Title: BMPs and Innovation evaluation protocol
Deliverable N.: D1.2.1

January/2023

Funding source:	EU Initiative on Climate-relevant Development Smart Innovation Through Research in Agriculture in developing countries - DeSIRA
Project Acronym:	WATDEV
Project Full Title:	Climate Smart WATer Management and Sustainable DEVelopment for Food and Agriculture in North-East Africa
CRIS Ref.:	FOOD/2021/425-767
Project duration:	48 months

Published by the WATDEV Consortium
Responsible partner: **CIHEAM Bari**
Contributing partners: **CNR, SYKE, ISRIC, ASARECA, HU, WLRI, WRC, KALRO**
Version: **Final**
Dissemination Level: **Public**

Funded by the European Union

AGENZIA ITALIANA PER LA COOPERAZIONE ALLO SVILUPPO

CIHEAM BARI

WATDEV CONSORTIUM

The project consortium is comprised of:

EGYPT	Heliopolis University (HU)
ETHIOPIA	Water and Land Resources Institute (WLRI)
FINLAND	Finnish Environment Institute (SIKE)
ITALY	Centro Internazionale di Alti Studi Agronomici Mediterranei di Bari (CIHEAM-Bari)
ITALY	Italian Research Council (CNR)
KENYA	Kenya Agricultural & Livestock Research Organization (KALRO)
SUDAN	Water Research Centre (WRC)
THE NETHERLANDS	International Soil Reference Center (ISRIC)
UGANDA	Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)

This publication was produced with the financial support of the European Union. Its contents are the sole responsibility of CIHEAM Bari and do not necessarily reflect the views of the European Union

DOCUMENT INFORMATION

Project number	FOOD/2021/425-767	**Acronym**	WATDEV
Full title	Climate Smart WATer Management and Sustainable DEVelopment for Food and Agriculture in North-East Africa		
Project URL	www.watdev.eu	**Document URL**	
Implementation Agency	AICS (Italian Agency for Development Cooperation)		

Deliverable	**Number**	D1.2.1	**Title**	BMPs and Innovation evaluation protocol
Project Activity	**Number**	A1.2	**Title**	A1.2 Setting the evaluation process of BMPs and Innovations

Date of delivery	**Contractual**	M8	**Actual**	M8
Status	Version 1.0		Draft	
Final review	25.12.2022	**AICS check**		
Type of document	□ prototype □ **report** □ demonstration □ other			
Dissemination level	□ **public** □ confidential			

Authors (Partner)	CIHEAM Bari			
Responsible Authors and contributors	**Name**	Si Mokrane, SIAD; Claudio, BOGLIOTTI; Gaetano, LADISA; Aymen, SAWASSI; Pandi, ZDRULI; Silvia LECCI	**Email**	siad@iamb.it bogliotti@iamb.it ladisa@iamb.it sawassi@iamb.it zdruli@iamb.it lecci@iamb.it
	Partner	CIHEAM Bari	**Phone**	

Abstract (for dissemination)	This deliverable provides BMP/I implementation guidance for the study areas (Egypt, Sudan, Ethiopia and Kenya). It begins by explaining the necessity of BMPs/Is, the goals of adding innovation into them, and how to choose them. Next, the study explains how to choose BMPs/Is and innovations and their possible benefits. The research also outlines BMPs/Is and innovation implementation in the study areas. Finally, the study suggests more research and action. These principles may help sustain the study locations and their ecosystems.
Keywords	BMPs, definitions, principles sets.

Index

Index of Figures

Acronyms and Abbreviations

AICS	Italian Agency for Development Cooperation
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa, Uganda
AU-EU	Africa-Europe
CIHEAM	Centre International de Hautes Etudes Agronomiques Mediterranéennes, Italy
CNR	Consiglio Nazionale delle Ricerche, Italy
DG DEVCO	The Commission's Directorate-General for International Cooperation and Development
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
HU	Heliopolis University, Egypt
ISRIC	International Soil Reference Center, The Netherland
KALRO	Kenya Agricultural & Livestock Research Organization, Kenya
R&I	Research and Innovation
WRC	Water Research Centre, Sudan
STI	Science, Technology and Innovation
SYKE	Finnish Environment Institute, Finland
WATDEV	Climate Smart WATer Management and Sustainable DEVelopment for Food and Agriculture in North and East Africa
WLRI	Water and Land Resources Institute, Ethiopia
BMP(s)/I(s)	Best Management Practice(s)/Innovation(s)
SES	Socio-Environmental Systems
IEG	Independent Evaluation Group
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action

Executive Summary

This deliverable discusses the development of an evaluation protocol for evaluating the effectiveness of Best Management Practices and Innovation (BMPs/Is) within the WATDEV project context. The protocol introduces two main bases: 1) Axiomatic definitions of principles, concepts, and domains, and 2) An operational base for assessment that sets the scale for comparing BMPs and Is. A review of relevant literature is presented to gain an understanding of the problem and the potential BMPs/I assessment, followed by a methodology established for the project and a conclusion for the implications and potential replicability of the presented method.

1. Introduction

Establishing a precise definition of impact assessment is both important and required in agricultural development programs, as there is considerable controversy regarding what really constitutes an effect to be evaluated (Maredia, 2009; White and Raitzer, 2017). (Lele and Goswami, 2021; Kurnianto et al., 2022) A large number of large development organizations believe that impact evaluation must address the issue of attribution by carefully defining a counterfactual for people who benefit from the program. The definition of attribution is ascribing the observed changes in indicators to the actual intervention (Lykhovyd and Lavrenko, 2020; Tielkes, 2022). As a result, creating a clear link enables a comprehension of the causal chain and the success or failure of a specific program's practice(s) (Baldi *et al.*, 2014). Attribution is essential, as several other factors might cause changes in indicators. This expectation of addressing the issue of attribution necessitates the use of experimental or quasi-experimental methodologies, which, when executed properly, permit a valid comparison between individuals who get the program's advantages and those who do not (Soulis, Psomiadis and Londra, no date). In addition, they provide the control of other variables that may have impacted the impact of a given program (Parry, Carter and Konijn, 1988; OECD, 2021).

The opposing viewpoint is accustomed to performing impact evaluations in which little effort is made to ascribe changes in the selected indicators to the intervention (Gertler *et al.*, 2016; Velasco-Muñoz *et al.*, 2022). Thus, this side opposes elevating experimental and quasi-experimental procedures above less rigorous and qualitative approaches that are commonly utilized in the field of impact evaluation(Barrett *et al.*, 2002). This discrepancy in definition lies at the heart of the debate around impact evaluation, yet neither term is inherently correct or incorrect; they are essentially distinct(Helling *et al.*, 2015; Surls, Borel and Biscaro, 2016). Both concepts have prompted beneficial research in the subject of development. Nonetheless, there are growing worries that we lack knowledge and proof of what works and at what cost(Jhorar, Smit and Roest, 2009). This is especially important given the global demand for more openness in public expenditure and development funds. Beyond the utilization of finances, policy choices substantially benefit from accurate and measurable data on the impact of a certain program’s practices(Jhorar, Smit and Roest, 2009; Valipour, 2015).

Due to this definitional disparity, several entrenched debates have formed over the technique of effect evaluation(Bazzani, 2003; Fewtrell, Kay and Benjamin, 2008). The use of quantitative measurements in impact evaluation is a source of contention. In the 1960s and 1970s, it was typical for projects to undergo a cost-benefit analysis, which is expressly predicated on determining what results would have occurred without the initiative using comparison groups(Sequeira *et al.*, 2022). In the 1980s, however, the emphasis switched with the emergence of participatory assessment, which opposes evaluations based on standards established by foreign implementers (Srivastava *et al.*, 2020). Additionally, it was frequently asserted that projects were unsuitable for quantitative evaluation. This shift in emphasis has had some repercussions, since it has resulted in a dearth of credible evidence about the magnitude of the benefits generated by development expenditure (Craswell *et al.*, 2007; Srivastava *et al.*, 2020). An analysis by the non-profit organizations revealed that none of the 339 evaluation studies contained in the database of the ALNAP could be characterized as rigorous impact evaluations(Slim and Bonwick, 2006).

This insight, supported by additional studies from a variety of sources and pertaining to various knowledge repositories, has helped to refocus attention on the use of quantitative measures in the area(Maredia, 2009). In recent years, it has been increasingly prevalent to place a strong focus on thorough effect evaluation. Robert McNamara established the IEG thirty years ago, giving the World Bank an early start (Clark, 1981; Rustin, 2006). Since then, the World Bank has added numerous programs to promote the development of impact evaluation. For instance, it designed the Development Effect Evaluation (DIME) program to give technical assistance to operational employees interested in including an impact evaluation into their project design (World Bank, 2013).

For the purposes of the present project, we define impact evaluation as the systematic investigation of the major and/or persistent changes in people's lives caused by the introduction of a certain set of practices. We thus choose a more restrictive and demanding approach that includes the requirement for a counterfactual, but we also consider the value in employing qualitative methods to supplement a quantitative investigation.

2. Methodology

2.1 Overview

Impact evaluation must be a systematic investigation of the changes brought by a specific action or sequence of activities in comparison to a counterfactual (Dragicevic and Shogren, 2021). Several dimensions and associated factors must be considered when formulating a strategy to evaluate impacts:

a) **Causality-impact association:** It refers to the capacity to affirm (with a certain degree of confidence) that a practice has caused measurable outcomes, given alternative plausible explanations.
b) **Spatial validity of practice's impacts:** Scalable validity is the extent to which results of impacts of a given practice could be up, down or out scaled to encompass for heterogeneity within or out of the initial environment it was assessed for.
c) **Sustainability and resilience:** intrinsically linked, environmental resources capacity of recovery from external pressure (exploitation) is at the core of sustainability analysis of changes brought by the introduction of practices.
d) **Cost and benefit:** refer to design implementation requirements as well as continuous adjustments through surveys and data collection, monitoring and evaluation of impacts in monetary terms.
e) **Ethical concerns:** Given that development projects aim to increase welfare of certain populations, it is critical ethical concerns (i.e.: religion, traditions, food diet, social structure, etc.).

2.2 Impact evaluation methods – A paradigm of contextual priorities

There is unlikely to be a universal methodology for assessing and weighting various evaluation techniques based on the entirety of the aforementioned dimensions and factors (Berkes, Folke and Colding, 2000; Wang and Grant, 2021). Different projects may have differing constraints and focus legitimately on various issues. Costs may and sometimes are the decisive issue for small development programs (Brown and Berry, 2022). Nonetheless, inadequate field and study context knowledge may also hinder the implementation of particular practice(Schmitz, 2016). In some circumstances, organizations with a focus on accountability, such as the World Bank, may be able to devote a great deal of attention to internal validation and implementation difficulties, which are essential for conducting high-quality impact assessments. While development organizations tend to assert that more rigorous methods are also more expensive, there does not appear to be a clear and significant cost difference between experimental and quasi-experimental methods. In addition, impact assessment feasibility tends to prioritize evaluation expenditures over quality (May, 2022).

In terms of ethical problems, given that the goal of development programs is to improve the well-being of particular communities, the fairness of assistance interventions is of paramount importance (Mubako, 2022). Whether it is permissible to provide help to certain individuals but not to others, the appropriate selection criteria, and the administration of aid are crucial ethical issues. When creating impacts assessment protocol, horizontal and vertical equity are two of the factors that need to be examined (Dunbar, 1988). Randomized control trials have been heavily criticized, whereas randomized rollout is more acceptable, as all eligible farmers are meant to receive treatment in the end, but this is not a trivial verification to implement (Avriel-Avni and Dick, 2019). Some assistance measures are more viable and simpler to implement than others due to the intricate interaction of political, economic, and sociocultural issues (Schmitz, 2016). Important is the capacity to obtain trustworthy data. The required sample size and statistical power (the probability-based capacity of a test to identify significant findings) are other crucial considerations (Brown and Berry, 2022).

Documented methods and approaches available in literature are not necessarily mutually exclusive and may be employed in varied configurations as complements, replacements, and robustness boosters; also, different methods can be utilized for different portions of a particular project. In the context of the WATDEV project, we propose an evaluation method built from scratch using a combination of experimental, quasi-experimental and statistical approaches. The theoretical design and framework are presented in the following section.

2.3 Integrated assessment of Socio-Environmental Systems (SES)

Social and ecological systems are founded on the notion that people are not distinct from nature. This notion, which asserts that the distinction between social systems and natural systems is arbitrary and artificial, was initially proposed by Berkes and Folke, and Berkes et al., 2000 further expanded its theory. Recent research into the notion of integrated environmental systems indicates that integration is a keystone and is crucial to the structure and operation of these systems, and essential to their resilience assessment (Berkes, Folke and Colding, 2000).

Regarding agricultural systems, the point of interaction between socio-economic and agro-hydrologic remained quite limited until the last several decades. Similar to how mainstream ecology attempted to remove people from their study, many social science departments neglected the environment entirely and restricted their focus to humans. Although some scholars (e.g.:(Payne, 2021)) had attempted to bridge the nature-culture divide, the majority of studies focused on investigating processes within the social domain alone, treating the ecosystem largely as a "black box" and assuming that if the social system performs adaptively or is well-organized institutionally, it will also manage the environmental resource base sustainably.

Elinor Ostrom and her numerous co-researchers have created a comprehensive "Social-Ecological Systems (SES)" framework (Ostrom, 2009; Teodosiu, Fiore and Hospido, 2022; Stiepani, Jiddawi and Mtwana Nordlund, 2023), under which much of the still-evolving theory of common-pool resources and collective self-governance is currently situated . In addition, it makes extensive use of systems ecology and complexity theory. There are elements of complexity theory (e.g.: quantum physics) that have little direct relevance to understanding SES, while the studies of SES contain social problems (e.g.: equality and human well-being) that have historically received less attention in complex adaptive systems theory (Chen, Sasaki and Okada, 2019; Yang *et al.*, 2022; Zarayeneh *et al.*, 2022).

SES theory incorporates concepts from theories pertaining to the study of resilience, robustness, sustainability, and vulnerability (e.g. (Gasparini, Manfredi and Asprone, 2014; Tripathi, 2017; Janić, 2022)), but is also concerned with a broader range of SES dynamics and characteristics than any of these terms implies. Although SES theory relies on a variety of discipline-specific ideas, such as island biogeography, optimal foraging theory, and microeconomic theory, it is considerably larger than these particular theories.

SES theory is a relatively recent idea that originated from a mix of disciplinary platforms and the notion of complexity produced by the work of several researchers, most notably the Santa Fe Institute, in 2002 (Xing *et al.*, 2021). Complex system theory is therefore a more significant "intellectual parent" of SES. SES research has been significantly more ‘self-conscious' and 'pluralistic' in its perspectives than complexity theory has ever acknowledged. This is due to the social context in which SES research has been conducted and the possibility that SES research will result in recommendations that will affect real people.

The study of SES from a complex systems viewpoint is a rapidly expanding multidisciplinary area that may be considered as an attempt to combine disciplines into a new body of knowledge that can be utilized to tackle some of the most pressing environmental issues of the present day (Xie, Wang and Chen, 2016; Morse, 2020; Kantabutra, 2022). Complex system management procedures may be enhanced by making them adaptable and flexible, able to deal with uncertainty and surprise, and by fostering the capacity to adapt to change. SESs are both complicated and adaptable, necessitating ongoing testing, learning, and knowledge and understanding development in order to adjust to change and uncertainty (Popovic and Kraslawski, 2015; Keating *et al.*, 2022).

Scale is essential when working with complex systems. Many subsystems may be differentiated in a bigger system, and because many complex systems are hierarchical, each subsystem is nested within a bigger subsystem, etc. A tiny watershed, for instance, may be regarded as an ecosystem, but it is part of a bigger watershed that is itself an ecosystem and covers all smaller watersheds. Each level on a scale has its own emergent features, and levels can be coupled via feedback linkages. Complex systems should always be evaluated or controlled at several scales concurrently (Venhaus, 2012).

2.4 Evaluation framework applied to agricultural BMPs/Is - The WATDEV approach

The objective of the ultimate WATDEV project is to promote sustainable agricultural development, with a focus on increasing yield, providing cutting edge solutions enhancing the economic well-being of farmers. The project seeks to improve agricultural production and promote sustainable farming practices, and provide support for scalable farming solutions.

2.4.1 SES context for BMPs/Is assessment

A. Target SES

Environmental resources exploitation, in the WATDEV context, is a state paradigm in which natural resources are used to their fullest potential in order to generate a production that can meet the demands of the market and the public. It is important to note that this exploitation often comes at the cost of the environment, as natural resources are not inexhaustible and their usage can often be damaging. Therefore, it is essential that exploitation of resources is managed carefully and responsibly in order to ensure the sustainability of the resources and the environment as a whole. Figure 1, 2 and 3 illustrate the different ways in which environmental resources exploitation can take place, and the potential impacts it can have on the environment.

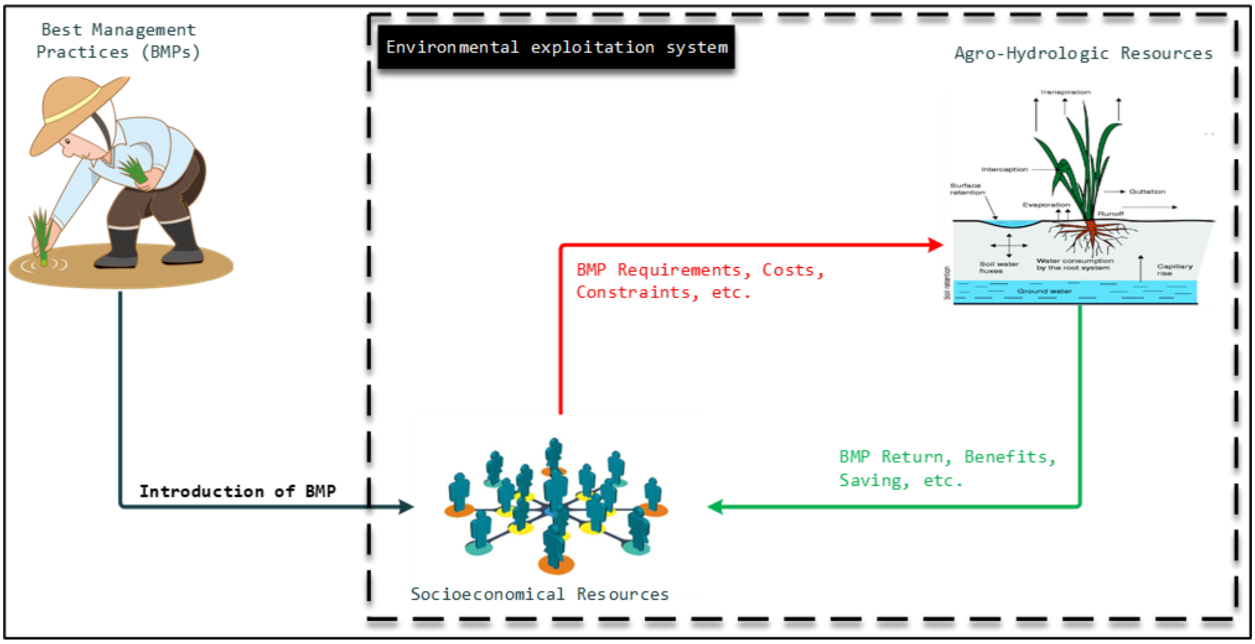

Figure 1 - Overview of natural resources exploitation for agricultural production

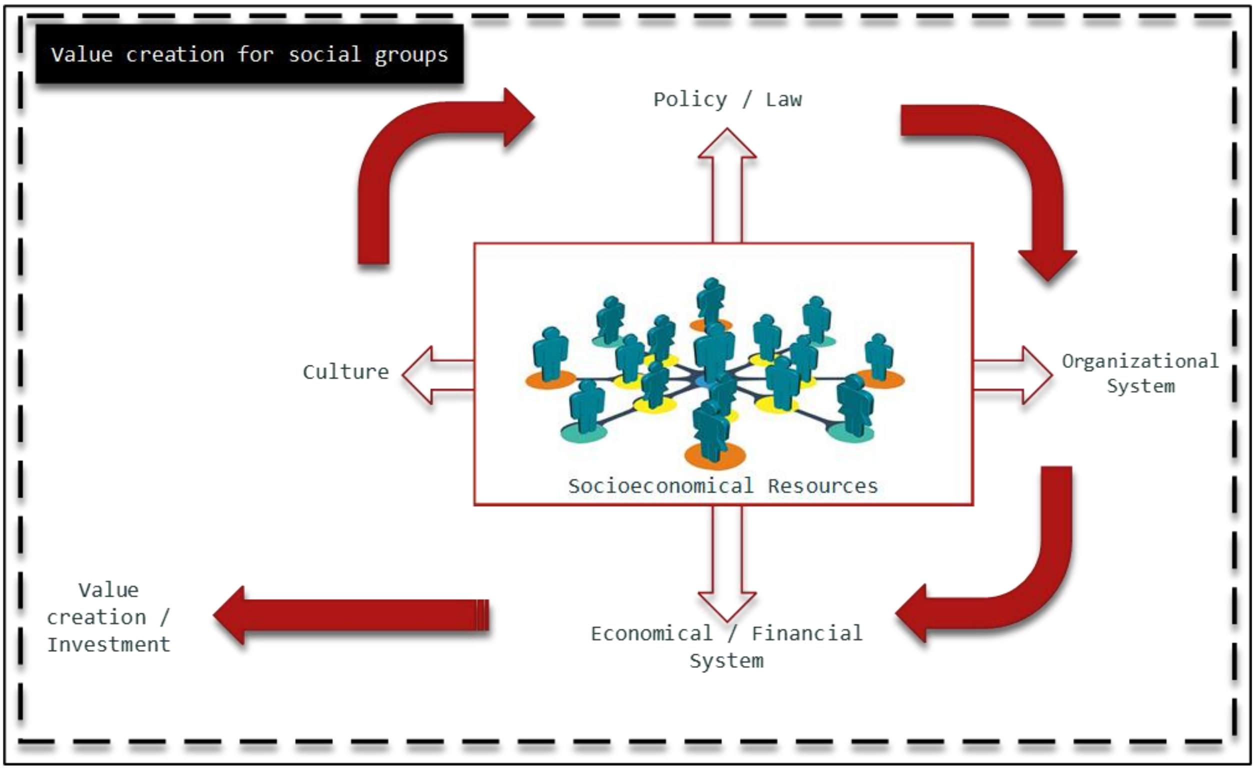

Figure 2 - BMPs/Is flow in the socio-economic system

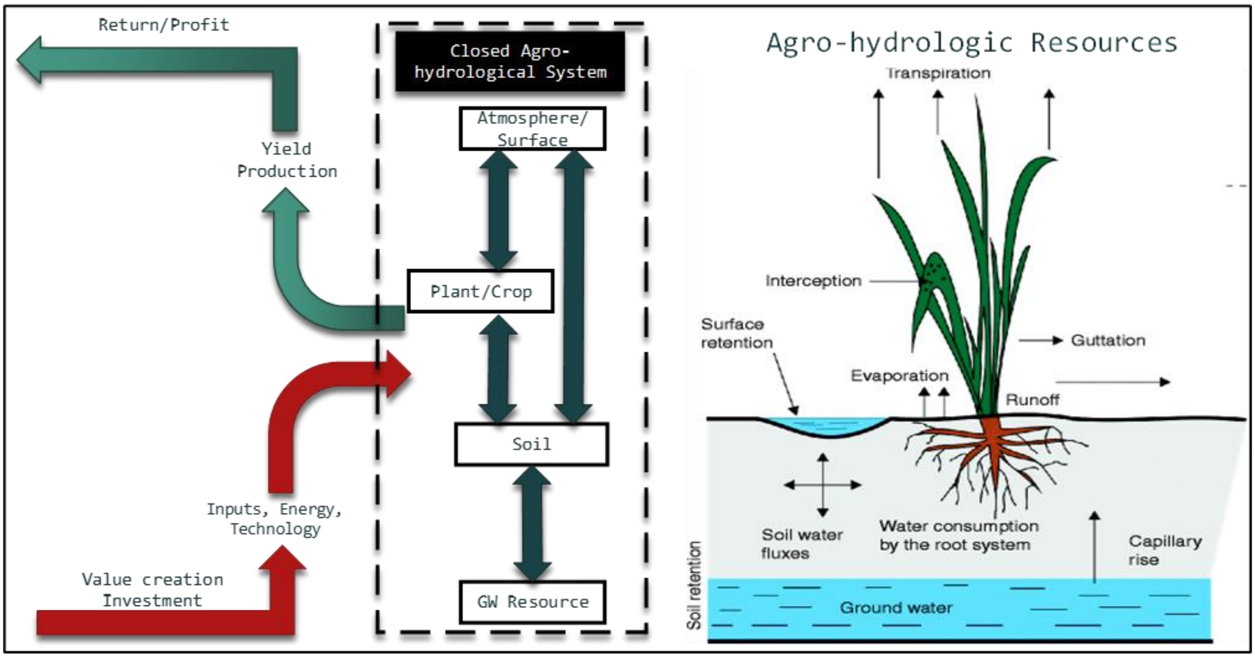

Figure 3 - Investment-Return flow and resources relationships within agro-hydrological system

B. SES scale domain

The hydrologic cycle is a crucial component of all ecosystems, especially cropping systems. Agricultural practices are an integrated part of the whole cycle with bilateral quantitative and qualitative effects (Figure 4). Interactions start at field scale (scale of the practice application) and integrate up to the watershed belonging to (natural divider of rain flows).

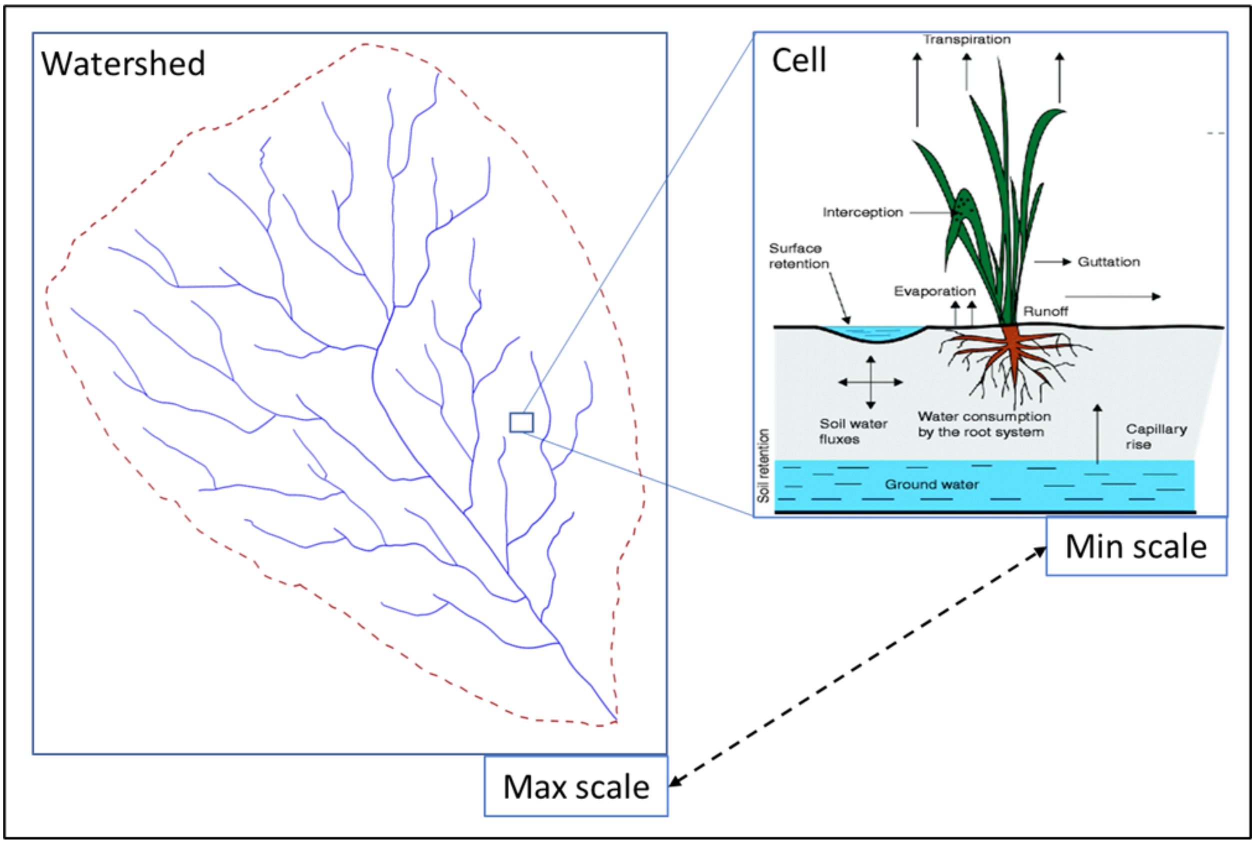

Figure 4 - Minimum and maximum scales for system up and down scaling

C. SES sustainability

Agro-hydrologic resources sustainability relies on the resilience of the system exchanges (capacity of renewability). It is composed of ground, subsurface and surface water, soil, vegetation and atmosphere (Figure 3).

D. Role of BMPs/Is integration into SES

A primary goal of a BMP/I is to enhance the performance of exploitation of these resources and preserve their depletion resilience (Figure 1). It can target the social component (socio-economic Resources) by proposing new structure of organization, decision making, economical system and management (Figure 2); as well as the natural resource system itself (Agro-hydrologic Resources) (Figure 3) by providing innovative solution for resource saving, restoration and crop productivity enhancement.

2.4.2 SES composition

A. Socio-economical resources (Figure 2)

- Culture: People and community defining characteristics, the only component that cannot be targeted by a BMP/I for change.
- Policy/law: Formally, the regulation that governs the functioning of the community.

- Organizational system: Form of arrangement of the community members and their roles.
- Economical/financial system: Monetary availability and access/delivery.

B. Agro-hydrological resources (Figure 3)

- Groundwater: Water held underground in the soil or in pores and crevices in rock typically below the rootzone.
- Surface water: It comprises water that collects naturally on the surface of the ground as well as artificial one (i.e.: depurated wastewater)
- Soil: Soil is the loose substance that covers the majority of land's surface. It comprises both inorganic and organic particles. The soil provides agricultural plants with structural support and is their supply of water and nutrients.
- Crop: Crop production is a subfield of agriculture that encompasses the growth of crops through field cultivation, vegetable growing, and fruit growing, among other methods. This industry provides vital food supplies and raw materials It is the main output of SES exploitation.

C. BMP/I flow assimilation into SES (Figure 1)

The journey of a BMP/I assimilation into SES (Figure 1) begin from socio-economic components of SES and, apart from the "Cultural" component of the "socio-economical resources", can target any component of the SES having as a primary goal the overall enhancement/optimization of the SES balance of investment vs. return. Effects/applications of a BMP/I can be direct (i.e.: Irrigation) or lateral/indirect (i.e.: law regulated pesticides' application).

2.5 BMPs/Is assessment

According to SES composition, a two steps assessment and one step scalability can be distinguished for evaluation of BMPs/Is. A feasibility assessment relative to both "socio-economical resources" and "Agro-hydrological resources". A benchmark relative only to "Agro-hydrological resources''; and scalability relative to area and scale of application. As follow:

2.5.1 Feasibility

A BMP/I is assigned the attribute "**Feasible"**, _only and if only_, it overpasses all the categorical ordered sequence of acceptance and feasibility evaluation that start from cultural acceptance and end up with agro-hydrological resource availability (Figure 2).

2.5.2 Benchmark

Reverse wise impacts sectors (i.e.: groundwater, soil, crop, etc.), similar impacts can be led by multitude sequences of SES components. It is mainly attributed to the socio-economic drivers of SES's BMPs/Is flow. This highlights a fundamental nonlinear relationship between the different SES components and results in the formation of “route dependencies”, a term used to describe local rules of interaction that shift and adapt as the system in its integrity undergo changes and/or external pressure.

A consequence of path dependency is the possibility for threshold (agro-hydrological resources' resilience thresholds) behavior and qualitative alterations in system dynamics in response to changes in external factors and the different possible configurations that can be assessed. Multiple feasible BMPs/Is can be found satisfying the two main requirements (positive return and sustainability), leading to adopting an optimization approach to council multiple requirements simultaneously. For WATDEV, three levels of benchmark are defined:

1. A BMP/I is said to be “**Profitable”**, if it satisfies the Return/Investment balance.
2. A BMP/I is said to be: “**Sustainable”** if it falls within the domain of feasibility of the resilience thresholds (resource resilience thresholds).
3. A BMP/I is said to be: sustainably profitable “**Optimal Solution**”, if it satisfies both precedent criteria.

2.5.3 Scalability

When we talk about scaling, we imply increasing the reach of the effectiveness of BMP/I impacts. Space domain validity of BMP/I is assessed through its impact consistency degree. Three criteria are defined for this purpose:

1. A BMP/I is said to be: “**Up-scalable”** when its validity (impact) is verified when going to a larger scale other than the one it was originally assessed for (i.e.: field scale à watershed scale)

2. A BMP/I is said to be: “**Down-scalable”** when its validity remain verified when going to a smaller scale other than the one it was originally assessed for (i.e.: watershed scale à field scale)

3. A BMP/I is said to be: “**Out-scalable”** when its validity remain true moving to another area (with the same scale) other than the one it was originally assessed for (i.e.: field scale area Aà field scale area B)

3. Conclusion

The WATDEV BMPs/Is evaluation protocol is a reliable method to assess the effectiveness of agricultural practices and innovations with a potential for wider adoption. It provides a comprehensive framework for BMPs/Is assessment, as well as sectors of potential improvement. Using the present evaluation protocol, the WATDEV project will be able to assess from a variety of perspectives, giving the holistic view of the framework, different BMPs/Is and compare quantitatively the different options. This makes it easier for decision makers to make informed decisions about future development strategies. Ultimately, this protocol will be a base for the futur planification and assessment activities to ensure that the project is delivering the results it is designed/aiming to.

8. References

Avriel-Avni, N. and Dick, J. (2019) “Differing perceptions of socio-ecological systems: Insights for future transdisciplinary research,” *Resilience in Complex Socio-ecological Systems*, pp. 153–190. doi: 10.1016/bs.aecr.2019.03.001.

Baldi, I. *et al.* (2014) “0278 The PESTIMAT program: development of a crop exposure matrix for pesticide exposure assessment in agriculture0278 The PESTIMAT program: development of a crop exposure matrix for pesticide exposure assessment in agriculture,” *Occupational and Environmental Medicine*, p. A35.1-A35. doi: 10.1136/oemed-2014-102362.108.

Barrett, C. B. *et al.* (2002) “The challenge of stimulating adoption of improved natural resource management practices in African agriculture,” *Natural resources management in African agriculture: understanding and improving current practices*, pp. 1–21. doi: 10.1079/9780851995847.0001.

Bazzani, G. (2003) “A DSS for water conservation policies impact assessment in agriculture,” *Advances in Water Supply Management*. doi: 10.1201/noe9058096081.ch67.

Berkes, F., Folke, C. and Colding, J. (2000) *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press. Available at: https://books.google.com/books/about/Linking_Social_and_Ecological_Systems.html?hl=&id=XixuNvX2zLwC.

Brown, I. and Berry, P. (2022) “National Climate Change Risk Assessments to inform adaptation policy priorities and environmental sustainability outcomes: a knowledge systems perspective,” *Climatic change*, 175(3–4), p. 13. doi: 10.1007/s10584-022-03464-2.

Chen, X., Sasaki, T. and Okada, I. (2019) *Coordination and Cooperation in Complex Adaptive Systems: Theory and Application*. Frontiers Media SA. Available at: https://books.google.com/books/about/Coordination_and_Cooperation_in_Complex.html?hl=&id=EjqmDwAAQBAJ.

Clark, W. (1981) “Robert McNamara at the World Bank,” *Foreign Affairs*, p. 167. doi: 10.2307/20040995.

Craswell, E. *et al.* (2007) *Integrated Assessment of Water Resources and Global Change: A North-South Analysis*. Springer Science & Business Media. Available at: https://play.google.com/store/books/details?id=Wbc_h0onmFsC.

Dragicevic, A. Z. and Shogren, J. F. (2021) “Preservation Value in Socio-Ecological Systems,” *Ecological Modelling*, p. 109451. doi: 10.1016/j.ecolmodel.2021.109451.

Dunbar, R. I. M. (1988) “Socio-ecological Systems,” *Primate Social Systems*, pp. 262–291. doi: 10.1007/978-1-4684-6694-2_12.

Fewtrell, L., Kay, D. and Benjamin, M. (2008) *Health Impact Assessment for Sustainable Water Management*. IWA Publishing. Available at: https://books.google.com/books/about/Health_Impact_Assessment_for_Sustainable.html?hl=&id=CWgnXNbz_n8C.

Gasparini, P., Manfredi, G. and Asprone, D. (2014) *Resilience and Sustainability in Relation to Natural Disasters: A Challenge for Future Cities*. Springer Science & Business Media. Available at: https://play.google.com/store/books/details?id=4C_ABAAAQBAJ.

Gertler, P. J. *et al.* (2016) *Impact Evaluation in Practice, Second Edition*. World Bank Publications. Available at: https://play.google.com/store/books/details?id=Zm8kDQAAQBAJ.

Helling, A. *et al.* (2015) “Economic Analysis of Climate Change Best Management Practices in Vermont Agriculture,” *Agriculture*, pp. 879–900. doi: 10.3390/agriculture5030879.

Janić, M. (2022) *Resilience, Robustness, and Vulnerability of Transport Systems: Analysis, Modelling, and Practice*. Springer Nature. Available at: https://play.google.com/store/books/details?id=5WCdEAAAQBAJ.

Jhorar, R. K., Smit, A. A. M. F. and Roest, C. W. J. (2009) “Assessment of alternative water management options for irrigated agriculture,” *Agricultural Water Management*, pp. 975–981. doi: 10.1016/j.agwat.2009.01.009.

Kantabutra, S. (2022) “Toward a System Theory of Corporate Sustainability: An Interim Struggle,” *Sustainability*, p. 15931. doi: 10.3390/su142315931.

Keating, C. B. *et al.* (2022) *Complex System Governance: Theory and Practice*. Springer Nature. Available at: https://books.google.com/books/about/Complex_System_Governance.html?hl=&id=2LVrEAAAQBAJ.

Lykhovyd, P. V. and Lavrenko, S. O. (2020) “Application of CROPWAT program for assessment of sweet corn water use,” *Interagency thematic scientific collection «Irrigated agriculture»*, pp. 50–53. doi: 10.32848/0135-2369.2020.73.9.

Maredia, M. K. (2009) *Improving the proof: Evolution of and emerging trends in impact assessment methods and approaches in agricultural development*. Intl Food Policy Res Inst. Available at: https://play.google.com/store/books/details?id=NJ2uScQxpcMC.

May, C. K. (2022) “Complex adaptive governance systems: a framework to understand institutions, organizations, and people in socio-ecological systems,” *Socio-Ecological Practice Research*, pp. 39–54. doi: 10.1007/s42532-021-00101-7.

Morse, W. C. (2020) “Recreation as a Social-Ecological Complex Adaptive System,” *Sustainability*, p. 753. doi: 10.3390/su12030753.

Mubako, S. (2022) “Scientific and Indigenous Knowledge for Socio-ecological Systems: A 20-Year Global Bibliometric Analysis,” *Socio-Ecological Systems and Decoloniality*, pp. 11–29. doi: 10.1007/978-3-031-15097-5_2.

OECD (2021) *The Development Dimension Private Philanthropy for Development – Second Edition Data for Action: Data for Action*. OECD Publishing. Available at: https://play.google.com/store/books/details?id=fQ9UEAAAQBAJ.

Ostrom, E. (2009) “A General Framework for Analyzing Sustainability of Social-Ecological Systems,” *Science*, pp. 419–422. doi: 10.1126/science.1172133.

Parry, M. L., Carter, T. R. and Konijn, N. T. (1988) *The Impact of Climatic Variations on Agriculture: Volume 2: Assessments in Semi-Arid Regions*. Springer. Available at: https://books.google.com/books/about/The_Impact_of_Climatic_Variations_on_Agr.html?hl=&id=kvhIzwEACAAJ.

Payne, G. (2021) “Placemaking: Bridging the Nature-Culture Divide?,” *Academia Letters*. doi: 10.20935/al1501.

Popovic, T. and Kraslawski, A. (2015) “Social Sustainability of Complex Systems,” *Computer Aided Chemical Engineering*, pp. 605–614. doi: 10.1016/b978-0-444-63472-6.00024-0.

Rustin, M. (2006) “Learning from Robert McNamara,” *Soundings*, pp. 52–61. doi: 10.3898/136266206820466624.

Schmitz, O. J. (2016) "Socio-ecological Systems Thinking," *The New Ecology*. doi: 10.23943/princeton/9780691160566.003.0005.

Sequeira, M. D. *et al.* (2022) "The Rural Fires of 2017 and Their Influences on Water Quality: An Assessment of Causes and Effects," *International journal of environmental research and public health*, 20(1). doi: 10.3390/ijerph20010032.

Slim, H. and Bonwick, A. (2006) *Protection: An ALNAP Guide for Humanitarian Agencies*. Oxfam. Available at: https://books.google.com/books/about/Protection.html?hl=&id=dCKPA4BZp9AC.

Soulis, K., Psomiadis, E. and Londra, P. (no date) "A new modelling approach for the evaluation of the EU Rural Development Program's contribution to the reduction of water abstractions in agriculture." doi: 10.5194/egusphere-egu2020-1489.

Srivastava, P. K. *et al.* (2020) *Agricultural Water Management: Theories and Practices*. Academic Press. Available at: https://books.google.com/books/about/Agricultural_Water_Management.html?hl=&id=M90IEAAAQBAJ.

Stiepani, J., Jiddawi, N. and Mtwana Nordlund, L. (2023) "Social-ecological system analysis of an invertebrate gleaning fishery on the island of Unguja, Zanzibar," *Ambio*, 52(1), pp. 140–154. doi: 10.1007/s13280-022-01769-1.

Surls, R., Borel, V. and Biscaro, A. (2016) "Soils in Urban Agriculture: Testing, Remediation, and Best Management Practices." doi: 10.3733/ucanr.8552.

Teodosiu, C., Fiore, S. and Hospido, A. (2022) *Assessing Progress Towards Sustainability: Frameworks, Tools and Case Studies*. Elsevier. Available at: https://play.google.com/store/books/details?id=JQxSEAAAQBAJ.

Tielkes, E. (2022) *Tropentag 2022 – International Research on Food Security, Natural Resource Management and Rural Development: Can agroecological farming feed the world? Farmers' and academia's views*. Cuvillier Verlag. Available at: https://play.google.com/store/books/details?id=FCqWEAAAQBAJ.

Tripathi, A. (2017) "Agricultural Vulnerability to Climate Change: Contribution of Socio-economic Factors," *Global Change, Ecosystems, Sustainability: Theory, Methods, Practice*, pp. 165–173. doi: 10.4135/9789353280284.n14.

Valipour, M. (2015) "Assessment of Important Factors for Water Resources Management in European Agriculture," *Journal of Water Resource and Hydraulic Engineering*, pp. 171–180. doi: 10.5963/jwrhe0402007.

Velasco-Muñoz, J. F. *et al.* (2022) "Adopting sustainable water management practices in agriculture based on stakeholder preferences," *Agricultural Economics (Zemědělská ekonomika)*, pp. 317–326. doi: 10.17221/203/2022-agricecon.

Venhaus, H. L. (2012) *Designing the Sustainable Site: Integrated Design Strategies for Small Scale Sites and Residential Landscapes*. John Wiley & Sons. Available at: https://books.google.com/books/about/Designing_the_Sustainable_Site.html?hl=&id=wv9T4WhrzJcC.

Wang, H.-H. and Grant, W. E. (2021) "Reflections of two systems ecologists on modelling coupled human and natural (socio-ecological, socio-environmental) systems," *Ecological Modelling*, p. 109403. doi: 10.1016/j.ecolmodel.2020.109403.

White, H. and Raitzer, D. A. (2017) *Impact Evaluation of Development Interventions: A Practical Guide*. Asian Development Bank. Available at:

https://books.google.com/books/about/Impact_Evaluation_of_Development_Interve.html?hl=&id=7ThlDwAAQBAJ.

World Bank (2013) *World Bank Group Impact Evaluations: Relevance and Effectiveness*. World Bank Publications. Available at: https://play.google.com/store/books/details?id=FqMantJ98yYC.

Xie, M., Wang, J. and Chen, K. (2016) "Coordinated Development Analysis of the 'Resources-Environment-Ecology-Economy-Society' Complex System in China," *Sustainability*, p. 582. doi: 10.3390/su8060582.

Xing, H. *et al.* (2021) "Water Resources Allocation Based on Complex Adaptive System Theory in the Inland River Irrigation District," *Sustainability*, p. 8437. doi: 10.3390/su13158437.

Yang, L. *et al.* (2022) "Study on Urban Resilience from the Perspective of the Complex Adaptive System Theory: A Case Study of the Lanzhou-Xining Urban Agglomeration," *International journal of environmental research and public health*, 19(20). doi: 10.3390/ijerph192013667.

Zarayeneh, N. *et al.* (2022) "Dynamic Community Detection Decouples Multiple Time Scale Behavior of Complex Chemical Systems," *Journal of chemical theory and computation*, 18(12), pp. 7043–7051. doi: 10.1021/acs.jctc.2c00454.