrigated area)	G13/B13
18	Output per unit water consumed (USD/m^3) ……………………(total actual gross revenue divided by total actual water used)	G13/I14

[1.] Purpose: To assist project managers/WUAs in managing their respective irrigation systems so as to increase output per unit area with efficient water use and land management, improved agricultural inputs and adoption of latest technology.

TABLE 5. Temporal comparison of productive efficiency.

Year	Output per unit irrigated area (USD/ha)		Output per unit water consumed (USD/m^3)	
	Season 1	Season 2	Season 1	Season 2
2021	J17 from Table 4	J17 from Table 4	J18 from Table 4	J18 from Table 4
2022				
2023				
etc.				

B. Indicators in Service Delivery Domain

Indicators in the service delivery domain are intended to measure the effectiveness of the water conveyance system—which stretches from the source (dam, diversion weir or pumping station) up to the farm boundary. The conveyance system can be tens of kilometers long or even less than a kilometer, managed by an independent service provider or by the irrigators themselves through their WUAs.

There can be a number of drivers, and hence several objectives, of benchmarking of system operational performance, depending on who the interested party is—farmers, regulatory agency or government. These objectives may be

- To improve knowledge of the links between water abstraction for food production and water resource stress. This knowledge will inform initiatives such as management of the water footprint (government);
- To improve knowledge of the impacts of water regulation (abstraction licensing) on irrigated production (regulatory agency);
- To improve understanding of the on-farm costs (capital and operations) of irrigated production (farmers);
- To improve knowledge of the patterns of energy consumption and opportunities for improving energy efficiency so as to reduce the energy requirement for pumping (farmers); and
- To help quantify water and environmental risks to the sustainability of irrigated agribusiness (government) (Knox et al. 2013).

For a project manager or a WUA in the Nile Basin, the immediate use of service delivery performance indicator results would be to:

- Determine the efficiency with which irrigation water is being delivered to the study scheme;
- Ensure that an adequate amount of water, commensurate with the irrigation schedule, is delivered to the scheme;
- Quantify the effectiveness of the service delivery and thereby the rationality of the associated operational fees, if any; etc.

In short, benchmarking indicators in the service delivery domain aid the management of an irrigation scheme in monitoring the adequacy of the water delivery system in satisfying the irrigation requirement.

The performance indicators to be used in this domain are irrigation supply per unit irrigated area and percentage of area cropped in relation to irrigation-equipped area. These indicators are described below.

(i) Annual (or seasonal) irrigation supply per unit irrigated area (or relative irrigation supply). This indicator refers to the total quantity of water supplied to the scheme (up to the boundary) for irrigation purposes in a year (or season) in relation to the total irrigated area in that year (or season). Conveyance losses upstream of the boundary are not considered. The derived value of this indicator is then assessed either against a predetermined target value or previous performance of the scheme, as explained below.

Comparison of indicator result with a predetermined irrigation water supply target. The irrigation water supply target can be determined by the responsible party based on a water allocation plan or by the local irrigation department based on detailed crop water requirement calculations (for example, 4 mm/day X m/(1,000 mm) X 100 growing days/season X 1 ha/0.5 efficiency X 10,000 m^2/ha = 8,000 m^3/ha per season illustrates a typical procedure for fixing a target).

If the actual value of the indicator computed at the end of an irrigation year or season is very close to the benchmark value, the performance of the scheme could be rated as good. However, there is room for a strong management team to significantly increase or decrease the amount of water supplied to the scheme based on the actual irrigation demand (i.e., by considering real-time data of crop, climate, soil, management efficiency and/or any new factors). Therefore, the resultant indicator must be analyzed in conjunction with details of the irrigation management inputs delivered during the irrigation year (or season). Subsequently, any discrepancy between the actual water supply and the targeted amount of water must be analyzed so as to capture any lessons that may have to be learnt, adopt a good practice or detect an area of improvement. To this end, it is very important for the scheme manager to keep a record of all interventions applied in the scheme.

Comparison of the indicator result against previous data of the same scheme or other schemes. Any temporal inconsistency in the indicator value of an irrigation scheme suggests the need to investigate whether the possible causes are attributable to constraints in the water delivery infrastructure. If the amount of water supplied to the boundary of a scheme shows a declining trend, the management could investigate the extent of conveyance water losses and the efficiency of water delivery to the scheme. If efficiency is found to be below the acceptable level, the responsible party can be prompted to identify the nature of the losses and then carry out corrective measures.

As highlighted above, the party responsible for management of the irrigation scheme, as end user of the benchmarking result, should ensure that delivery of water to the farm boundary is consistent with the predetermined water allocation plan.

Relevance of another indicator in the service delivery domain. The existing guidelines also include another performance indicator, namely annual relative water supply, which takes into account the contribution of rainfall over and above irrigation supply. However, a rainfall-based indicator is of little or no use for irrigation performance benchmarking. For example, rainfall occurring a few hours or days after an irrigation event is most likely to be wasted due to surface runoff and deep percolation. Under such circumstances, the rainfall-based indicator would show low value, which would wrongly imply poor performance. However, rainfall information must be considered when analyzing the relative irrigation supply indicator if rainfall did influence irrigation scheduling.

(ii) Percentage of area cropped in relation to irrigation-equipped area (or potential created). This indicator measures the proportion of irrigation-equipped area that is used for crop production. It is in the interest of farmers, the irrigation manager, government and the public to ensure that the area equipped for irrigation through large investment is fully cropped. However, sometimes a portion of the command area may be left out of irrigation due to shortage of available water, deterioration of land due to salinity or for some other reason. For example, tail-reach farmers in gravity-fed irrigation systems might be forced to make do without irrigation when head-reach farmers divert an excess amount of water. This indicator, a measure of the proportion of area cropped in relation to irrigation-equipped area, would help

the management of a scheme identify the root causes of the problem and subsequently take concerted corrective measures.

The templates for compilation of parameters for determining service delivery performance are presented in Tables 6 and 7.

TABLE 6. Template[1] for determining major service delivery performance indicators.

	A	B	C	D	E
1	Performance indicator	Required data type	Required data value	Benchmark indicator value	Result (%)
2	Seasonal volume of irrigation water supplied per unit irrigated area (m^3/ha) = Relative irrigation water supply	Sum of daily measured water delivery to water users (m^3)	I14 from Table 4	H14 from Table 4	Deviation (C2-D2)/D2*100 (-) = undersupply (+) = oversupply
3		Irrigated area (ha)	B13 from Table 4	B13 from Table 4	
4	Proportion (%) of area cropped to equipped (or irrigated to potential created)	Area equipped (ha)	From Table 4: top	100%	Percentage of area irrigated (C5/C4)*100
5		Area irrigated(ha)	B13 from Table 4		

[1] Purpose: To assist project managers/WUAs in managing their irrigation systems so as to optimize the use of available water resources.

TABLE 7. Percentage deviation of relative water supply and usage of irrigable area.

Year	Seasonal volume of irrigation water supplied per unit irrigated area (m^3/ha)		Proportion of area cropped to equipped area (or irrigated to potential created) (%)	
	Season 1	Season 2	Season 1	Season 2
2021	E2 from Table 6	E2 from Table 6	E4 from Table 6	E4 from Table 6
2022				
2023				
etc.				

C. Indicators for Economic/Financial Performance

As in the case of indicators discussed above, the objectives of benchmarking the financial performance of an irrigation scheme too depend on who the interested party is: farmers, regulatory agencies or government. These objectives may include the following:

- To identify opportunities for improving profitability and reducing the on-farm production costs associated with irrigation water, fertilizer and energy use (farmers, regulatory agencies);
- To quantify the value (benefit) of water associated with the production of key commodity crops, and its links with rural sustainability and local employment (regulatory agencies, government);
- To highlight the links between improving water efficiency and business sustainability (farmers, regulatory agencies) (Knox et al. 2013).

For a project manager, the immediate utility of the financial performance indicator result is in assessing a number of parameters such as revenue per cubic meter of irrigation water, cost per hectare, revenue collection performance, etc., as required by the relevant interested party.

In this document, the scope of the financial performance indicator is limited to the O&M cost recovery ratio because information on other aspects of financial performance is presumed to be either confidential or difficult to gather. This indicator helps us judge the sustainability of an irrigation scheme by showing whether the actual O&M expenditure is regularly being met from its own revenue. Collection of O&M fees below the actual O&M costs indicates the inefficiency of the irrigation scheme manager or the WUA. Excessive O&M costs incurred due to faulty specifications, poor workmanship, deferred maintenance, etc., are also an indicator of the inefficiency of the management team. Therefore, the derived value of economic performance indicators must be interpreted in conjunction with performance indicators from the other domains.

The value of the indicator, O&M cost recovery ratio, is derived by dividing the total O&M cost incurred in running the irrigation scheme during the monitoring period (season or year) by the irrigated area.

Apart from the above-mentioned way of levying a fee based on actual O&M costs, the primary stakeholders of a scheme may opt to levy water charges (for O&M) on the basis of volumetric water measurement. In this case, successful collection of the entire fee payable during an irrigation season would imply best performance. This approach has also the potential of incentivizing those who use water efficiently, thereby contributing to the goal of meeting the irrigation performance benchmark. A potential challenge in this approach could be the need to institutionalize volumetric measurement of water delivered to every plot. This challenge has for decades been a key topic of discussion among researchers, financers and irrigation institutions. Thus, the first pilot sites envisaged for BIP in the Nile Basin must consider volumetric water measurement with the additional mission of generating learnings for replication across the whole basin.

In lift irrigation schemes, the cost of energy consumed in pumping water has a substantial impact on irrigation productivity and sustainability. Hence, it would be important to monitor energy consumption per unit irrigated area (in terms of USD/ha or kilowatt hours (KWh)/ha). High energy use and cost would suggest the need for interventions such as a switch to less expensive energy sources, making mechanical improvements in the pumping system, synchronizing pumping with water-saving technologies and practices, etc.

It is imperative for project managers and/or stakeholders to design and implement an appropriate financial management system as a precondition for benchmarking of the financial performance of a scheme.

Templates for compilation of the parameters for determining the economic efficiency performance are presented in Tables 8 and 9.

TABLE 8. Key economic efficiency performance indicators[1] for benchmarking of irrigation projects.

	A	B	C	D	E
1	Performance indicator	Required data type	Required data value (USD)	Calculation of actual indicator value	Benchmark indicator value
2	O&M cost recovery ratio	Actual O&M cost (USD)			
3		Revenue (USD)		C2/C3	1
4	Volumetric water fee collection ratio (optional)	Actual revenue (USD)			
5		Planned revenue (USD)		C4/C5	1

[1] Purpose: To assist project managers/WUAs in managing their irrigation systems so as to encourage efficient water use, maximum O&M cost recovery and hence ensure sustainability.

TABLE 9. Temporal comparison of the economic efficiency of irrigation schemes.

Year	O&M cost recovery ratio		Volumetric water fee collection ratio (optional)	
	Season 1	Season 2	Season 1	Season 2
2021	D3 from Table 8	D3 from Table 8	D5 from Table 8	D5 from Table 8
2022				
2023				
etc.				

D. Indicators for Environmental Performance Domain

The objective of benchmarking of environmental performance is primarily to:

- Assess any adverse effect associated with irrigation management;
- Judge the sustainability of an irrigation scheme; and
- Regulate irrigation management practices, thereby minimizing or eliminating water wastage and avoiding reduction of land productivity due to salinity, waterlogging and/or erosion.

The indicators identified for tracking environmental performance measure the impacts of irrigated agriculture on land and water resources (Malano and Burton 2001). The commonly used indicators are the level of changes in water quality, waterlogging, salinization and groundwater depth (Malano and Burton 2001). In India, successful benchmarking practitioners have used the land damage index, which is expressed as a percentage of damaged land in relation to irrigable area of a scheme, as an environmental performance indicator (WRD 2009). The land damage index is appealing because it uses simple, visible and easily measurable parameters, and therefore is used as an environmental performance indicator in this guidance.

Templates for compilation of parameters for determining environmental performance are presented in Tables 10 and 11.

TABLE 10. Template for key environmental performance indicators for benchmarking of irrigation projects[1].

	A	B	C	D	E
1	Performance indicator	Required data type	Required data value (ha)	Deviation (%)	Benchmark indicator value
2	Land damage index	Area affected by salinity, waterlogging or erosion (ha)			
3		Command area (ha)	B13 From Table 4	(B2 – B3)/B3*100	0

1. Purpose: To assist project managers/WUAs in ensuring sustainability of the irrigation scheme.

TABLE 11. Temporal comparison of environmental performance in terms of the land damage index.

Year	Land damage index	
	Season 1	Season 2
2021	D3 from Table 10	D3 from Table 10
2022		
2023		
etc.		

E. Gender Inclusiveness Performance Indicators

Gender-inclusiveness performance indicators measure equal access for women to water resources and merit-based decision-making roles. The task of using these indicators entails identifying the presence or absence of gender-based differences relating to water control and use at the scheme level. The following gender performance indicators are suggested (van Koppen 2002):

- Equal farm-level access to water;
- Equal participation in forums required for strengthening access to water; and
- Merit-based decision-making roles.

A template for compilation of parameters for determining gender performance is presented in Table 12. The information is to be gathered by communicating with direct and indirect stakeholders, and the performance ranked as follows:

- The performance is ranked as good (+) if women farm decision-makers are on the same footing as men farm decision-makers (i.e., there are virtually no gender-based differences);
- The performance is ranked low (-) if most of the women farm decision-makers face major problems compared to men who farm under similar conditions; and
- The performance is ranked as moderate (+/-) if mild differences that have a negative effect on women farm decision-makers are found (van Koppen 2002).

If the indicators show the presence of gender-based differences, the irrigation manager/agency should rectify the root causes of the problem.

TABLE 12. Template for compilation of parameters for determining gender performance indicators.

Year	Performance indicators		
	Equal farm-level access to water	Equal participation in forums required for strengthening access to water	Merit-based decision-making role
2021 season 1			
2021 season 2			
2022 season 1			
2022 season 2			
……..			
etc.			

Note:

Performance value to be filled: ‘good’, ‘moderate’ or ‘low’.

5. CONCLUSIONS AND RECOMMENDATIONS

Upstream Nile Basin countries are characterized by low crop yields and hence low water productivity. This indicates a need for guidance on how to expedite identification and dissemination of good agricultural practices, water conservation and efficient water-use measures. However, the effort to close the yield and income gaps cannot be a one-time job. It requires continuous assessment of performance and then working toward identification and adoption of improved practices and technologies. This would allow the use of available irrigable land effectively and efficiently with an accent on higher production of high-value crops using less water. Toward this goal, NB countries should adopt benchmarking, coupled with participatory irrigation management, as a vital tool to improve irrigation productivity. Such an approach could contribute to mitigating future water stress while judiciously increasing agricultural productivity and farm income across the NB.

External benchmarking is recommended to continuously assess the effectiveness of irrigation sector policy and strategy. It would have to be implemented by national policy-makers, macro-level planners, researchers and/or regional agencies. We recommend the following four indicators as the focal points of external benchmarking in the Nile Basin—with input data presumed to be obtained from non-confidential sources such as published annual statistical reports and other online sources:

(i) Average national yield of major irrigated crops;

(ii) Percentage of irrigated area in relation to area equipped with infrastructure;

(iii) Area having pressurized irrigation as a proportion of the total irrigated area; and

(iv) Trend of national cropping patterns: (a) percentage of water-intensive crops, (b) percentage of high-value crops, and (c) percentage of crops used as inputs in agro-processing.

The internal benchmarking approach, on the other hand, is recommended for assessing the performance of an irrigation scheme by its manager, or a group of schemes under one umbrella by the person at the top of the management. The following six indicators are suggested for internal benchmarking:

(i) Output per unit irrigated area (USD/ha);

(ii) Output per unit water consumed (USD/m^3);

(iii) Seasonal volume of irrigation water supplied per unit irrigated area (m^3/ha);

(iv) Percentage of area cropped in relation to irrigation-equipped area (%);

(v) O&M cost recovery ratio; and

(vi) Land damage index

Reference data (benchmarks) would be sourced from local research results and/or any other acceptable standard (e.g., maximum crop yield achieved by local researchers).

Moreover, the following three gender performance indicators are included: (i) equal farm-level access to water; (ii) equal participation in forums required for strengthening access to water; and (iii) merit-based decision-making role.

The following crucial institutional arrangements are recommended for successful implementation of BIP in the NB countries:

- Provincial/state government agencies tasked with irrigation development should adopt benchmarking as a management tool for improving the performance of irrigation schemes. Their national counterparts should use their supervisory role to enforce application of the benchmarking process.
- Irrigation staff working at the grassroots level must be (i) well-trained; (ii) vested with mandatory irrigation management guidelines; and (iii) provided with continuous technical backstopping to implement irrigation management and BIP as a package rather than piecemeal.
- Shortcomings that could derail the participatory irrigation management (PIM) approach should be assessed and rectified. Subsequently, PIM should be integrated with benchmarking and promoted with intensive technical support to ensure that dissemination of best practices and correction of deficiencies is done more effectively.
- Tailor-made benchmarking tools (online, mobile applications and/or software) should be designed and disseminated with the involvement of stakeholders.
- The potential application of satellite-derived geospatial information for BIP in the Nile Basin should be assessed.

Finally, it is recommended to Nile-Sec to promote (i) standardization of key performance indicators (i.e. their definition, collection methods and use) to ensure that the results of BIP are accurate and as comparable as possible; (ii) continuous awareness-raising sessions for member countries on BIP synchronized with PIM; (iii) adoption of site-specific, meaningful and affordable indicators for internal and external benchmarking by member countries; (iv) national and regional workshops for exchanging best practices, success stories and challenges related to BIP and PIM; (v) regional cooperation for improving water-use efficiency through data sharing; and (vi) investment and incentive mechanisms for institutionalizing BIP by member countries.

References

Alexander, P.J.; Potter, M.O. 2004. Benchmarking of Australian irrigation water provider businesses. *Irrigation and Drainage* 53(2): 165–173. Available at https://doi.org/10.1002/ird.131 (accessed on June 27, 2021)

Allam, M.N.; El Gamal, F.; Hesham, M. 2005. Irrigation systems performance in Egypt. In: *Irrigation systems performance,* (eds.), Lamaddalena, N.; Lebdi, F.; Todorovic, M.; Bogliotti, C. Bari, Italy: CIHEAM Bari. Pp. 85–98.

Awulachew, S.B.; Smakhtin, V.; Molden, D.; Peden, D. (eds.). 2012. *The Nile river basin: Water, agriculture, governance and livelihoods*. Abingdon, Oxon, UK: Routledge.

Battilani, A.; Letterio, T.; Chiari, G. 2014. *Action B5— Benchmarking: Benchmarking tool manual.* Brussels, Belgium: European Commission. (Life11 ENV IT 035 WSTORE2 Final Report Action B.5)

DTIC (Department of Trade, Industry and Competition, Republic of South Africa). 2009. *The stakeholder accord on water conservation: Guideline for baseline water use determination and target setting in the irrigation sector*. Pretoria, South Africa: Republic of South Africa. (SAWC G1).

El-Marsafawy, S.M.; Swelam, A.; Ghanem, A. 2018. Evolution of crop water productivity in the Nile delta over three decades (1985–2015). *Water* 10(9): 1168. Available at https://doi.org/10.3390/w10091168 (accessed on June 27, 2021)

Elshaikh, A.E.; Yang, S.; Jiao, X.; Elbashier, M.M. 2018. Impacts of legal and institutional changes on irrigation management performance: A case of the Gezira irrigation scheme, Sudan. *Water* 10(11): 1579. https://doi.org/10.3390/w10111579

FAO (Food and Agriculture Organization of the United Nations). 2016. AQUASTAT main database. Rome, Italy: FAO. Available at http://www.fao.org/nr/water/aquastat/data/query/results.html (accessed on October 8, 2020).

FAO. 2020. FAOSTAT: Food and agriculture data. Rome, Italy: FAO. Available at http://www.fao.org/faostat/en/#data (accessed on October 8, 2020)

Haileslassie, A.; Agide, Z.; Erkossa, T.; Hoekstra, D.; Schmitter, P.; Langan, S. 2016. On-farm smallholder irrigation performance in Ethiopia: From water use efficiency to equity and sustainability. Nairobi, Kenya:

International Livestock Research Institute (ILRI). (LIVES Working Paper 19). Available at https://cgspace.cgiar.org/handle/10568/77017 (accessed on October 8, 2020)

ICID (International Commission on Irrigation and Drainage). 2007. **Declaration of Tehran on PIM**. New Delhi, India: ICID. Available at https://www.icid.org/decl_tehran_1.html (accessed on June 23, 2021).

Kahan, D. 2010. *Farm business analysis using benchmarking*. Rome, Italy: Food and Agriculture Organization of the United Nations. (Farm Management Extension Guide 4).

Knox, J.W.; Daccache, A.; Hess, T.M.; Else, M.; Kay, M.; Burton, M.; Thelwall, D.; Malano, H. 2013. *Benchmarking agricultural water use and productivity in key commodity crops*. Cranfield, Bedfordshire, UK: Cranfield University. (Final Report WU0122).

Kotb, T.; Boissevain, W. 2012. Water saving due to irrigation improvement in the Nile delta. In: *BALWOIS 2012: Proceedings of the Fifth Conference on Water Climate and Environment, May 28-June 2, 2012, Ohrid, Republic of Macedonia*. Ohrid, Republic of Macedonia: BALWOIS.

Malano, H; Burton, M. 2001. **Guidelines for benchmarking performance in the irrigation and drainage sector**. Rome, Italy: International Programme for Technology and Research in Irrigation and Drainage (IPTRID) Secretariat, Food and Agriculture Organization (FAO).

Malano, H.; Bos, M.G.; Vlotman, W.; Molden, D. 2004. *Benchmarking of irrigation and drainage projects*. New Delhi, India: International Commission on Irrigation and Drainage. (ICID Task Force Report).

Mekonnen, M. 2011. *Spatially and temporally explicit water footprint accounting*. PhD dissertation. Faculty of Engineering Technology, University of Twente, Enschede, the Netherlands.

Multsch, S.; Elshamy, M.E.; Batarseh, S.; Seid, A.H.; Frede, H.G.; Breuer, L. 2017. Improving irrigation efficiency will be insufficient to meet future water demand in the Nile Basin. *Journal of Hydrology: Regional Studies* 12: 315–330. Available at https://doi.org/10.1016/j.ejrh.2017.04.007 (accessed on June 27, 2021)

NBI (Nile Basin Initiative). 2012. **Agriculture, food security and livelihoods in the Nile basin**. Chapter 5 in *State of the River Nile Basin 2012*. Entebbe, Uganda: NBI. pp. 121–161. Available at http://nilebasin.org/nileis/system/files/Nile%20SoB%20Report%20Chapter%205%20-%20Agriculture.pdf (accessed on June 23, 2021).

NBI. 2016. **Nile basin water resources atlas**. Entebbe, Uganda: NBI. Available at https://atlas.nilebasin.org/ (accessed on June 23, 2021).

NBI. 2019. *Technical report 2a—Irrigation development projection in the Nile Basin countries: Scenario-based methodology*. Entebbe, Uganda: NBI. (Water Resources Management 2015-03).

Oakley, W. 2013. **Limitations of benchmarking uncovered**. Available at https://williamoakley1.wordpress.com/2013/08/19/limitations-of-benchmarking-uncovered/ (accessed on March 28, 2020).

Swelam, A. 2016. *Raised-bed planting in Egypt: An affordable technology to rationalize water use and enhance water productivity*. Amman, Jordan: International Center for Agricultural Research in the Dry Areas (ICARDA).

van Koppen, B. 2002. *A gender performance indicator for irrigation: Concepts, tools, and applications*. Colombo, Sri Lanka: International Water Management Institute. 42p. (IWMI Research Report 59). Available at https://doi.org/10.3910/2009.064 (accessed on June 27, 2021)

WRD (Water Resources Department, Government of Maharashtra). 2009. **Report on benchmarking of irrigation projects in Maharashtra state 2007–2008**. Mumbai, India: Water Resources Department, Government of Maharashtra. Available at https://wrd.maharashtra.gov.in/Upload/PDF/BenchmarkingofIrrigationProjects-2007-08.pdf (accessed on June 23, 2021).

Annex A. REVIEW OF INTERNATIONAL AND REGIONAL EXPERIENCE ON BENCHMARKING

A1. Benchmarking Agricultural Water Use and Productivity in Key Commodity Crops in the United Kingdom

The first attempt to introduce benchmarking to the irrigation sector in the UK (Knox et al. 2013) was made in a 2010–2013 project involving 360 farms, covering a total of 3,000 ha owned by 80 growers. One of the drivers of this initiative was the interest among UK growers and farming businesses to improve resource-use efficiency and reduce production costs. The project's mission was to establish a model benchmarking system for two irrigated high-value commodity crops: potato and strawberries. The key performance indicators (KPIs) for the benchmarking project were identified by researchers at the outset but were revised after getting a response from growers on the relevance and availability of data. The final KPIs thus selected are shown in Table A1. However, the indicators developed for potato benchmarking were not all appropriate for use in the strawberry case. The learning from the preparatory phase of the project was that KPIs must be crop-specific and easily available. Also, it was important to involve key stakeholders/farmers in the process.

The data collection methodology used by the researchers involved (i) interviews to gather historical data from the period 2009–2011; and (ii) a pilot benchmark web tool (online data collection system) for use during the project period. However, the online data collection system was constrained by the reluctance of some farmers to log into the system even if the required data was simple and readily available. As a result, the researchers were forced to make many site visits to collect data. Such a limitation is typical of external benchmarking (for reasons explained in Section 4).

The benchmarking exercise for both potato and strawberries showed significant variation—after accounting for varietal, agroclimatic and soil differences—among growers in terms of irrigation water-use efficiency and output per unit volume of water applied. The study identified areas of improvement applicable to each farm. Its recommendation was in favor of promoting benchmarking among UK growers but with due consideration to adaptability and sustainability. The researchers also recommended the development of a 'UK irrigation benchmarking service'. The project culminated in the development of an online benchmarking tool, which was embedded within the UK Irrigation Association (UKIA) website[3].

The online benchmarking tool was designed for UK potato growers to upload their field data as a feedback mechanism which was aimed at assessing their performance relative to other growers. The website has the following message to invite farmers to use the benchmarking service:

> *Benchmarking...enables you to compare your irrigation performance with other growers. It is like 'looking over the fence' to see what your neighbors are doing and finding ways to improve what you are doing. Benchmarking can help you answer key questions such as:*
>
> - *How well am I performing now compared with others?*
> - *Can I perform better, reduce costs, reduce water usage, and increase profitability?*
> - *How do I do it—change/improve infrastructure, improve soil water management, adopt best industry practices?*[4]

TABLE A1. Key performance indicators used in irrigated potato and strawberry farming in the UK.

Domain	Key performance indicators specific to crop	
	Potato	Strawberry
System operation	Irrigation water applied (mm)	Irrigation applied per unit cropped area (m^3/ha)
	Relative water supply	
	Relative irrigation supply	
Agricultural productivity	Total productivity (t/ha)	Crop productivity (Class 1 fruit t/ha)
	Irrigation water-use efficiency (t/m^3 applied water)	Irrigation water-use efficiency (Class 1 fruit kg/m^3 applied water)
		Water productivity (m^3/kg Class 1 fruit)
Financial performance	Output per unit volume of water applied (GBP/m^3)	Output per unit volume of water applied (GBP/m^3)
		Product value (£/t Class 1 fruit)
		Total gross crop value (GBP)
		Output per irrigated area (GBP/ha)
Environmental performance	Energy consumption per unit irrigated area (kWh/ha)	

Source: Knox et al. (2013).

3. http://79.170.40.182/iukdirectory.com/benchmarking/ - This web page was accessed at the beginning of this study but was unavailable as of April 2021.
4. http://79.170.40.182/iukdirectory.com/benchmarking/ - This web page was unavailable as of April 2021.

A2. Irrigation Benchmarking Service by Government Agency in India

The Water Resources Department of the Government of Maharashtra state in India (WRD 2009) is responsible for constructing and rehabilitating irrigation infrastructure, managing the delivery of water to irrigation schemes and collecting the O&M fee. The total irrigation area developed in the state until 2008 was about 4.33 Mha, of which only 2.76 Mha (64%) was actually cropped. In 2001–2002, the department adopted benchmarking as a tool to evaluate the performance of irrigation projects in its control. It started the initiative with 84 irrigation projects with 10 indicators; increased them to 254 projects with 11 indicators in 2002–2003; and further to 262 projects with 11 indicators in 2004–2008 (Table A2).

The department releases annual benchmarking results for each project along with the probable causes of low performance. The information is for use by field officers, who are required to prepare and implement detailed action plans for correcting the deficiencies. Examples of previous improvement measures include: Changes in cropping pattern, canal repairs to minimize conveyance losses, advising farmers to avoid flood irrigation, enhancement of O&M cost recovery, etc. In all cases, the field officers are required to strictly adhere to the existing irrigation management guidelines.

The success factors of the BIP exercise in Maharashtra have been:

- The provincial/state government agency tasked with irrigation development adopted benchmarking as a management tool for improving the performance of irrigation schemes;
- Irrigation staff at the grassroots level were (i) well-trained; (ii) equipped with mandatory irrigation management guidelines; (iii) required to address irrigation management as a whole package rather than in bits and pieces; and (iv) supported with continuous technical backstopping; and
- Participatory irrigation management was applied effectively to disseminate best practices and rectify deficiencies.

TABLE A2. Performance indicators and benchmarking targets used by the Water Resources Department of the Government of Maharashtra state in India in 2007–08.

Performance indicator	Target value
Annual irrigation water supply per unit irrigated area (m^3/ha)	Major and medium projects: 7,692 m^3/ha Minor projects: 6,667 m^3/ha
Ratio of utilized (cropped) area to irrigation potential of project	Potential fully utilized (or proportionate to water available in reservoir)
Output (agricultural production) per unit irrigated area (INR[1]/ha)	In high water-deficit areas Major: 21,000 Medium: 23,000 Minor: 16,000
	In water-abundant areas Major: 32,000 Medium: 40,000 Minor: 36,000 (Target values also set for intermediate water-deficit areas)
Output (agricultural production) per unit irrigation water supply (INR/m^3)	In high water-deficit areas Major: 2.69 Medium: 2.8 Minor: 2.4
	In water-abundant areas Major: 4.16 Medium: 5.4 Minor: 5.4 (Target values also set for intermediate water-deficit areas)
Cost recovery ratio [ratio of recovery of water charges to cost of providing service; water charges include cost of operation (staff salary) and maintenance]	1
Total O&M cost per unit area (= ratio of total O&M cost incurred and area irrigated during the irrigation year) (INR/ha)	Major: 1,250 Medium: 1,200 Minor: 1,150
Total O&M cost per unit water supplied for irrigation (total O&M cost/total quantity of water supplied) (INR/m^3)	Major = 0.16 (1,250/7,692) Medium = 0.16 (1,200/7,692) Minor = 0.17 (1,150/6,667)
Revenue per unit of water supplied (ratio of total revenue and quantity of water supplied for irrigation) (INR/m^3)	10% more than O&M cost per unit of water supplied (about INR 0.18/m^3)
Land damage index (ratio of land	No target but should be very small or zero

damaged to irrigable area)	
Equity performance (of head, middle and tail reaches) (= ratio of sum of actual area irrigated by reach in all seasons to projected irrigable command area in head, middle and tail reaches)	1 for head, middle as well as tail reaches

Source: WRD 2009.

1. INR = Indian rupee.

A3. Benchmarking of Australian Irrigation Water Provider Business

This exercise in benchmarking was focused on the business performance of Australia's irrigation water providers which undertake the delivery of water from natural sources or storage facilities to the farm gate. The driver for initiating benchmarking was the need to manage the water delivery business in a sustainable manner (Alexander and Potter 2004).

There are about 30 irrigation water provider businesses in Australia, delivering water to about 2 Mha with a combined turnover of more than AUD 200 million/year as of 2002. Each of these companies serves a certain number of irrigation schemes in its respective command area. Hence, it can be presumed that irrigation water provider companies are not competitors but share the common motive of increasing the efficiency of delivering water up to the farm gate.

The Australian National Committee on Irrigation and Drainage (ANCID) commenced benchmarking of irrigation water provider businesses in 1998. Most of these businesses are members of ANCID, and were financers of the benchmarking process and the beneficiaries of it. Benchmark data are collected, analyzed and reported annually. The businesses use the benchmarking results for the purpose of tracking their own performance, setting business priorities and goals, etc.

The quality of benchmarking service provided by ANCID has been improving from year to year, resulting in an increased level of ownership of the data and process by the beneficiaries.

(*Note:* ANCID transformed[5] into Irrigation Australia Ltd in 2007. No document was found on its progress.)

5. https://www.irrigationaustralia.com.au/about-us

A4. Benchmarking Initiatives in the Nile Basin

A4.1. Irrigation Performance Initiatives in Egypt

Egypt has been implementing (Kotb and Boissevain 2012) an irrigation improvement initiative from the early 1980s with local and international funding. The irrigation improvement package consisted of replacing scattered individual pumps with a single lifting point at the tertiary level, subsurface drainage, quaternary-level improvement, laser land leveling, delivery canal and main canal improvement and strengthening the participation of water users in the O&M of the improved facilities. As of 2012, the resultant improvements in the Daqalt branch canal (one of the improved areas in the middle Nile Delta) were:

- An increase of about 30% in conveyance efficiency at the tertiary level. This resulted in improving head-tail equity and reduction of irrigation time by about 50–60%;
- Land saving of 2% by replacing the open canal system with piped flow; and
- An increase in crop yields by 10–15%.

A study (El-Marsafawy et al. 2018) on crop water productivity (CWP) in the northern Nile Delta region of Egypt showed that mean CWP for all crops increased by 41% between the 10-year period 1985–1994 to the period 1995–2004, and by 22% between the period 1995–2004 to the period 2005–2015. Crop-wise, the increments in CWP from the first decade (1985–1994) to the third decade (2005–2015) were: Winter tomato (210%), mango (154%), summer tomato (145%), winter onion (132%), Nili tomato (128%), grapes (122%) and flax (114%). Most of the increase in CWP was predominantly related to increase in crop yield, which in turn was attributable to better agronomic practices and/or higher yielding varieties. Some of the other good agricultural practices that contributed to an increase in crop yield, and hence an increase in CWP, were:

- Using raised beds instead of basin irrigation increased wheat yield by 25%, and reduced the volume of water applied by 25%, which was mainly due to reduction in soil evaporation. Also, the raised-bed system reduced production costs by 25% compared to the traditional system.
- Subsidized land leveling, implemented on a massive scale, contributed to better water distribution uniformity, increased crop production and reduction in run-off losses.

- Crop production was supported with research on various aspects including soil fertility management.

In sum, Egypt has been striving continuously to achieve higher standards of irrigation performance by adopting good practices. The approach followed looks like internal benchmarking though it is not explicitly defined as such.

A4.2. Irrigation Performance in Ethiopia

The issue of irrigation performance improvement in Ethiopia has mostly been addressed by researchers rather than the parties responsible for executing interventions. Among the few research studies done on irrigation performance assessment in Ethiopia, Haileslassie et al. (2016) evaluated the on-farm performance of nine smallholder irrigation schemes in four regional states of Ethiopia. The findings were:

- Crop yields were generally low; for example, the lowest recorded maize yield was 0.65 t/ha or 200% lower than the achievable yield of 2 t/ha reported by the Ethiopian Institute of Agricultural Research. The low crop yields were attributed to a combination of over-irrigation/under-irrigation and limited access to improved seeds, fertilizer and extension services.
- Most schemes suffer inequity in water distribution across reaches; the head reaches are generally over-supplied at the expense of tail-end farms.

However, the above-mentioned study was focused on irrigation performance assessment rather than benchmarking of irrigation performance because of the following limitations:

- It was driven by the researchers' own interest; there was no involvement by the responsible authorities in using the findings as inputs for improvement.
- The study was more like a one-time performance-gap analysis. Benchmarking is all about a continuous cycle of performance gap identification followed by implementation of corrective measures.
- There is no information whether the findings of the study were used as decision-making inputs by policymakers or irrigation managers.

A4.3. Irrigation Performance Assessment in Kenya

This example from western Kenya refers to a study conducted to quantify and rank the performance of three pump-irrigation schemes. The evaluation was limited to the rice production season because of better data availability compared to the second season, which is dominated by non-rice crops. Eleven performance indicators gleaned from the IPTRID-IWMI benchmarking guidelines were used in this exercise. Historical data for five years (2012–2016) were obtained from records kept by the scheme managements. The findings were:

- Water supplied by the schemes is sufficient to meet crop water demands.
- The irrigation schemes have low water-use efficiency.
- The schemes are not financially self-sufficient.

The researchers recommended improvements in O&M measures and monitoring and evaluation (M&E) systems. The study was a one-time exercise aimed at quantifying the performance of three schemes using historical data. It was driven by the researchers' own interest with no involvement of the scheme managements in using the findings as inputs to improve the schemes.

A4.4. Irrigation Performance Assessment in Sudan

Like their counterparts in the other NB countries, most researchers in Sudan have been engaged in assessing the impact of certain types of technologies and practices on irrigation productivity. One study (Elshaikh et al. 2018), however, examined the impact of institutional instability on the performance of the Gezira irrigation scheme. It used two indicators, namely, annual irrigated area and irrigation supply, recorded during the period 1970–2015. The findings suggest that:

- From 1925 to 1994, management of the Gezira scheme was under the Ministry of Irrigation and Water Resources (MoIWR). From 1970 to 1994, irrigated area varied between 480,000 and 730,000 ha yearly, and irrigation water supply was almost equal to irrigation requirement; average water supply in excess of requirement was about 12%.
- From 1995 to 1998, management of the scheme was transferred to the then newly established Irrigation Water Corporation (IWC), and yearly irrigated area declined to about 300,000 ha. Average water supply in excess of requirement was about 29%. IWC was

constrained by insufficient finances because water fee collection was the responsibility of the Sudan Gezira Board (SGB). IWC was terminated in 1998.

- From 1999 to 2005, management of the Gezira scheme was shared by SGB (minor canals) and MoIWR (larger canals). The scheme deteriorated heavily during this period because of inappropriate canal dredging (i.e., over-excavation) which adversely affected the designed hydraulic characteristics of the canals. Consequently, yearly irrigated area varied between 300,000 ha and 430,000 ha, and average water supply in excess of requirement was about 63%.
- From 2006 to2010, management of the Gezira scheme was shared by WUAs (minor canals) and MoIWR (larger canals). During this period, annual water supply increased from 7 BCM to 9 BCM. However, there was no improvement in performance: The yearly irrigated area varied between about 400,000 ha and 600,000 ha, and the average water supply in excess of requirement was about 67%.
- From 2011 to 2014, management was shared by WUAs and SGB; and MoIWR was relieved of its responsibilities in 2012. However, SGB lacked the requisite capacity, which led the scheme into further deterioration. The irrigated area in 2010/11 was 520,000 ha and average water supply in excess of requirement was about 80%.
- Since the end of 2014, management of the Gezira scheme is back with the MoIWR.

The study concluded that changes in policies and institutional arrangements have had an adverse effect on the performance of the Gezira irrigation scheme.

This study was a one-time exercise aimed at quantifying excess water supply using historical data. It too was driven by researcher interest with no involvement by the party responsible to use the findings as inputs for improvement of the scheme. It did not throw light on (i) the root causes of institutional instability; (ii) the reason for increasing water supply to the scheme as of 2006 when irrigated area was decreasing and vice versa; and (iii) possible solutions for improving performance. However, it made a good case for initiating BIP in the Gezira scheme. Apart from this, no documentation has been found on benchmarking of irrigation performance in Sudan.

ONE RIVER
ONE PEOPLE
ONE VISION

Nile Basin Initiative Secretariat
P.O. Box 192
Entebbe – Uganda
Tel: +256 414 321 424
+256 414 321 329
+256 417 705 000
Fax: +256 414 320 971
Email: nbisec@nilebasin.org
Website: http://www.nilebasin.org

/Nile Basin Initiative
@nbiweb

Eastern Nile Technical Regional Office
Dessie Road
P.O. Box 27173-1000
Addis Ababa – Ethiopia
Tel: +251 116 461 130/32
Fax: +251 116 459 407
Email: entro@nilebasin.org
Website: http://ensap.nilebasin.org

ENTRO

Nile Equatorial Lakes Subsidiary Action Program Coordination Unit
Kigali City Tower
KCT, KN 2 St, Kigali
P.O. Box 6759, Kigali Rwanda
Tel: +250 788 307 334
Fax: +250 252 580 100
Email: nelsapcu@nilebasin.org
Website: http://nelsap.nilebasin.org

NELSAP-CU