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Background: Irrigated agriculture is often evaluated but few reviews of evaluation methodology adapted to this object are available in the literature. Besides, recommendations to improve evaluation in this field are lacking.

Purpose: The purpose of the paper is to contribute filling this gap.

Setting: Not applicable.

Intervention: Not applicable.

Research Design: Not applicable.

Data Collection and Analysis: Desk review.

Findings: This review shows the evolution of evaluation methodology in the field of irrigated agriculture pointing out a trend towards more comprehensive methodologies. The review also suggests some methodological tools to improve evaluation process.

Keywords: irrigated agriculture; evaluation methodology; plurality of evaluation; intended users; viewpoint

Introduction

In view of the large capital investments made for the capture, storage, and distribution of water in the last century, and the high social and economic expectations irrigated agriculture awaken, stakeholders are obviously concerned by the performance of irrigated agriculture (Murray-Rust & Snellen, 1993). To evaluate the performance of this agriculture is thus of particular interest to stakeholders in this field. To evaluate consists in following-up, understanding and passing judgment on a given situation, and decision makers, donors or managers rely on this judgment to adjust their policy, funding or action (Girardin *et al.*, 2005).

Some 40 years ago the focus was on building new irrigation facilities and two main types of evaluation approaches were used. One closely resembled an audit, i.e., its aim was to check the implementation of the project. The other consisted in research aimed at characterizing the performance of the new system and possibly to identify bottlenecks and the good practices needed to improve it and to ensure satisfactory results. Today the situation has changed in two ways: i) fewer new irrigation systems are being built and the challenge is to get the best results from facilities that have been operating for decades thanks to rehabilitation and/or modernization rather than designing new facilities that could reach the best performance, ii) benefiting from decades of experience, engineers acknowledge that in an irrigation system the 'hardware' (the infrastructure) and the 'software' (capacity building, institutional reforms, etc.) are of equal importance. As a consequence, investment programs now almost systematically include accompanying measures and some kind of participatory process at one stage or another of the program. This means that not only the object of evaluation has changed but also the context in which evaluations are carried out. In response to these changes, former methods have been updated and new evaluation approaches have flourished but progress is still required if evaluation approaches are to support appropriate decision making.

In this context, the paper has three objectives: 1) to review the range of existing evaluation approaches of irrigation systems together with their terminology and to identify the context in which each is appropriate, 2) to identify specific methodological developments that need to be promoted to improve evaluation of these systems, and 3) to analyze changes in evaluation methods.

In reviewing evaluation methods, the paper follows Girardin et al. (2005) and Bos et al. (2005) by asking three fundamental questions: What are we evaluating? Why and for whom is the evaluation being carried out? From whose viewpoint, how and by whom is it being carried out? By providing detailed answers to these questions, the three first parts of the paper present the range of existing approaches and analyze which methodological developments need to be promoted. The fourth and final part discusses changes in the way irrigation systems are evaluated, their limits, and the best way forward.

What are We Evaluating?

Towards a More Comprehensive Representation of Irrigation System Performance

Comparing irrigation systems worldwide in the 1970s, Bos and Nugteren (1974) defined overall irrigation performance through different components of the water-delivery system: conveyance efficiency (efficiency of the canal network from uptake to offtake); distribution efficiency (from offtake to individual fields) and field application efficiency (from the field inlet to the crop). In the 1980s, a debate emerged on the need for and the nature of a more generic framework. Levine (1982) suggested a shift in focus from the water supply network to understanding and planning the behavior of the main actors of the system. He also introduced the concept of relative water supply to evaluate the management of the system. Garces (1983), cited in Rao (1993), considered irrigation systems in a more comprehensive way and developed a method with four broad interacting subsystems: water, humans, the environment and economics. The water subsystem is described by three water-based performance indicators, which are considered like proxies of the success in achieving the crop production objective. These indicators are productivity, equity (the point is to check whether the production and the flow are distributed equally among sections of the irrigation system) and efficiency of water use. The human subsystem was characterized by the flexibility in decision making of the irrigation actors and by the farmer's satisfaction with the irrigation system. The environmental subsystem has three descriptors: waterlogging, soil toxicities and irrigation water quality. As for the economic subsystem it is represented by i) the portion of operation and maintenance that is self-generated by the irrigation system, ii) the fraction of the maximum collectible that would equal the operation and maintenance expenses of the system and iii) the percentage of the total amount due that is actually collected. Following a similar philosophy, Abernethy (1990) considered that irrigation water supply had to be assessed by three primary characteristics, adequacy, timeliness, and equity. However, he reckoned that irrigation systems have five overall goals (productivity, equity, profitability, sustainability, and quality of life), and that sound water management was a necessary but not sufficient condition for reaching these goals.

As the representations of irrigation systems became more comprehensive, assessing their performance became harder. Small and Svendsen (1992) broke down the complex irrigation process into five individual nested systems: the irrigation system, the irrigated agriculture system, the agricultural economic system, the rural economic system, and finally the politico-economic system. Each system produces an output that is used as an input in the following system (e.g. the irrigation system supplies water to the crop, which is part of the irrigated agriculture system). Their representation provided a clear identification of the level at which the different objectives could be reached and showed that different spatial and temporal scales need to be combined. By doing so, these authors laid the foundations for a generic assessment framework for irrigation performance.

Today everybody agrees that an irrigation system has to be considered in a comprehensive way and that the object of evaluation is multifaceted. These characteristics not only call for new performance indicators but also for methodological improvements of evaluation. Some progress may be achieved in the causal analysis of the system. Most evaluation theorists however consider this step as a prerequisite rather than the evaluation itself. Scriven (1991) defines the evaluation as the process of "determining the merit, worth and value" of the object at stake. Guba and Lincoln (1989) further argued against outsiders' expertise, which could be inappropriate for people in charge of the system. We propose to combine their recommendations in a two-step approach: (1) to identify causal links in the evaluation system and (2) to compile internal and external sources of information in order to inform the system. These steps are detailed and discussed hereafter.

Causal Links In The Evaluation System

In the global field of evaluation one of the most important changes, observed by Mackay and Horton (2003), was that since the 1980s, evaluators have moved towards a better understanding of the theories and assumptions underlying the programs being evaluated. It is acknowledged that today the strength of an evaluation is not stating whether a program is successful or not, but rather identifying the causal mechanisms that lead to the success or failure, and giving sound and feasible recommendations for the improvement of the program being evaluated. As stated by Scriven (1991:42), "using quantified indicators without clarifying causal links between sub-systems is merely monitoring. It may notice a gap between achievements and goals but does not explain why".

In the specific field of irrigation system evaluation, these changes and strengths are unfortunately not so common. Irrigation system evaluation methods that are meant to support decision-making do not meet the requirements of policy makers and managers because the evaluation is performed at a level which is different from the one at which decisions can be taken but the links between both levels are often not identified. Most of the time, the limitation comes from the methodology itself which performs the evaluation on a number of sub-system components but which does not propose any aggregation process. These methods would be improved significantly by identifying the causal mechanisms that link the evaluable actions to the objectives. Breaking down an overall non-measurable objective into intermediate and elementary sub-goals by identifying their causal relationships ensures that the evaluation system will be operational. The breaking down of a general objective into sub-goals is commonly called an objective tree (Consultative Group on International Agricultural Research (CGIAR), 2006). Similarly, the logical framework and results chain can help define indicators for the different sub-goals up to the level of activities (Guijt, 2002). These tools are particularly suitable for the evaluation of complex and comprehensive systems.

When evaluation systems adopt the principle of sub-goals they will naturally have a dashboard format (Girardin et al., 2005), which mirrors the objective tree (see Figures 1 and 2) and which is particularly appropriate for fostering operational information and for the ease and transparency of information dissemination. The dashboard contains first-order panels of indicators at the lower level where elementary objectives can be assessed, intermediate panels and a limited number of monitoring panels containing aggregated indicators at upper levels where decisions can be taken. This format is more suitable for decision-making than complex composite indicators or integrated models (which are rapidly considered to be black boxes), and should consequently be promoted. Informing the elementary objectives sets challenges that we discuss in the following section.

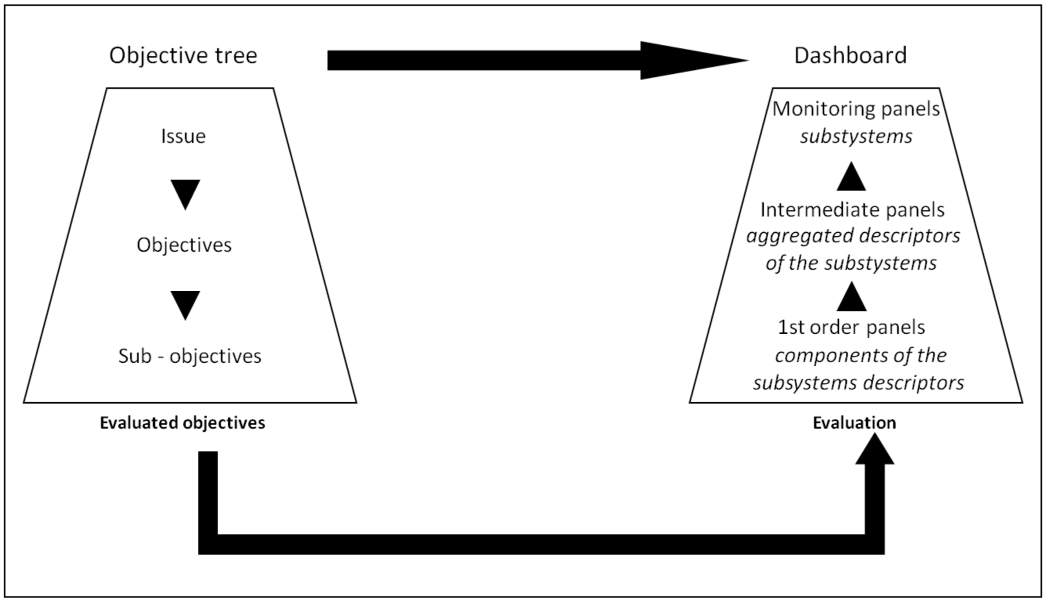

Figure 1. Objective Tree and Dashboard Format: an Objective Tree that Breaks Down the Objectives in Order to Evaluate them can be 'Inversed' into a Dashboard that Structures the Results of the Evaluation for Decision Making (adapted from Girardin *et al.*, 2005)

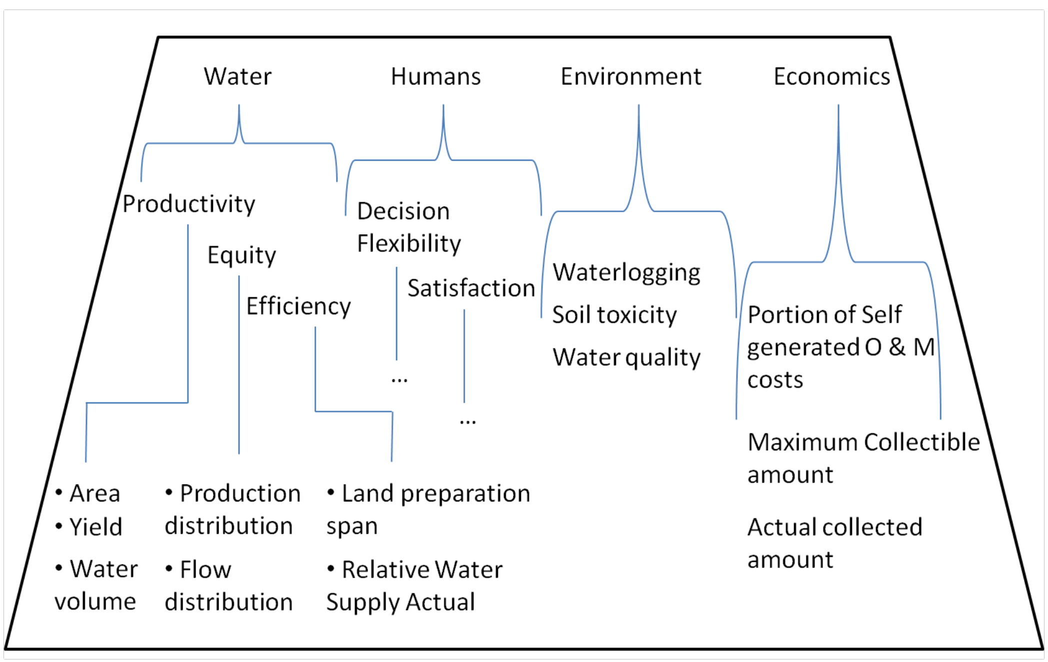

Figure 2. Illustration of Garces' Representation of Irrigation System in a Dashboard Format

Informing the Evaluation System

Quantitative assessments have some limitations. In heavily instrumented site-specific research assessments, typical issues of data scaling and uncertainty occur for the simple reason of cost: parameters cannot be measured everywhere. For example, as part of an analysis of irrigation performance over an irrigation district covering around 2600 ha spread over 19 soil units, Dechmi et al. (2003) compared irrigation depth and soil properties. However, soil properties were characterized through collection of only 39 samples. Given the heterogeneity of the soil the size of the sample was insufficient, leading to problems of data scaling.

These limitations of quantitative approaches called the methodologies into question. In addition, the impression of accuracy created by quantitative assessment was reported not only to be overstated but often not to be needed for strategic-level decision making (Cashmore, 2004; Lee, 2006). The innovations and potential gains that can be derived from the combination of qualitative and quantitative approaches along with the challenges involved, are now acknowledged (Delarue, 2007; Rao & Woolcock, 2003). As detailed above, a comprehensive representation of irrigation system performance will inevitably lead to a high number of sub-system components to assess. Valuing them quantitatively is difficult, time consuming and costly. All types of available data should consequently be used to inform these sub-system components. Methodological pluralism is especially relevant in these systems in which the components do not necessarily require quantitative assessment and where qualitative data is often readily available amongst the farmers whose expertise is poorly used by the evaluators.

Methodological pluralism not only calls for the use of quantitative and qualitative data but also for the combination of approaches. Qualitative methods like exploratory interviews, qualitative pretesting and observations can be used to pinpoint and prioritize the required information (Madey, 1982). Such insights from the field will considerably enhance the relevance of the analysis and will help reduce the evaluation to its essentials (Rao & Woolcock, 2003).

Why is the Evaluation being Done and For Whom?

Evaluation Objectives

One criterion that can be used to classify an evaluation system is its objectives. Here our intention is not to list all possible objectives but rather to clarify and classify the existing range of objectives. The tight link between objective and approach was underlined by Cashmore (2004), who stressed the importance of the explicit definition of the substantive purposes and outcomes of the evaluation since the rationale of the evaluation greatly influences the methodology to be used.

Mackay and Horton (2003) described a continuum between a research-oriented and a utilization-focused evaluation. All evaluations aim to identify relevant actions to improve the performance of the irrigation system, but research-oriented evaluations prioritize the generation of knowledge and accountability, whereas utilization-focused evaluations (U-FE) aim to support action, improvement and learning (Patton, 1997). As described by Mackay and Horton (2003), researchers consider that once the findings of research-oriented evaluations are made available, the evaluation process can be handed over to policy makers. As a consequence, research-oriented evaluations do not include in the learning process of evaluation the persons which will be in charge of implementing the findings of the evaluation. On the contrary, U-FE aim to provide useful information for “primary intended users” (Patton, 1997), who need to be identified and involved. In irrigation systems they can be donors, policy makers, managers, or users. U-FE lead to capacity-building, learning and design for future actions. For Mackay and Horton, the above examples represent the two extremes of the continuum. However, it should be underlined that the extremes of the continuum could also be defined with respect to the purpose or to the intended users (Patton, 1997), since the three components (purpose, intended users, and approach) are tightly linked.

Intended Users and Participants of the Evaluation

Each evaluation pursues specific objectives targeting specific users or associating different participants. Objectives and participants are intrinsically linked, as detailed in the previous section. In this section, we would like to underline the fact that the intended users of an evaluation also includes the end-users and that this has strategic implications.

In theory, the design and complexity of the evaluation should be adapted to its end users. However, adapting the design of an evaluation system to changing users is a challenge that is faced by evaluators of irrigation systems today. Irrigation systems are currently subject to the transfer of management responsibility from the state to water users associations or other types of organizations, a process that raises a number of issues described in detail by Abernethy (2010) from a historical perspective. This transfer also impacts the rationale of classical evaluation, since farmers' representatives become stakeholders and decision makers. As a consequence, and in order to facilitate understanding and utilization, new evaluation methods need to be developed to ensure simplicity, clarity and straightforward implementation.

From Whose Standpoint was the Evaluation Made, How, and by Whom?

Plurality of Evaluation

As mentioned in the previous section, the evaluation objectives influence the approach used. Different actors have different set of objectives for the irrigation system, i.e., different objective functions and different definition of performance. As a consequence, evaluation should be considered as substantially pluralistic (Russ-Eft & Preskill, 2001 in Mackay and Horton, 2003). In this section we underline how biased an evaluation can be when it is carried out from only one standpoint.

Figure 3 illustrates the different categories of actors, their main spatial scale of intervention and some of their typical objectives regarding irrigation schemes. The figure does not aim to be comprehensive but underlines how expectations differ with the type of actor and his/her spatial scale of action. In addition, expectations not only differ but may be contradictory from one scale to the other. For example, at the farm level, the farmer's objective is to receive enough water at the right time to grow his own crops, whereas at the irrigation system level, the manager's objective is to provide the best water service possible with respect to reliability, adequacy, timeliness, and equity among farmers. The objectives at the irrigation system level (e.g. equity) are thus partially opposed to the ones at the farm level (e.g. covering individual needs).

Guba and Lincoln (1989) stress that when the plurality of viewpoints and of values is acknowledged, then the question of whose viewpoint and values are to be taken into account and how the different position might be accommodated becomes paramount. We recognize how biased an evaluation can be when it represents a specific point of view. The limitations of any evaluation system are primarily set by the viewpoint from which it is carried out. However, the benefits of evaluation may be to assess to what extent the stakes of each actor were or were not taken into consideration. Rey et al. (1996) analyzed the perception of irrigation performance from the water users' viewpoint (the farmer) and from the water provider's viewpoint (the manager) and concluded on the need for a participatory approach to improve water management strategies at the scale of the irrigation system. Ghazouani et al. (2009) compared farmers' and engineers' representations of an irrigation modernization program in an oasis in southern Tunisia. They underlined the limitations of each approach and the added value of a combination of experts and farmers' knowledge for the design of the irrigation modernization program.

Actors' Involvement in the Process

This section clarifies the evaluation terminology related to the actors' involvement in the process.
Identifying the role played in the evaluation process by those directly involved in the system being evaluated, Delarue et al. (2009) defined three evaluation approaches: independent (the people involved are the sources of information), collaborative (the people involved are consulted and/or associated at various stages of the evaluation process) and participatory (the people involved are real stakeholders). Collaborative evaluation is similar to what Johnson et al. (2003) defined as functional participation in which the evaluator's goal in implementing a participatory approach is to obtain opinions and feedback from the users or local actors. The participatory approach is close to what Monnier et al. (1992) defined as the 'pluralistic' approach for public policy evaluation in which the evaluation is based on the discussion of the policy by a group comprising the different stakeholders concerned by the policy.

Depending on the evaluator's position, evaluation can be internal or external. Internal evaluations, which are necessarily collaborative or participatory, involve the people responsible for the program activities in the evaluation processes. They tend to be implemented more often than external evaluation, which is often seen as a form of control or audit (Mackay & Horton, 2003).

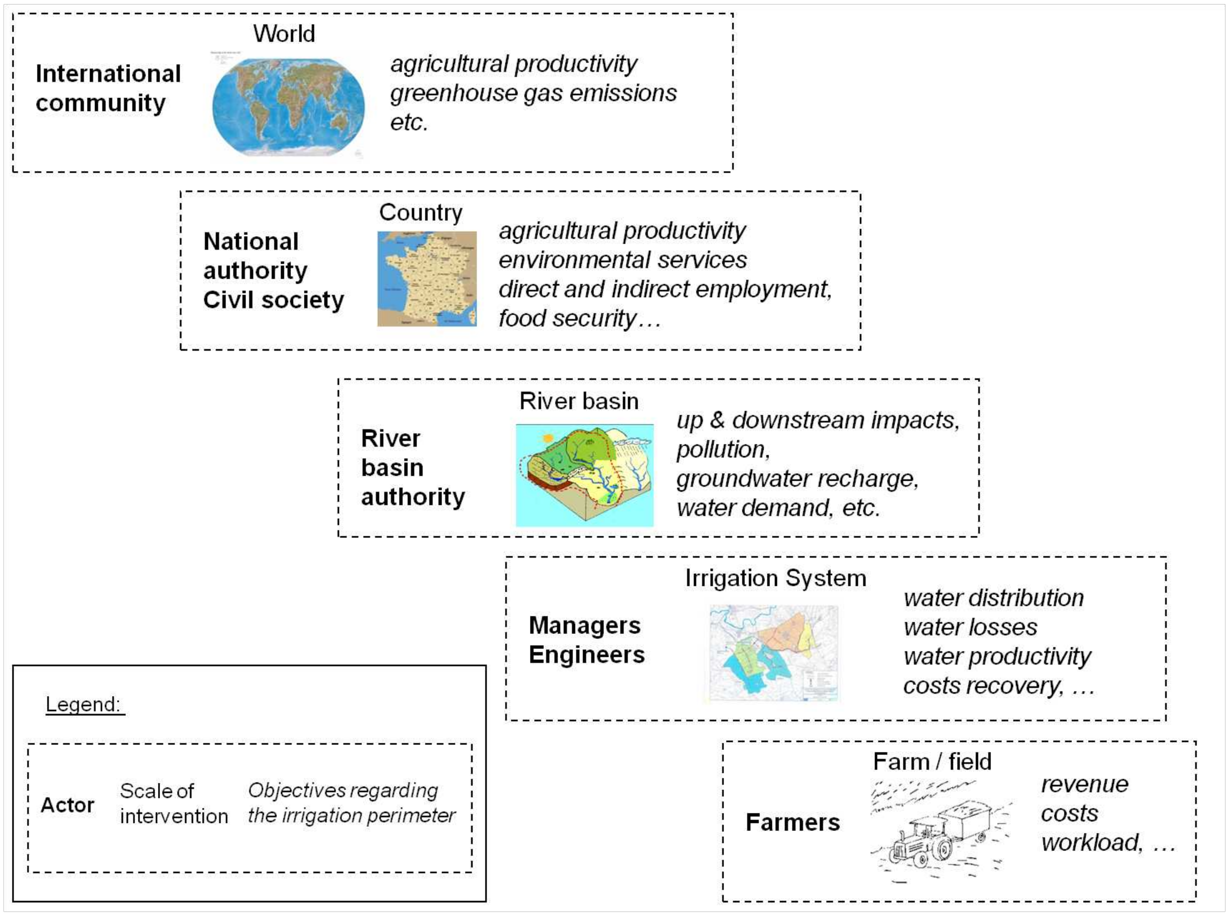

Figure 3. The Evaluation's Viewpoint: Each Actor is Characterized by his Scale of Intervention and his Objective Function

Analysis of Evaluation Approaches for Irrigation Schemes

The third objective of the paper is to review the range of previously mentioned evaluation approaches and to retrieve some orientations.

Unbalanced Viewpoints

By analyzing the points of view expressed in evaluations, we observed that performance evaluations of irrigation schemes were traditionally carried out from managers' and policy makers' viewpoints, and used their objectives and performance criteria. However, public policies target all categories of stakeholders, and decision makers require different evaluation viewpoints before deciding on appropriate policy orientations. In addition, it is widely accepted that the farmers' points of view can help understand the success or failure of a policy or a program. Wichelns and Oster (2006) mentioned the fundamental disconnection between public and social objectives and farm-level goals with regard to irrigation. Van Schilfgaarde (1994) reported that public officials often pay insufficient attention to understanding farm-level goals when designing projects and deciding on policies. Pereira (2009) stressed that irrigators have a different perception of problems, practices and objectives than non-farmers. Facon (2006) believed that evaluation of irrigation system performance should rely much more on the farmers' needs than it usually did. Sagardoy (2007) went a step further, considering that evaluation of a program should include the farmers' perception of the new situation. In his opinion, there was a need to distinguish the needs for monitoring emanating from policy makers from the monitoring needs emanating from farmers. Some approaches thus were developed in which an additional criterion was included (Garces, 1983; International Fund for Agricultural Development - Office of Evaluation, 2009; Renault *et al.*, 2007; Uysal & Ati□, 2010). This criterion reflected the farmers' view by expressing their degree of satisfaction with the system. Although this was a positive development, we believe it is not sufficient to provide a true insight into the farmers' situation. Evaluations in which the farmers' views are central are required to balance the views expressed in the performance evaluation of irrigation schemes. But, the challenge is to capture the diversity of views expressed by farmers. By measuring the farmers' degree of satisfaction with the activities of water projects, Abernethy et al. (2001) made a promising move in this direction. As suggested by these authors, the results of such opinion polls should definitely orient the design of projects.

Evolving Objectives and Users

Evaluations conducted from the same viewpoint and consequently based on the same criteria can be compared. The fact that -from the policy makers' point of view- most existing irrigation schemes in developing countries were reported to be performing significantly under their potential (Facon, 2006; Raju & Pillai, 1999) and that the failure of irrigation projects was still too frequent (Inocencio *et al.*, 2007) called decades of evaluation into question. But, we consider that instead of stigmatizing the management of the irrigation schemes and farmers' practices, such analyses should question how the potentials were established. If most of the schemes perform under the norm, the problem may lie not only in the schemes themselves but also in an inappropriate norm. Similarly, if failure is much more widespread than success, the way success or failure is defined needs to be investigated. Potential and success are determined by comparing the performance reached by the system to the performance expected from the system. Too optimistic expectations are almost systematic and might result from rapid ex-ante evaluations that mainly reflect the views of the 'more vocal' actors; namely, those of the decision makers / managers who need to convince the donor of the project's high potential. Setting more realistic expectations could be ensured by the representation of broader viewpoints. The evaluation of irrigation systems would definitely benefit from realistic 'unbiased' expectations since it would allow a more accurate analysis of the situation and higher learning potential.

We are in an era of rapid change and ever increasing complexity. The complexity comes from more and more stakeholders whose objective functions include an increasing number of objectives, even - and especially - contradictory ones (e.g. production vs. natural resources). This widening of both the users and the objectives clearly calls for new strategies such as those discussed previously in the paper.

A Promising but Challenging Trend of Change

In the past, evaluators mostly conducted external and independent or collaborative evaluations promoting sectorial, segmented assessments. Today there is a shift towards internal and participatory evaluations. But, to what extent this shift is truly on track remains to be seen. For example, D'Aquino and Seck (2001) showed how often the ubiquitous 'participatory' concept cited in development programs is far from its original meaning and goals.

Figure 4 illustrates the changes in evaluation approaches and applies to the global field of evaluation as well as to the specific case of evaluation of irrigation systems. Change is represented in a three-dimensional space symbolizing the components of the evaluation approaches: the position of the evaluator ('who is conducting the evaluation?'); the objectives of the evaluation ('why?'); and the role played by the stakeholders in the evaluation process ('how is evaluation carried out?'). The two extremes are the audit approach and the internal learning-process approach. An evaluation process of the latter type, in which the different viewpoints are acknowledged and the different actors have agreed on an original objective function, is extremely challenging. But, today farmers' viewpoints are often still disregarded, and setting consensual priorities, which would enable further tangible improvement of irrigation systems, is still far from being achieved. We have thus not yet reached internal and participatory evaluations despite the fact that progress is being made.

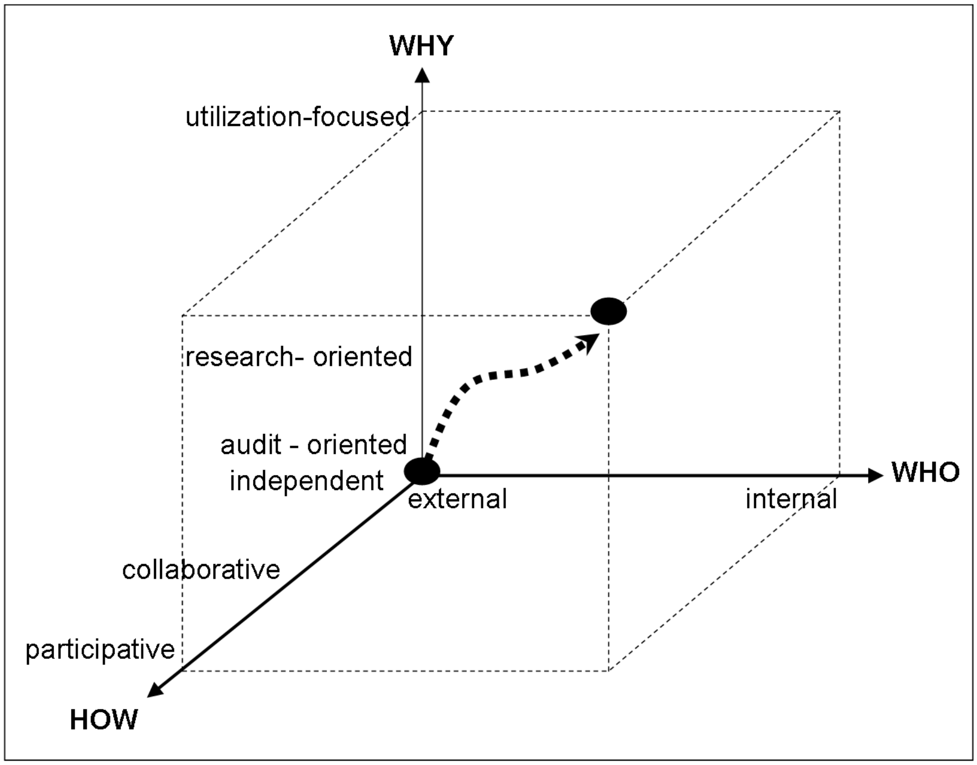

Figure 4. Changes in the Field of Evaluation: The Analysis of 'How', 'Why' and 'by Whom' the Evaluations were Conducted Revealed a Trend Among some of the Main Evaluation Concepts

Conclusion

The scope of performance evaluation of irrigation systems broadened enormously in recent years calling for significant methodological developments. We used an existing framework (Bos *et al.*, 2005; Girardin *et al.*, 2005) to analyze evaluation approaches step by step. In applying this framework to the variety of existing approaches, the aim of this review was threefold. First, it was to clarify the range of existing approaches, the reason for their development and their terminology. Second, was to identify gaps in existing methods and to analyze why and which methodological developments are required to improve the impact of performance evaluation on decision making in irrigation systems. Finally, it was to characterize and discuss changes in evaluation approaches.

To improve the impact of any evaluation process, three main recommendations are made. First, the evaluation system should identify causal links between objectives at different levels. Second, we should take the best out of all sources of information: qualitative as well as quantitative. Third, evaluation tools should promote simplicity, clarity and straightforward implementation.

When analyzing changes in evaluation approaches, we particularly questioned the unbalanced viewpoints represented in performance evaluation of irrigation systems. An increasing number of initiatives are now being taken to characterize farmers' points of view, but policy makers' and managers' viewpoints are still over-represented to the detriment of those of farmers, even if the added value of the latter is acknowledged. Engineers' and policy makers' expectations cannot completely match societal expectations, especially those of a variety of stakeholders. These diverse expectations need to be taken into account to establish a realistic potential and to define the success of the irrigation schemes. Even if a consensus cannot be reached, objectives, choices and priorities need to be acknowledged and established in a transparent way. In addition, the change in objectives and in intended users implies new conditions for evaluation and calls for an adaptation of existing methods and a revision of how terms of reference for evaluation are prepared.

Finally, we characterized changes in approaches with respect to previous methodological aspects. Today an evaluation system should be part of a learning process even if the evaluation pursues accounting goals. Once the targeted objective-function has been defined, a simple and dynamic form of evaluation needs to be developed that allows the irrigation system to be fully and efficiently assessed and monitored, the objective function to be updated, the causal mechanisms of failure or success to be identified, thus leading to an understanding of how to act on these mechanisms. The current international concern about the ability to feed the world tomorrow may result in a second phase of building and rehabilitating large irrigation systems. To decide on such investments, updated evaluation approaches will be needed and in this context, the orientations suggested in this paper can provide valuable inputs.

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