CGIAR | Independent Science and Partnership Council

An Evaluation of CGIAR Centers' Impact Assessment Work on Irrigation and Water Management Research

Standing Panel on Impact Assessment
April 2015

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Merrey, D.J. 2015. *An Evaluation of CGIAR Centers' Impact Assessment Work on Irrigation and Water Management Research*. Rome, Italy, Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council (ISPC). 83 pp.

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Acronyms and abbreviations

AR	Aerobic rice
AWD	Alternate wetting and drying (of rice)
BBM	Broad bed maker
BCR	Benefit cost ratio
CA	Comprehensive Assessment of Water Management in Agriculture
CAC	Chinese Agricultural University
CCAFS	Climate Change, Agriculture and Food Systems
CCER	Center Commissioned External Review
CGI	Crop genetic improvement
CGIAR	Formerly: Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CPWF	Challenge Program on Water and Food
CRP	CGIAR Research Program
EIA	Environmental impact assessment
epIA	*ex-post* impact assessment
GHG	Greenhouse gas
IA	Impact assessment
IAA	Integrated agriculture-aquaculture (system)
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute (now IWMI)
ILRI	International Livestock Research Institute
IMPSA	Irrigation Management Policy Support Activity
IMT	Irrigation management transfer
INRM	Integrated natural resources management
IPG	International public good
IRR	Internal rate of return
IRRC	Irrigated Rice Research Consortium
IVC	Inland Valley Consortium
IWMI	International Water Management Institute (formerly IIMI)
MSC	Most significant change (story)
MUS	Multiple use services (water supply systems)
NARES	National agricultural research and extension system
NPV	Net present value
NRM	Natural resources management
NRMR	Natural resources management research
PIM	Participatory irrigation management
PIPA	Participatory impact pathway analysis
POR	Policy oriented research
PRA	Participatory rural appraisal
R&D	Research and development
R4D	Research for development
RT	Reduced tillage
RWC	Rice Wheat Consortium
SCALES	Sustaining Collective Action Linking Economic and Ecological Scales in Upper Watersheds (Project)
SIAC	Strengthening Impact Assessment in the CGIAR
SLO	System level outcomes
SPIA	Standing Panel on Impact Assessment
STAR	System of temperate and tropic aerobic rice
TOR	Terms of reference
ZT	Zero tillage

Acknowledgements and Author's Disclosure

This study could not have been carried out without the assistance of a number of people. Tim Kelley at SPIA managed the overall process and it was a pleasure to work with him. The focal points at the participating Centers and Programs were also very helpful, especially but not only the following people: Madar Samad (IWMI), Alain Vidal and Michael Victor (CPWF), Aden Aw-Hassan (ICARDA), Claudia Ringler (IFPRI), Takashi Yamano (IRRI), Suhas Wani (ICRISAT), Olaf Erenstein and Manale Kassie (CIMMYT), Ricardo Labarta (CIAT), Mutsa Masiyandima (Africa Rice), and Charles Crissman (WorldFish). I am also grateful to the IWMI librarians for their assistance. A first draft of this study was circulated to SPIA members and the Centers. I am grateful for the very useful and constructive comments received from SPIA (via Tim Kelley), M. Samad, Claudia Ringler, and Charles Crissman. A revised draft was peer-reviewed through SPIA. Since these reviewers revealed their identity I also do so here: I am very grateful for insightful comments from Jeff Bennett and David Seckler; they assisted greatly in clarifying some points in this paper.

It is important for the reader to realize that I have long-standing linkages and relationships to some of the Centers, Programs and people that are the focus of this study. I worked at IWMI for over 20 years, from 1985 to 2006, where I held numerous positions and participated in or led many research projects. My more recent positions at IWMI included Deputy Director General for Programs (1998-2000) and Director for Africa (2000-2005). I have continued to work for IWMI as a consultant, including five contracts to date during 2014; and I continue to have close professional and personal relationships with some IWMI staff members. I have also been involved in the Challenge Program on Water and Food (CPWF) from its inception; I have worked directly for CPWF, including a project impact evaluation in 2007-2008 and work on the Basin Focal Project (both contracted through CIAT), and a commissioned study in Ethiopia (2010, contracted through IWMI). In 2011-2012, I was a consultant to the Nile Basin Development Challenge (contracted through ILRI). These linkages are both an advantage and a disadvantage: an advantage because of my previous experience, background and knowledge of major irrigation and water management research programs; a disadvantage as clearly I am not a completely disinterested party. SPIA was aware of these linkages when I was contacted to carry out this study – presumably SPIA felt the advantages outweighed the advantages. I am not conscious of any systematic bias affecting my conclusions in this study, but it is important that the reader be aware of this potential.

My training is in social anthropology, not agricultural economics. This disciplinary background combined with many years of experience doing applied research focused on institutional and policy issues in an interdisciplinary context obviously affects my perspectives.

Finally, all the assistance provided notwithstanding, I am solely responsible for the contents of this study and any errors it may contain.

Douglas J. Merrey, 2 October 2014

Executive Summary

Introduction

This study was commissioned by the Standing Panel on Impact Assessment (SPIA), a unit supporting the CGIAR Independent Science and Partnership Council. Over the past decade, policy and natural resources management (NRM) research have come to represent large percentages of the total CGIAR research investment. This has led SPIA to devote more attention to evaluating the impacts of research in these domains. Recently, SPIA's new program on Strengthening Impact Assessment in the CGIAR (SIAC) has begun targeting previously under-evaluated areas of CGIAR research, including water management as well as policy and natural resources research more generally. This paper is a critical review of impact evaluations (IAs) of irrigation and water management research carried out or commissioned since approximately 1991. It is the first step in what SPIA envisions may lead to future water management research impact assessments.

The specific objectives of the study were:

1. To estimate the total investment in irrigation and water management research and related activities within the CGIAR since 1990;
2. To critically review existing economic, social and environmental impact assessments of CGIAR research on water management;
3. To provide a summary of the estimated economic, social and environmental impacts (or influence as the case may be) documented by the IA studies that are deemed to be reasonably credible, whether in quantitative and qualitative terms; and
4. To identify areas that appear to warrant serious attention for future adoption and impact assessment studies.

There is no clear definition of the irrigation and water management domain; the study began with a narrow definition but as it progressed broadened it somewhat. The CGIAR tends to classify water management research as either policy or natural resources management research – or both. Therefore, the study briefly discusses, as it applies to water management research, the results of recent SPIA work examining the challenges in assessing the impacts and returns on investments of such research, especially attribution, defining counterfactuals, and precise measurement of impacts.

Water management impact evaluations

Thirty two water management IA cases were identified, many of them represented by multiple publications or reports. There is some overlap among these (for example IAs of programs under which specific technologies were also assessed); and most of them are really IAs of specific technologies or in some cases policies, but not the research leading to the development and uptake of the technologies. This distinction is important: CGIAR centers have published research demonstrating the impacts of adoption of irrigation in general or specific water management technologies on poverty and incomes, but the innovations studied were not necessarily products of CGIAR research. Only 14 cases are classified as IAs of irrigation and water management *research*. Estimating the total investment in water management research has proven to be very difficult; we have not been able to obtain sufficient data to provide a reasonable estimate. A provisional and incomplete total of $657.3 million based on existing data is surely an under-estimate. The total IWMI investment since 1990 is about $456 million; extending back to its founding in 1984 would give a

figure just under $500 million. These figures are all nominal not constant dollars. SPIA's estimate of $800 million since IWMI joined the CGIAR in 1991 is therefore probably a reasonable approximate figure.

The water management IAs reviewed included seven program evaluations and ten project evaluations. Eight IAs evaluate a technology innovation, ten evaluate a new management practice (of which several combine a technology and management innovation), and six evaluate a policy or institutional innovation. This latter finding is somewhat surprising as water management research is often classified as largely policy-oriented. None of the water management research IAs refers explicitly to the contribution of the research to the CGIAR SLOs, and none clearly measures impacts on poverty, equity, gender, or ecosystems.

Main conclusions of the study

The study discusses the 14 research IAs in some detail, finding both strengths and weaknesses in all of them. Overall, t*he most important conclusion that emerges from this survey is that the CGIAR has seriously under-invested in both ex-ante and ex-post economic, social and environmental impact assessments of its work on irrigation and water management.* This statement applies across the board, with only a few partial exceptions. This study has reviewed a number of excellent and credible assessments of impacts of specific innovations. However, there are very few credible methodologically sophisticated economic impact assessments of water management research, and none of the environmental or social impacts of this research (as distinguished from water management interventions). Looking at the major water management-related research programs, we found only one whose outputs, outcomes and impacts have been assessed in a comprehensive and credible manner – the Irrigated Rice Research Consortium.

A weakness common to nearly all the water management IAs examined is their lack of attention to differential impacts on various categories of farmers, rural landless people, consumers and other stakeholders, and on larger ecosystems. Few of the water management research IAs clearly measure impacts on poverty, equity, gender, or ecosystems. Only one study asked whether a seemingly positive innovation assessed (alternate wetting and drying of rice in the Philippines) had significantly contributed to the reduction of poverty (it had not). Further, as CGIAR research shifts to landscapes and agro-ecological systems, it becomes critically important to examine the impacts of research-based innovations on those at different locations within ecosystems, river basins or watersheds; differentiate farm-level impacts from system-level impacts; and identify impacts on the overall ecosystem.

Similarly, there are too few environmental impact assessments of water management research. Water management is an environmental intervention; the CGIAR therefore needs to be able to assure its stakeholders that its research is having positive environmental as well as social impacts – or at least not doing environmental or social harm. Related to this observation, none of the research IAs explicitly links its findings to the CGIAR System Level Outcomes (SLOs).
Most of the credible water management impact assessments of *research* measure the impact of technologies, management practices, or packages thereof. Examples are zero tillage in South Asian rice-wheat systems (enabled by a specific tractor-drawn seed drill), aerobic rice, alternate wetting and drying of rice, water infrastructure gate operational models, and enhancing soils for water retention. There are just three attempts to evaluate international public good water management policy research, and one of these is focused largely on science quality, not influence on policies. Despite the difficulties, the CGIAR needs to do more to assess the returns on its investments in research on water management policies and institutions. Such assessments are inherently difficult

and not amenable to standard agricultural economic regression-based tools that seek to demonstrate attribution. This is a call for innovation in impact assessment methodologies.

Summarizing the estimated economic, social, and environmental impacts or influence documented by the IAs proved to be challenging. There is clear evidence that three eco-regional programs have had positive impacts on food security, incomes and livelihoods of millions of Asian farmers. There is evidence that IWMI's and IFPRI's work on policy and institutional issues has contributed substantially to the scientific literature, and some evidence that their work (especially IWMI's work on IMT and on the groundwater-electricity nexus in India) has influenced government policies. The Indian groundwater mining—electricity policy nexus research done by an IWMI team has clearly had major impacts in Gujarat state, but there is very little evidence as to what the impacts of IMT might have been. IWMI as well as IFPRI have contributed importantly to global knowledge of water: IWMI's map of water supply and demand has been cited numerous times, and IWMI has contributed greatly to understanding concepts of "efficiency" of water use and "water accounting" in a river basin context and of "water productivity". However, there has been no formal assessment of the influence of this work. There is anecdotal evidence that the CPWF may have had substantial influence on the policy and research agenda as well. However, there is too much missing data to come to any conclusion on the value added of all this work. An important but undocumented impact is the CGIAR contribution to building capacity.

Recommendations for future impact assessments

The study makes recommendations on potential candidates for future IAs. Because IWMI is the leading center for water management research, it seems especially important to gain a better insight into the value added, contributions, outcomes and impacts of its work than we currently have. High priority candidates, in order of priority, at IWMI include:

1. The *Comprehensive Assessment of Water Management in Agriculture* (CA), approximately 2003-2008.
2. The *IWMI-TATA IWMI water policy research program in India*, 2000 to the present.
3. *IWMI's regional programs* in Central Asia (2000 to present) and Africa (2000 to present).
4. IWMI's signature work on *Asian large-scale irrigation,* 1984 to the present.
5. The *AgWater Solutions Project*, funded by the Bill and Melinda Gates Foundation, approximately 2009-2012.

Other possible specific candidates include IWMI's work on river basin modeling, waste water reuse for irrigation, and sustainable agriculture in wetlands. Assessing the CA provides an appropriate context for examining the impacts and benefits and costs of IWMI's pioneering work on mapping water supply and demand, irrigation efficiency and water productivity, and water accounting in a basin context.

There have been three long-term eco-regional programs with significant water management research, the Rice Wheat Consortium (RWC) in northern South Asia, the Irrigated Rice Research Consortium (IRRC) in Asia and the Inland Valley Consortium (IVC) in West Africa. This study has reviewed the impact assessment work done by the RWC and IRRC. For RWC we have important and credible IAs of a specific innovation, zero tillage. For IRRC we have IAs of specific interventions as well as a meta-analysis of the program that includes an *ex-ante* and short-term *ex-post* analysis. Both programs are candidates for full comprehensive *ex-post* impact assessments, as both have collected considerable data to provide good baselines. The IVC has been implemented under various names since 1993, but apparently there has never been an IA done on the value added of this program.

Therefore, we strongly recommend that Africa Rice and SPIA consider implementing a comprehensive *ex-post* IA.

Another area of significant water management investments is rainwater harvesting and supplementary irrigation, by ICARDA, ICRISAT, the World Agroforestry Center and to some extent CIAT. Yet apparently no impact assessments of the investments in these research programs have been carried out. Therefore, we recommend that SPIA work with these centers to design and carry out a formal *ex-post* IA of their work on rainwater management, and consider doing a similar study on the work on supplemental irrigation.

The WorldFish-led Integrated Agriculture-Aquaculture (IAA) work in Asia and Africa is another good candidate for a full follow-up *ex-post* IA. This should include the investment in research, and should include the African as well as Asian cases. Studies already carried out by WorldFish in Asia, discussed above, indicate very high returns; and its work constitutes important methodological advances in the assessment of impacts of systemic interventions in ecological systems (in contrast with work on single-dimensional interventions). It is possible the foundation and data already exist to do this study fairly quickly. Such a study could also be a useful test of new methodologies appropriate for assessing impacts of interventions in complex agro-ecosystems.

Finally, the CPWF is a major candidate for future social, economic, and environmental impact assessments, the returns on the research investments, and the lessons learned from implementing a large-scale partnership-based eco-regional research program which attempted to promote management and evaluation innovations as part of its implementation process. Sufficient time has passed to carry out IAs of selected Phase I projects, including but not only three of the four projects which had been evaluated as they were ending. A comprehensive meta-analysis of the quality, influence and outcomes of both phases would also be useful and would provide a foundation for a future *ex-post* IA of the program.

Other conclusions and recommendations

Credible, convincing evaluations of returns on investments in true international public good (IPG) policy and natural resource management research are very rare because they are fiendishly difficult to do. Attribution of impacts is nearly impossible because of all the multiple impact pathways, competing, complementary and independent sources of influence other than the research, the complexities of understanding human motivations, and the long time lag between research and impacts. Linear pathways based on simplistic models of human behavior are not adequate. The CGIAR needs to broaden its repertoire of impact assessment tools to include, for example, contribution analysis.

Further, much CGIAR water management research is consumed by other researchers: it adds to a body of scientific knowledge, but the route from publication in scientific journals to actual uptake and application is murky at best. The CGIAR should consider distinguishing more clearly between research that contributes to basic scientific understanding and research that is aimed at achieving specific outcomes (changes in behavior) and impacts (such as poverty reduction). The former research can be evaluated using normal science procedures (such as peer review and citation analysis) to assess its influence; the latter should be rigorously assessed in terms of impacts and returns on investment.

Another factor affecting the measurement of the impact of policy and NRM including water management research is the time frame used to measure the impact. The impacts of policy changes

or interventions in natural resource systems often continue over decades. While the widespread adoption of an improved crop variety, technology or farm management practice may occur within a relatively few years, international public good policies such as irrigation management transfer normally play out over decades. It is difficult to know when we should measure the impacts and benefits versus costs of a policy or NRM research program. The continuing evolution and transformation over time further complicates attribution, quantification of costs and benefits, and creation of counterfactuals.

This suggests another danger: if the CGIAR's donors were to insist on typical benefit-cost studies such as they are accustomed to for crop genetic improvements, it may create perverse incentives for Centers to focus their research on easy-to-assess innovations, rather than on the complex social-economic-policy issues where measurable impacts, if they occur at all, will be over a long term and difficult to attribute to specific research. There is a strong presumption and some evidence that policy and NRM research are critically important in the agricultural development process; but quantifying the value in concrete objective financial terms is not realistic or possible with current methodologies. This is not an argument for not doing *ex-post* IAs; on the contrary, more documentation of the adoption of improved research-based water management technologies and the returns on the research investment is needed, in addition to measuring the impacts and benefits of policy and NRM research. In addition, there is an urgent need to invest in improving impact and benefit-cost assessment technologies.

The CGIAR research paradigm is undergoing a major transformation, from identifying and promoting uptake of single dimensional innovations, to trying to understand complex human-based agro-ecological systems as systems, and to enhance the overall productivity and sustainability of these systems. This research has adopted participatory integrated interdisciplinary methodologies. This transformation raises additional complex issues regarding assessing impacts and returns on research investments. Again, these are not arguments for reducing the investments in policy and NRM research; rather, they are a call for innovative design and implementation of research programs and of approaches to assessing their impacts and returns on investment.
A major impediment to doing credible *ex-post* IAs is that programs and projects are not designed from their earliest stages to facilitate impact assessments. The lesson is clear: requiring major research investment programs to develop a credible theory of change and impact pathway and a plan to monitor processes, lessons, outputs, outcomes and impacts will increase the potential to assess the actual impacts and returns on the investment at some future date. To the extent possible, the anticipated outputs should be explicitly linked to the CGIAR SLOs. This will require ensuring that the program pays close attention to social and environmental impacts, and avoids focusing only on "average" impacts. One implication is that a senior IA specialist should be an integral member of the research team from the beginning. An adequate budget needs to be allocated to make this work.

An important corollary is that for programs intended to have clear developmental outcomes and impacts, it is critical to engage meaningfully with stakeholders – partners, consumers, farmers, etc. – from the earliest stages. Research aimed at policy, institutional, management or technological innovation should be driven to a large degree by demand, though 'demand' may be a product of a process of engagement between scientists with new ideas and stakeholders who will have an interest in the results.

These suggestions are even more critical in landscape or agro-ecological systems research, the emerging paradigm for several CGIAR Research Programs (CRPs) including Water, Land and Ecosystems. Water management research is no longer a matter of inventing a better water delivery schedule or institutional arrangement for irrigation scheme operation and maintenance. Water is a

resource managed along with other resources as an integral part of complex agro-ecological or river basin systems. How water is managed in upland areas has important impacts downstream. The allocation of costs and benefits of interventions among multiple stakeholders within ecosystems is not straightforward. The focus of NRM including water management research is increasingly on sustainably improving the flow of ecosystem services, rather than increasing the productivity of a single crop. This makes the measurement of impacts and value added by research even more complex.

Given these developments, impact assessment methodological innovation becomes even more critical. The CGIAR will not be able to demonstrate the value added of policy-oriented water management research investments until more effective qualitative as well as quantitative methodologies are developed and widely used. Some of the studies discussed in this paper are important methodological contributions, but more can be done. SPIA should consider developing a partnership among CGIAR impact assessment scientists and impact assessment specialists from advanced institutions to identify, develop, test and disseminate more effective impact assessment methodologies.

The study concludes by noting that the CGIAR has invested hundreds of millions of dollars in irrigation and water management research over the past 25 or so years; but it has invested far too little in documenting and analyzing the impacts and value-added of this research. Water management research budgets have begun increasing in the last few years. It is therefore critical that the CGIAR be in a position to provide its investors with credible and reasonably representative evidence on the returns to these investments.

An Evaluation of CGIAR Centers' Impact Assessment Work on Irrigation and Water Management Research

1. Background and Purpose

This study was commissioned by the Standing Panel on Impact Assessment (SPIA), a unit supporting the CGIAR Independent Science and Partnership Council. SPIA's role is to lead and coordinate assessments of the impacts and value added of research supported by the CGIAR and undertaken by the 15 CGIAR centers and their partners. Over the past decade, policy and natural resources management (NRM) research have come to represent increasingly large percentages of the total CGIAR research investment. This has led SPIA to devote increasing attention to evaluating the impacts of research in these domains. Recently, SPIA's new program on Strengthening Impact Assessment in the CGIAR (SIAC) has begun targeting previously under-evaluated areas of CGIAR research. These include livestock management, forestry, agroforestry, biodiversity and irrigation management – as well as policy and social sciences and NRM more generally. This report is a critical review and assessment of impact evaluations (IAs) of irrigation and water management research carried out or commissioned since approximately 1991[1].

An initial and very rough estimate of the total investment by donors in irrigation and water management research (hereafter, simply water management research) since the establishment of the International Irrigation Management Institute (IIMI) in 1984 is $800 million. IIMI joined the CGIAR in 1991, and in 1997 changed its name to the International Water Management Institute (IWMI). This study therefore focuses on the period since IWMI joined the CGIAR. However, IWMI is not the only center investing in water management research; therefore this review assesses studies of the impact of water management research done by other centers as well as IWMI.

The Terms of Reference (TOR; see Appendix 1) for this desk study recognizes that there are no precise boundaries delimiting the domain of "irrigation and water management". Therefore, the following working definition was adopted initially: it refers to technologies and practices that bring water to the root zone of crops. "Watershed management" is excluded as this is an entire domain in itself; but rainwater harvesting and supplementary and full irrigation are included. In addition to water management practices and technologies, policy and institutional arrangements for managing water are also included. As the study proceeded, this definition proved too narrow; we return to this issue below. This study is the first step in what SPIA envisions may lead to future water management research impact assessments: it is intended to lay the groundwork for a subsequent scoping study to assess the potential to use state-of-the-art IA methodologies and new data for implementing future impact assessments of specific water management interventions and policies deriving from CGIAR research.

[1] SIAC is a $4-year initiative to improve CGIAR's impact assessments; this study falls under Activity 3.3, studies of a number of under-evaluated areas of research.

The specific objectives of the study are to:

1. Estimate the total investment in irrigation and water management research and related activities within the CGIAR since 1990.
2. Review what the CGIAR and other institutions have done in assessing the economic, social and environmental impacts (or influence as the case may be) of CGIAR research and related activities in the area of irrigation and water management. The review should make critical judgments about the credibility (rigor) and scale of those studies relative to the total amount of investment. This should include identification of gaps (research 'successes' that do not feature in the impact assessment literature) and weaknesses in the reviewed studies, some of the promising methods and approaches used to-date, and key challenges in assessing large scale, long term impacts of CGIAR research in this area.
3. Summarize the estimated economic, social and environmental impacts (or influence as the case may be) documented by the IA studies deemed to be reasonably credible, whether in quantitative and qualitative terms.
4. Based on survey or even anecdotal evidence, identify management interventions or policy actions deriving from specific lines of CGIAR irrigation and water management research that appear to warrant serious attention for future adoption and impact assessment studies.

The next section explains the approach and methodology followed in undertaking this study. Section 3 discusses the challenges and limitations involved in assessing the impact of water management research. Section 4 is an overview of completed IAs reviewed as part of this study; it also attempts a rough estimate of the water management research investment. Section 5 is a critical assessment of the strengths and limitations of selected IAs organized by CGIAR Center. Section 6 identifies gaps in terms of important water management projects and programs that have not been evaluated but perhaps ought to be, and offers recommendations for future impact assessment work on water management research.

2. Approach and Methodology

After finalizing the TOR, a message was sent to all CGIAR Center Directors General and SPIA focal points as well as CGIAR Research Program (CRP) directors by the SPIA Chair informing about the objectives and timeframe of the study and requesting their assistance. The message was also sent to the former Director of the Challenge Program on Water and Food (CPWF) which had officially closed in December 2013. Many responded very quickly, and most of those for whom this water management study was relevant designated a contact person or persons with whom the author then interacted. The CRPs are too recent to have done any impact assessments; those that responded deferred to their lead Center or to IWMI. Table 1 summarizes the Center and Program responses and names of the contact person. One center (ILRI) did not respond but we were aware of an IA done on a water management intervention; it is listed in the table. Those not listed either did not respond or were not deemed relevant. In some cases we interacted by email (and in one case Skype) to obtain clarifications of the studies provided or to clarify what kinds of IAs were being sought.

In addition to using the contacts to obtain IA studies, we also searched relevant websites for additional studies. These included the CGIAR Science Council's impact website (http://impact.cgiar.org/); the International Initiative for Impact Evaluation (http://www.3ieimpact.org/en/); and Center websites. The SPIA contact (Tim Kelley) provided copies of recent IA work done by SPIA, especially on policy and NRM research; the librarian at IWMI kindly provided copies of journal articles on request.

Table 1: Center Responses and Main Contact Persons

Center/ Program	Contact Persons	Provided Studies
1. IWMI	Madar Samad	Yes
2. IRRI	Takashi Yamano	Yes
3. IFPRI	Claudia Ringler	Yes
4. ICARDA	Aden Aw-Hassan	Yes, but none are research IAs, only of technologies
5. ICRISAT	Suhas Wani	Yes, but none are IAs of research
6. CIAT	Ricardo Labarta	Yes, but none are IAs of research – he confirmed no IAs on water management research done to date
7. Africa Rice	Mutsa Masiyandima	Yes, but none are research IAs
8. WorldFish	Charles Crissman	Yes – initially confirmed no IAs on water management research done to date, but later provided studies on Integrated Agriculture-Aquaculture systems
9. CIMMYT	Olaf Erenstein, Manale	Yes
10. CPWF	Alain Vidal, Michael	Yes
11. WLE	Andrew Noble	Deferred to IWMI (no IAs, too recent)
12. CCAFS	Bruce Campbell	Deferred to IWMI (no IAs, too recent)
Center not responding but IA Case Included in this Study		
13. ILRI	No response	No, but a case is included

We first read the recent studies and reviews of policy and NRM research impacts commissioned and/ or produced by SPIA, to gain a better understanding of the issues and challenges involved and the current state of knowledge. While reading the water management research IAs done or commissioned by the Centers, a table was prepared to record key findings and strengths and weaknesses of the studies; this table is included here as Appendix 2. Thirty two water management IA cases were identified, many of them represented by multiple publications or reports; there is some overlap among these (for example IAs of programs under which specific technologies were also assessed). Further, as discussed below, some – in fact most – are really IAs of specific water management technologies but they are not assessments of the research leading to the development and uptake of the technologies. This distinction is important. Most existing water management interventions are not the products of CGIAR research; they have multiple and usually obscure origins. There are quite a few studies assessing the impacts and performance of adoption of "irrigation" in general or specific water management technologies, usually with positive findings. These studies are useful to understand the impacts of introducing water management innovations, but tell us nothing about the returns on the research that produced such innovations. These impact studies are different from assessments of the uptake, outcomes and impacts of water management *research*; there are relatively few such studies. We return to this distinction below; these IA cases constitute the main database for the study.

Estimating the total investment in irrigation and water management research has proven problematic. Records are not kept using this category. The CGIAR website financial pages were searched, but no useful information was found there. The author emailed all of the center focal points with whom he is in contact to request this type of data; some responded, while others were not able to find the data. In the case of the *research* IAs reviewed there are data but they vary in what costs are included. For example, some program and project IAs include extension costs and in-kind contributions of partners; others do not. In the case of IWMI, the premier CGIAR water management research institution which accounts for more than half of the total water management research budget, the total operational expenditures since 1991 as shown in the summary pages of annual financial reports provided by the IWMI Controller were used. Estimating the total CGIAR investment in irrigation and water management research is a task that needs further work.

3. Challenges and Limitations

3.1 The mission and system-level outcomes of CGIAR research

The mission of the CGIAR has evolved over time, but its current mission statement is as follows:

> To reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership and leadership (CGIAR 2011).

Four strategic System-Level Outcomes (SLOs) are defined, and all CGIAR research is expected to contribute to achieving one or more of these outcomes:

- Reduced rural poverty;
- Improved food security;
- Improved nutrition and health; and
- Sustainably managed natural resources.

The CGIAR claims to have important "core competencies" or special strengths, including research to increase agricultural production, NRM research, and policy research. As a global enterprise, the CGIAR is expected to produce "international public goods" (IPGs) that contribute to achieving these outcomes. The four SLOs are linked, such that most research contributes to achieving two or more of the SLOs: improved food security for example through production of nutritious food will also contribute to better health and reduction of poverty; sustainably managing natural resources such as water, land and fish contributes to long-term food security and better nutrition, and through diverse ecological services, reduction of rural poverty.

3.2 CGIAR impact assessment: Crops, policies and NRM

Assessment of the impacts, value added, and benefits compared to costs of research is a vital tool both to justify CGIAR investments to donors, and as a strategic management tool to ensure its investments are targeted effectively to achieve the SLOs. The CGIAR literature on assessing the impact of research classifies research into three types: crop genetic improvement (CGI), policy-oriented research (sometimes, POR), and natural resources management research (sometimes, NRMR). Integrated pest management is sometimes linked with CGI (e.g. Raitzer and Ryan 2008), and sometimes discussed as a fourth type of research (e.g. Renkow and Byerlee 2010). Until the mid/late 1990s, the largest share of CGIAR resources were being invested in CGI, and most of the earlier research impact assessment work understandably was measuring the returns on CGI investments. However, in recent years, as investments in policy and NRM research have grown, concerns have arisen about the return on these investments (e.g. Raitzer and Ryan 2008). This has led to special efforts to document the returns on policy and NRM investments through commissioned studies and reviews. Their purpose has been to measure the returns on these investments and to develop appropriate methodologies for assessing the impacts of policy and natural resources management research (e.g. Science Council Secretariat 2006; Waibel and Zilberman, eds. 2007; Raitzer and Ryan 2008; Walker, Ryan and Kelley 2010; CGIAR Independent Science and Partnership Council 2012).

There are long-standing methodologies in the agricultural economics literature for assessing the impact and economic value of research-based technologies such as improved crop varieties. Over the years, the CGIAR has been able to demonstrate fairly conclusively the substantial value added

from investing in research on improved crop varieties. Relative to assessing the impact of policy and NRM research, assessing the impact of CGI research is straightforward, though not without limitations and methodological challenges. The science of evaluating the impacts of basic technologies continues to improve, as argued by de Janvry, Dunstan and Sadoulet (2011). In general, impact assessments find much higher rates of return on basic technology research investments compared to policy and NRM investments – leading Renkow and Byerlee (2010) to argue that the CGIAR should re-balance its investments by reducing policy and NRM research and increasing investments in crop genetic improvement. Indeed, an earlier "state of the art" study of the costs and benefits of policy oriented research concluded that the cost of the policy research reviewed far exceeded the value of the identifiable benefits (Raitzer and Ryan 2008). As Walker, Ryan and Kelley (2010:1453) put it, "… evidence of impacts in the policy [and one could add NRM] arena is scanty and fragile. In contrast, documentation on the impact of research on crop genetic improvement in the CGIAR is copious and robust." These judgments are possibly premature: because of the extreme complexity of policies, institutions and ecosystems, we do not as yet have effective and agreed-upon tools and criteria to document and measure the outcomes and impacts of research on these domains. The inability to identify or measure impacts is largely a reflection of the limitation of traditional IA tools. These are not a good reasons to reduce investments in research on these domains; rather, they are good reasons to increase investments in methodologies and approaches for documenting and measuring the value of research outcomes and impacts, and to consider alternative IA frameworks such as "contribution analysis" (Mayne 2008, 2012; Mayne and Stern 2013).

There are important overlaps between policy oriented and NRM research; for example the Raitzer and Ryan (2008) study classifies all of IWMI's research as policy-oriented – but all of it is also clearly NRM-focused (and some is on very specific management practices and even technologies). The Science Council Secretariat (2006), in a report on NRM impact assessment, noted that a significant portion of NRM research could also be labelled as policy research. As Raitzer and Ryan note, policy oriented research does not define a specific sector or discipline; rather it "is based on the intended primary pathway to impact" (p.6). Influencing policy is an important means to achieving impacts on poverty and food security. Similarly, while NRM research is aimed at sustainable management of natural resources – a key SLO – it is also aimed at achieving food security, reducing poverty, and improving nutrition. Food systems are inherently complex and identifying effective entry points to enhance their productivity and sustainability requires integrating divergent conceptual frameworks and methodologies (Foran et al. 2014). Thus, while improved NRM is an end in itself, it is also a means to other ends. And like policy research, NRM research rarely produces a well-defined innovation whose dissemination and adoption is straightforward (as is an improved crop variety) and whose impacts are easily measurable on a large-scale "international goods" level. Much though not all NRM research is aimed at influencing policies in the expectation that more appropriate policies will in the long term lead to measurable impacts.

The four SLOs adopted by the CGIAR imply that it should be measuring impacts based on these four outcomes: poverty reduction, improved food security, improved nutrition and health, and sustainable management of natural resources. Surprisingly, a CGIAR Independent Science and Partnership Council (2011) study on measuring the environmental impacts of agricultural research finds a "… very thin record of accomplishment in environmental impact assessment in the CGIAR. Off-site environmental impacts of CGIAR research have largely been overlooked" (p. viii; see chapter by Renkow in that volume). Environmental impact assessment is clearly another important consideration in water management research.

3.3 NRM and policy impact assessment challenges and opportunities

Policy and NRM research share a number of problems when trying to measure their impacts and benefits compared to costs. Three are discussed here: attribution, counterfactuals, and precise measurement of the benefits. Walker, Ryan and Kelley (2010) assess the credibility of methods such as *ex-post* interviews as ways of attributing policy changes to the research and influence of CGIAR centers. Policy decisions invariably have complex roots, with multiple sources of influence, some not necessarily publicly acknowledged. The most critical activity or output of a CGIAR center or other institution may not be publication of a study but discretion and personal relationships. Therefore, how to attribute the benefits generated by a policy or NRM innovation where there are multiple actors is highly problematic (Science Council Secretariat 2006).

Because of the unique contexts of national policies and natural resource management systems, it is usually impossible to construct a rigorous counterfactual: what would have happened if there had been no policy change or change in NRM practices? The status quo, i.e. an assumption nothing would have changed without the innovation, is suspect. Location-specificity of many policy and NRM innovations also raises public goods issues. Walker, Ryan and Kelley (2010) note that constructing a credible counterfactual proved very challenging in the case studies they reviewed. Finally, quantifying the benefits attributable to the innovation nearly always requires multiple assumptions and projections into the future. The four (out of six) policy case studies reviewed by Walker, Ryan and Kelley (2010) able to quantify benefits had high internal rates of return (IRR) but low net present values (NPV). Raitzer and Ryan (2008) are less positive in their conclusions after reviewing 24 policy research cases: because of the difficulty in measuring impacts quantitatively and problems of attribution and counterfactuals, they conclude the level of influence and measured impacts did not justify the overall research investment in policy up to that time. It is notable that these reviews, commissioned by SPIA, apparently did not consider alternative impact evaluation methodologies drawn from disciplines other than agricultural economics; Mayne and Stern (2013) reviews some of these alternative methodologies.

Another factor affecting the measurement of the impact of policy and NRM research is the time frame used to measure the impact. This is rarely discussed in the IA literature, but the impacts of policy changes or interventions in natural resource systems often continue over decades. While the widespread adoption of an improved crop variety may occur within a relatively few years, international public good policies such as irrigation management transfer play out over decades, as countries experiment, adopt, learn lessons, further revise, and adapt through additional innovations. It is therefore an incremental and cumulative process, with multiple sources of influence. At what point should we measure the impacts and come to a conclusion as to the benefits versus costs of a policy or NRM research program? And of course this evolution and transformation over time further complicates attribution, quantification of costs and benefits, and creation of counterfactuals. We return to this issue in section 6.3. The timing issue is in addition to the methodological issues already discussed.

The shift to integrated natural resources management (INRM) research, exemplified by the increasing adoption of landscapes – complex socio-economic-agro-ecological systems – as the unit of analysis will make the assessment of impacts of research even more challenging in future. Several of the new CRPs are adopting a landscape conceptual framework for their work; and rather than a single-minded focus on improved crop or livestock production, they are emphasizing increasing the range, value and sustainability of multiple ecosystem services. Further, these programs are implemented by multiple partners, often on large scale landscapes and river basins. In such a context, even assessing the impact of basic technological innovations or new management practices becomes more problematic: for example, farm-level costs and benefits of adopting a specific water

or land management practice may not reflect impacts at landscape scales. Positive impacts for individual farmers may have negative impacts downstream (or, alternatively, may have multiple public good benefits not easily quantified). Attribution of benefits, defining counterfactuals and cost-benefit analysis will become increasingly problematic. We return to these issues in section 6.3. Recognition of these issues is leading to innovations in program and project design as well as in impact assessment methodologies. The Challenge Program on Water and Food (CPWF) pioneered the design of research projects based on explicit theories of change and impact pathways (i.e. a hypothesis about how the planned research will lead to intermediate outcomes and in turn eventually to measurable impacts on poverty, food security, and ecosystem services). "Impact pathways" has become a common terminology in recent studies of policy and NRM research impacts, though their use as management and monitoring tools remains rare. As discussed below, the CPWF has also experimented with "Most Significant Change" (MSC) stories and other techniques to document influence and outcomes. Although these are not satisfactory means to assess the actual benefits and costs of the research over time, they may contribute to creating a baseline and to understanding the process and dynamics through which outcomes and impacts have been achieved. We return to some of these issues again in sections 5 and 6.

3.4 Defining the "irrigation and water management" domain

Section 1 notes that the following working definition of "irrigation and water management" was initially adopted: "technologies and practices that bring water to the root zone of crops". Therefore, "watershed management" is excluded as it is an entire domain in itself; but rainwater harvesting, supplementary and full irrigation are included, as are policies, institutions, practices and technologies that relate to water management. Implementing this definition has proven challenging, and as the IA cases were reviewed, it became clear that the definition is too narrow. In its first 15 years, IIMI was clearly focused on "irrigation management" as it name at the time implies. Similarly, water management research by IRRI and IFPRI in those early days was largely focused on "irrigation."

However, over time IWMI, IFPRI and others have broadened their focus; "water management" is a very broad term. For example, IWMI's programs now include research on integrated water resources management in river basins, management of water in rainfed agricultural systems, watershed management, recycling of urban waste, and ecosystem services. IFPRI's program has similarly broadened, for example to include hydro-economic modeling of river basin management options. Similarly, the CPWF program, especially in phase 2, did not emphasize "irrigation" as a topic; it focused more broadly on landscape management (the three African basins and the Andes), balancing hydropower and other water uses in the Mekong, and management of the interface of fresh and saline water in the Ganges delta. For the purpose of this study, all of IWMI's and CPWF's work has been included, even though not all the work would fit under a narrow definition of irrigation and water management. As the study progressed, the integrated agriculture-aquaculture (IAA) work done by WorldFish was also added.

Further, although water management cases have been included in SPIA's reviews of impact assessments of policy and NRM research, the domain also includes more basic technological research. Examples are zero tillage wheat in the rice-wheat systems of South Asia that was made possible by the introduction of a specialized seed drill, and the use of a broad bed maker in vertisol soils in Ethiopia. Irrigation and water management therefore cross cuts technology, policy and NRM research. Even crop genetic research is included: aerobic rice is a major technology – crop variety -- developed to save water as it does not require puddling; it is included in this study as a water management practice precisely because it enables production of rice in water-scarce contexts through better management of water. Therefore it combines a crop variety with specific water management practices, in contrast for example with breeding of drought-resistant varieties.

Finally, management of water is done in the context of complex agro-ecological systems. Therefore, any credible assessment of the impacts of water management research must be done in full recognition of this fact. The "irrigation and water management" domain is indeed complex with no clear boundaries demarcating it from others.

4. Overview of Completed Impact Assessments and Research Investments

4.1 Characteristics of water management research IAs

Some Centers responded to the request for assistance from the SPIA Chair by offering assessments of the impacts of various water management technologies and practices. Although many of these have been produced or validated by research, they are not assessments of the impacts of the *research*. We have included some of these studies. In one case we did so to accommodate a Center representative; other cases were included because they add value to associated research IAs or represent topics that should be considered for future research IAs. I have included four types of evaluations: *ex-ante* impact assessments, *ex-post* impact assessments (epIAs), several program or project evaluations that are not strictly IAs but are a source of lessons or provide a foundation for possible future epIAs, and several technology (not research) IAs.

Both Appendix 2 and Appendix 3 list the 32 cases that form the database for this scoping study. Appendix 2 provides brief summaries and background information and comments on strengths and weaknesses of both the IAs and the programs, projects, or innovations assessed. Appendix 3 is more focused, providing information on the type of innovation, type of IA, data used in the IA, and some comments on their credibility and other aspects; it also provides information on whether the program or innovation is a real or potential international public good (IPG). Table 2 synthesizes and consolidates the information in Appendix 3 by type of case, IPG or not, and type of study. This consolidation produces 25 cases, many of which are represented by more than one publication.

Table 2: Classification of IA Cases

Case	Type of Case					IPG? [Yes/ No]	Research IA [Yes/No]
	Program	Project	Technology	Management Practice	Policy/ Institution		
IWMI							
1. IWMI's Research Program on IMT, 1992-2005	X					Y	Y
2. IMT Action Research Project in Pakistan, 1995-2000		X				N	Y
3. Electricity-groundwater reform in Gujarat, India, 2004-2008					X	Y	N
4. Improvements in environmental quality due to changes in sluice gate operations, Bac Lieu Province, Vietnam, 2001-2010		X		X		N	Y

Case	Type of Case					IPG? [Yes/ No]	Research IA [Yes/No]
	Program	Project	Technology	Management Practice	Policy/ Institution		
5. Impact of soil remediation research to improve water holding capacity project, northeast Thailand, 2002-2005		X		X		Y	Y
6. Malaria control through environmental & irrigation management	X			X		N	Y
7. IMT policy impact studies					X	Y	N
8. Other irrigation & water management impact studies			X		X	Y	N
9. Ferghana Valley IWRM Project impacts, 2001-2005		X			X	N	N
10. IWMI's gender program	X					Not applicable	N [Partly]
11. IWMI-TATA Program mid-term CCER	X					Not applicable	N
12. Evaluation of IMAWESA Project, phase II, 2010-2013		X				Not applicable	N [Partly]
IFPRI							
13. GRP22 ("Water Resource Allocation: Productivity and Environmental Impacts")	X					Y	Y
CPWF							
14. Forthcoming meta-analysis of CPWF & other references listed in Table 2	X					Y	N
15. Aerobic rice-'STAR' in Asia Project, 2004-2008			X			Y	Y
16. Water & land management at interface between fresh and saline water environments-evaluation of Vietnam component [Bac Lieu], 2004-2008		X		X		Y	Y
17. Citizen participation in managing water [SCALES Project], 2005-2007		X			X	N	Y [Partly]

Case	Type of Case					IPG? [Yes/ No]	Research IA [Yes/No]
	Program	Project	Technology	Management Practice	Policy/ Institution		
18. "Models for Implementing Multiple-Use Water Supply Systems for Enhanced Land and Water Productivity, Rural Liveli-hoods and Gender Equity" [MUS] Project		X			X	Y	Y
CIMMYT & Rice-Wheat Consortium							
19. Rice Wheat Consortium & Zero Tillage [ZT] in Rice-Wheat Zone, South Asia, 1999-2007	X [partly]		X	X		Y	Y
ICARDA							
20. Improved Supplementary Irrigation [ISI] of wheat, Syria			X	X		Y	N
21. Economic & environmental impacts WH in low rainfall area (Badia Benchmark Site), Jordan			X			Y	N
IRRI							
22. Irrigated Rice Research Consortium [IRRC],1997-2012	X					Y	Y
23. Aerobic rice adoption China, Philippines cases			X			Y	N
24. AWD adoption Bangladesh				X		Y	N
25. AWD adoption, Central Luzon, Philippines, 2001-2005				X		Y	N
26. AWD adoption Vietnam, 2005-2011				X		Y	N
ILRI							
27. Broad bed maker (BBM) plow, Ethiopia, 1986-2008		X	X			Y	Y
WorldFish							
28. Integrated aquaculture-agriculture (IAA) & systems, Asia, Africa [Bangladesh project]	X		X	X		Y	N
TOTAL	**7.5**	**10**	**8**	**10**	**6**	**20**	**13.5**

Note: Some cases are either program or project IAs, involving a specific technology, management practice or policy; and there are a few innovations that combine a technology and management practice. Some cases are in our judgment potential IPGs (or not) even if this is not clearly indicated in the studies. These are defined in terms of potential applicability on a large scale, in other provinces of large countries such as India, or in other regions or countries. A few cases have been counted 'partly' as 0.5 case.

The water management research IAs reviewed include seven program evaluations (eight if RWC is included) and ten project evaluations. Eight IAs evaluate a technology innovation, ten evaluate a new

management practice (of which several combine a technology and management innovation), and six evaluate a policy or institutional innovation (seven if IWMI's IMT work is counted, but the IA focuses on its work and not the policy itself). The relatively low number of policy or institutional innovation cases is somewhat surprising in the sense that "irrigation and water management" research is usually considered in CGIAR classifications to be primarily on policies and institutions. Some of the program evaluations (for example the Rice-Wheat Consortium [RWC] and the Irrigation Rice Research Consortium [IRRC]) have policy and institutional components but these are not captured clearly in the IAs. Twenty of the cases included here are either actual or potential IPGs – other cases evaluated are innovations that have limited relevance elsewhere. Only 14 cases are classified as *research* IAs. Table 3 lists these cases; they are complemented in some cases by assessments of the farm-level or environmental impacts of technologies produced by programs for which we have assessments of the research investments. For example, the benefits and costs (impacts) of the investments in research under the RWC and IRRC have been evaluated; and the impacts of specific technologies or practices researched by these programs have been separately evaluated. The latter studies strengthen the overall credibility of the program IAs by including dimensions or using methodologies not included in the program IAs. It is therefore a potential model for evaluations of other multi-dimensional long-term research programs.

Table 3: Water Management *Research* Impact Assessments and Investments

Case	Total Research Investment (US$)	Notes
1. IWMI's Research Program on IMT, 1992-2005	No estimate provided	It would be possible to estimate the research investment but estimating the value of impacts attributable to IWMI's research is not possible. Even estimating the initial value of adopting an IMT could not be done in any credible manner.
2. IMT Action Research Project in Pakistan, 1995-2000 – IWMI	No estimate provided	It would be possible to estimate the research investment but estimating the value of impacts attributable to IWMI's research is not possible.
3. Groundwater management through management of electric supply, Gujarat, India, 2002-2008 -- IWMI	No estimate provided	It would be possible to estimate the research investment; and estimating the total value of the innovation, though difficult, would be possible.
4. Improvements in environmental quality due to changes in sluice gate operations, Bac Lieu Province, Vietnam, 2001-2010 – IWMI	No estimate provided	This study estimates the non-market value of impacts; including the cost of the research would be possible.
5. Impact of soil remediation research to improve water holding capacity project in northeast Thailand, 2002-2005 – IWMI	272,660	This includes IWMI research costs only.
6. Malaria control through environmental & irrigation management – IWMI	No estimate provided	Provides estimates of other implementation costs but not the investment in research.
7. GRP22 ("Water Resource Allocation: Productivity and Environmental Impacts"), 1994-2010 – IFPRI	Approx. 12.5 million	Estimated investment from C Ringler email 9 July 2014. The focus of the IA is on outputs and outcomes. It would be possible to estimate the research investment but estimating the value of impacts attributable to IFPRI's research would be challenging.
8. Aerobic rice-'STAR' in Asia Project, 2004-2008 – IRRI	1,605,596	CPWF plus partner contributions.
9. Water & land management at interface between fresh and saline water environments-evaluation of Vietnam component [Bac Lieu], 2004-2008 – IRRI, IWMI	679,000	It is not clear if this is the cost of the entire project or the Vietnam portion only; and the study refers to other unquantified inputs.
10. Citizen participation in managing water [SCALES Project, Andes], 2005-2007 – CIAT	785,662	It is not clear if this includes the Nile portion or is only the Andes portion of the project.
11. Models for Implementing Multiple-Use Water Supply Systems for Enhanced Land and Water Productivity, Rural Livelihoods and Gender Equity [MUS] Project – IWMI	1.6 million	This figure is the CPWF direct investment; other costs not quantified.
12. Rice Wheat Consortium: Zero Tillage [ZT] in Rice-Wheat Zone, South Asia (1999-2007) – CIMMYT	Program: 11.5 million, 1994-2007 [RWC costs: $2.9m over 19 years; CIMMYT costs: $600,000 over 12 years]	Total figure from Laxmi, Erenstein and Gupta 2007 includes many assumptions—difficult to attribute costs specifically to ZT; it includes extension & other costs. ZT, not the entire program, is evaluated.

Case	Total Research Investment (US$)	Notes
13. Irrigated Rice Research Consortium [IRRC],1997-2012 – IRRI	18.5 million, 1997-2012	This is an estimated total from all sources & refers to the entire program. The allocation to the "Water Savings Work Group" was $2.1 million.
14. Broad Bed Maker (BBM) plow, Ethiopia, 1986-2008 – ILRI	63.6 million 1986-2008	This includes extension and training costs; no disaggregation of research from other costs is given.

None of the water management research IAs refers explicitly to the contribution of the research to the CGIAR SLOs, and none clearly measures impacts on poverty, equity, gender, or ecosystems. The meta-analysis of the Irrigated Rice Research Consortium notes that that the program had been focusing on the "mean" impact of technology interventions but had not differentiated groups or categories of farmers and other rural people (Rejesus, Martin and Gypmantasiri 2013). This observation applies to all of the studies reviewed, except for one study of integrated agriculture-aquaculture systems but that is not strictly speaking a *research* IA. The assessment of the impact of electricity supply reform on groundwater management by Shah et al. (2008) discusses the negative impacts of the reform on poor farmers and landless people in general terms but does not quantify this.

Section 5 discusses the most important water management research IAs in more detail.

4.2 Estimating investments in water management research

There is no credible straightforward way to estimate the total CGIAR investment in irrigation and water management research without doing an in-depth analysis of Center accounts. The source of the $800 million figure quoted (from the TOR) in section 1 is not clear but is probably close to reality. It is stated as the estimated total since IIMI was established in 1984 – when IIMI was not part of the CGIAR. Although it would be reasonable to attribute 100% of IIMI's budgets from 1984 to about 1995 to irrigation and water management, after that time IWMI expanded its mandate to include land management and broad IWRM topics as well. Other centers do not necessarily track their investments in water management as a category. Further, existing water management research impact assessments do not use comparable or standardized estimates of costs. Only eight of the 14 research IAs listed in Table 3 contain cost data; but they vary as to what is included. Some include only Center project allocations, some also include estimated in-kind costs, and some also include estimated extension costs. Many are not precise about what is included. For example, the IA of the broad bed maker offers a total investment cost of $63.6 million including research, extension, training, equipment, etc. (Rutherford 2008); but no breakdown is provided to disaggregate this rather high figure. Bennett (2013) evaluates IFPRI's water management research program from 1994 to 2010 but does not provide any data on the total investment; an estimate was received later from a researcher at IFPRI. Flows of funding among centers, and possible double-counting of CPWF funds further complicates estimating the total CGIAR water management research investment.

Defining the irrigation and water management research domain is also a major factor. For example, we have included one case of a crop variety that enables significant water savings (and requires a different irrigation regime), aerobic rice. But we have not included other research on drought resistant crop varieties. Many crop management practices are clearly water-management related, for example direct seeding of rice, a significant water-saving practice; but these are not all captured in this study.

Table 4 provides a rough estimate of the investments in water management research *in nominal terms* based on whatever data could be obtained. It also includes some blank cells where no data could be found.

Table 4: Estimates of Total Investments in CGIAR Water Management Research

Center/ Program	Estimated Water Management research Investment (US$)	Period	Notes, Explanations, Source
IWMI	456,000,000	1990-2013	Based on summary total expenditures in financial reports, excludes CPWF column. Inclusion of expenditures from 1984-1989 would bring the total to just under $500 million.
IFPRI	15,500,000	1994-2013	Based on email from C Ringler; includes period after GRP program figure in Table 3.
IRRI	-		See IRRC
ICARDA	-		No data
ICRISAT	15,136,000	1991-mid 2014	Spread sheet provided
Africa Rice (IVC)			No data
WorldFish	8,000,000	1989-2005	IAA projects in Bangladesh. Source: proposal submitted to SPIA in 2011
CIAT	-		No data
CIMMYT	-		See RWC
ILRI	2001 study: 12,300,000	1986-2001	Nominal research & extension costs; Rutherford, Odero & Kruska 2001
	2008 re-study: 63,600,000 [not used in total]	1986-2008	Total estimated research & extension investments, Rutherford 2008. ILRI's own investments are not clear.
CPWF	120,000,000	2003-2013	Alain Vidal, by Skype
IRRC	18,500,000	1997-2012	Rejesus et al. 2013
RWC	11,900,000*	19 years to 2007	Laxmi, Erenstein & Gupta 2007
WLE	-	2012-2013	Included in IWMI accounts
TOTAL	**657,336,000****		

* Total RWC was 11.9 million. Laxmi, Erenstein and Gupta (2007) give $2.9 million and $600,000 as, respectively RWC and CIMMYT costs respectively allocated to ZT work.

** Provisional total.

5. Assessment of Strengths and Limitations of Completed Research Impact Assessments

This section is organized by Center and Program. It analyzes a subset of the impact studies and evaluations in more detail, focusing on their methodology, rigor, strengths and limitations, and the potential for follow-up impact assessments.

5.1 IWMI

5.1.1 Irrigation Management Transfer (IMT)

Although its mission statements have evolved over the years, irrigation and water management has been the core of IWMI's mandate since its inception in 1984. It was created initially to address critical management issues affecting the performance of massive irrigation investments during the 1960s-1980s, especially but not only in Asia. One major thrust of its research since the 1980s has been the reform of irrigation management institutions in government-managed schemes, with a special focus on the transfer of some irrigation management responsibilities to farmers' organizations. In 2005-2006, IWMI carried out an *ex-post* impact assessment of its work on irrigation management transfer (IMT; see Giordano, Samad and Namara 2006). This study was commissioned by SPIA (Science Council Secretariat 2006).

This was a largely qualitative assessment done by senior IWMI researchers that reviewed IWMI's work on IMT since the early 1990s and tried to document the influence of IWMI's research on policies and operations in selected countries where it has worked, as well as its contribution to the IMT knowledge base. Using an "outcome pathway" IWMI had recently developed as part of its strategic planning process, the study focuses on three potential outcomes: raised awareness of new research, employment of improved policies, and employment of improved techniques. The study uses multiple methodologies, including bibliometric and webmetric analyses, a focused formal survey, and informal feedback. The study finds IWMI's IMT work has had considerable "usage impact" (i.e. awareness creation); its recommendations had been adopted in Sri Lanka and Nepal, two countries where it worked closely with policy makers and implementing agencies for many years[2]. For example, in Sri Lanka, the government amended the legal framework to recognize farmers' organizations as legal entities and their roles in management of irrigation schemes, and formalized a management structure on large schemes that gives representatives of farmers' organizations real authority in making decisions about water management and scheme maintenance. In Nepal, as a result of IWMI's and others' research, the irrigation policy stipulates that at least one third of water user association representatives must be females; and other IWMI recommendations covering capacity building, environmental protection, water rights, operation and maintenance, and switching to variable rather than flat rate user fees have been included in a new Irrigation Regulation. IWMI's IMT guidelines for Central Asia are "strongly appreciated" and used in that region (but the sample surveyed is very small); and there is a continuing high demand for the IMT guidelines co-published with FAO (Vermillion and Sagardoy 1999). The overall conclusion is that there has been an "... overall positive contribution from IWMI to IMT theory and application ... large and continuing

[2] Disclosure: The author was the co-leader of a Sri Lankan project which had considerable impact on policy, as summarized by Giordano, Samad and Namara (2006); this is the Irrigation Management Policy Support Activity (IMPSA).

demand for IWMI research products on IMT. Direct and indirect data sources also indicate that IWMI policy and operational level interventions have in general contributed positively to IMT decision-making and action …" (Giordano, Samad and Namara 2006:17). There is no attempt to quantify IWMI's research costs or the value of benefits generated by the research. Overall, IWMI has not clearly documented the influence of its own IMT research in the countries where it works and in other countries, and has not clearly assessed the impacts of its IMT work.

This study is a heroic attempt to document outcomes and influence (not impacts) in the absence of any baseline data or counterfactual. There was no coherent IMT research program; rather, there were a number of discrete project activities over the years. And there had never been any explicit theory of change or attempt to document impact pathways and outcomes and measure impacts built into the projects[3]. The attribution problems in trying to assess the actual influence of IWMI's work are daunting; and they are prohibitive for trying to assess and place a value on the actual impacts of IWMI's IMT program. Surprisingly, the study does not try to assess the quality of the publications on IMT, unlike some other IAs reviewed below. One section of the study tries to document outcomes of three specific projects in Pakistan, Indonesia and Sri Lanka, but found little sustained impact[4].

In the late 1990s IWMI carried out systematic assessments of the impacts of IMT in three countries: Colombia, Indonesia, and Sri Lanka (Vermillion and Garcès-Restrepo 1998; Vermillion et al. 2000; Samad and Vermillion 1999; also see Vermillion 1997). These studies were carried out within no more than five years of the reform, possibly not enough time to observe major impacts. Not surprisingly, they therefore found modest impacts at best: governments may have achieved some budgetary savings, but the performance of irrigated agriculture did not improve; farmers did not benefit significantly and did not increase their own investments in operations and maintenance of schemes. There is no way to estimate a counterfactual: what would performance have been without IMT. In one of these cases, Sri Lanka, IWMI undoubtedly influenced the IMT policies though Samad and Vermillion (1999) do not address this point. These papers are therefore examples of studies of the impact of the adoption of water management policy reform, but they are not examples of the impact of the research investment in IMT.

Giordano, Samad and Namara (2006) express an aspiration to do a more formal impact assessment after further time elapses – it had excluded work that IWMI was currently doing in South Africa and Cambodia. However, given that most of the available evidence suggests the impacts of IMT have been minimal, there are no baseline data or counterfactuals, and the attribution problem is fundamentally insoluble, it seems doubtful that an attempt to do an epIA of IWMI's work on this topic would be fruitful. What might be valuable, however, is a systematic study of the outcomes and impacts of IMT programs, including documentation of the impact pathways and the underlying reasons for whatever results have emerged. In addition, documenting IWMI's roles in helping develop or guide IMT policies in specific countries would also be useful.

5.1.2 Reform of groundwater governance through reform of electric supply in Gujarat, India

Since the 1950s and 1960s, parallel to huge public investments in canal irrigation, Indian farmers have been installing pumps to exploit groundwater for irrigation. Many Indian states including

[3] IMPSA was an exception: the final report included a checklist of actions and reforms that was used informally to monitor outcomes.

[4] The Pakistan project referred to is included in this paper in Appendix 2 as item 2; see Bandaragoda 1999. The Sri Lankan project referred to here was a follow-on project to IMPSA.

Gujarat encouraged this expansion of groundwater pumping through provision of subsidized electricity. By the 1970s, evidence was growing that groundwater was being rapidly depleted in many regions; over the next few decades a variety of solutions were proposed but not implemented. At the same time, the subsidized electricity began to bankrupt electric supply companies and to undermine the quality of service; however it was politically impossible to introduce metering and raise electric rates. In the early 2000s, an IWMI team led by Professor Tushaar Shah proposed a radical solution to the government of Gujarat. This solution involved separating electric lines supplying power for domestic use and small industries in villages (which was to be metered) from the lines supplying electricity for pumping groundwater. The latter would be based on a flat-rate charge to be raised slowly over time, and would provide a high-quality reliable electricity supply on a strict reliable schedule for a limited number of hours per day. The policy reform proposal is outlined in an IWMI Research Report (Shah et al. 2004).

A paper published a few years later documents the impact of the adoption of this reform (with some modifications) in the state of Gujarat (Shah et al. 2008). What became known as the "IWMI proposal" was debated for several years, then pilot tested; and based on the success of the pilot test, the government implemented the policy state-wide in 2003-2006, under the name "*jyotigram* scheme" (lighted village). This involved an investment of nearly $300 million to rewire the entire state. As documented by Shah et al. (2008), the adoption of this radical reform has had dramatic state-wide impacts: the quality of life in rural villages has been substantially enhanced, non-farm economic enterprises have increased, the power subsidy for agriculture had been cut in half and the state electricity board became financially solvent, and the depletion of groundwater has been reduced. Medium to large-size farmers have benefited from the reliable water supply; however small and marginal farmers have been harmed because of reductions in the scope of water markets and the increased price of pumping.

The study claims that this radical reform was a direct result of IWMI's research-based recommendation but does not trace the precise impact pathway. The claim is credible, but to a large degree the rapid adoption of the recommendations may have been the result of the reputation and social-political network of the lead researcher. The study does provide some data on the benefits and costs of the reform, but does not attempt a formal quantified impact assessment and benefit-cost analysis of the research. It is likely the investment in the research was quite modest; but the returns are extremely high. Nevertheless, as the study notes, poor farmers and landless people were harmed – a seemingly negative impact on equity. However, it is possible that the growth of non-farm economic enterprises has provided new employment opportunities, turning this impact into a more positive outcome.

Shah et al. (2008) state that the Gujarat scheme could be adopted by other South Asian regions facing the same problems. It would be interesting to find out whether other states have adopted this policy since 2008, and if not why not. As part of the same study, a more formal *research* epIA should be carried out that assesses the benefits and costs but also identifies more clearly the impact pathway through which the recommendation was adopted in Gujarat but not, apparently, elsewhere.

5.1.3 Other research IAs

IWMI has carried out epIAs on three projects: 1) improvements in environmental quality due to changes in sluice gate operations, Bac Lieu Province, Vietnam, 2001-2010 (Wichelns et al. 2010); 2) impact of soil remediation to improve water holding capacity research project in northeast Thailand, 2002-2005 (Saleth et al. 2009); and 3) malaria control through environmental and irrigation management, action research 2000-2002 (Namara et al. 2008). All three of these studies were done

by IWMI staff members, though the lead authors are economists who were not directly involved in project implementation[5]. An IA was carried out for one other IWMI-led project supported by CPWF (the Multiple Use Water Supply Systems project, MUS); this is discussed under the CPWF heading as IWMI had no institutional involvement in that assessment.

Wichelns et al. (2010) is an unpublished environmental IA (EIA) submitted to SPIA (see Bennett 2011). Focusing on non-market values of flora and fauna in the Mekong delta, it reports on the value of environmental benefits of using an operational model developed by IWMI researchers to manage gate operations at the interface of fresh and salt water in the Mekong delta. Methodologically, it combines the use of participatory rural appraisal (PRA) and surveys to estimate "willingness to pay". It estimates that the benefits "likely" exceed the costs of gate operations but does not estimate the benefits and costs of the research investment itself. This is a very specific project – closer to technical assistance than research – that did not produce an IPG[6].

In contrast, Saleth et al. (2009) is a classic epIA of a specific project in northeast Thailand on soil remediation to enhance its water and nutrient holding capacity through the addition of a type of local clay. The research was conducted from 2002-2005 under the Soil Remediation Research Project in collaboration with Australian and local partners. Initial studies showed that the application of locally available bentonite clay improves soil fertility and water holding capacity and dramatically increases yields. The project supported trials and demonstrations in farmers' fields, through farmer networks and farmer field schools.

The benefits were assessed for the period 2002-2008. Saleth et al. (2009) provide a detailed impact pathway and discussion of the roles of multiple partners, which is useful to clarify attribution. It is focused entirely on the returns to IWMI's modest research investment of $272,660; it does not seek to assess the returns to all costs associated with dissemination of the innovation. The data were collected through a sample survey (250 farmers, both users and non-users; therefore it is a "with-without" comparison). The authors use several analytical methodologies to understand the average impacts. Its detailed cost-benefit analysis finds a very high NPV, IRR and BCR at sample level, and when projected regionally it is even higher. Overall, the study likely under-estimates the total benefits as it focuses only on yields over a three year period and does not project into the future. The study claims this technology is scale-neutral, but there is no effort to address selectivity issues and no effort to disaggregate female and male farmers or poor and prosperous farmers. The study states this technology is potentially relevant to other areas of Asia and Africa, making it a potential IPG.

The third study by Namara et al. (2008) is an epIA of IWMI's research in the dry zone of Sri Lanka on controlling malaria through environmental and water management interventions. This was a major part of a long term (though modest) program on malaria control through agro-ecological system management in Asia and Africa. During the 1990s numerous multi-disciplinary diagnostic studies were carried out in Sri Lanka which suggested a substantial potential for reducing malaria through water management and infrastructure interventions. This study examines the impacts of a three year action research program based on the findings of the previous diagnostic research. It confirms the positive impacts (reduced mosquitos and malaria incidence) of the intervention in the sample villages.

[5] This is simply a statement of fact and does not imply anything regarding the credibility of the studies.

[6] This project was presumably related to the CPWF project "Water and land management at interface between fresh and saline water environments-evaluation of Vietnam component", whose impact was assessed by McDonald (2011); see below and case 20 in Appendix 2. However, neither study acknowledges the other.

The study uses multiple sources of data, including detailed data collected during project implementation and the results of a 2004 sample survey in intervention and control villages. It estimates the value of malaria control through cost of illness and willingness to pay methodologies. Because the national incidence of malaria decreased substantially during the project period, the study tries to separate the impact of the action research from the overall trends. Surprisingly, the study does not analyze the full costs of the research: rather, it focuses on the return to the investment in rehabilitation of an eight km canal ($17,800). Therefore, this is not an assessment of the benefits and costs of the research program, only of the specific intervention. Indeed, if all the costs of the research program were included, it is likely the costs would have greatly exceeded the relatively modest benefits. There is no evidence that the agro-ecological management approach to controlling malaria has been expanded in Sri Lanka and therefore no evidence of actual impact. Although the authors claim this research has suggested the potential value of agro-ecological management interventions in southwest India and East Africa as well as Sri Lanka, the study itself had a very limited number of beneficiaries and like the Vietnam gate operation study is not a clear IPG.

5.1.4 Other IWMI studies

Over the years, IWMI has carried out studies of the impacts of the introduction of irrigation (in general) on poverty, as well as the impacts of specific water management policy reforms and technologies. These studies are not studies of the impacts of water management research, but they do serve the purpose of documenting the impacts of adopting better water management practices. Examples of studies of the impacts of irrigation include Namara et al. (2010), Hagos et al. 2012, and Inocencio et al. (2007); they document poverty impacts in general and specifically in Ethiopia, and outcomes benefits of irrigation investments in sub-Saharan Africa compared to other regions, respectively. Examples of studies of the impacts of specific water management technologies include Shah et al. (2000) on treadle pumps in South Asia, Adeoti et al. (2007) on treadle pumps in Ghana, Venot et al. (2012) on small reservoirs in SSA, and Giordano and deFraiture (2014) on small private pumps in SSA.

IWMI has also commissioned external reviews of programs (CCERs), for example its work on gender (Rathgeber 2009) and the IWMI-TATA Water Research Program in India (Burke, Joshi and Chopra 2004).[7] The groundwater-energy nexus study was done under the IWMI-TATA Program, but the impacts came after the CCER was completed. In addition, IWMI has published twenty two-page summaries of "success stories"[8], but none of these provide either a reference to a credible impact study or sufficient detail to assess their credibility – they are intended as public relations documents. IWMI and ICRISAT have also jointly published a study on uptake of water management research based on ten case studies of IWMI's work (Kane-Potaka 2013)[9]. This study is based mainly on interviews with stakeholders and attempts to identify common elements that lead to successful uptake of research for development findings.

5.1.5 IWMI: Concluding observations

The IAs discussed above under "other research IAs" are of relatively small scale projects, not major programs involving large investments; two of the three are not even IPGs. The IMT program was

[7] In its comments on an earlier draft of this paper, IWMI listed six other CCERs of the outcomes of its work, but did not provide copies. As far as is known, they are not published.
[8] Available at: http://www.iwmi.cgiar.org/publications/success-stories/ (accessed 20 August 2014).
[9] The work was done by Kane-Potaka while she was head of communications at IWMI, but published after she moved to ICRISAT.

relatively large scale, but IWMI's assessment has not attempted to quantify the research investment or assess the returns on this investment. The assessment of the impact of IWMI's policy recommendation on groundwater and energy in Gujarat is an example of a relatively small research investment having a major impact; but the study is not a formal epIA – this remains to be done. Other impact studies summarized above and in Appendices 2 and 3 are studies of the impacts of introducing irrigation in general or specific water management interventions; or they are program evaluations; none are assessments of *research impacts*.

David Seckler, a former Director General of IWMI, in his review of an early draft of this paper, suggested that

> the greatest benefits of IWMI's research are the results of two projects. First, the analysis and projections of future world water supply and demand; and, second, IMWI's contribution along with others in exploding the myth of simple "water efficiency" in water policy analysis, together with a refined analytic system of water use in a basin context.[10]

The analysis of water in a basin context led to the now-common approach to "water accounting" as a way of tracing where water goes in river basins. A related contribution to the science of water management is the development and application of the concept of "water productivity". Early references include the following: Seckler (1996), Molden (1997), Seckler et al. (1998), and Molden et al. (1998). A decade later, the final report on the "Comprehensive Assessment of Water Management in Agriculture" (CA; see Molden, ed. 2007) used these and other concepts to assess the status of water for food and identify critical trends and issues. This body of work has been frequently cited and has provided a foundation for a large body of work by IWMI scientists as well as by others; it is therefore surprising that IWMI has not commissioned an assessment.

The available studies suggest that IWMI has in the past not consistently collected the data that would be needed to assess project or program impacts at a future date, making it problematic to carry out epIAs. There is also no evidence that IWMI has attempted *ex-ante* IAs for its projects and programs, which would establish a base line for future epIAs. Stated differently, while we believe there is considerable anecdotal evidence that IWMI has had important impacts on both water science and water management in developing countries over the years, the Institute has not made this case as yet. We therefore must conclude that over the years, IWMI has apparently under-invested in documenting the impacts and value added of its research programs. Section 6 makes recommendations on programs and projects that could be good candidates for future IAs.

5.2 IFPRI

IFPRI has been working on various aspects of irrigation and water management policy for many years, sometimes in partnership with IWMI, and sometimes on its own or partnering with other CGIAR centers. Like IWMI, IPFRI has done studies of the impact of irrigation on poverty and economic growth – a recent example that parallels similar studies done by IWMI is Dillon (2011), documenting the positive household consumption and risk reduction impacts of irrigation in Mali.
IFPRI recently commissioned and published an external review of its research program on "Water Resource Allocation: Productivity and Environmental Impacts", covering the period from 1994 to 2010 (Bennett 2013). This is a program evaluation, not a research impact assessment, though it does assess the evidence for influence and outcomes of three country-level research projects. The review uses multiple methodologies to assess the quality, relevance, reputation and outcomes of the program and its researchers. The methodologies include bibliometric analysis, a formal survey,

[10] Unpublished peer review by David Seckler of an earlier draft of this paper.

interviews, and critical reading of documents. The assessment is organized around three themes: 1) global modeling, 2) river basin hydro-economic modeling, and 3) institutions.

Bennett (2013) summarizes the conclusions as follows:

- IFPRI water research is highly regarded.
- IFPRI water researchers are productive at a high level.
- IFPRI water research impacts have often been limited.
- Publication strategy needs to be better coordinated.
- Projects need to be better targeted.
- Projects need to be better integrated into policy processes.
- Research partnerships need to be broadened.

In essence it is a positive assessment of the quality and relevance of the research, the publication record, and the reputation and productivity of the researchers. The study refers almost in passing to its contribution to research capacity building – an outcome that should have been quantified. No benefit-cost analysis is attempted; indeed the study does not provide any information on the costs of the program, and claims that quantifying the benefits of what is essentially a pure IPG program is not possible. Nevertheless, the study does assess the outcomes and influence of three country research projects in Vietnam (river basin modeling), Ghana (basin modeling and network analysis), and India (institutional reform). In all three cases, while both the research and the researchers are highly regarded according to those interviewed, the study found no evidence of impacts on policy. In order to achieve greater influence on policy and potentially have greater impacts, Bennett (2013) recommends that IFPRI researchers should engage more than they have with policy makers throughout the research process, and combine more attention to research demand with research driven by the researchers' own priorities.

In many ways this evaluation of IFPRI's water research program is a model for others to follow. It is an in-depth, objective evaluation that uses quantitative and qualitative data as the basis for its conclusions, and it was carried out by an external evaluator with strong credentials. Perhaps it forms a useful foundation for future epIAs of IFPRI's water management research; for example quantifying the capacity building impacts would be useful, and epIAs of the country projects would likely yield valuable insights. Attempting a full epIA of the entire program would be a challenge.

5.3 CPWF

5.3.1 Background to CPWF[11]

Although IWMI was the implementing center for the Challenge Program on Water and Food (CPWF), the program was managed separately, especially during its second phase. At the beginning of Phase I, approximately 2003/4-2008/9, the CPWF called for proposals which could be led by a non-CGIAR center but had to include one — indeed projects were required to include non-CGIAR institutions. These were to receive at least 30 percent of the budget. These projects were located in nine river basins, some transnational and some not. It was only after many of these projects had begun that the CPWF management began developing its ideas regarding theories of change and the use of impact pathways as project management as well as monitoring and evaluation tools. An attempt was made to "retrofit" projects to include these tools. A centrally-managed project developed a "Participatory Impact Pathway Analysis" (PIPA) methodology for planning, monitoring and evaluating

[11] Some information in this subsection is based on the author's personal experience; it has also benefited from a discussion by Skype with Alain Vidal, CPWF Director during Phase II.

complex projects. PIPA involves the project stakeholders working together to make their assumptions about how the project will achieve impacts explicit; participants construct problem trees, carry out visioning exercises and draw network maps to help clarify the "impact pathways. Two logic models are then constructed, an "outcomes logic model" that hypothesizes how medium term impacts will be achieved (which actors will make what changes, etc.), and an "impact logic model" that describes how the project will improve people's livelihoods if the planned outcomes are achieved. This is a somewhat idealized description: projects varied considerably in the extent to which they made practical use of these tools[12].

Ultimately, impact assessments were done on only four of the Phase I projects. These were done as Phase I was ending, i.e. too early to be useful epIAs; perhaps because of funding constraints, no epIAs of Phase I projects were commissioned during Phase II. There was a transitional period from Phase I to Phase II (overlapping with both) during which "Basin Focal Projects" were implemented in an attempt to consolidate the data and major trends and issues on the nine river basins (see Fisher and Cook, eds. 2012)[13]. As Phase I was nearing completion, the CPWF adopted the "Most Significant Change" (MSC) story technique to document complex change processes; two volumes were published (Harrington et al. 2008; de Leon et al. 2009). MSC stories continued to be used in Phase II. In response to the recommendations of an external review, Phase II (approximately 2009-2013) focused on six transnational basins, and identified a "basin development challenge" as the focus of projects in each basin. Phase II projects were designed with explicit theories of change and impact pathways, and were intended to be evaluated based on both the quality of the science and the outcomes achieved. Initially, Phase II included a modest monitoring and evaluation budget, but this was drastically reduced as part of the response to drastic budget cuts in 2012. In part based on lessons learned in the first phase, the second phase of the CPWF placed great emphasis on learning from experiences. A more explicit concept of "Research for Development" (R4D) as a learning process was developed; and most meetings of project and basin leaders were devoted to identifying and sharing lessons learned from the research *process* as well as results (e.g. Hall 2013). Basin leaders were encouraged to prepare "institutional histories" as a means of capturing lessons learned from the program.[14]

The remainder of this section is divided into two subsections. The next subsection discusses the four IAs commissioned for selected Phase I projects. The final subsection discusses significant findings from the recent external review and from a forthcoming book synthesizing lessons. It then reiterates a few key observations on impact assessments based on the CPWF experience.

5.3.2 Impact assessments of four Phase I CPWF projects

There were over 50 funded Phase I projects[15]. Through a centrally-managed project on impact assessment, CPWF claims that it "carried out *ex-ante* impact assessment of 29 of the 32 CPWF First

[12] Disclosure: at the time the author was the project leader for one of the Phase I projects that was "retrofitted" by developing an impact pathway though the author left IWMI before the project was completed.
[13] Disclosure: The author was the initial leader of the Limpopo basin focal project (for a year), and worked on institutional issues as part of this initiative. See Merrey and Cook 2012.
[14] Disclosure: The author was the first author of the institutional history for the Nile Basin Development Challenge (Merrey, Swaans and Le Borne 2013).
[15] See https://sites.google.com/a/cpwf.info/phase1/phase-1-project-completion-reports, accessed 5 July 2014. This site lists 53 projects not including the basin focal projects and small grants. A companion page mentions 68 projects in phase I, 2004-2009.

Call Projects through constructing impact pathways for each project."[16] However, these do not seem to be readily available. Only four projects were formally assessed. It is likely the four were chosen because they were seen as relatively successful, or were considered sources of useful lessons. Clearly, they are in no way representative of the entire Phase I program or its projects, and therefore cannot be used to assess the overall impact of the program. The four projects assessed were: 1) "Developing a System of Temperate and Tropical Aerobic Rice (STAR) in Asia" implemented by IRRI; 2) "Managing Water and Land Resources for Sustainable Livelihoods at the Interface between Fresh and Saline Water Environments in Viet Nam and Bangladesh" (Vietnam component), also implemented by IRRI; 3) the Colombia component of "Sustaining Collective Action Linking Economic and Ecological Scales in Upper Watersheds" (SCALES), implemented by CIAT; and 4) "Models for Implementing Multiple-Use Water Supply Systems for Enhanced Land and Water Productivity, Rural Livelihoods and Gender Equity" [MUS], implemented by IWMI. All four are *ex-ante* impact assessments.

The STAR Project: Aerobic rice

The STAR Project was implemented in China, India, Lao PDR, Thailand and the Philippines. Aerobic rice is a variety that can achieve reasonably high yields without puddling and flooding—hence it saves water and enables rice cultivation under conditions of water scarcity. It combines a rice variety and new water management practices. The STAR project builds on previous research, especially that done by the Chinese Agricultural University (CAC, IRRI's partner in this project). Templeton and Bayot (2011) is a commissioned IA; the first author is from the Australian Centre for Agricultural Research but the second author is from IRRI; therefore it is not an entirely external evaluation.

The primary purpose of this evaluation was to asses changes that STAR had brought about at all levels along the research-to-impact pathway; the analysis was therefore done using an impact pathway framework and documented both intended and unplanned but real outcomes (for example capacity building) and initial impacts. It is a broad largely qualitative assessment, though it does attempt a benefit-cost analysis. The economic assessment focused on China but the evaluators also visited the Philippines. No primary data were collected for the study; rather, expert assessments based on existing information were used. The study also used "Extrapolation Domain Analysis' (EDA), a methodology developed by a Phase I Andes project. EDA combines several existing spatial analysis techniques to identify areas suitable for implementing specific ecosystem management practices (Rubiano and Soto 2009). The CPWF funding plus partner contributions approximated $1.6 million. Using "conservative" expert-based judgments, the study concludes that STAR has a very high BCR (11:1) overall; and in China an even higher BCR (21:1) and a NPV of $37million for 30 years. However, the evaluators recognize that this *ex-ante* IA is based on many assumptions and recommends a follow-up IA after five years – including quantification of the capacity building benefits. We would add inclusion of environmental impacts as well. We return to other IAs of related aerobic rice research projects in section 5.5 below.

Managing the interface of fresh and saline water

The Water and Land Management at the Interface between Fresh and Saline Water Environments Project was also implemented by IRRI, with other CGIAR as well as national partners. Although implemented in two countries, the IA focused on Vietnam (McDonald 2011). In Vietnam, this project built on previous projects including a transitional project funded by the CA. Overall, the study tried to

[16] See https://sites.google.com/a/cpwf.info/phase1/phase-1-projects-overview/impact-assessment-of-research-in-the-cpwf-a-basin-focal-project, accessed 5 July 2014. The reference to "the 32 CPWF First Call Projects" refers to those that were funded fairly early in Phase I; some of the others were funded later as funding became available.

identify what the CPWF project contributed to reducing poverty and food insecurity in the Mekong Delta. The study was commissioned by the CPWF from an independent consultant. It focused on the actual impact pathway followed by the project to arrive at a "realistic evaluation" interpretation. The methodology was entirely qualitative, using MSC and other stories, interviews, workshops with project staff, and document analysis methodologies. No primary data were collected, and although the TOR mentions trying to quantify impacts, this was not attempted as the evaluator, perhaps correctly, felt it was premature. The study cost is given as $679,000, but it is not clear if this is the cost of the entire project or the Vietnam portion only; and the study refers to other unquantified inputs.

McDonald (2011) offers a plausible explanation of the outcomes and incipient impacts attributable to the project and reasons for its success – up to a point. There is no reference to the IA conducted by Wichelns et al. (2010) of IWMI's modeling work, discussed above. One of the three outputs of the project – an improved Vietnamese River Systems and Plains model to manage the fresh and saltwater interface – is precisely the innovation Wichelns et al. evaluate. McDonald (2011) does not clearly discuss the roles of the participating CGIAR centers, IRRI (the lead), IWMI and WorldFish. These gaps limit its usefulness. This project is a potential IPG in the sense that its experiences are relevant to other large deltas in Asia (e.g. in Bangladesh and Myanmar). It may therefore be useful to carry out a proper epIA now that more time has passed since the project was completed.

SCALES

The "Sustaining Collective Action Linking Economic and Ecological Scales in Upper Watersheds" (SCALES) project was implemented through CIAT in the Andes and the Nile River Basin. Córdoba and White (2011) evaluate the collective action mechanism, *Conversatorio of Acción Ciudadana*, used to promote civil society participation in public policy decisions in one watershed in Colombia. This evaluation was carried out by CIAT researchers; it is not externally commissioned. Indeed it is not strictly speaking an IA; and the project was in essence a watershed management project. The study attempts to evaluate the credibility of a previously-published MSC story using qualitative data, such as interviews, social network analysis, and participatory videos. The use of social network analysis is a strength; but the authors note there was no baseline network analysis to compare before and after. Using participatory video is also a useful innovation. In the end, the authors conclude that all the outcomes anticipated in the impact pathway were achieved. The study is sympathetic and uncritical, perhaps because colleagues implemented the project. More important, part of its intention was to assess whether the collective action mechanism used is an IPG. The authors conclude that it is but their reasons are not convincing: *Conversatorio of Acción Ciudadana* seems to be very specific to Colombian conditions. This project could be a candidate for a future epIA; however, since it is not a clear IPG we would not recommend investing in an epIA.

MUS

The "Models for Implementing Multiple-Use Water Supply Systems for Enhanced Land and Water Productivity, Rural Livelihoods and Gender Equity" (MUS) Project was implemented by IWMI in collaboration with IRC International Water and Sanitation Centre and other partners. The basic premise is that by designing rural water supply systems to meet the full range of people's water needs, the schemes will be more sustainable and make far greater contributions to their well-being than schemes designed for a single use such as irrigation only, or domestic water supply only. As it evolved, the project developed, and in pilot study countries tested, ideas involving participatory methodologies, the use of learning alliances, the "learning wheel" and diverse partnerships. The project was transformed from an applied research project to an advocacy project that used applied research as one of its strategies. It worked at multiple levels ranging from small rural communities in eight countries to national policy levels, to using international forums for promotion of their ideas. At

the end of the CPWF project, the partners formed an active MUS network (http://www.musgroup.net/), attracted new partners and support for its work, and have made considerable intellectual progress, especially related to the institutional reforms necessary for rapidly scaling MUS up and out (e.g. van Koppen et al. 2014).

The evaluation of the MUS Project was the first of the four commissioned, and was the only IA that attempted to evaluate the entire project (Merrey and Sibanda 2008)[17]. National consultants were engaged in four implementation countries which had produced MSC stories (Colombia, South Africa, Thailand, Zimbabwe). The consultants carried out informal and semi-structured interviews following a format provided to them and held workshops in three of the four countries. A separate consultant attempted an *ex-ante* benefit-cost analysis, using many rather heroic assumptions. Nevertheless, this was not a normal end-of-project impact evaluation; rather it was an attempt to understand the innovative approach to project implementation, the results, and lessons learned. The evaluation attempted to create a plausible account of changes (outcomes) that had occurred as the result of the project. The methodology was very transparent in terms of holding the three country workshops to discuss preliminary findings and get feedback, and the draft report was shared with the project leaders for further feedback.

The evaluation presents evidence that the Project had indeed contributed significantly to creating awareness, knowledge and interest, and in some cases implementation skills in the countries where it worked. This was attributed to the project's implementation based on its own theory of change (creation of "learning alliances" and use of a conceptual model for learning and sharing and reinforcing new knowledge [the "learning wheel"]). The authors offered a number of very specific recommendations for the future; and this evaluation was the only one that commented on the impact of CPWF management. Further, building on a previous benefit-cost analysis of MUS schemes, the report attempts an *ex-ante* IA in the five river basins where the project worked (but excluding potential global benefits).The total CPWF project investment was $1.6 million; the study does not provide specifics on other contributions. The economic analysis arrives at a NPV after 10 years of $226.5 million and a benefit-cost ratio of 2.68 in the five basins analyzed. This evaluation, combined with the documentation that has continued through the MUS network, provides a foundation for a future IA.

Van Koppen et al. (2014) provide an update on the current status of MUS investments. It explicitly links MUS to the current strong interest in local and community driven development programs, noting that when this is done, water services is by far the most common priority. It claims there are now over 200 cases of MUS implementation, some very substantial (for example the Mahatma Gandhi National Rural Employment Guarantee Scheme in India). Although the authors claim it is "premature" to carry out an IA on MUS investments, we would argue that it is not premature to carry out a combined *ex-ante* and *ex-post facto* IA of the CPWF project.

5.3.3 Lessons and implications of the CPWF for future impact assessments

All four of the project evaluations discussed in the previous subsection are largely focused on understanding the processes by which the research projects contributed to achieving desirable outcomes and ultimately impacts. They are therefore not conventional research impact

[17] Disclosure: This author was the first author of this assessment. He had also been involved in the design and early implementation of the project when he was Director for Africa at IWMI, and has remained informally associated with the subsequent MUS activities since then. The report was never published by CPWF because of time constraints of the lead author; but it is referred to in several CPWF reviews including Woolley and Douthwaite (2011) and chapter six in Harrington and Fisher (2014).

assessments; indeed in all four cases it would have been premature to attempt to measure *ex-post* impacts. There is evidence that two of these projects have possibly contributed to achieving substantial food security or poverty reduction (STAR and MUS) and are clear IPGs. The project on managing the fresh-saline water interface may also be an IPG with potential for larger impacts. The Colombia collective action component of the SCALES project seems to be site specific, though there may be broad lessons for research aimed at strengthening collective management of watersheds.

Similarly, other CPWF publications have emphasized learning lessons from applied research that addresses environmental, poverty and food security issues in complex agro-ecological and river basin contexts. Examples are the MSC publications (Harrington et al. 2008; de Leon, Douthwaite and Alvarez 2009). This theme has continued in the recent external evaluation of Phase II of the CPWF program (Hall, Bullock and Adolph 2014) and a recent meta-analysis of the lessons learned written largely by program participants (Harrington and Fisher, eds. 2014). Both are explicitly aimed at capturing lessons from the CPWF experience and using these to influence future NRM research programs, especially the Water Land and Ecosystems CRP. Chapter 6 in the edited volume (Johnson, Swallow and Meinzen-Dick 2014) is the only section that attempts to systematically analyze CPWF outcomes, with a special emphasis on institutional research. The authors analyze a subset of refereed journal articles on water management institutions; included in the analysis is an assessment of the average impact factor of the journals, number of citations, etc. They conclude that CPWF publications have had a substantial impact in the short (5.2 years) period covered.

We conclude this discussion of the CPWF with two observations. First, the current trend is towards carrying out water management research in the context of complex agro-ecological systems, involving multiple CGIAR and non-CGIAR partners, and with explicit expectations that the research will achieve substantial outcomes leading ultimately to contributions to the four CGIAR System Level Outcomes. The CPWF offers important evidence, tools and guidance on how to design such programs – including how to design for achieving outcomes, monitor for learning lessons, and assess what kinds of changes can be attributed to the research. Research for development programs must be designed and implemented in ways that include *ex-ante* IAs and make future *ex-post* IAs possible. This conclusion assumes that such complex programs aimed at increasing the productivity and sustainability of agro-ecosystems and improving the wellbeing of people depending on these systems will indeed have the expected substantial long-term positive impacts. Since new CRPs such as the Water Land and Ecosystems Program build on the CPWF experience and are based on this assumption, it is critical to plan for impact assessments from the beginning and invest in the monitoring and documentation of lessons needed to assessment impacts.

Second, the CPWF constitutes a substantial investment in water management research – some $120 million. However, the emphasis on learning lessons notwithstanding, the program under-invested in collecting data for monitoring and assessing progress towards outcomes and impacts, and under-invested in project impact assessments. In view of the claim that the CPWF is an important source of lessons for future CGIAR research, it seems critically important to carry out systematic epIAs over the next few years. We return to this topic below in section 6.

5.4 Rice Wheat Consortium (CIMMYT)

The Rice Wheat Consortium (RWC) for the Indo-Gangetic Plains[18] was an eco-regional NRM research program implemented in the irrigated plains of northern India and Pakistan, southern Nepal, and

[18] This program won the King Baudouin Science Award of the CGIAR in 2004; see: http://www.cimmyt.org/en/news-and-updates/item/the-rice-wheat-consortium-wins-prestigious-science-prize, accessed 10 July 2014.

parts of Bangladesh, where a wheat crop is sown immediately after harvesting the rice crop. The program, implemented from 1999 to about 2007, was led by CIMMYT but included other CGIAR centers (IRRI, ICRISAT, CIP, IWMI) as well as multiple national partners. Although many issues were addressed by the program, the most important and widely adopted innovation proved to be the spread of a locally designed tractor-drawn seed drill that enabled farmers to sow wheat without tilling the soil – hence "zero tillage" (ZT) as the short term to refer to the innovation. This work built on previous research and development of the seed drill; CIMMYT's role was to catalyze partnerships among the various partners including private firms. There was strong institutional support, especially in northwest India, where ZT has had the greatest impact. The roles of the other CGIAR centers are not discussed in any of the available impact assessment studies –perhaps they had no role in ZT dissemination.

There are quite a few studies of the economic and environmental impacts of the adoption of ZT, especially in northwest India and northern Pakistan (Erenstein, Malik and Singh 2007; Erenstein et al. 2007; Farooq, Sharif and Erenstein 2007; Erenstein and Laxmi 2008; Erenstein 2009a, 2009b; and Pal, Sekar and Kar 2010 [this study was commissioned by SPIA from the Indian Agricultural Research Institute in New Delhi]). Two studies are *ex-post* impact assessments of the research investment: Laxmi, Erenstein and Gupta (2007), a study commissioned by SPIA, and Erenstein and Laxmi (2010), a journal article that focuses on diverging counterfactual scenarios. Erenstein (2009c) is a methodological study on technology specification effects in farm surveys. All but one of these studies were done by program researchers.

The studies used multiple methods including focus group discussions, farm surveys and official data on uptake and impacts. Zero tillage of wheat following harvesting of the rice crop saves land preparation costs and water, often leads to higher wheat yields because of timely sowing and more efficient use of inputs, and in some cases reduces weeds. It therefore increases farmers' profitability through both yield increases and cost reductions. The various studies arrive at differing numbers in terms of cost saving, profitability, and adoption levels, with Haryana farmers having the highest adoption rates and benefits; but study results are all consistently positive (though there is also quite a bit of dis-adoption and partial adoption). Differences among regions generally reflect differences in institutional and policy support. There is evidence for positive environmental results in terms of reduced groundwater extraction and reduced CO_2 emissions (Pal, Sekar and Kar 2010), though more rigorous studies are needed to confirm these results. Further, these benefits will remain limited as long as conventional tillage continues for rice and other crops.

Laxmi, Erenstein and Gupta (2007) is an *ex-post* assessment of the impacts and returns on the research and development investment in ZT that draws on previous reports and studies (including sample surveys reported in other studies referenced here), focus group discussions in adopting villages with adopters, non-adopters, and dis-adopters, and modeling of welfare impacts. Its use of multiple methodologies and its transparency about assumptions and limitations are strengths of the study. The focus group discussions confirmed the findings from other studies and surveys. The papers by Erenstein and Laxmi (2010) and Erenstein (2009c) address specific methodological issues in more detail and therefore complement the original study. The studies could only make "reasonable assumptions" about the counterfactual. The authors assume that with no CIMMYT-RWC there would have been a five-year lag time for adoption—they consider this a "conservative lower bound". On attribution, they therefore attribute this five year gain to the efforts of the RWC and CIMMYT with no further attribution to consortium partners.

They conclude the zero tillage (and reduced tillage [RT], an option adopted by some farmers) research program has been highly beneficial, with a benefit cost ratio of 39, a net present value of $94 million and an IRR of 57 percent. Using more optimistic scenarios that assume ZT induces a 10

percent yield gain and 10 percent cost savings (with reduced tillage at half these values), the NPV goes to $164 million, the benefit-cost ratio to 68, and the IRR to 66 percent. Therefore they conclude the modest investment in research has produced very high welfare gains[19]. The Erenstein and Laxmi (2010) and Erenstein (2009c) studies test the robustness of these benefits with various counterfactual and cost-yield assumptions, and alternative definitions of the innovation, and confirm the highly positive results. In the focus group discussions some social differences emerged, for example laborers perceived there will be less demand for their services. Although ZT is in principle scale-neutral, it is likely that adoption will vary among farm sizes. Further work on the social impacts of ZT would be useful.

Laxmi, Erenstein and Gupta (2007) do not include environmental and social impacts due, they say, to lack of data. Pal, Sekar and Kar (2010) partially fill this gap in an environmental IA commissioned by SPIA; this case is also discussed by Bennett (2011). The study considers environmental impacts both in terms of farm profitability and off-farm impacts of greenhouse gas (GHG) emissions through lower tractor use. The study surveyed 66 farmers and asked about their willingness to pay for (unspecified) water savings; the average was Rs 7,100 (US$ 142). This study is undoubtedly a good foundation for further environmental IA work; as other studies note, the potential for substantial environmental benefits will be achieved only when conservation agriculture practices are used throughout the year.

Although these studies are very useful IAs, there are other issues of concern. For example, they provide very little information on the impact pathways, and do not clearly delineate the roles and value added of other partners (especially other CGIAR centers), if any. RWC and CIMMYT seem to be interchangeable – no distinction is made. Previous research investments –including the actual development of the original seed drill, which has a long history beginning in Australia – are treated as sunk costs. Another issue is that ZT was not the only topic researched by the RWC; therefore this is really an impact assessment of zero tillage and not the program. The assumptions made on allocation of RWC costs to ZT discussed in the Appendix of Laxmi, Erenstein and Gupta (2007) also suggest this is an assessment of the returns on the investment in ZT, not the returns on the entire RWC program. If it turned out that ZT was the only significant innovation adopted from the RWC research program, the benefit-cost ratio of the program would be reduced (though likely would remain positive). Now that about seven years have passed since the RWC program finished, it may be timely to do *an ex-post* impact assessment of the entire program as well as ZT.

5.5 Irrigated Rice Research Consortium (IRRI)

The Irrigated Rice Research Consortium (IRRC), like the RWC, was a long-term eco-regional program. It was led by IRRI and continued over a 15 year period, funded largely by one donor (Swiss Development Corporation) over four phases. It was intended to provide a platform to facilitate identification, development, dissemination and adoption of NRM technologies suitable for rice-based ecosystems in participating Asian countries. It was a partnership of NARES with IRRI scientists. Working Groups were formed to address several potential innovations such as direct seeded rice, integrated pest and rodent management, post-production technologies, and nutrient management. A Water Savings Group worked on two innovations specifically related to water management: aerobic rice and alternative wetting and drying (AWD).

The study by Rejesus, Martin and Gypmantasiri (2013) is a detailed "meta-analysis" of IRRC published by IRRI; Rejesus, Martin and Gypmantasiri (2014) is a published journal article summarizing the

[19] The entire RWC Program involved a total investment of $11.5 million from 1994 to 2007. The specific RWC [CGIAR] investment was $2.9 million; and CIMMYT apparently contributed an additional $600,000 over a 12 year period.

results and emphasizing the lessons from the IRRC experience for other NRM research programs. The objectives of the meta-analysis were 1) to determine the multidimensional impacts of the technologies developed and/ or disseminated by IRRC; and 2) document the pathways and mechanisms that led to their successful adoption. The multiple dimensions included economic, sociocultural, environmental, policy, scientific and institutional dimensions. As a "meta-analysis", the study largely relied on existing documents and studies, easily accessed data, and short field visits. For water management specifically, the study also drew on the following studies: aerobic rice adoption in China and the Philippines (Flor 2007, Ding et al. 2010, Templeton and Bayot 2011 [cited above under CPWF]); AWD adoption in Bangladesh (Kürschner et al. 2010); AWD adoption in Central Luzon, Philippines (Rejsesus et al. 2011); and AWD adoption in Vietnam (Diangkanay-Quicho 2013).

Overall, Rejesus, Martin and Gypmantasiri (2013) conclude that there were a wide range of positive impacts of the program at all levels; they commend the "consortium" model and document very positive economic returns and high benefit-cost ratios even within the project period. They analyze in detail the actual impact pathways through which the IRRC partners achieved these impressive outcomes and impacts. These were developed *ex-post facto* by the evaluators for each Working Group in the relevant countries; learning alliances or impact platforms played critical roles in dissemination.

The authors review the various impact assessment studies done in some detail (referenced above), identifying important methodological issues while also making recommendations for strengthening them. An important programmatic recommendation is in future to include an IA specialist from the beginning of the project for better monitoring of uptake. Methodological issues characterizing the program IA studies include: need to investigate heterogeneity of impacts (for example gender, small and large farmers) rather than focusing only on "average" farmers; use of more rigorous counterfactual frameworks to account for selection problems; more serious investment of time and resources to estimate adoption numbers; and the need for future studies to examine poverty impacts. Overall, the authors strongly recommend future use of more modern IA methodologies, i.e. going beyond the traditional types of analysis. Similarly, they recommend use of more sophisticated qualitative methodologies such as network analysis to achieve a better understanding of impact pathways and how the interventions affect various social categories. The evidence on environmental impacts was judged to be "thin"; this dimension needs more work in the future.

The total investment in the program was $18.5 million from 1997 to 2012. The allocation to the "Water Savings Work Group" was $2.1 million. The study attempts an overall epIA for the program period (1997-2012) and extends this four more years into the future (2013-2016). Even within the program period and using conservative assumptions, the overall returns on the IRRC research investment are very positive. Overall, among all the technologies promoted by IRRC, the highest returns to research investments were from AWD; the returns on aerobic rice were lower and even negative in the Philippines. An attempt to assess the poverty impacts of selected technologies including AWD using a "case study" approach found that incomes improved but not enough to raise people above the poverty line. Because many of the technologies had been developed through research that preceded IRRC, attribution is difficult. This applies to both AWD and aerobic rice; apparently these are treated as sunk costs.

Rejesus, Martin and Gypmantasiri (2014) emphasize IRRC's lessons for other NRM programs: "fostering partnerships, collaborations, and cross-country learning; involving social scientists for monitoring, evaluation, and impact assessment; and, having long-term support and involvement of donors." Overall, this program IA is especially useful and valuable. Unlike RWC, IRRC invested in a proper *ex-ante* multi-dimensional analysis of the program, the lessons learned, and the outcomes and impacts achieved to date as well as likely to be achieved in the near future. It might have been

strengthened if there had been a separate survey but this would have been an expensive and time consuming exercise. It reflects more methodological sophistication than most of the IAs reviewed in this study. It is thus a model for designing future program impact assessments. Follow-up epIAs of the program and/or its major innovations, especially AWD and aerobic rice, would be good investments.

5.6 ILRI (Broad Bed Maker)

A broad bed maker (BBM) was designed and disseminated as part of a technical package aimed at enabling vertisol soil farmers in Ethiopia to go from one to two crops per year, thereby increasing their incomes. It is essentially a land and water management technology. It was introduced in the early 1990s under the Joint Vertisol Project in which ILRI was a partner. Other parts of the package included improved seeds, fertilizer, pesticides, and training. Over the years, the government continued to invest in extension and training, and the BBM itself as well as the elements of the technical package have been modified. ILRI commissioned two separate impact assessments of the BBM and the investment in research and extension, in 2001 and 2008, but led by the same consultant (Rutherford, Odero and Kruska 2001; Rutherford 2008). Using 1998 data, Rutherford, Odero and Kruska (2001) assessed the impact of the BBM technical package and estimated its welfare benefits. These were disappointing as the high costs made the package risky, and training was not adequate. They found the costs of research and extension exceeded the benefits but predicted these would turn positive by 2005. Rutherford (2008), using data from a smaller sample survey than had been done earlier, confirms modestly positive returns over 23 years, using economic surplus methodology. Nevertheless, nationally adoption remains far below potential: 100,000 farmers on 63,000 ha as of 2008. Recent innovations have enhanced the value of the package, and the government has ambitious expansion plans. On the other hand the study found little spontaneous adoption, and identified numerous constraints to wider adoption that must be addressed.

The earlier report describes the IA methodology in some detail; this is not the case in the 2008 study. A strength of the study is its attention to policy and implementation processes, though it does not use impact pathway terminology. Overall, the study uses standard economic IA methodologies, not more recent ones that could perhaps more precisely capture the differential impacts among different categories of farmers.

5.7 WorldFish (integrated agriculture-aquaculture systems)

"Irrigation and water management" was initially defined somewhat narrowly, as technologies and practices that bring water to the root zone of crops. Initially, this led to the exclusion of work done by WorldFish on integrated agriculture-aquaculture (IAA) systems. This exclusion is similar to the exclusion of watersheds, but as the study proceeded, and WorldFish shared some of its work on IAAs, it became clear that this work constitutes a very important contribution to water management research. WorldFish shared several excellent assessments of the impacts of adoption of IAA in Bangladesh and Malawi (e.g. Dey et al. 2010, 2013; Murshed-e-Jahan and Pemsl 2011; Antle, Murshed-e-Jahan and Crissman 2013). Dey et al. (2010) analyze the impacts of adoption of IAA in Malawi, based on a sample survey in 2004. Dey et al. (2013) examine the potential of various rice-fish combination systems in Bangladesh, while Murshed-e-Jahan and Pemsl (2011) analyze the impacts of a long-term training program using data from surveys in 2002/3 and 2005/6. Both studies find significant positive impacts on farmers' technical efficiency, total factor production and net incomes, leading to higher food consumption and better nutrition. Antle, Murshed-e-Jahan and Crissman (2013), a study supported by SPIA, builds on previous Bangladesh papers and tests new

methodologies for predicting *ex-ante* and assessing *ex-post* impacts in complex systems. They use a simulation modeling based approach to overcome the limitations of normal with-without, before-after average treatment types of IAs. The results confirm the efficacy and value-added of this approach as well as confirming the positive impacts of the IAA project.

These are useful and methodologically sophisticated assessments of the impacts of IAA interventions. They do not go the extra step and analyze the returns to the investments in IAA research, but they provide important foundations and methodological guidance for such studies in the future.

5.8 Other Centers

When the SPIA Chair contacted CGIAR centers and leaders of CRPs about this study, we anticipated there would be at least some water management research IAs available from other centers, including ICARDA, ICRISAT, CIAT, Africa Rice, and the World Agroforestry Center. ICARDA and ICRISAT did send a few assessments of the impacts of technologies on which they had worked. The ICARDA cases are listed in Appendix 2. Both ICARDA and ICRISAT have important long-standing research programs on irrigation and water management, especially water harvesting. But apparently neither Center has carried out IAs of their water management research investments (noting here that we excluded watershed management). CIAT responded that after searching, it had not yet done any IAs of its water management research. Africa Rice sent numerous reports related to the long-standing (since 1993) Inland Valley Consortium (IVC), an agro-ecological program in West Africa led by Africa Rice that has a significant water management focus. Donors have continued to support projects on management of rice-based inland valley ecosystems but apparently no research impact assessments have ever been done. This is surprising considering the large investments in the program and is in contrast to the two other agro-ecological programs reviewed, RWC and IRRC. The World Agroforestry Center did not respond; but it too has a record of supporting research on water harvesting.

6. Conclusions and Recommendations for Future Impact Assessments of Irrigation and Water Management Research

The next subsection presents the major conclusions emerging from the review of irrigation and water management research impact assessments. This is followed by a discussion of programs and projects that are potential candidates for future impact assessments. The final subsection offers other recommendations for designing research programs in ways that will facilitate future assessments of their outcomes and impacts. Taken together, these sections respond explicitly to the four objectives of the study.

6.1 Major conclusions on water management research impact assessments to date

6.1.1 Estimated investment in irrigation and water management research

The TOR asked for an "estimate of the total investment in irrigation and water management research and related activities since 1990". This has proven to be the most difficult issue to address, and we have not succeeded in obtaining sufficient data to provide a reasonable estimate. All figures here are in nominal terms. Table 4 offers a provisional total of $657.36 million, surely an under-estimate. The total IWMI investment since 1990 is about $456 million; extending back to its founding in 1984 would give a figure just under $500 million. SPIA's $800 million figure is therefore probably a reasonable approximate estimate for the entire CGIAR investment in irrigation and water management research since 1991.

6.1.2 Review of completed impact assessments and estimated impacts

The second study objective asked for a review of what the CGIAR and others have done in assessing the impact or influence of CGIAR research and related activities in irrigation and water management, while the third objective asks for a summary of the estimated economic, social and environmental impacts or influence documented by those IA studies deemed reasonably credible whether in quantitative or qualitative terms. The study has reviewed available IAs in detail in the previous sections with these objectives in mind; here we attempt to summarize the major conclusions emerging from the reviews.

The most important conclusion that emerges from this survey is that the CGIAR has seriously under-invested in both ex-ante and ex-post economic, social and environmental impact assessments of its work on irrigation and water management. This statement applies across the board, with only a few partial exceptions. This study has reviewed a number of excellent and credible assessments of impacts of specific innovations. Examples are zero tillage in northern India, aerobic rice, and alternate wetting and drying of rice. However, there are very few credible methodologically sophisticated economic impact assessments of water management *researc*h, and none of the environmental or social impacts of this research. Looking at the major water management-related research programs, we found only one whose outputs, outcomes and impacts have been assessed in a comprehensive and credible manner – the Irrigated Rice Research Consortium.

IWMI is the lead institution for irrigation and water management research in the CGIAR. Surprisingly, while it has commissioned external reviews of programs (for example gender and the IWMI-TATA Program in India) in order to obtain strategic guidance, IWMI has never commissioned or carried out impact and benefit-cost assessments of any of its major research programs with one partial exception: its work on irrigation management transfer (IMT). That study was an assessment of the influence of its research and support programs on IMT carried out by its own staff. It did not attempt to quantify the impacts and value-added of IMT research – this might have been an impossible task given that no systematic monitoring data had been collected during the program period; and it did not even attempt a quantitative assessment of the quality of its publications on the topic. IWMI researchers did publish an important paper on the impacts of its recommendations to the Government of Gujarat on addressing the over-pumping of groundwater by reforming its electricity policies. A few IAs were carried out by its own researchers of relatively small programs which at best are limited IPGs (agro-ecological management for malaria control, gate operations to manage salinity, soil remediation). Given IWMI's substantial investments of about $456 million on water management research since 1991 (and nearly $500 million in nominal terms since its founding in 1984), the paucity of attempts to document the returns on this investment is a serious gap. We return to this in section 6.2 where other candidates for IAs are discussed.

To its credit, IFPRI commissioned a critical meta-analysis of the outputs, outcomes, quality and influence of its water management research program implemented from 1994 to 2010. This program constituted an investment of approximately $12.5 million. This review came to positive conclusions on all the criteria used except for the evidence that IFPRI's work has had discernible influence on policies in the countries where it has worked. But this study is not a full *ex-post* impact assessment: it does not attempt to quantify the social and economic returns on the investment or the environmental impacts of IFPRI's water work. Admittedly, because of the true IPG nature of the research outputs, such an assessment would be difficult. In principle, it would be possible to assess the impact of IFPRI's work at the level of the countries where it ran projects (Ghana, India, Vietnam), but these projects may not be sufficiently large to justify the cost of the IA.

Two major long-term agro-ecological programs, the Rice-Wheat Consortium (RWC) led by CIMMYT and the Irrigated Rice Research Consortium (IRRC) led by IRRI have invested in impact assessment studies. However, RWC's impact studies, implemented largely by its own researchers, have focused on the returns to one innovation, the adaptation and adoption of a tractor-drawn seed drill that enables zero or reduced tillage of wheat immediately following the rice harvest in northern South Asia. While this work is useful and credible, it does not reflect an attempt to assess the impacts and returns on the overall RWC investment of some $11.5 million over about 13 years. In contrast, the IRRI-led IRRC program has invested in assessing the impacts of its water management technologies and management practices (aerobic rice, alternate wetting and drying). IRRI has also commissioned a meta-analysis of the overall program, its outputs and impacts, and an *ex-post* and *ex-ante* analysis of the returns on this investment ($18.5 million over about 15 years). This meta-analysis by Rejesus, Martin and Gypmantasiri (2013, 2014) is quite comprehensive, critical and credible. Both the RWC and IRRC studies provide the foundation for carrying out thorough comprehensive epIAs in the near future.

ICRISAT, ICARDA the World Agroforestry Center, and to some extent CIAT have historically carried out water management research. Some but not all of this work has been focused on watershed management, which was excluded from this study. But these institutions have also worked on such topics as rainwater harvesting technologies and supplementary irrigation. While ICARDA and ICRISAT were able to provide studies of the economic and environmental impacts of specific water management technology or management interventions, they have apparently never carried out any

impact studies of their investments in water management research. WorldFish has implemented important research programs on integrated agriculture-aquaculture (IAA) systems in Asia and Africa. It too has carried out useful studies of the impacts of farmers' adopting IAA practices; and a study supported by SPIA breaks new ground methodologically in assessing systemic impacts (Antle, Murshed-e-Jahan and Crissman 2013). However, these studies do not take the extra step of assessing the returns on the research investments. ILRI has carried out two IAs of work it did some years ago on a broad bed maker for vertisol soils in Ethiopia. ILRI did not respond to the SPIA Chair's message; as a result we are missing work it has done on livestock water productivity (e.g. Peden, Taddesse and Haileslassie 2009). This work was initially supported by the Challenge Program on Water and Food (CPWF) and was implemented in collaboration with IWMI.

The total CPWF investment was roughly $120 million over about ten years, most of which went to CGIAR centers. Almost from the beginning, the CPWF attempted to be innovative in its approach to project and program design for impact, and in using various tools to capture lessons learned, significant outcomes, and emerging impacts. Its contributions are in ways to design applied R4D programs for achieving specific outcomes tied to longer term impacts on food security, poverty and the environment. We return to this in subsection 6.3 below. The CPWF commissioned impact assessments of just four of the 50-70 projects (depending on how one counts) implemented in Phase I. Only two of these analyzed the entire project and attempted an *ex-ante* assessment of the returns on the investment (based on multiple assumptions). None are *ex-post* IAs. Therefore, we have no credible basis to judge the impacts and returns on the Phase I investments of the CPWF or of its project portfolio. The second phase was completed only at the end of 2013. A qualitative external evaluation focused on lessons for the future has been carried out, and the Program has just published a book that attempts to capture the lessons learned from the program. Although it is premature for an *ex-post* IA of the entire CPWF, epIAs of specific Phase I projects ought to be done. It would also be possible to do an *ex-ante* assessment of the entire program (and especially Phase II), followed at a later date by an *ex-post* IA, as discussed in subsection 6.2.

Finally, it should be noted that CPWF was designed to be a 15-year program in three phases. However, it was cut short at the end of Phase II, and indeed its funding was reduced before Phase II had been completed. If the planned Phase III had been implemented, it is likely the program would have focused on carrying its promising Phase II outcomes forward and attempt to scale them out and up. RWC and IRRC are two programs that continued for sufficient time to demonstrate real impacts; CPWF did not continue for enough time to achieve its potential[20].

The third study objective was to attempt a summary of the estimated economic, social, and environmental impacts or influence documented by the IAs that is reasonably credible. Given an investment in the range of $800 million in water management research since 1991, what can we say about the overall influence, outcomes and impacts of this work? Unfortunately, there is no definitive answer. There is clear evidence that the RWC and IRRC eco-regional programs and WorldFish's IAA work, taken together, have had positive impacts on food security, incomes and livelihoods of millions of Asian farmers (as well as contributing to the scientific literature). There is evidence that IWMI's and IFPRI's work on policy and institutional issues have contributed substantially to the scientific literature, and there is evidence that some of IWMI's work (especially IWMI's work on IMT and the

[20] This author was involved with the Nile Basin Development Challenge, and as the program was ending, the Ministry accepted the program's recommendations for changing how the Ethiopian government's sustainable land management program is implemented. Two State Ministers invited the research team to work with the Ministry in implementing the recommendations. However, this has not been possible, at least not on a scale that makes a difference. This is a lost opportunity. The lack of continuity and commitment hampers the CGIAR in achieving real impacts, in the experience of this author.

groundwater-electricity nexus in Gujarat, India) has influenced government policies; but there is very little evidence as to what the impacts might have been or the value of these impacts compared to the research investment (early IWMI studies on the impacts of IMT found mixed and at best modest impacts). There is anecdotal evidence that the CPWF may have had substantial influence on the policy and research agenda as well. However, there is too much missing data to come to any conclusion. For example, both IWMI and IFPRI (and others) have contributed substantially to raising awareness, influencing the policy agendas, and, very important but undocumented, building capacity.

6.1.3 Concluding remarks

In addition to the paucity of assessments of aggregate impacts, a weakness common to nearly all the water management IAs examined is their lack of attention to differential impacts on various categories of farmers, consumers and other stakeholders, and on larger eco-systems. None of the water management research IAs refers explicitly to the contribution of the research to the CGIAR SLOs, and none clearly measures impacts on poverty, equity, gender, or ecosystems. Several studies, for example the meta-analysis of IRRC, note the lack of data available to disaggregate impacts on women and men, small and large farmers, and landless people. The impacts on other stakeholders such as consumers are completely ignored. Further, as attention shifts to landscapes and agro-ecological systems, it becomes critically important to examine the impacts of research-based innovations on those at different locations within ecosystems, river basins or watersheds, and differentiate farm-level impacts from system-level impacts. The research on the different meanings of water productivity at different system scales is an example of this insight —which has not been addressed in most water management research IAs. Documenting and measuring ecosystem systemic trends will also be critical.

Similarly, there are too few environmental impact assessments of water management research. Exceptions include the IWMI study of the impact of changing gate operations in the Mekong Delta on flora and fauna, and the impact of ZT on groundwater and GHGs in northern India, though these are limited in scope. Water management is an environmental intervention; the CGIAR therefore needs to be able to assure its stakeholders that its research is having positive environmental as well as social impacts – or at least not doing environmental or social harm. Related to this observation, as noted, none of the research IAs explicitly links its findings to the CGIAR System Level Outcomes (SLOs). Only one study asked whether the seemingly positive innovation assessed (AWD in the Philippines) had significantly contributed to the reduction of poverty (it had not).

Finally, most of the credible water management research IAs measure the impact of technologies, management practices, or packages thereof. Examples are ZT, aerobic rice, AWD, gate operational models, and enhancing soils for water retention. There are just three attempts to evaluate the outcomes and influence of IPG water management policy research: the evaluations of IMT, groundwater-electricity nexus in India, and the MUS Project. The latter attempts an *ex-ante* IA of the costs and benefits of the research; the others do not attempt to assess the benefits and costs of the research. The evaluation of IFPRI's water research program may be considered another case, though its main focus is on the science, not its influence on policies. It too does not attempt a benefit-cost analysis. Despite the difficulties, the CGIAR needs to do more to assess the returns on its investments in policies and institutions. Such assessments are inherently difficult and not amenable to standard agricultural economic regression-based tools that seek to demonstrate attribution.

6.2 Gaps: Candidate programs and projects for future evaluation

The fourth study objective asks for "identification of management interventions or policy actions deriving from specific lines of CGIAR irrigation and water management research that appear to warrant serious attention for future adoption and impact assessment studies". This objective is understood to mean two things: identification of programs and projects whose impacts and/ or influence should be assessed; and to provide other recommendations ("management interventions or policy actions") for enhancing the credibility of future IAs. This subsection addresses the first of these two items – candidates for evaluation. It draws both on the work done for this study as reflected in the previous sections, and on the author's knowledge of CGIAR water management research, especially the work done by IWMI.

6.2.1 IWMI

Because IWMI is the leading center for water management research, it seems especially important to gain a better insight into the value added, contributions, outcomes and impacts of its work than we currently have. IWMI likely accounts for at least 60 percent of the total CGIAR irrigation and water management research investment over the past 25 years[21]; and through its management of the Water Land and Ecosystem CRP and its participation in other CRPs addressing water management-related issues, its dominance of water management research may increase. Several candidates are suggested for such an impact assessment. The following suggested candidates are all high priority, but presented here from highest to lower priority:

The *Comprehensive Assessment of Water Management in Agriculture* (CA), approximately 2003-2008.This program was led by IWMI but included many partners and constituted an attempt to synthesize available knowledge on the water and food nexus and provide credible recommendations on future policies and investments. Its work is frequently cited; and it was an important flagship program for IWMI. It was also an important reason for IWMI's winning the Stockholm Water Prize in 2012. However, its impacts and value added have never been formally assessed. The CA built on and consolidated the earlier pioneering work done by IWMI on mapping global water supply and demand, refining the concepts of "irrigation efficiency" and "water accounting" within a river basin systems perspective, and developing and applying the concept of "water productivity". Therefore, an assessment of the CA provides an appropriate context to assess the impacts of this earlier work as well.

The *IWMI-TATA IWMI water policy research program in India*, 2000 to the present. This program is a partnership between IWMI and the Sir Ratan TATA Trust, Mumbai, India. There is evidence that its work has had considerable impact on policies in India; an example is the groundwater-electricity policy nexus studies reviewed above (Shah et al. 2004, 2008). This is a unique partnership that has continued for a long period of time. In early 2014 the program won the 'Water for Life' UN-Water Best Practices Award.[22] A comprehensive IA aimed not only at documenting the influence, impacts and valued added of the project but the impact pathways and lessons learned from its implementation mode would be very useful and may well be of interest to the TATA Trust.
IWMI's regional programs, especially Central Asia (2000 to present) and Africa (2000 to present)[23]. Both programs were launched the same year; and both have developed partnerships with many national, regional, international partners with a dual focus on capacity building and applied research. Given the substantial investments involved, a comprehensive meta-analysis followed by a focused

[21] This is a rough estimate by the author, subject to further analysis. It may be too conservative.
[22] http://www.srtt.org/news/events/IWMI_tata_programme.html.
[23] Disclosure: The author was the first Director for Africa at IWMI and established this program.

ex-post IA would generate insights into the quality, outcomes, and past and potential future impacts of these programs.

IWMI's signature work on *Asian large-scale irrigation,* 1984 to the present. IWMI has had a major focus on improving the performance and management of Asia's large-scale irrigation systems since its inception, and continues this work under WLE. But no assessment has ever been made of the quality, influence and impacts of this work.

The *AgWater Solutions Project*, funded by the Bill and Melinda Gates Foundation, approximately 2009-2012. This project was led by IWMI but also included multiple partners. It was an attempt to generate new insights and water management investment opportunities in Africa and Asia. Its work is frequently cited and both IWMI and FAO have built other work on its results. A formal comprehensive meta-analysis and *ex-ante* IA would be useful now, to provide a foundation for a possible future comprehensive *ex-post* IA.

Other possible though lower priority candidates for epIAs at IWMI include its work on river basin modeling, waste water reuse for irrigation (now called "resource recovery and reuse"), and sustainable agriculture in wetlands. There would undoubtedly be value in carrying out impact assessments of other IWMI projects; but given limitations on resources, concentrating on a few major initiatives such as those suggested above may offer the best returns on the IA investment.

6.2.2 Regional agro-ecological research programs

This study has reviewed the impact assessment work done by the RWC and IRRC. For RWC we have important and credible epIAs of a specific innovation, zero tillage. For IRRC we have IAs of specific interventions (AWD, aerobic rice) as well as a meta-analysis of the program that includes an *ex-ante* and short-term *ex-post* analysis. Both programs are good candidates for full comprehensive *ex-post* impact assessments, as both programs have collected considerable data and carried out sufficient surveys to provide good baselines.

Missing from this discussion is the Inland Valley Consortium (IVC) in West Africa, led by Africa Rice. This program was initiated in 1993 and according to project documents provided by Africa Rice, has continued under other names to date. Inland valleys constitute potentially highly productive rice production areas with good management of water, land and nutrients, and with favorable policies and institutional arrangements. The program (in its various incarnations) is a long-standing one with a significant water management focus; although we do not have figures on the total investment (despite requesting this), it is substantial. Therefore, we strongly recommend that Africa Rice and SPIA consider implementing a comprehensive *ex-post* IA. It should begin with a meta-analysis along the lines of the IRRC assessment, then proceed to a full assessment of its economic, social and environmental impacts as a basis for estimating the returns on the investment.

6.2.3 Other water management programs

ICARDA, ICRISAT, the World Agroforestry Center (which hosts the Southern and Eastern African Rainwater Network) and to some extent CIAT have all carried out substantial research programs over many years on rainwater harvesting technologies and in some cases supplementary irrigation. Yet apparently no impact assessments of the investments in these research programs have been carried out: the representatives of ICARDA, ICRISAT and CIAT confirmed this, while the World

Agroforestry Center did not respond to the SPIA Chair's message[24]. While we have no figures on the dollar value of these research investments, it is likely to be substantial. Therefore, it is recommended that SPIA work with all of these centers to design and carry out a formal epIA of their work on rainwater management, and consider doing a similar study on the work on supplemental irrigation (for example, the work discussed above by ICARDA).

Another good candidate for a full follow-up epIA is the WorldFish-led Integrated Agriculture-Aquaculture (IAA) work in Asia and Africa. This should include the investment in research, and should include the African as well as Asian cases. Studies already carried out by WorldFish in Asia, discussed above, indicate very high returns; and its work constitutes important methodological advances in the assessment of impacts of systemic interventions in ecological systems (in contrast with work on single-dimensional interventions). It is possible the foundation and data already exist to do this study fairly quickly. Such a study could also be a useful test of new methodologies appropriate for assessing impacts of interventions in complex agro-ecosystems.

Finally, as discussed above, the CPWF is a major candidate for future social, economic, and environmental impact assessments, the return on the research investments, and the lessons learned from implementing a large-scale partnership-based eco-regional research program which attempted to promote management and evaluation innovations as part of its implementation process. Sufficient time has passed to carry out epIAs of selected Phase I projects, including but not only three of the four projects which had been evaluated as they were ending (STAR, MUS, managing the fresh-saline water interface). A comprehensive meta-analysis of the quality, influence and outcomes of both phases would also be useful; the latter would provide a foundation for a future epIA of the program.

6.3 Other Recommendations

This subsection includes other observations and recommendations emerging from this study that would enhance the credibility and usefulness of future assessments of outcomes, influence, and impacts of water management research.

6.3.1 Credible evaluations of IPG policy and NRM research?

Credible, convincing evaluations of returns on investments in true IPG policy and natural resource management research are very rare. This is because it is fiendishly difficult – a kind of "wicked problem" – to attribute poverty, food security, environmental or nutritional impacts to specific research outputs. Attribution is nearly impossible because of all the multiple impact pathways, competing, complementary and independent sources of influence other than the research, the complexities of understanding human motivations, and the long time lag between research and impacts. Linear pathways based on simplistic models of human behavior are not adequate. The CGIAR needs to broaden its repertoire of impact assessment tools to include, for example, contribution analysis.

Further, much CGIAR water management research is consumed by other researchers: it adds to a body of scientific knowledge, but the route from publication in scientific journals to actual uptake and application is murky at best. The CGIAR should consider distinguishing more clearly between research that contributes to basic scientific understanding and research that is aimed at achieving specific outcomes (changes in behavior) and impacts (such as poverty reduction). The former

[24] An internet search confirms its long-standing work on rainwater harvesting but did not reveal any impact assessments.

research can be evaluated using normal science procedures (such as peer review and citation analysis) to assess its influence; the latter should be rigorously assessed in terms of impacts and returns on investment.

Another factor affecting the measurement of the impact of policy and NRM including water management research is the time frame used to measure the impact. This is rarely discussed in the IA literature, but the impacts of policy changes or interventions in natural resource systems often continue over decades. While the widespread adoption of an improved crop variety, technology or farm management practice may sometimes occur within a relatively few years, international public good policies such as irrigation management transfer usually play out over decades, as countries experiment, learn lessons, further revise and adapt through additional innovations. At what point should we measure the impacts and come to a conclusion as to the benefits versus costs of a policy or NRM research program? And of course this evolution and transformation over time further complicates attribution, quantification of costs and benefits, and creation of counterfactuals.

This suggests another danger: if the CGIAR's donors were to insist on typical benefit-cost studies such as they are accustomed to for CGI, it may create perverse incentives for Centers to focus their research on easy-to-assess innovations such as improved scheduling of water deliveries, rather than on the complex social-economic-policy issues where measurable impacts, if they occur at all, will be over a long term and difficult to attribute to specific research. There is a strong presumption and some evidence that policy and NRM research are critically important in the agricultural development process; but quantifying the value in concrete objective financial terms is not realistic or possible with current methodologies. This is not an argument for not doing epIAs; on the contrary, more documentation of the adoption of improved research-based water management technologies and the returns on the research investment is needed, in addition to measuring the impacts and benefits of policy and NRM research. It is also a call for investing in further development of benefit-cost analytical methodologies to assess the value added from policy and NRM research; and to conduct more meta-analyses of research programs such as those done for IFPRI's water research and for IRRC.

The CGIAR research paradigm is undergoing a major transformation, from identifying and promoting uptake of single dimensional innovations, to trying to understand complex human-based agro-ecological systems as systems, and to enhance the overall productivity and sustainability of these systems (Sayer and Cassman 2013). This research has adopted participatory integrated interdisciplinary methodologies, such as the R4D model adopted by the CPWF and advocated by others (Hall 2013; Sayer et al. 2013). This transformation raises complex issues regarding assessing impacts and returns on research investments: attribution, counterfactual, and precise measurement of the benefits and their values. *Contra* Walker, Ryan and Kelley (2010, these are not arguments for reducing the investments in policy and NRM research; rather, they are really a call for innovative design and implementation of research programs and of approaches to assessing their impacts and returns on investment.

6.3.2 Ways forward: Designing programs for impact

A major impediment to doing credible epIAs characterizing many of the studies reviewed is that the program or project reviewed was not designed from its earliest stages to facilitate assessing outcomes, influences and impacts. The attempt to assess the impacts of IWMI's work on IMT is a case in point. IRRC on the other hand did attempt to collect the data required for assessing its impacts, though the review notes some gaps such as social, environmental and poverty impacts and adequate quantitative data on adoption (Rejesus, Martin & Gypmantasiri 2013). The CPWF at an early stage of Phase I attempted to "retrofit" its projects with explicit theories of change, outcome

and impact logic models and participatory impact pathway analysis with mixed results. These were explicitly incorporated in its Phase II basin development challenge programs, though not adequately funded and supported.

However, the lesson is clear: requiring major research investment programs to develop a credible theory of change and impact pathway (where appropriate — it may not be for some IPG research) and a plan to monitor processes, lessons, outputs, outcomes and impacts (as they occur and *ex-ante*) will increase the potential to assess the actual impacts and returns on the investment at a future date. The anticipated outcomes and impacts should be explicitly linked to the CGIAR SLOs[25]. This will require ensuring that the program pays close attention to social and environmental impacts, and avoids focusing only on "average" impacts. One implication is that a senior IA specialist should be an integral member of the research team from the beginning and for large programs should be fairly senior. An adequate budget needs to be allocated to make this work and should not be the first item to be cut when budgets are squeezed. Following through with *ex-post* IAs (and environmental IAs) will also be critically important, but these must use methodologies that are appropriate for assessing complex long-term agro-ecological research.

An important corollary is that for programs intended to have developmental outcomes and impacts (i.e. excluding high-level IPG research aimed mainly at contributing to science), it is critical to engage meaningfully with the program stakeholders – partners, consumers, farmers, etc. – from the earliest stages. Research aimed at policy, institutional, management or technological innovation should be driven to a large degree by demand, though 'demand' may be the product of a process of engagement between scientists with new ideas and stakeholders who will have an interest in the results. Maintaining the momentum of stakeholder engagement is not always easy; but using innovation platforms and other means to give stakeholders a strong voice and mixing short and long term returns is possible.

These suggestions are even more critical in landscape or agro-ecological systems research, the emerging paradigm for several CRPs, including Water, Land and Ecosystems. Water management research is no longer a matter of inventing a better gate operating model, water delivery schedule, or institutional arrangement for irrigation scheme operation and maintenance. Water is a resource managed along with other resources as an integral part of complex agro-ecological or river basin systems. How water is managed in upland areas has important impacts downstream. The allocation of costs and benefits of interventions among multiple stakeholders within ecosystems is not straightforward. The focus of NRM including water management research is increasingly on sustainably improving the flow of ecosystem services, rather than raising the productivity of a single crop. This makes the measurement of impacts and value added by research even more complex.

Given these developments, impact assessment methodological innovation becomes critical, a point also made by some of the IAs reviewed in this paper as well as several peer reviewers. The CGIAR will not be able to demonstrate the value added of policy-oriented water management research investments until more effective qualitative as well as quantitative methodologies are developed and widely used. Some of the studies discussed in this paper are important methodological contributions. Examples are Erenstein (2009c) on specification bias; Erenstein and Laxmi (2010) on the robustness of benefits given various counterfactual assumptions; Antle, Murshed-e-Jahan and Crissman (2013) on simulation modeling approaches; and Córdoba and White (2011) on the use of network analysis. More can be done. For example, Rubiano and Soto (2009) offer a methodological guideline for using Geographical Extrapolation Domain Analysis to understand where specific

[25] In his unpublished review of an earlier version of this paper, Jeff Bennett recommended that SPIA commission a short briefing paper on how to do this in practice, a recommendation which this author supports.

innovations may be most relevant as well as for assessing impacts *ex-ante* and *ex-post*. Since "sustainably managed natural resources" is a CGIAR SLO, it seems critical to invest more in methodologies that quantify environmental impacts[26]. "Contribution analysis", discussed above, is another type of methodology that can be applied (Mayne 2008, 2012; Mayne and Stern 2013). SPIA should consider developing a partnership among CGIAR impact assessment scientists and specialists from advanced institutions to identify, develop, test and disseminate more effective impact assessment methodologies.

To conclude, the CGIAR has invested hundreds of millions of dollars in irrigation and water management research over the past 25 or so years; but it has invested far too little in documenting and analyzing the impacts and value-added of this research. Water management research budgets have begun increasing in the last few years. It is therefore critical that the CGIAR be in a position to provide its investors with credible and reasonably representative evidence on the returns to these investments.

[26] For example see Olander et al. (2014) on methodologies to quantify GHGs in international agriculture.

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Appendices

Appendix 1. Terms of Reference

Terms of Reference for a Consultant to evaluate the impact assessment activity to-date on Irrigation and Water Management Research in the CGIAR

Many studies over the years have sought to document the impacts of agricultural research although the vast majority of these have focused on crop germplasm improvement, i.e., adoption and impact of improved crop varieties. As such there remain serious gaps in the extent to which impact assessment of other components of the CGIAR portfolio have been conducted. To fill this gap, one of the major activities of SPIA's new program on Strengthening Impact Assessment in the CGIAR (SIAC) targets what we consider to be under-evaluated areas of CGIAR research, such as livestock management, irrigation management, agroforestry, policy and social sciences, biodiversity and natural research management.

One broad area of CGIAR research and related activities that is considered to be under-evaluated is irrigation and water management. This is a large area of CGIAR activity and although precise numbers are difficult to come by, it is estimated (roughly, needs validation) that over $ 800 million has been invested by donors in this area of research since 1984 [when IIMI was established]. In spite of this sizeable investment, there have been relatively few studies that have attempted to assess the impact of this investment or to quantify the benefits derived.

As a first step in this process, SPIA is commissioning a critical review of the impact assessment work to-date on irrigation and water management research, broadly conceived (i.e., embracing much of IWMI's research, IRRI's research on rice wetting and drying management, IFPRI's water policy research, etc.[27]). This desk study would include IA work done within and outside the CGIAR, with the goal of evaluating how comprehensively and effectively these assessments cover the fields. The boundaries of "irrigation and water management" are not precisely defined; the working definition used here is technologies and practices that bring water to the root zone of crops. This definition therefore excludes "watershed management" and "landscape approaches". This definition will be periodically reviewed in the course of the review. The review will focus on research since about 1991 (i.e. when IIMI joined the CGIAR), though any significant impact assessments prior to that time may also be reviewed.

In addition to identifying the strengths and limitations of the existing impact assessments in irrigation and water management research (in terms of scale effects, rigor of causal relationships, or how close the impact indicators of the studies correspond to the System-Level Outcomes of the reformed CGIAR system), the desk study would seek to identify the major constraints and limitations (e.g., methodological, data-related, resource-related, etc.) which would in turn highlight potential for new work. For example, new initiatives may emphasize targeting intermediate impacts (e.g. estimates of the impact on water-use efficiency), changes in irrigation management policy or simply adoption of research outputs, rather than ultimate, CGIAR system-level outcomes and impacts.

This background review will lay the groundwork for a subsequent scoping study report which would assess the potential for utilizing state of the art approaches and possibly new data for launching a

[27] The scope will be defined as the review is implemented, but likely will also include work by ICARDA, ICRISAT, CPWF, and WLE.

series of impact assessments of specific improved irrigation management interventions or policy actions deriving from CGIAR irrigation management research. Ultimately, this and other critical reviews of past studies and scoping study reports will form the basis for the SIAC Project Steering Committee recommending to the Fund Council Committee on Evaluation and Impact Assessment some specific areas for further impact assessment work under the SIAC program that has good potential for generating large scale, long term economic, social and environmental impacts from under-evaluated CGIAR research.

Specific objectives of the background review

The desk study would seek to provide:

1. An estimate of the total investment in irrigation and water management research and related activities within the CGIAR since 1990.
2. A review of what the CGIAR and other institutions have done in assessing the economic, social and environmental impacts (or influence as the case may be) of CGIAR research and related activities in the area of irrigation and water management. The review should make critical judgments about the credibility (rigor) and scale of those studies relative to the total amount of investment. This should include identification of gaps (research 'successes' that don't feature in the impact assessment literature) and weaknesses in the reviewed studies, some of the promising methods and approaches used to-date, and key challenges in assessing large scale, long term impacts of CGIAR research in this area.
3. A summary of the estimated economic, social and environmental impacts (or influence as the case may be) documented by the IA studies deemed to be reasonably credible, whether in quantitative and qualitative terms.
4. Based on survey or even anecdotal evidence, identification of management interventions or policy actions deriving from specific lines of CGIAR irrigation and water management research that appear to warrant serious attention for future adoption and impact assessment studies.

Modus Operandi

The desk study will be conducted by a consultant with technical expertise in, and knowledge of, irrigation and water management and the CGIAR. Prior experience of *ex-post* impact assessment is highly preferable Some key reference material would be provided by the ISPC Secretariat, although considerable interactions with relevant CRPs and CGIAR Centers, e.g., IWMI, IRRI, IFPRI, ICRISAT, ICARDA, and other relevant individuals and would be required. The SPIA Secretariat will facilitate initial contact with these institutions. The review is expected to take place between May and June 2014, with a draft final report submitted to SPIA by early July 2014. No travel is envisaged under these terms of reference. The consultant will report to the SPIA Secretariat in Rome – Timothy Kelley (timothy.kelley@fao.org). SPIA members/Secretariat will provide feedback on an outline report and the draft final report.

Peer-review: The draft final report should be sufficiently developed to be ready for peer-review by two external reviewers (in addition to SPIA's own comments on it). The consultant should outline how she/he has addressed the comments made by the peer-reviewer when submitting the revised final report.

Output

The outputs will include:

1. An annotated outline of the report in early June 2014
2. A well-developed draft final report by early July 2014
3. A final report reflecting feedback from reviewers within two weeks of receiving comments.

Appendix 2: Summary Evaluations of Impact Assessment Studies on CGIAR Irrigation and Water Management Research

Case	References	Brief Summary	Strengths*	Limitations*
		IWMI		
1. IWMI's Research Program on IMT, 1992-2005	Giordano, Samad & Namara 2006 [also see Science Council 2006—a brief summary; Giordano, Samad & Namara. 2007- a slightly condensed version of the RR]	Reviews IIMI/ IWMI work on IMT from 1992 [not previous work] to measure, to the extent possible, the outcomes of IWMI research on the overall IMT knowledge base & IMT policy and operations in specific countries where IWMI played a direct role in shaping or implementing IMT reform. Focused on 3 potential outcomes: • Raised awareness of new research, • Employment of improved policies, and • Employment of improved techniques These were based on an outcome pathway developed around that time to assist in tracking & measuring research outputs and impacts. "… overall positive contribution from IWMI to IMT theory and application … large and continuing demand for IWMI research products on IMT. Direct and indirect data sources also indicate that IWMI policy and operational level interventions have in general contributed positively to IMT decision-making and action …" [p.17]	Uses multiple methodologies, direct & indirect, to assess influence, outcomes of IMT research-bibliometric and webmetric, formal survey, qualitative feedback, etc. Mostly qualitative assessment except the web & bibliometrics. Web & Google Scholar metrics suggest considerable "usage impact" [i.e. awareness] Documents adoption of IWMI recommendations in Sri Lanka & Nepal where IWMI worked most on IMT over a period of time. Documents high demand for IMT guidelines [one with FAO, one specific to Central Asia] and strong appreciation & use of Central Asia guidelines [but sample is small]. Draws lessons for future IWMI research; emphasizes value of 'outcome analysis' prior to 'impact analysis' at a later date. Annex 2 is a detailed institutional 'outcome typology' on which this study is based.	Study was done by IWMI researchers—not a commissioned external review (but RRs are peer-reviewed]. No benefit-cost analysis attempted for 3 reasons: insufficient time since recommendations etc., attribution issue, and lack of baseline or counterfactual data. Study expresses aspiration to do a more formal study after further time elapses. Tries to document outcomes of specific 3 projects (Pakistan, Sri Lanka, Indonesia) – weak data, & in the SL case, found little sustained impact. Study does not evaluate quality of pubs. Since most IWMI research on the impacts of IMT shows minimal impacts compared to expectations – would a formal impact assessment show any major benefit?
2. IMT Action Research Project in Pakistan, 1995-2000	Bandaragoda 1999	This participatory action research project is discussed briefly in Giordano et al. 2006, which refers to subsequent progress on IMT that may be	Study provides detailed description of what was done on 4 pilot sites in 2 provinces, including the conceptual basis, assumptions, process, initial	Study was done by IWMI researcher—not a commissioned external review (but RRs are peer-reviewed]; it was written as the project was ending; therefore no longer-

Case	References	Brief Summary	Strengths*	Limitations*
		attributable to the IWMI project. Bandaragoda was the project leader; his report describes in detail the conceptual basis and assumptions, the design of the intervention, and initial outcomes as well as issues affecting success. Conceptual basis was broad water resources and mixed property regime replacing narrow irrigation system and state property focus.	outcomes, and issues and challenges. Giordano et al discuss some subsequent developments that may be attributed to the IWMI project. There may be merit in doing a follow-on IA study of the action research sites, especially if performance data can be found for both action research sites and controls. This study could include an assessment of the influence of the IWMI work [including previous research] on policies, capacities, etc.	term perspective on outcomes and impacts. Study is clearly written in a "diplomatic" style, understating resistance from the bureaucracy. Slow implementation of enabling framework and bureaucratic resistance limited the outcomes, despite apparent strong interest by farmer organizations. Apparently there was no further follow-up by IWMI to this project. No baseline data provided on system performance—but this may be available from other IWMI sources.
3. Electricity-groundwater reform in Gujarat, India, 2004-2008	Shah et al. 2004; Shah et al. 2008	Shah & his colleagues had been studying groundwater depletion issues for quite some time; and had noticed the nexus with increasingly bankrupt electric supply companies (multiple publications); in a 2004 IWMI RR they proposed a radical approach whose elements included separation of agricultural power lines from normal supply; metering of the latter & provision of reliable 24 h service; slowly increasing flat rates for the former, with a rationed by totally reliable supply. This recommendation was shared with Gujarat policy makers who adopted its elements. The 2008 publication documents many of the outcomes of implementing this policy.	Shah et al. 2008 provides a detailed analysis of the pre-existing conditions, implementation of the new policy, and its impacts. The recommendations emerging from the research, as expressed in Shah et al. 2004, are innovative and unique. Implementation in Gujarat is likely a function of the first author's reputation and network in that state (but this is not discussed in the paper); the recommendations could be adopted in other Indian states and indeed other countries in principle. This program would lend itself to a proper external IA, including estimated benefits and costs; but such a study should examine why the recommendations were adopted	The study is by the IWMI researchers responsible for the research, but is published in a respected peer-reviewed journal. The study states but does not document precisely the pathway from the research-based recommendations to adoption of the new policy. The study provides some cost and benefit figures, but does not attempt a proper benefit-cost analysis (not a formal IA; no counterfactual). The study notes that while the benefits of the new policy are substantial, poor farmers, landless people etc. were harmed, e.g. from reduction in the water market due to limits on pumping time.

Case	References	Brief Summary	Strengths*	Limitations*
			only in Gujarat [other states may offer a partial counter-factual].	
4. Improvements in environmental quality due to changes in sluice gate operations, Bac Lieu Province, Vietnam, 2001-2010	Wichelns et al. 2010 [See also Bennett 2011]	See CPWF section – water & land management interface fresh & saline water. This must have been part of the same project, or possibly the CA project that preceded CPWF, but neither report refers to the other. The CPWF project was led by IRRI but this paper reports only IWMI's work. Unpublished report submitted to SPIA. IWMI & others were invited to carry out studies and propose alternative sluice gate operations to balance differential demands of rice and shrimp farmers through control of salinity [and acidity]. Provincial authorities have apparently used the IWMI model to modify gate openings. Focus of study is on non-market benefits of changed gate operations. After PRAs to get a deeper understanding, designed & implemented sample survey; used "willingness to pay" as method to arrive at benefits, as the ambiguities and challenges of direct measurement are daunting. "To the extent that provincial officials have relied on IWMI's modeling efforts, the Institute's researchers have contributed to a meaningful public policy program that generates notable values for residents of Bac Lieu Province."	Detailed description of the technical (hydrologic, chemical, etc.) dimensions of the problem, as well as detailed descriptions of perceptions of changes by those interviewed. Average estimates of willingness to pay for continuing sluice gate operations ranged $39-73/hshld/year, of which aggregated average for environmental benefits was $8.31(0.3-.04% of average annual hshld income). Study estimates full non-market value at $50-200,000 annually, which "likely" exceeds cost of sluice gate operations.	Study done by IWMI researchers, not external review; not published, no evidence of peer review. Not comprehensive—focus only on non-market values of flora and fauna. Study states that rice and shrimp yields are higher & producers have better access to markets, but no figures are given. No cost figures for research, sluice gate operations are given. Very specific case, not really a public good with wider application.
5. Impact of soil	Saleth et al.	*Ex-post* IA of research using multiple	Included here because of significant	Study was done by IWMI researchers—

Case	References	Brief Summary	Strengths*	Limitations*
remediation to improve water holding capacity research project in northeast Thailand, 2002-2005 [Estimated research investment $272,660]	2009	methods. In NE Thailand, sandy soils with low water holding & nutrient capacity limit productivity. Other remediation measures used by farmers have various drawbacks. Research demonstrated benefits of applying locally-sourced bentonite [clay]; the study then worked with farmer networks to disseminate. It leads to significantly higher yields, has long-term benefits, and is scale-neutral. Study uses a sample of 250 farmers [users & non-users] and then multiple data sources to estimate impact at regional level. Research was conducted 2002-2005; benefits assessed for period 2002-2008.	impact on water-holding capacity of soils. Provides a detailed impact pathway—roles of multiple partners [also helps in attribution]. Uses the 'Potential Outcome Framework' proposed by Rubin, & 4 approaches to estimate average impacts (results vary among 4 approaches). Vegetable farmers net benefit $2,950-$3,960; rice farmers lower ($230-430) all per ha Provides detailed analysis costs-benefits of research: very high NPV, IRR, & BCR at sample level, and even higher at regional level. Done for project as a whole, and from IWMI's perspective (with conservative estimates of values attributable to IWMI). This intervention is said to be potentially relevant for other places in Asia and Africa.	not a commissioned external review (but RRs are peer-reviewed]. Study may under-estimate total benefits as it is focused only on yields; and the benefits are only for a 3-year period, not projected into future.
6. Malaria control through environmental & irrigation management, action research 2000-2002	Namara et al. 2008	Impact assessment of IWMI's work in the dry zone of Sri Lanka on controlling malaria through environmental & water management interventions. Since the 1990s IWMI had worked on malaria control through management of the agro-ecological system in Asia & Africa; this study examines multi-disciplinary work in6 villages in the dry zone of Sri Lanka. Diagnostic research suggested substantial potential to reduce malaria	Makes use of the same impact pathway model as in the IMT research. Focus is on quantifiable impacts (welfare of the population) but also discusses qualitative outcomes. Uses multiple sources of data [especially project publications] & a sample surveys; some baseline data were available. Sample survey in 2004 in intervention and control	Study done by IWMI researchers, published in a national refereed journal; not a commissioned external review. Relatively limited number of beneficiaries—not a broader public good.

Case	References	Brief Summary	Strengths*	Limitations*
		incidence through water management & infrastructure interventions; action research done 2000-2002 (3 years). Findings confirm positive impacts [reduced mosquitos & malaria incidence] of the interventions in the intervention villages.	villages. Value of malaria control established through cost of illness and willingness to pay methodologies. Uses a standard model to assess demand for preventive health care. Because Sri Lanka experienced a decline in malaria incidence during the study period, the IA makes a special effort to identify reductions and benefits attributable to the project. Overall positive impact of project, but project benefit-cost depends on methodology used—authors conclude it is modestly positive. Study demonstrates the potential for agro-ecological interventions, and suggests same approach has potential in southwest India and east Africa.	
7. IMT policy impact studies	Vermillion 1997, Vermillion and Garcès-Restrepo 1998, Vermillion et al. 2000, Samad & Vermillion 1999	In the late 1990s IWMI's senior staff became concerned that IWMI was advocating IMT but had no evidence on its impacts. It therefore did a literature review, and carried out a number of case studies using a common methodology. These were in Indonesia, Colombia, and Sri Lanka. They were comparisons of with-without IMT at the level of user-managed canals or schemes. In general, the findings showed that while governments were reducing their own costs for O&M, farmers were not increasing their O&M	Systematic performance assessments using quantitative data comparing performance of schemes/ sub-systems with and without "turnover" These studies partially filled a gap in knowledge of IMT impacts. These products are among the most-cited papers as discussed in IWMI's attempt to assess the impacts of its own IMT work.	These were not explicitly linked in any way to IWMI's own research; therefore they are not assessments of IWMI's research impacts. They were done too soon after the IMT had occurred to draw firm conclusions—and there have been no follow-up studies.

Case	References	Brief Summary	Strengths*	Limitations*
		investments; and the performance in terms of water delivery and yield did not change much. *None of these studies linked explicitly to IWMI's research.*		
8. Other irrigation & water management impact studies	Shah et al. 2000, Adeoti et al. 2007, Inocencio et al. 2007, Namara et al. 2010, Hagos et al. 2012, Venot et al. 2012, Giordano & de Fraiture 2014	Over the years, IWMI has published studies of the impacts of specific water management technologies, and/or of introducing 'irrigation'. These include treadle pumps (Shah et al., Adeoti et al.), small reservoirs (Venot et al.), small power pumps (Giordano & de Fraiture), costs of irrigation in SSA (Inocencio et al.) and irrigation in general (Namara et al.). *None of these studies assess the contribution of IWMI's research to the development and/or adoption of these technologies.*	The papers by Shah et al. (2000) on treadle pump adoption in Bangladesh and India and by Inocencio et al. (2007) on the costs of and returns on irrigation investments in SSA are both widely cited. Most of these studies are methodologically rigorous and useful assessments. Taken together, these studies document the high returns on irrigation investments and positive impacts that can be achieved.	These were not explicitly linked in any way to IWMI's own research; therefore they are not assessments of IWMI's research impacts.
9. Ferghana Valley IWRM Project impacts, 2001 to 2005	Abdullaev et al. 2009	The project introduced 2 innovations: one unit to manage main canals even if they cross provincial boundaries, and unions of WUAs. The paper assesses impacts on water delivery & productivity of crops.	Assessment compare before project with after the project on South Ferghana Canal. Based on water delivery/ha in 9 units, & farm level wheat & cotton yields. Water deliveries improved, yields declined but causes not water management	No economic analysis, no counterfactual. Inconclusive study.
10. IWMI's gender program	Rathgeber 2009	This is an assessment of the trajectory of IWMI's research on gender issues; it finds that in recent years gender research has not been very strong at IWMI, and recommends ways to make it more mainstream and relevant.	Commissioned a prominent gender specialist to carry this out. Includes citation analysis as a major part of the analysis.	Not an assessment of overall impacts and benefits-costs of the program; more qualitative aimed at suggesting ways to strengthen the program.
11. IWMI-TATA Program mid-term CCER	Burke, Joshi & Chopra 2004	This was a mid-term commissioned review of the first phase of the IWMI-TATA Program in India.	The review made many useful suggestions for focusing the program and for guiding its future	There is no attempt at documenting the impacts of the Program—indeed it was probably premature to do so at that time.

Case	References	Brief Summary	Strengths*	Limitations*
			direction.	
12. Evaluation of IMAWESA Project, phase II, 2010-2013	Jackson 2013	A broad assessment of the implementation and outcomes of the project.	Commissioned by IWMI after a competitive process, in consultation with the donor, IFAD, from a firm specializing in IA. Overall very positive assessment.	Based on documents, a survey of 147, & interviews. Uses a "value for money" framework but there are no quantitative measures except survey results, no economic analysis of impacts (these were not requested in the TOR).
		IFPRI		
13. GRP22 ("Water Resource Allocation: Productivity and Environmental Impacts"), 1994-2010	Bennett 2013	A commissioned review done by a very well-respected IA specialist, and published in IFPRI's IA series. It is a comprehensive review of this program, 1994-2010, around 3 themes: global modeling, river basin modeling, and institutions. Conclusions: • IFPRI water research is highly regarded. • IFPRI water researchers are productive at a high level. • IFPRI water research impacts have often been limited. • Publication strategy needs to be better coordinated. • Projects need to be better targeted. • Projects need to be better integrated into policy processes. • Research partnerships need to be broadened.	Study uses multiple methodologies to assess quality, relevance, reputation, outcomes of research-bibliometric, formal survey, interviews, etc. Very positive conclusions regarding the quality, relevance, of the work, the publication record, and the researchers. While not highlighted or even quantified, refers to the contribution made to capacity building (many young researchers associated with the program)	The study does not attempt to do a benefit-cost analysis; and does not provide any information on costs [quantifying benefits of a program producing public goods is said not to be possible] Assessed the influence-outcomes of 3 research projects: Vietnam (river basin modeling), Ghana (basin modeling and network analysis), and India (institutional reform). In all 3 cases, while the research & researchers are highly regarded, the study found no evidence of impacts on policy. The study could have quantified the capacity-building contributions which appear to have been substantial [perhaps not in TOR]. Study recommends more engagement with policy makers throughout research process, and combining more attention to demand to complement research driven by researchers' priorities.
		CPWF		
NOTE: This section assesses reviews of CPWF program impacts, and commissioned impact assessments of specific CPWF projects. The latter are cross-referenced to specific CGIAR centers where relevant.				

Case	References	Brief Summary	Strengths*	Limitations*
14. Forthcoming meta-analysis of CPWF	Harrington & Fischer, eds. 2014 [forth-coming]	I was given a proof version; publication is expected in August 2014. It is a retrospective assessment of the CPWF, its evolution including changes in thinking over time based on experience, achievements, lessons learned.	This is a fairly open discussion of lessons learned that are relevant for future R4D research. Claims quite a few positive outcomes and even impacts from specific projects – often in the form of 'stories' [several chapters, but esp. chapter 8; this is based on project documents & sometimes external reviews—such as those below]. Chapter 6 [research on institutions] analyzes specific projects' outcomes based on project documents & sometimes external reviews—such as those below, & also assesses publications—quality, citation analysis, impact factors of journals etc.	Written by authors very closely involved in CPWF management & implementation. With the exception of one chapter (7), the book is not sufficiently critical of the larger CGIAR [institutional] context in which it operated. No attempt to discuss benefits-costs or do a more formal IA. A lot of repetition among chapters.
15. CPWF-program phase II (external assessment)	Hall, Bullock & Adolph 2014	I was given an unedited and later a near-final version—its publication will be very soon. This is a commissioned external review of the CPWF, with a focus on the lessons for the future & implications for CRPs. It is a rich source of observations and recommendations. It is based on desk review of reports, interviews, participation in events, & some field visits. The authors also had access to the forthcoming edited book (Harrington & Fischer eds.2014, forthcoming).	Thoughtful, insightful, with a focus on lessons for the future, done by a senior set of external evaluators. Like Harrington & Fischer, eds., it seeks to influence future natural resource R4D programs, especially WLE.	Does not attempt quantitative *ex-post* facto IA [which would be premature]. Indeed it is not a formal IA but rather a broader review of the CPWF with an emphasis on lessons from Phase II.
16. CPWF-program phase I [selected projects]	Wooley & Douthwaite 2011	Uses experience of 5 Phase I CPWF projects to explore value of partnership approach to improve resilience in complex agro-ecological systems.	Makes interesting argument with evidence from cases for R4D with multiple partners at multiple scales of complex adaptive systems.	Not a formal IA; rather it is an attempt to draw lessons from the experiences of 5 projects for which some form of evaluation was available, written by

Case	References	Brief Summary	Strengths*	Limitations*
		Argues interventions need to be at 3 or more levels. This approach is claimed to be superior to CGIAR 'business as usual' research.		former director of Phase I and former MT member who led the impact program
17. CPWF Most Significant Change [MSC] Stories	Harrington et al. 2008; de Leon, Douthwaite & Alvarez 2009	Both volumes use the "MSC" technique to monitor, evaluate, document change processes in complex participatory rural development programs where there is no pre-programmed objective or specific indicators. The 1st round was for Phase I projects. MSCs were sought for technical innovations & partnership change in 1st round, no specification in 2nd round. For the latter BFP & small grant projects also included. 54 cases in round 1 (Harrington et al.), 15 more in round 2; de Leon et al. report a consolidated 44 for which information was most complete.	Sources of important insights into incipient change processes, innovations, early uptake – technological, practice & (some) policy, and new insights and/or conceptual frameworks for analysis. Several of the MSC stories were used to select projects for further IA [see cases below].	Reported by researchers themselves, not independent. Early stages of potential long-term systemic change processes—needs follow up. No quantification, in many cases baseline not clearly established. Therefore indicative of possibilities, not IAs. A follow-up analysis now that some time has passed may be useful as part of a broader IA of CPWF.
18. CPWF-Small grants	Wooley 2011	This is a review of experiences with a 'small grants for impact' program in which CPWF invited proposals for very small grants in 2005; 14 funded for a total of <$1million. Using 4 criteria, 4 outstanding on all 4 & 6 contributed to 1 or more. Concludes such small grants are a good investment.		Written by the former Director of CPWF [during Phase I]. Very little information is provided on each of the projects—only 1 page summaries. Not useful as an IA.
19. Aerobic rice-'STAR' in Asia Project, (Developing a System of Temperate and Tropical Aerobic Rice (STAR) in Asia). 2004-2008 [Estimated research	Templeton & Bayot 2011	Cross reference IRRI as lead institution. 'Developing a System of Temperate and Tropical Aerobic Rice (STAR) in Asia' is full name of project. Implemented in China, India, Lao PDR, Thailand, the Philippines; the economic assessment is focused on China but the authors visited Philippines as well. These 2	Primary purpose was to assess changes that STAR project brought about at all levels along the research-to-impact pathway – output, outcome and impact – the analysis was undertaken within an impact pathway framework. This is a strength—the analysis tries to	Commissioned *ex-post* IA, first author is from Australian Centre for International Agricultural Research, 2nd is from IRRI. Therefore not strictly external. Evaluation was right after completion, insufficient time for full economic evaluation. Estimates based on expert assessment of

Case	References	Brief Summary	Strengths*	Limitations*
investment $1,605,596]		countries account for 75% of resources. Aim of the project was to develop water-efficient aerobic rice technologies, building on previous work esp. in China, done by Chinese Agriculture University, IRRI's Chinese partner. Broad largely qualitative assessment of the project, excluding environmental impacts.	understand the project's trajectory and to document intended & unplanned but real outcomes [e.g. capacity building] & impacts. Water saving leads to cost reduction esp, if pumping is involved; & some labor saving compared to alternative crops. Using conservative expert-based judgments, concludes very high net value, B:C [11:1] of STAR. For China, NPV of $37m for 30 years, & 21:1 B:C Recommends follow-up IA after 5 years including quantification of capacity building benefits.	available info, qualitative & quantitative; and use of 'extrapolation domain analysis' [Rubiano & Soto 2008—a CPWF publication] [i.e.no primary data collection]. B/C analysis based on many assumptions [necessary given early stage].
20. Water & land management at interface between fresh and saline water environments-evaluation of Vietnam component [Bac Lieu], 2004-2008 [Estimated research investment $679,000; but not clear if it is entire project or Vietnam only]	McDonald 2011	Cross reference IWMI study on sluice gate operations above. Cross reference IRRI as lead institution; WorldFish & IWMI as partners. "Managing Water and Land Resources for Sustainable Livelihoods at the Interface Between Fresh and Saline Water Environments in Viet Nam and Bangladesh" is full CPWF project name. It worked in both Vietnam & Bangladesh; this evaluation focus on Vietnam. Project was led by IRRI. In Vietnam, it built on previous projects & a transitional project funded by the CA. Overall, this evaluation was intended to identify what contribution the CPWF project had made to reducing poverty	Independent person commissioned by CPWF to do this IA. Focused on the actual impact pathway followed by the project and attempted a "realistic evaluation" interpretation. This involved working with the team to construct an actual logic model, compared to what had been planned. Uses stories, interviews, qualitative analysis, following methodologies from the literature for identifying plausible impacts; builds on MSC stories. The TOR emphasized an approach to facilitate learning. Provides plausible examination of	Carried out too soon after project ended to perceive full impact. Based on documents, interviews, workshops with participants—no survey or primary data collection. Although TOR mentions trying to quantify, no attempt is made to do IA—no data, and premature. Strangely, this evaluation makes no reference to the sluice gate IA by IWMI (Wichelns et al.), nor does it provide a clear discussion of the actual roles of IRRI, WorldFish, and IWMI.

Case	References	Brief Summary	Strengths*	Limitations*
		and food insecurity in the Mekong Delta.	the outcomes and incipient impacts attributable to the project, and the reasons for its relative success. As is the case for the STAR evaluation, a follow-up IA after 5 years [i.e. now] seems relevant.	
21. Citizen participation in managing water [SCALES Project; Andes], 2005-2007 [Estimated research investment: $785,662, but it is not clear if this includes the Nile portion or is only the Andes portion]	Córdoba & White 2011	CIAT was implementing CGIAR center for this specific activity. IA of a project activity that intended to enhance collective action in one site: the Coello watershed of Colombia, under the project "Sustaining Collective Action Linking Economic and Ecological Scales in Upper Watersheds" [SCALES]. *Conversatorio of Acción Ciudadana* was the collective action mechanism used to promote civil society participation in public policy decisions.	Objective was to evaluate the effectiveness of the *Conversatorio* process; used qualitative techniques, building on an MSC story and guided by the impact pathway developed half way through the project. In a sense it tried to evaluate the credibility of the MSC story using qualitative data, and also to assess whether this case represents an 'international public good'. Used interviews and social network analysis, participatory video, open and semi-structured interviews, & review of secondary data. Evaluation found that all the outcomes anticipated in the impact pathway were achieved. [This therefore sets up a potential follow-up IA.] Use of social network analysis a strength of the methodology; but the report notes there was no baseline network analysis to compare before-after. Use of participatory video an interesting innovation.	Strictly speaking this is a watershed project and therefore not included in the definition of water management for this study. Too soon to evaluate actual impacts. CIAT staff members carried out the IA-not externally commissioned. No quantitative analysis attempted except of social links created by the project; & the conclusion notes the CPWF cost was about $160,000 [not including some other local costs] and the *Conversatorio* process led to agreements with government authorities with financing of over $600,000. Study is very sympathetic to project, few critical remarks made; claims this is a potential international public good but arguments not convincing [CAC seems very specific to Colombian conditions].
22. Models for Implementing Multiple-Use Water	Merrey & Sibanda 2008	Cross reference IWMI as lead institution. Of the 4 commissioned IAs, this is the	Follows a qualitative methodology to create a plausible account of changes that have occurred as a	This IA was never published because of time constraints of the author; it is referred to in other review for example

Case	References	Brief Summary	Strengths*	Limitations*
Supply Systems for Enhanced Land and Water Productivity, Rural Livelihoods and Gender Equity [MUS] Project [Estimated research investment: $1.6 million from CPWF; other costs not quantified]		only one that attempted to evaluate the entire project. National consultants were used in 4 countries, and a consultant was also hired to attempt an *ex-ante* benefit-cost analysis [with many heroic assumptions]. Special focus on countries with MSC stories. Not a normal end-of-project evaluation; was an attempt to understand the innovative approach to project implementation, the results of this approach, & most important, the lessons for CPWF and others. Concludes that "the most important achievement of the MUS Project has been its contribution to conceptualizing, legitimizing and raising the profile of MUS both as a topic worthy of detailed scientific study, and as a potentially powerful tool for improving the livelihoods of poor people by providing a higher-level water service than is often the case in rural water supply programs and irrigation projects." This applies at multiple levels.	result of the project. Very transparent in terms of sharing the draft report with MUS project leaders; & workshops on draft country reports in 3 countries. Offers very clear and specific conclusions and strategic forward-looking recommendations to CPWF. Presents evidence the Project contributed significantly to raising awareness, knowledge, interest and in some cases implementation skills in most of the countries where it was active. Reasons include emphasis on partnerships and joint learning by diverse stakeholders through "Learning Alliances," combined with identifying effective "champions of change". Project used its own theory of change based on 'learning alliances," "learning wheel", rather than CPWF impact pathways. Evolved from a normal research project to an advocacy project seeking to maximize impacts through learning partnerships supported by research. The only IA to comment on CPWF management & its impacts. Building on a previous B:C analysis of MUS, attempted a benefit-cost analysis in the 5 basins where the project worked, excluding global benefits: NPV after 10 years estimated at $226.5 million & B/C	Wooley & Douthwaite 2011, and chapter 6 in Harrington & Fischer, eds 2014 forthcoming. The first author was involved in the inception of the MUS project when he was IWMI Director for Africa, and remained partially engaged in its implementation—therefore it is not an external IA. Disclosure: first author of the MUS study is the author of this report to SPIA.

Case	References	Brief Summary	Strengths*	Limitations*
			ratio of 2.68. This report provides a good basis for a follow-up IA, especially as MUS has been widely adopted, and is now driven by a network of institutions.	
CIMMYT & Rice-Wheat Consortium				
23. Rice Wheat Consortium: Zero Tillage in Rice-Wheat Zone, South Asia (1999-2007) [Estimated research investment: $11.5 million, 1994-2007 but includes many assumptions; RWC costs: $2.9m over 19 years; CIMMYT costs: $600,000 over 12 years]	R&D impacts Laxmi, Erenstein and Gupta 2007, & Erenstein and Laxmi 2010 ZT impacts Erenstein, Malik and Singh 2007; Erenstein et al. 2008; Farooq, Sharif and Erenstein 2007; Erenstein and Laxmi 2008; Erenstein et al. 2008; Erenstein 2009a, 2009b; and Pal, Sekar and Kar 2010 Methodological Erenstein 2009c, Erenstein & Laxmi 2010 [See also Bennett 2011]	Zero Tillage (ZT) for wheat is the most widely adopted innovation emerging from the CIMMYT-led Rice Wheat Consortium (RWC). Erenstein et al. 2007, 2012; Erenstein 2009a, b, & Pal, Sekar & Kar 2010, & Erenstein & Laxmi 2008 assess the impact of ZT in northern India; Farooq, Sharif & Erenstein 2007 do the same for northern Pakistan, while Erenstein et al. 2008 compare the two regions. Laxmi, Erenstein & Gupta 2007 is an IA of the RWC investment, focused on the costs-benefits of ZT (and reduced tillage [RT]—difficult to disentangle these] in the IGP (India), commissioned by SPIA. Erenstein & Laxmi 2010 also assess the impact of the R&D investment. RWC was an eco-regional NRM program launched 1994, led by CIMMYT with IRRI, national partners, and other international centers. It developed and promoted a number of resource conserving technologies that increase farm level productivity, conserve natural resources, and limit negative environmental impacts. Most wide-spread innovation is ZT of wheat after rice. A specialized ZT seed drill was a	RWC built on previous research and development of ZT seed drill; its role [and CIMMYT's] was to catalyze partnerships among various parties including private firms; strong institutional support in India [esp. Haryana] enabled rapid diffusion in contrast with Pakistan. Laxmi, Erenstein & Gupta study methodology has 3 components: review of various reports and studies [including sample surveys reported in other studies referenced here]; focus group discussions with farmers [in adopting villages but with adopters, non-adopters, & dis-adopters], and modeling of welfare impacts—multiple methodologies a plus. Transparent about assumptions, limitations. Rapid diffusion ZT/RT, especially in western IGP. ZT saves land preparation costs, saves water, reduces weeds, higher wheat yields [timely sowing, more efficient use of inputs] – leading to higher profitability through both yield & cost effects [multiple sources	3 reports are peer-reviewed RRs [CIMMYT, Comprehensive Assessment], 1 peer-reviewed article; and Laxmi et al. is a CIMMYT-RWC RR & is an expanded version of a report submitted to & peer-reviewed by SPIA; all are by researchers involved in the program [mostly CIMMYT], not external assessments. Laxmi et al. do not try to include environment & social impacts due to data limitations. Only "reasonable assumptions" are possible for counter-factual; assume with no CIMMYT-RWC lag time of 5 years for adoption as a "conservative lower bound". Attribution issue: "we attribute the gains of bringing the ZT uptake five years forward to the efforts of the RWC and CIMMYT in India, without further attribution to consortium partners." [No way to really know what would have happened with no RWC-CIMMYT]. Note: no distinction made between CIMMYT & RWC. Other partners' value added not specified—assumptions end up giving CIMMYT all the credit. Studies do not provide sufficient detail on impact pathways—i.e. do not clearly delineate roles of various partners.

Case	References	Brief Summary	Strengths*	Limitations*
		key innovation enabling this practice. These case studies provide more data on adoption of ZT & and its benefits in both India & Pakistan, using the same survey data as in the research IA (no.20). Examine yield, water saving, benefits-costs, environmental impacts. Benefits greater in Haryana India than in Punjab Pakistan. Erenstein 2009b focuses specifically on water productivity in the 2 regions, and for rice vs wheat. Big differences because of differences in institutions, water sources. Huge potential for water savings in rice production [and notes importance of energy pricing, citing IWMI's work above] Erenstein 2009c is a companion to others & addresses the issue of specification bias. They add more clarity and strengthen research IA papers. Discuss complexities in sampling & attribution [ZT adopters, partial adopters, dis-adopters, non-adopters] Relatively robust methodologies, sensitivity analysis, e.g. paper on specification bias. [Comprehensive Assessment partially supported studies]	using different methods give different results, but all are consistently positive]. ZT scale-neutral though early adopters are better off; potential use for other crops, multiplier effects of seed drill industry—needs more study. Environmental benefits substantial but needs more rigorous study; these benefits limited as long as ZT not used for rice & other crops. Focus group discussions confirmed findings from studies, surveys. *Ex-ante* assessment with conservative values, ZT/RT research program is highly beneficial: benefit-cost ratio 39, net present value US$ 94 million, IRR 57%. Discounted economic surplus (US$ 96 million) dwarf the discounted cost of the 'with' case (US$ 2.5 million). More optimistic scenario, assume ZT induces 10% yield gains and 10% cost savings (and half these values for reduced tillage): estimated NPV US$ 164 million with benefit cost ratio 68 & IRR 66%. Therefore, high welfare gains from modest investment in research. Erenstein & Laxmi 2010 focus on the robustness of the benefits even with various counterfactual assumptions, and cost/yield assumptions. Erenstein 2009c addresses the	Focus groups: laborers perceive less demand for their services. Concludes ZT not a panacea, but stepping stone to CA. Annex provides details about how costs & benefits were allocated & assumptions made. Many assumptions made. Investments previous to RWC treated as sunk costs, inflating benefits. This is not an assessment of the entire RWC program investment but only of ZT.

Case	References	Brief Summary	Strengths*	Limitations*
			concern with how specification of a technological innovation affects survey results by distinguishing 3 alternative contrasts.	
ICARDA				
Note: Several interactions with ICARDA led to identifying these two studies which I agreed to include. It appears ICARDA has never done any studies of the impacts of its research on water management; its IAs are studies of specific technologies ICARDA has researched and promoted.				
24. Improved Supplementary Irrigation [ISI] of wheat, Syria	Yigezu et al. 2010; 2014	1986-1990 ICARDA & Syrian Ministry of Agriculture & Agrarian Reform launched a project to promote ISI focusing on irrigation scheduling for spring wheat. Technology package included improved varieties & organic fertilizer as well. Yigezu et al.2010 is an unpublished paper (commissioned by SPIA?) reporting on IA of shift from TSI to ISI for spring wheat [but study also looks at shift entirely rainfed to ISI] C/B analysis at farm level [benefits are yield, water saved, & estimation reduction of salinity] Yigezu et al. 2014 is published in a refereed journal; it focuses on ISI benefits in deep-well areas where salinity is not an issue; therefore benefits are water savings, reduced pumping costs [as energy is subsidized, uses estimate marginal product of irrigation water]; examines shift surface TSI to sprinkler ISI, & also surface TSI to surface ISI. ISI practiced on about 22% of farms—paper therefore examines benefits of a policy that would lead to wider adoption- a penalty for excessive	Counterfactual is traditional supplementary irrigation [TSI] Fairly large representative sample for 66% of wheat areas, 61% wheat production in Syria. Data collected 2009-2010, i.e. 20 years after the project. Benefits of ISI are cumulative over time; and have little or no additional cost. Study is up front about limitations, for example on estimated water savings. Yigezu et al.2014 focus on ISI benefits – mostly in the form of cost savings, not yield improvements-- & potential for policy changes that would achieve these benefits; includes estimates of benefits at national level.	Yigezu et al. 2010 is an unpublished paper (commissioned by SPIA; see Bennett 2011); benefits & costs are all Syrian pounds, not converted to USD; no information on research process; this is not an assessment of the benefits of the research [as there is no discussion of research costs] but only of the ISI itself. Bennett 2011 also summarizes this study. Yigezu et al. 2014 give conversion to USD in a footnote, otherwise in SYP. Like other study, it assesses benefits ISI not of the research project. [Paper does not really explore why 20 years after project only about 20% of farmers have adopted ISI—only speculates on possible reasons.] Offers elegant but politically unfeasible policy option—PEAIW.

Case	References	Brief Summary	Strengths*	Limitations*
		application of irrigation water (PEAIW). Claims high penalty would lead to ISI adoption that would actually benefit farmers while conserving a lot of water.		
25. Economic & environmental impacts WH in low rainfall area (Badia Benchmark Site), Jordan	Akroush, Shideed & Bruggeman 2011; 2014	The 2011 paper is a chapter in a book on water management interventions in CWANA. This chapter attempts to provide an environmental & economic assessment of 2 WH interventions in this site: contour ridges with shrubs & runoff strips with barley; the 2014 paper carries the assessment further, examining shrubs & barley with and without WH, & finds the economic & financial returns to WH, already high, are enhanced when environmental impacts are considered.	Overall very positive returns on investment in the WH techniques; 2014 study is methodologically more rigorous.	These are IAs of the technologies themselves, not the research; in the 2011 paper there is no clear counterfactual but in the 2014 paper the counterfactuals are "traditional pits" and "barley farmer practice".
IRRI				
26. Irrigated Rice Research Consortium [IRRC],1997-2012 [Estimated research investment: $18.5 million in total; a little over $2.0 million went to the Water Savings Work Group]	Rejesus, Martin & Gypmantasiri 2013, 2014	IRRC was a 15-year program funded by SDC in 4 phases, intended to provide a platform to facilitate identification, development, dissemination, and adoption of NRM technologies suitable for irrigated rice-based ecosystems in several Asian countries through partnerships of NARES with IRRI scientists. Rejesus, Martin & Gypmantasiri 2013 is a detailed meta-analysis of IRRC published as a special report by IRRI. Rejesus, Martin & Gypmantasiri 2014 is published in a refereed journal emphasizing lessons from IRRC for NRM research. The objective was to determine the	Rejesus et al. 2013 conclude –wide range of impacts at multiple levels; commends 'consortium' model, documents very positive economic returns, high benefit-cost ratio even within project period. Also analyzes impact pathways. Quite a comprehensive study. While commending the IAs done by IRRC, study offers suggestions for strengthening them, for example investigating heterogeneity of impacts [e.g. gender], using more modern IA methodologies, better monitoring of uptake. Recommend including IA specialist in project from beginning.	Authors of the 2 documents are now apparently independent researchers [at a US university] but seem to be former IRRI staff [?], commissioned by IRRI. The 2013 report is not clear on this but see http://irri-news.blogspot.com/2012/07/impact-of-irrcs-four-phases-evaluated.html. IRRC's technologies are broader than water management but include it—for example AWD Study did not carry out primary data collection; depended on 'meta-analysis of project documents, reports & short field visits. Review of impact studies focuses on several methodological issues including:

Case	References	Brief Summary	Strengths*	Limitations*
		multidimensional impacts (i.e., economic, sociocultural, environmental, policy, scientific, institutional) of the technologies developed and/or disseminated by IRRC, as well as document the pathways and mechanisms that led to successful adoption of these technologies. A "meta" impact assessment approach is used where the analysis of impact evidence mainly relies on existing documents (or studies), easily accessible data sources, and short field visits. Technologies included direct seeded rice, IPM, rodent management, post production technologies, site-specific nutrient management. Water Savings Group worked on AWD & aerobic rice (AR). Rejesus, Martin & Gypmantasiri 2014 is a journal article presenting results from IRRC study, and emphasizing lessons for other NRM programs: "fostering partnerships, collaborations, and cross-country learning; involving social scientists for monitoring, evaluation, and impact assessment; and, having long-term support and involvement of donors." Lessons: IRRC's institutional emphasis on partnerships, collaborations, & cross-country learning has strongly contributed to the variety and	More comprehensive than most NRM IAs. Review of AWD impact studies in Philippines, Bangladesh, elsewhere: overall positive in both pump & gravity systems, but authors note the methodological issues in all the studies, especially need for control of selection issues. Review of the few studies of AR including those in next row and above in CPWF section [Templeton & Bayot 2011] reflect methodological issues that need to be addressed in future studies, especially selection issues. Need to conduct economic IAs of IRRC technologies using current methods available in the literature (i.e., those in World Bank publication of Khandker et al. 2010), or preferably if resources and the opportunity are available, the more advanced impact assessment options recommended by de Janvry et al. (2011). Study attempts an overall IRRC IA using economic surplus models for various combinations of technologies–detailed explanation of methodology, assumptions, limitations: Economic surplus meta-analysis AWD in Philippines—arrives at very high NPV, IRRs, even with conservative assumptions (pp.33ff).	1) Majority of economic impact studies do not use a rigorous counterfactual framework to account for selection problems due to observable and unobservable variables; 2) IAs on IRRC technologies have not addressed potential differences in impact on different groups of farmers and/or stakeholders. Most focus on the "mean" impact of the technology intervention to the "average" farmer/ stakeholder. 3) Should be more serious investment in time and resources to rigorously estimate adoption numbers. Need for future study on poverty impacts—only approx. estimate was possible. Notes available evidence on sociocultural, gender, institutional, and policy impacts for some of the areas are limited. AWD assessed pp. 73 ff. Reviews mostly qualitative data indicating positive impacts, but AWD was part of a package, therefore attribution difficult. [AWD precedes IRRC—therefore attribution to this project only has limitations.] AR assessed pp. 77 ff. Notes lack of gender analysis in IAs; also lack of analysis of social categories farmers, mechanisms for change/ theory of change [impact pathways]; need to use more advanced qualitative methodologies e.g. network analysis. Reviews environmental impacts: evidence 'thin'; needs more work.

Case	References	Brief Summary	Strengths*	Limitations*
		magnitude of impacts generated; IRRC's decision to include a social scientist in the CU responsible for conducting IA of individual NRM technologies was important for successful documentation of multi-dimensional NRM impacts; early involvement of social scientists in NRM research institutions would enable establishment of M&E protocols to measure impacts; use of new IA methodologies to address under-researched issues e.g. heterogeneity of impacts, poverty impacts, environmental impacts; continuity and stability of IRRC research efforts over 15 years were essential in achieving the multi-dimensional impacts documented.	Similar analysis AR in Philippines: finds very low to negative returns (pp.41 ff). Overall highest return to research investment is from AWD among all IRRC technologies (pp. 48 ff). High rate of return on entire IRRC research investment. Attempts analysis of poverty impacts using 'case study' approach for selected technologies including AWD in Philippines (pp. 56 ff): incomes improved but not enough to rise above poverty line where farmers were poor. Broadly positive analysis of impacts on livelihoods, poverty, institutions, policies. Pp. 112ff: impact pathway analysis of IRRC. The evaluators constructed impact pathways *ex-post* facto for each working group (technology) in relevant countries, including AWD, AR: multi-stakeholder groupings and learning alliances [innovation platforms] played critical roles. Evaluated implementation process, pp. 140 ff. Influence assessment pp. 145ff.	Citation analysis, human resources development analysis –both very positive but for former no statistical analysis, for latter no independent quantitative & qualitative analysis.
27. Aerobic rice adoption China, Philippines cases	Flor 2007; Ding et al. 2010	An early version of Ding et al. was used by Templeton & Bayot 2011 [cross reference CPWF, IRRC]; both studies are discussed briefly in Rejesus, Martin & Gypmantasiri 2013. Flor 2007 is a masters thesis in anthropology. It is a qualitative study of farmers'	Flor 2007 is useful for understanding farmers' perceptions & motivations. Ding et al. 2010 provide a baseline on adoption that may be useful for future studies. CPWF had provided partial support to the larger program on AR.	Flor 2007 is not an IA. Ding et al. 2010 is also not an IA, but a study of adoption patterns and reasons.

Case	References	Brief Summary	Strengths*	Limitations*
		understandings and adoption strategies using decision trees (Philippines). Ding et al. 2010: The aim was to understand patterns of adoption & driving forces in China based on household micro economic survey data in 3 counties in North Anhui (adopters & non-adopters).		
28. AWD adoption Bangladesh	Kürschner et al. 2010	This study is briefly summarized in Rejesus et al. 2013. Cross reference IRRC, CPWF Objectives: to analyze the approaches and the organizational environment of dissemination; to assess constraining and enabling factors of adoption and short-term impacts; & to draw general lessons learned with the AWD technology	Commissioned & co-financed by IRRI & GIZ from a unit of a German university. Both qualitative & quantitative data used, including survey of adopters, non-adopters, & those not trained in AWD. Adoption is in very early stages; study is useful for re-focusing project not as an IA.	Not an IA of the research; it is largely focused on issues affecting uptake (mostly institutional), conditions affecting farmers' decisions, and comparison of AWD yields, benefits to normal production.
29. AWD adoption, Central Luzon, Philippines, 2001-2005	Rejesus et al. 2011	This study is discussed in Rejesus et al. 2013. Cross reference IRRC AWD adoption by farmers in deep well systems; survey in 2005.	AWD—significant reduction of irrigation time [and therefore cost] with no significant yield labor or profit impact.	Journal article by IRRI team; lead author is apparently a partner not on IRRI staff. Not a research IA, only assesses the technology itself. Uses propensity score matching (PSM) & regression-based approaches to assess the impact of AWD and control for selection bias. [Methodologically more rigorous than most]
30. AWD adoption Vietnam, 2005 to 2011	Diangkanay-Quicho 2013	This is an M.Sc. thesis (agricultural economics). It evaluates the adoption & economic impacts of AWD in a province in southern Vietnam among pump users. Uses various data sources including panel data from 2009 & 2011 surveys.	Quite sophisticated statistical tools used [Rejesus was an advisor]. Irrigation frequency & labor reduced, with no effect on yields; significant & positive impact on incomes. Uses an impact pathway conceptual framework	Not an IA of research, but of AWD technology. Did not address total labor cost & total cost –time constraint.

Case	References	Brief Summary	Strengths*	Limitations*
ILRI				
31. Broad Bed Maker (BBM) plow, Ethiopia, 1986-2008 [Estimated research& extension investment: $63.6 million since 1986; no clear data given on research investment]	Rutherford, Odera & Kruska 2001; Rutherford 2008	Rutherford is a consultant to ILRI. BBM enables vertisol soil farmers to go from 1 to 2 crops/year, increasing their incomes & wellbeing. Introduced in the early 1990s under the Joint Vertisol Project in which ILRI was a partner. BBM is part of a technical package including improved seeds, fertilizer, pesticides, training, etc. Rutherford, Odera & Kruska 2001 was based on 1998 data; Rutherford 2008 is more recent & comprehensive. Early study – disappointing welfare benefits, high risk because of cost; training was insufficient. Current BBM model is different from the one evaluated in 2001. 2001 study: costs of research & extension exceeded benefits, but projected this would turn positive by 2005—which is confirmed by 2008 study.	Attempts an IA of the research & extension investment. Nationally, 100,000 farmers on 63,000 ha adopted it, so low; but government has ambitious plans for expansion. Recent innovations have enhanced the package & its benefits; but little spontaneous adoption: this increases during government pushes (subsidies etc.). Study identified multiple constraints to wider adoption that need to be addressed. Economic surplus methodology over a 23year period; smaller survey for 2008 study than earlier. This is a comprehensive assessment, examining implementation, policy, etc. well as impacts. Modestly positive returns on investment	Methodology used is described in detail in the early report, not in the 2008 report. Fairly standard—not reflecting more recent methods. The BBM TP is being assessed—and the elements of this as well as the design of the BBM have evolved.
WorldFish				
Initially it seemed there were no IAs of irrigation and water management research as defined in the TOR (Charles Crissman email, 23 June 2014). However, a broader definition of 'water management" would include work on integrated aquaculture-agriculture (IAA) systems (Charles Crissman emails 8 July 2014).				
32. Integrated aquaculture-agriculture (IAA) & systems, Asia, Africa [Bangladesh IAA projects 1989-2005, Approx. $8m]	Dey et al. 2010, 2013; Murshed-e-Jahan & Pemsl 2011; Antle, Murshed-e-Jahan & Crissman 2013	These studies, 3 from Bangladesh & 1 from Malawi, examine the impacts on livelihoods, food security and wellbeing of production systems that integrate fish with crop production—in Asia, rice and fish. The key characteristic is the synergy among the sub-systems; and interventions are intended to enhance	Assessing system performance rather than the productivity of a single technology or practice necessitates a broader methodology; these studies use total factor productivity, technical efficiency, returns to labor, and net incomes to measure impacts.	These are not IAs of the research investment; they are studies of the impacts of the interventions themselves.

Case	References	Brief Summary	Strengths*	Limitations*
		that synergy. The "Development of Sustainable Aquaculture Project" went beyond introducing specific technologies to using an approach involving on-farm experimentation and transfer based on farmer-scientist research partnership that included substantial long-term training & extension support.	These and similar studies provide a foundation for assessing research impacts and returns on research investments. Antle, Murshed-e-Jahan & Crissman 2013 is a SPIA-supported paper that builds on the previous Bangladesh papers and tests new methodologies for predicting *ex-ante* and assessing *ex-post* impacts in complex systems. They use a simulation modeling based approach to overcome the limitations of normal with-without, before-after average treatment types of IAs; the results confirm the efficacy and value-added of this approach as well as confirming the positive impacts of the IAA project.	
CIAT				
No IAs done of water management research (R Labarta email, 22 June 2014)				
ICRISAT				
Note: Most of ICRISAT's water management work is on watersheds, not included here. While there are some studies of technology impacts, no research impact assessments were provided.				
Africa Rice				
Note: No IAs of water management-related research programs. Inland alley Consortium is a long-standing program with a strong water management component but aside from project reports no research IAs have been done.				

Note: Centers that did not respond to the SPIA Chair's email request are not listed in this Appendix.

* This includes strengths and weaknesses of the impact assessment and of the program assessed.

Appendix 3: Characterization of Water Management Impact Assessments

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
IWMI						
1. IWMI's Research Program on IMT, 1992-2005	Giordano, Samad & Namara 2006 [also see Science Council 2006—a brief summary; Giordano, Samad & Namara 2007- a slightly condensed version of the RR]	Policy	Qualitative, internal, focused on influence of IMT research by IWMI; not quantitative IA assessment *Ex-post* program IA	Multiple: documents, bibliometric, webmetric, small focused survey, qualitative feedback. No baseline data. No counterfactual. No estimates of impacts.	Moderate: refereed publication, but limited. Documents high demand for IWMI pubs on IMT. Clear IPG	Since most IWMI research shows limited impacts of IMT, what would formal IA of the program show? Attribution & measurement issues would limit usefulness
2. IMT Action Research Project in Pakistan, 1995-2000	Bandaragoda 1999	Policy [tested through action research]	Qualitative, internal, focused on project process etc. not impacts. Not an IA of research investment. *Ex-post* project IA	Data collected as part of participatory action research. No baseline data No counterfactual	Moderate: refereed publication, but author was project leader National scale, not IPG	Written at end of project—insufficient time for impacts
3. Electricity -groundwater reform in Gujarat, India, 2004-2008	Shah et al. 2004; Shah et al. 2008	Policy [proposed in 2004 study, assessed in 2008 study]	Combined qualitative, some quantitative. Not a full IA of the research investment. *Ex-post*	Multiple sources. Process & impacts [before, after]	Moderately high: refereed pubs, main author was proponent of the innovation Provincial scale but in large country—potential IPG	Personal relationships of lead author critical; lends itself to a proper IA
4. Improvements in environmental quality due to changes in sluice	Wichelns et al. 2010	Management practice (sluice gate operation)	Combined qualitative, quantitative, estimates value of impacts but not IA of research investment. Example	Multiple including survey of farmers	Weak; done by IWMI researchers for SPIA, not published. Provincial scale, not an IPG	Seems to be part of a larger study but this is not acknowledged Summarized in

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
gate operations, Bac Lieu Province, Vietnam, 2001-2010			of *ex-post* EIA (see Bennett 2011)			Bennett 2011
5. Impact of soil remediation research to improve water holding capacity project in northeast Thailand, 2002-2005	Saleth et al. 2009	Management practice (applying clay)	Quantitative & qualitative *ex-post* IA of research investment	Multiple including survey of farmers	Fairly high: sophisticated methodology, refereed publication, led by a then IWMI researcher not involved in project implementation. Provincial, but IPG as technique is transferable	
6. Malaria control through environmental & irrigation management	Namara et al. 2008	Agro-ecological management intervention--program	Quantitative & qualitative *ex-post* IA of research investment (program)	Baseline data from project pubs, sample survey intervention & control villages.	Moderate: published in refereed national journal; led by IWMI researcher not directly involved in the research. Local focus, not a clear IPG	Limited number of beneficiaries; study claims similar approach to agro-ecological interventions potential in south west India, east Africa
7. IMT policy impact studies	Vermillion 1997, Vermillion and Garcès-Restrepo 1998, Vermillion et al. 2000, Samad & Vermillion 1999	Policy reform	Quantitative *ex-post* IA of the impact of the reform [not of research]	Quantitative survey data	Fairly high: used a consistent methodology. However, the studies may have been too soon after adoption to measure impacts successfully. Clear IPG	Only three countries; not related directly to the influence or impact of research.
8. Other	Shah et al.	Multiple : policies,	These are quantitative	Varies, some are	All are fairly high: reasonable	Not assessments of

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
irrigation & water management impact studies	2000, Adeoti et al. 2007, Inocencio et al. 2007, Namara et al. 2010, Hagos et al. 2012, Venot et al. 2012, Giordano & de Fraiture 2014	technologies	and *ex-post* facto IAs ; but they are not research IAs	based on survey data, others used data from other sources.	samples, good quality data in general. Clear IPGs	the impacts of water management research.
9. Ferghana Valley IWRM Project impacts, 2001 to 2005	Abdullaev et al. 2009	Institutional (arrangements for managing a canal, union of WUAs)	Quantitative—water delivery & farm yields before & after innovation. Not an IA of research	Available data	Weak: no economic analysis, no counterfactual, inconclusive. Not at IPG	Not a useful study.
10. IWMI's gender program	Rathgeber 2009	Not applicable	Mostly qualitative assessment CCER of trajectory of IWMI's gender program, with quantitative citation analysis. Program evaluation; not an IA of research investments	Documents, interviews, citations	Useful as an evaluation of the program, done by a well-respected external gender specialist.	Useful for IWMI's management but not for this study
11. IWMI-TATA Program mid-term CCER	Burke, Joshi & Chopra 2004	Not applicable	Mostly qualitative--CCER	Interviews, documents	Useful as an evaluation of the program, done by well-respected external specialists	Useful for IWMI's management but not for this study
12. Evaluation of IMAWESA Project, phase II, 2010-2013	Jackson 2013	Not applicable	Qualitative & quantitative evaluation of a donor-funded project; not a benefit-cost IA of research investments	Documents, interviews, on-line survey	Useful as an evaluation of the project, commissioned by IWMI through a competitive process	Uses a "value for money" framework but no economic analysis of impacts attempted
IFPRI						

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
13. GRP22 ("Water Resource Allocation: Productivity and Environmental Impacts")	Bennett 2013	Not applicable	Comprehensive review/ evaluation of IFPRI's water research program, 1994-2010. Not a benefit-cost IA of research investments.	Multiple data sources & methodologies, qualitative & quantitative	High. Commissioned review by a well-respected external IA specialist, published in IFPRI IA series. Very useful as an assessment of IFPRI's research program	No benefit-cost analysis attempted; study claims quantifying benefits of a program producing public goods is not possible. Study does assess influence-outcomes of 3 research projects & found no evidence of impacts on policy
CPWF						
NOTE: This section assesses reviews of CPWF program impacts, and commissioned impact assessments of specific CPWF projects. The latter are cross-referenced to specific CGIAR centers where relevant.						
14. Forthcoming meta-analysis of CPWF	Harrington & Fischer, eds. 2014 [Forth-coming]	Program design: multiple partners collaborating to address a development challenge, using new learning tools	Retrospective of lessons learned from a major CGIAR program. Not a benefit-cost IA	Multiple, mostly qualitative but some quantitative (e.g. citation analysis)	High as a source of lessons learned by program leadership; not as an IA. Strong IPG	Except on chapter, not sufficiently critical; no attempt to do IA or assess benefits-costs (too soon)
15. CPWF-program phase II (external assessment)	Hall, Bullock & Adolph 2014	Not applicable (see item 11,this table)	Commissioned external review of CPWF and lessons learned. Not a benefit-cost IA	Multiple: documents, interviews, field visits, participation in events. Largely qualitative	High as source of lessons from CPWF for future programs in CGIAR, but not as an IA	Broad review with an emphasis on lessons for the future. Thoughtful, insightful
16. CPWF-program phase I [selected projects]	Wooley & Douthwaite 2011	R4D with multiple partners working at multiple scales of complex	Review by former director of CPWF & former head of IA to identify lessons	Uses documentation produced by the 5 projects reviewed	Useful for insights, not independent	

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
		adaptive systems	learned from 5 phase 1 projects. Not a benefit-cost IA			
17. CPWF Most Significant Change [MSC] Stories	Harrington et al. 2008; de Leon, Douthwaite & Alvarez 2009	Usefulness of MSCs to monitor, document, learn from change processes	Edited volumes with comments by editors on MSC stories collected from CPWF projects Not a benefit-cost IA	MSC stories provided by project leaders. Entirely qualitative	Reported by researchers themselves, not independent. Source of useful insights into incipient change processes and/ or new conceptual frameworks	Several MSC stories used to select projects for IAs (see below); may be useful for selecting projects for future IAs
18. CPWF-Small grants	Wooley 2011	Small grants to complement larger research program	Review of experience with 6 small grants—lessons, not an IA	Mostly qualitative	Written by former director of CPWF. Little information on the projects reviewed	
19. Aerobic rice-'STAR' in Asia Project, 2004-2008	Templeton & Bayot 2011	Aerobic rice: growing rice in water-scarce conditions. See IRRI studies below	*Ex-post* IA of project, focused on China sites though authors visited Philippines as well	Mainly qualitative to understand the research to impact pathway; benefits and costs based on expert assessment & available data; excludes environmental impacts	Moderate. Commissioned; 1st author is external. Published on line by CPWF. Evaluation was right after project completion—insufficient time passed. No primary data collected. Many assumptions behind benefit-cost analysis. IPG as aerobic rice is widely relevant	Sets the stage for a follow-up benefit-cost IA
20. Water & land management at interface between fresh and saline water environments-evaluation of	McDonald 2011	Management tools for managing fresh-saline water environments IRRI as lead; IWMI, WorldFish as partners	*Ex-post* IA, focused on Mekong delta site; intended to identify contribution of CPWF project	Mainly qualitative; attempts "realistic evaluation" interpretation focused on actual impact pathway: emphasis on learning lessons,	Moderate. Independent evaluator commissioned by CPWF, published online by CPWF. Evaluation was right after project completion—insufficient time passed. Possible IPG—applicable on	Sets the stage for a follow-up benefit-cost IA

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
Vietnam component [Bac Lieu], 2004-2008		See no. 4, above, under IWMI		provide "plausible" examination of outcomes and incipient impacts	other deltas in Asia	
21. Citizen participation in managing water [SCALES Project], 2005-2007	Córdoba & White 2011	Institutional (collective action mechanism on a watershed in Colombia) CIAT as lead	*Ex-post* evaluation of the effectiveness of a process; not a benefit-cost IA	Interviews, social network analysis, participatory video, review of 2ndary data. Report notes there was no baseline data	Moderate: Carried out by CIAT staff, not external; very sympathetic to project, few critical observations; published on line by CPWF. Use of social network analysis a strength. Claims this is an IPG but not convincing-the mechanism seems Colombia-specific	Too soon to have evaluated benefit-cost; provides baseline for possible *ex-post* IA in future.
22. "Models for Implementing Multiple-Use Water Supply Systems for Enhanced Land and Water Productivity, Rural Liveli-hoods and Gender Equity" [MUS] Project	Merrey & Sibanda 2008	Combination of policy, institutional innovation IWMI as lead	Evaluation of the process to create a plausible account of changes that had occurred as a result of the project. Attempted an *ex-ante* benefit-cost analysis of research	Project documents; data collected by national consultants; workshops	Moderate: commissioned by CPWF; first author had been involved in project when at IWMI; not published but cited by other published papers. Strong IPG.	Presents evidence of significant outcomes & high potential for impacts. Sets scene for possible benefit-cost IA.
CIMMYT & Rice-Wheat Consortium						
23. Rice Wheat Consortium & Zero Tillage [ZT] in Rice-Wheat Zone, South Asia (1999-2007)	R&D impacts Laxmi, Erenstein and Gupta 2007, & Erenstein and Laxmi 2010	Combination technology [special tractor-drawn seed drill] & management practice [ZT] as a proxy for program	*Ex-post* & *ex-ante* IA with estimated benefits, costs. Pal et al. is an environmental IA Program IA but focused on ZT as the	Multiple sources including focus groups, surveys, program data & reports.	Moderately high: IAs carried out by CIMMYT staff & an Indian partner (Pal et al.), but published as CIMMYT and Comprehensive Assessment RRs, a SPIA peer-reviewed report & in refereed journals.	RWC was an agro-ecological program with multiple facets; IAs focus entirely on ZT, and all but one report on favored parts of India.

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
	ZT impacts Erenstein, Malik and Singh 2007; Erenstein et al. 2008; Farooq, Sharif and Erenstein 2007; Erenstein and Laxmi 2008; Erenstein et al. 2008; Erenstein 2009a, 2009b; and Pal, Sekar and Kar 2010 Methodological Erenstein 2009c, Erenstein & Laxmi 2010 [see also Bennett 2011]	CIMMYT lead, with other centers participating	main innovation.		Other papers on ZT impacts available—increase credibility of this work & add more insights into impacts-see next item (21) Strong IPG	Bennett (2011) notes methodological weaknesses of environmental IA by Pal et al. A full *ex-post* IA of entire RWC program might be useful.
ICARDA						
Note: Several interactions with ICARDA led to identifying these two studies which I agreed to include. It appears ICARDA has never done any studies of the impacts of its research on water management; its IAs are studies of specific technologies ICARDA has researched and promoted.						
24. Improved Supplementary Irrigation [ISI] of wheat, Syria	Yigezu et al. 2010; 2014	Technology package-improved varieties, organic fertilizer with ISI	*Ex-post* cost-benefit at farm level of technology [yield, water saved, estimated salinity	Large representative sample, collected 20 years after project;	Moderate. Leaves many questions unanswered, for example why 20 years after project only 20% farmers have adopted	Discussed in Bennett 2011. Not a research IA—no data on costs of research.

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
			reduction]; and environmental IA Not a research IA	biophysical data from previous research	Possible IPG – technology applicable elsewhere	
25. Economic & environmental impacts WH in low rainfall area (Badia Benchmark Site), Jordan	Akroush, Shideed & Bruggeman 2011, 2014	2 water harvesting technologies—contour ridges with shrubs & runoff strips with barley	*Ex-post* environmental & economic IA of technologies. 2011 is a chapter in a book on the project; 2014 is a peer-reviewed journal article. Not a research IA	Data collected during technology trials; soil surveys for environmental impacts (on organic matter).	Moderately high. Possible IPG – technology applicable elsewhere.	Not a research IA—no data on costs of research
IRRI						
26. Irrigated Rice Research Consortium [IRRC],1997-2012	Rejesus, Martin & Gypmantasiri 2013, 2014	15-year partnership-based research, communication, capacity building program. Two water management innovations included: AWD & aerobic rice	*Ex-post* "meta" analysis of multiple impacts of the IRRC. Rejesus et al. 2013 is a full commissioned report; Rejesus et al. 2014 is a journal article summarizing results & emphasizing lessons for NRM research. Research program IA	Existing documents, easily accessible data sources, & short field visits.	High: commissioned external review, uses multiple sources of data, analyzes impact pathways as well as benefits-costs. Comprehensive; comments on methodologies used in IA studies discussed below. Overall, AWD & aerobic rice impact studies –positive impacts, but methodological issues esp. control for selection, need to use more up to date methodologies, include IA specialist from beginning of project. Strong IPG	An excellent research IA Offers useful critical remarks and recommendations for planning IAs from beginning of such NRM programs. Reviews environmental impacts but evidence "thin".
27. Aerobic rice adoption China, Philippines cases	Flor 2007; Ding et al. 2010	Drought-tolerant rice varieties grown in non-puddled non-flooded soils	Flor 2007 is a masters degree thesis-a qualitative anthropological study on farmers' understanding	Ding et al use household survey data from 3 counties	Moderate; these are more useful to understand farmers' perceptions & as baseline for future studies Strong IPG	Cross reference CPWF study-Templeton & Bayot 2011; Rejesus et al. 2013, 2014

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
			Ding et al 2010 is an adoption study Not a research IA			
28. AWD adoption Bangladesh	Kürschner et al. 2010	Water management practice—alternately wetting & drying rice	Commissioned project assessment—broad approach; main focus is on issues affecting uptake, comparison of yields Not a research IA	Qualitative & quantitative including survey	Moderate: Adoption is at an early stage; study is useful for re focusing project, not as an IA; useful as baseline. Strong IPG	Cross reference Rejesus et al. 2013, 2014; CPWF Not a research IA
29. AWD adoption, Central Luzon, Philippines, 2001-2005	Rejesus et al. 2011	Water management practice—alternately wetting & drying rice	Benefits-costs of AWD adoption; journal article Not a research IA	Farm level survey data	High: more rigorous methodologically than most IAs Strong IPG	Cross reference Rejesus et al. 2013 Not a research IA
30. AWD adoption Vietnam, 2005 to 2011	Diangkanay-Quicho 2013	Water management practice—alternately wetting & drying rice	M.Sc. thesis – adoption & economic impacts. Not a research IA	Various sources including panel data from 2009, 2011	Moderate [not a refereed study] Provides baseline for possible future IA Strong IPG	Not a research IA Useful description of project
ILRI						
31. Broad Bed Maker (BBM) plow, Ethiopia, 1986-2008	Rutherford, Odera & Kruska 2001; Rutherford 2008	Technology package for vertisols: land shaping plow plus improved seeds, inputs, training	*Ex-ante* & *ex-post* IA of research & implementation program; traces evolution of program. Research program IA	Survey data [2008 sample smaller than 2001], plus interviews, document review; economic surplus methodology	Moderately high: *ex-ante* done in 2001; *ex-post* re-study in 2008. 2001 costs exceeded benefits but projected it would be positive by 2005; 2008 study finds modest positive benefit-cost Potential IPG but not discussed as such	Standard methodology-may reflect methodological problems
WorldFish						
32. Integrated aquaculture-agriculture (IAA)	Dey etal. 2010, 2013; Murshed-e-	Combination technology package &	*Ex-ante* and *ex-post* IAs of the technologies and project strategy	Existing and new survey data, plus other sources	High: sophisticated methodologies used; very positive impacts; Antle,	These papers are well done; good foundation for

Case	References	Type of innovation	Type of IA	Data used	Credibility	Notes
& systems, Asia, Africa, 1989-2005 [Bangladesh projects 1989-2005]	Jahan & Pemsl 2011; Antle, Murshed-e-Jahan & Crissman 2013	innovative participatory training-extension	Not research IAs		Murshed-e-Jahan & Crissman 2013 paper is especially innovative methodologically Definite IPG	research IA; methodological contributions
CIAT						
Note: No IAs done of water management research (R Labarta email, 22 June 2014)						
ICRISAT						
Note: Most of ICRISAT's water management work is on watersheds, not included here. While some studies of technology impacts were provided, no research impact assessments were provided.						
Africa Rice						
Note: No IAs of water management-related research programs. Inland alley Consortium is a long-standing program with a strong water management component but aside from project reports no research IAs have been done (M Masiyandima email, 25 June 2014).						

Note: Centers that did not respond to the SPIA Chair's message are not included here.

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