

**COMPREHENSIVE ASSESSMENT OF WATER
MANAGEMENT IN AGRICULTURE**

**IMPACTS OF IRRIGATION
FAO & IWMI
Consultancy**

**Final report:
Literature review summary by thematic factors**

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1 BACKGROUND

The following report corresponds to the consultancy project supported by FAO and IWMI with the purpose of giving a step forward on addressing one of the ten research questions of the Comprehensive Assessment of Water Management in Agriculture (CA) project: *What have been the benefits, costs and impacts of irrigated agricultural development and what conditioned those impacts?* As stated by CA, **of all the means of using water for agriculture is the most contentious because of the magnitude of water use by this sector**, and because of the debate as to whether the benefits of irrigation in terms of poverty reduction, economic development and food production have outweighed the social, financial and environmental costs.

During the study, a literature review was carried out on publications dealing with impacts of irrigation focusing in Latin American (LA) countries. This activity had three objectives:

- Summarize publications findings on irrigation impacts on these countries by thematic factors
- Propose a methodology and outline for preparing the literature review to integrate results on impacts of irrigation cutting across different water resources sectors.
- Specify the type, breadth and scope as well as the reliability of the information available.

The product of the study is a data base in Excel file format (*Irrigation impact references.xls*), which encloses the categorization and classification by thematic factors and key words of the publications found on irrigation impacts methodologies and studies undertaken in LA countries. Additionally, references are included for the corresponding local institutions in charge of water management for some LA countries (*Regional institution* spread sheet), as well as, international institutions (*International links* spread sheet) and relevant local organizations or programs (*Regional links* spread sheet) linked to irrigation and water issues.

In the following report, the literature review methodology and searching criteria are described followed by a detail explanation of classification principles used for assembling the data base of literature reviewed. Next, a section on how to use the data base is included to facilitate searching inside it. Moreover, general results of the literature review are mentioned making emphasis on findings regarding irrigation impact approach and location of the studies; summary of irrigation impacts by thematic factor are presented based on some selected documents. Finally, some comments on information availability are discussed.

2 LITERATURE REVIEW METHODOLOGY

In order to select key words for searching publications on irrigation impacts, the following methodology was implemented:

1. General literature reading on the irrigation sector in LA region with the purpose of identifying variables and relevant issues involved in irrigation development. Among the most relevant documents found at this stage are *Recent Latin American developments in irrigation* (Maletta, 2000) and the EPTD¹ Discussion Paper No. 64, *Irrigation and water resources in Latin America and the Caribbean: challenges and strategies* (Ringler et al, 2000). In the final data base, some of these consulted documents were classified under “General impact approach”.
2. Determination of research questions, based on the previous reading, to assess irrigation impacts
3. Grouping the research questions according to a thematic factor
4. Literature review using these thematic factors as key words
5. Definition of more key words derived from the first search findings giving, depending on information details degree, two different level category (See [Figure 2.1](#)).

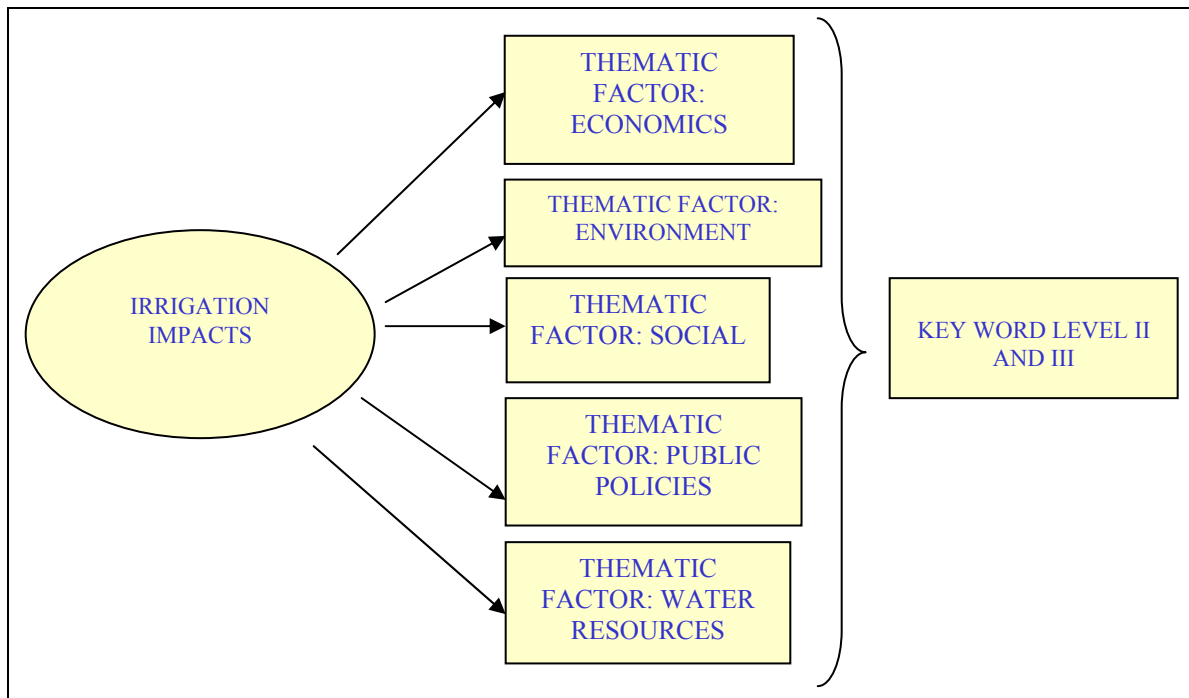
In brief, the set of key words used for literature review were an interactive process that started with the definition of secondary research questions which in its turn were the output of a first general literature review (more detail in Section 3). Along this methodology, the information sources consulted were libraries and internet engines. The visited libraries in Mexico City are:

- World Bank
- Comisión Económica para América Latina (CEPAL)
- Colegio de México
- Facultad Latinoamericana de Ciencias Sociales

Further searches were also carried out using the keywords on Internet search engines (such as Yahoo, Google and Altavista). Most of the publications of the previous institutes are available on line, therefore, emphasis on internet search was made. Keywords were used to search the various databases encompassed broad terms (such as ‘economic impacts of irrigation’) as well as specific terms (such as ‘irrigation assessment’ and ‘development and irrigation agriculture’). Multiple iterations of searches were conducted and screened. On the other hand, direct searches were conducted in specific institution related to irrigation and agriculture web pages such as FAO, World Bank, OCDE. Finally, also institutions in some LA country were directly consulted mainly for statistic information and governmental programs.

¹ Environment and Production Technology Division, International Food Policy Research Institute

Figure 2.1 Definition of keywords



3 CLASSIFICATION PRINCIPLES

The classification principles are based on the literature review methodology (see previous section) which links a thematic factor and secondary research questions derived from the original of the CA study: *What have been the benefits, costs and impacts of irrigated agricultural development and what conditioned those impacts?* The purpose of this classification is to simplified the researches' job who collaborate in the CA studies by easily identify the published studies which could enhanced their research process and contribution when answering the mentioned research question.

In *Table 3.1* and *Table 3.2*, the thematic factors and key words linked to the main research question are presented. As previously mentioned, five grand thematic factors were determined: economic, social, environment, public policies and water resources (See [Figure 2.1](#)). Then, for each one of them, two levels of key words were selected aiming to complete a set of keywords presented in the already review documents. As a result, for each specific research sub-question, a group of key words -under 3 different levels of categories- is linked. The idea is to have alternatives for classifying the publication in question under 3 different levels of categories. This means that Keywords on level III have more specified information than the thematic factor itself (Key word I). Moreover, when classifying a document, the combination of key words II and III with all the thematic factors gives flexibility and good understanding of the document content. For instance, a document mainly related to Social issues, can also raised information on Water Transfers or Irrigation Institutions. However, only one thematic factor should be linked to one publication.

Table 3.1 Thematic factors and key words linked to the main research question

Link to the research question: <i>What have been the benefits, costs and impacts of irrigated agricultural development and what conditioned those impacts?</i>	Key word I (Thematic factor)	Key word II	Key word III
How agriculture irrigation improves commercial balance (i.e. food exports vs imports)?	Economic	Food security	Food production
How irrigation development ensures food supply for population in quantity and quality?			
How irrigation increases the household income and how it reflects an increment in the GNP agriculture sector contribution?		Development	Household income
How irrigation influences social equity and poverty alleviation?			Poverty
How irrigation development influences the creation of new markets (i.e new suppliers due to new demand, new clients due to new agriculture products)?		Livelihoods	
		Employment	
How much has the agriculture sector productivity and labor force increase due to the switch from rain fed agriculture to irrigated agriculture?		Agriculture	Productivity
How much has the agriculture costs increase with irrigation services?			
How much private investments have been directed to the irrigation sector?		Wealth distribution	Subsidies
Who captures the irrigation subsidies: farmers or general consumers?			Support programs
How irrigation influence wealth distribution?	Social	Gender	
How human settlements are influenced by the irrigation development projects		Organizations	Water Users Association
How the irrigated agriculture introduces women to labor market?			
How irrigation becomes a factor for social structures creation (i.e. Water users associations, etc)?	Environment	Water quality	Pollution
How irrigation introduces pollution or reduces water quality?		Water transfer	Lake and rivers
How much has water transfer from the environment to irrigation increased?, what is its impacts, (i. e. Lakes, ecological flow from rivers, introduction of new water bodies, alteration of water resources availability among basins)?			
How irrigation contributes to hydraulic erosion and soil fertility reduction (salinity)?		Soil degradation	Salinity
			Erosion
How irrigation has increased human contact with chemical substances?		Health	Diseases
How irrigation induces human diseases (i.e. Malaria, etc)?			
How irrigation increases access to water for domestic purposes?	Water access		

NOTE: In this case, “Water transfers” refers to shifts of water concessions or uses from one sector to another, specifically from environment to agriculture

Table 3.2 Thematic factors and key words linked to the main research question (continuation from Table 3.1)

Link to the research question: <i>What have been the benefits, costs and impacts of irrigated agricultural development and what conditioned those impacts?</i>	Key word I (Thematic factor)	Key word II	Key word III
How irrigation evolution is directly related to institutional changes, (i. e. Irrigation management transfers to users associations, creation of institutions)?	Public policies	Irrigation management	Irrigation institutions
How irrigation enhances governmental water control?			Technology
How much does the irrigation development cost to public budgets (i. e. public investments on large-scale irrigation projects construction, subsidies, supports programs for irrigation modernization, etc.)? What is the opportunity cost for the country?		Public budget	Evaluation methods
			Irrigation infrastructure investments
		Irrigation projects	Large scale projects Small scale projects
How irrigation development has change the water allocation collective and individual water rights		Water rights	
How irrigation has conducted the development of water markets?		Water market	Water value
How irrigation represents an important role on water price estimation as the main water user, i.e. fees for water delivery, water rights exchanges?	Water price		
How water competition among sectors enhances a better water management?	Water resources	Water management	Water competition
How irrigation development increases the pressure on water resources exploitation?		Water exploitation	Water allocation
How irrigation generates competition among sectors for water allocation?		Water use efficiency	
How irrigation affects general water resources use efficiency?			Wastewater
How irrigation facilitates waste water management?			

Before allocating keywords to each document, a previous classification was done considering others four variables: location of the study, impact assessment approach, case study data and, other cutting across sectors. The meanings of these variables were defined as follows:

1. Location of the study. It refers to the name of the country or region where it was placed. During the literature review, several documents related to irrigation impact assessment methodologies were found which are not directly linked with LA countries but have relevant and useful information. A category of “Global” was created under this variable in order to include all these documents.
2. Impact assessment approach. Based on the findings, basically the studies use three different approaches on the irrigation impact analysis: direct, indirect or general approach -which includes the previous two mentioned-. This variable was included because it was considered extremely useful for researchers to know in advance the approximation method used for assessing the irrigation impacts. According to the literature review, generally the analysis on irrigation impacts consider both, cost and benefits, however a more clear distinction is done whether is direct or indirect the impact. This is why, it was decided to classify the irrigation impact approach into direct, indirect and general (for those who discussed both types) understanding that cost and benefits are generally presented as a parallel analysis.
3. Case study data. There are some documents that correspond to a case study which could be useful either for the methodology used and the results obtained. If a researcher is interested in case study data or in application of impact assessment methodologies, there is an option for selecting the documents with case studies data.
4. Cutting across sectors. In this variable, if other sectors beyond the irrigation sector are considered in the document, it was specified which of them was mentioned or if just the irrigation sector was considered within the document.

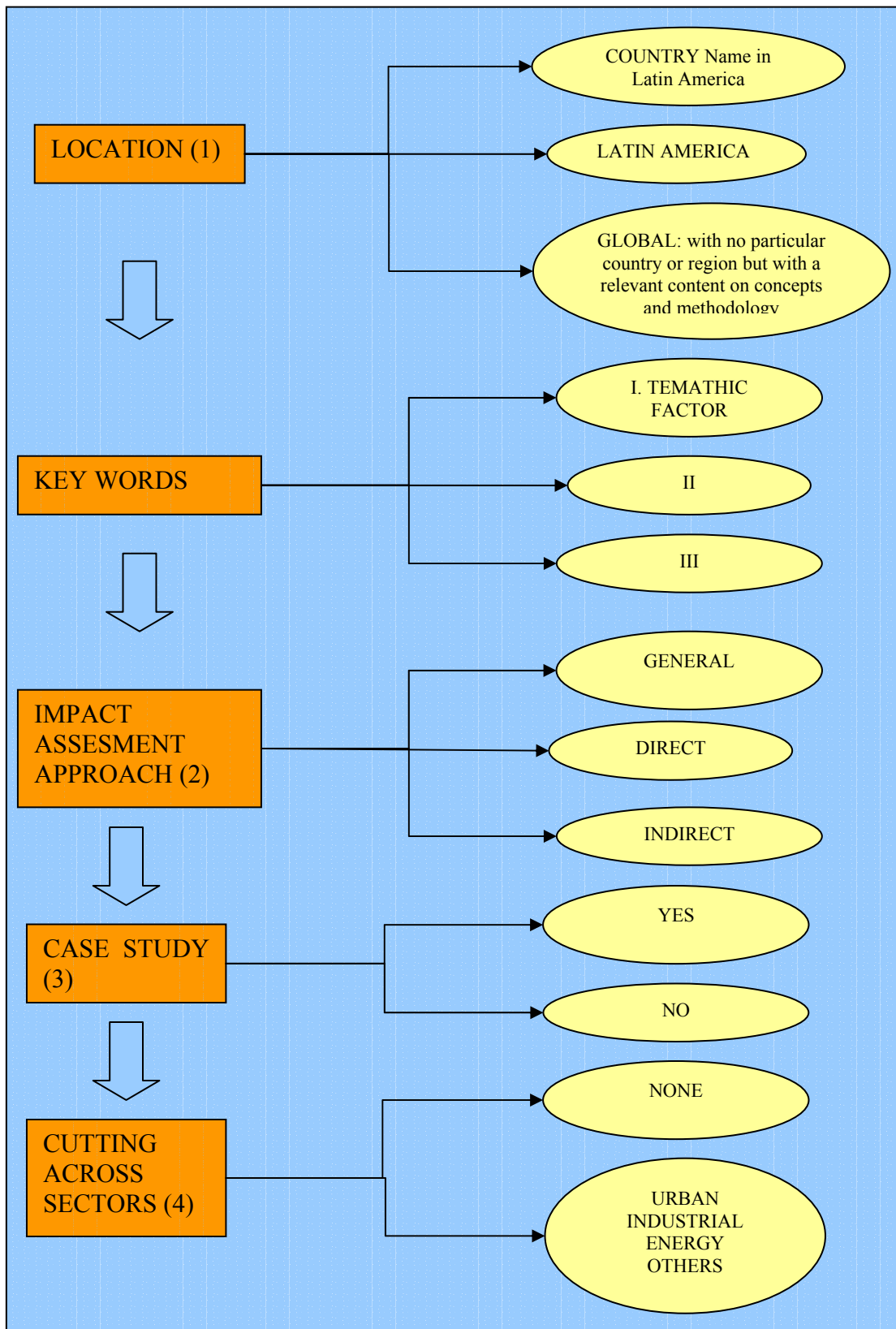
In *Figure 3.1*, a summary of the classification principles together with the keywords designation for the reviewed document is shown. All documents presented in the Excel file, were classified following the vertical order as presented in this figure based on the abstract content or the table of content. The final data base arrangement indicating the corresponding variable for each one of the Excel file columns is presented in *Table 3.3*.

Table 3.3 Data base arrangement by Excel file columns

Column A, B, C	Column D	Column E	Column F	Column G	Column H to M	Column N
Key words: thematic factor, level II and level III	Impact Approach	Case Study	Location: country or region	Cutting across sectors	Document description: Author, year, title, publisher, abstract (if available), original key words (if available)	Availability: link to the document on the web

Once the publication was identified, the corresponding thematic factor (or Key word I) was selected based on the abstract content. Then, following the same procedure, key word II and III were selected as well as the other characteristics variables (Column D to G). It is important to mention that during the publications classification, several changes were made to the key words in order to give more consistency to the keywords selection trying to avoid incongruence.

Figure 3.1 Classification principles for the irrigation impacts literature reviewed



4 USING THE DATA BASE

The researcher will be able to consult the documents data base on irrigation impacts publications by using a filter in all the variables previously mentioned (See *Table 3.3*) or just in one of them. The information available for each on of the documents is:

- Authors
- Year
- Title
- Publisher
- Abstract (if existing)
- Other key words (when specifically is mentioned within the document)
- Availability (the internet link where it is available or the file name)

The researcher should use *Table 3.1* and *Table 3.2* (also founded in the first spread sheet of the Excel file) as a guide for finding the keywords that correspond to her or his interest. For instance, a researcher is working on assessing irrigation impacts related to the question: *How irrigation influences social equity and poverty alleviation?* As a result, according to *Table 3.1*, the thematic factor linked to this question is *Economic*. Once the thematic factor is defined, the researcher could go directly to the file on the *Publications data base* spreadsheet and use the filters arrows to select the corresponding thematic factor on the first column. Following this example, 35 publications under the thematic factor of *Economic*. can be found and this set of publications can be further filter based on the other key words and characteristics (See *Figure 3.1* and *Table 3.3*). For instance, if the researcher needs a case studies for her/his study, then on the *Case Study* variable (column E) should select YES having as a result the selection of 10 publications that will help to answer the initial secondary research question focus on case study data bases. Furthermore, this set of publications can be prioritized by using more variables or by reading the abstract of each one of them.

5 RESULTS

The current number of references classified on the Excel file is 274 but this is just a representative sample. More references could be added following the same classification principles, by authors themselves or institutions interested in the topic, if the data base is properly installed on the internet. Taking this first literature review as a representative sample, studies availability gaps can be detected and decisions on supporting or enhancing research studies can be prioritized. The summary results are presented in *Table 5.1* to *Table 5.5* and based on these, in the following paragraphs some discussion is presented making emphasis on important findings.

5.1 Irrigation impact approach

Irrigation is a complex system that requires a multidisciplinary perspective in order to define a clear methodology -or epistemological frame- for assessing its impacts which should consider available information and resources to implement it. The irrigation impact approach is normally made from a general perspective (See *Table 5.1*), i.e. the analysis on irrigation assessment considers, cost and benefits or, in another words direct and indirect impacts. The lack of perspective in most of the reviewed documents can be observed by the fact that only 28% of them undertook some kind of cutting across sectors analysis. Nonetheless, a more conservative but effective analysis could be done by making a single assessment on direct impacts with a case study. However, only four of

these type on documents where found in the literature review carried out. More of these studies are found in the local governments who required annual assessments on their supporting programs for financing irrigation which represent an important budget, i. e. the *Informe de evaluación Alianza Contigo* in Mexico. Unfortunately these documents' access is commonly more restricted for researchers. As a conclusion, there is an important research gap on irrigation assessment methodologies that successfully could bring a good understanding and measurement of irrigation costs and benefits.

Table 5.1 References found by type of impact approach, existence of case study, and presence of cutting across sectors

Classification principle		Number of references	Percentage of total references
Impact approach	General	156	58%
	Direct	15	5%
	Indirect	102	37%
Case study content	Yes	90	33%
	No	184	67%
Analysis of impacts including cutting across sectors		77	28%

5.2 Location of the studies

Most of the review documents are global studies (around 40%) without a LA or local perspective; only 20 complete studies were found about irrigation in LA (See Table 5.2) but countries like Mexico have an important number of studies focusing on national circumstances. The selection of the location of the studies is directly related with surface irrigated area; Mexico is by far the most irrigated country in LA having 6,320 thousand ha.

Table 5.2 References found by the location of the study

Region/Country	Number of references
Global	107
Latin America (LA)	20
Mexico	47
Argentina	29
Brazil	15
Colombia	10
Chile	8
Peru	7
Ecuador	5
Others	26
TOTAL	274

5.3 Thematic factors

Table 5.3 to Table 5.5 have been prepared to present results by thematic factors. Additionally, a summary of four of the most relevant studies found are discussed in order to portray what has been written or studied about irrigation impacts for specific thematic factors such as economic, social,

environmental and water resources. From the number of references found by thematic factor (See Table 5.3), it can be said that there is an important attention concentrated around public policies given the debate and research documentation around the privatization process on the water sector, i.e. water transfer to irrigation water users associations, the creation of new water markets, and the new role of state on water management. Secondly, water resources is distinguish by its number of references found which is mainly given the water competition among sectors and being irrigation the main water user.

Table 5.3 References found by thematic factor

Thematic Factor (Key word I)	Number of references
Economic	35
Social	34
Environmental	43
Public Policies	88
Water resources	74
TOTAL	274

Table 5.4 References found by key words level II

Key words II	Number of references
Agriculture	23
Development	19
Employment	4
Food security	3
Gender	12
Health	12
Irrigation project	5
Irrigation management	75
Livelihoods	1
Organizations	3
Pollution	2
Public Budget	1
Soil degradation	3
Water Management	34
Wastewater	12
Water exploitation	2
Water market	13
Water price	2
Water quality	12
Water rights	8
Water transfer	2
Water use efficiency	13
Wealth distribution	9
n.a	4
TOTAL	274

In

Table 5.4 and Table 5.5 the number of references found for each one of the defined keywords is mentioned. Some of the reviewed documents were clearly focus in one of the thematic factors and therefore, it was not necessary to include an additional key word -level II or III-. Only 4 documents have just a thematic factor linked and no key words and, 134 reviewed documents are lacking of a third level key word (See Table 5.4 and Table 5.5).

Table 5.5 References found by key words level III

Key words III	Number of references
Diseases	9
Erosion	1
Evaluation methods	9
Food production	3
Household income	2
Irrigation infrastructure investments	3
Irrigation institutions	3
Lake and Rivers	1
Large scale projects	5
Pollution	9
Poverty	24
Productivity	1
Salinity	1
Small scale projects	10
Subsidies	8
Technology	9
Water access	1
Water allocation	4
Water competition	9
Water Users Association	22
Water value	6
n.a	134
TOTAL	274

5.3.1 Economic impacts:

In the publication *Latin America employment, analysis of the 25% from Economically Active Population* (Sirvent, 1997) the research question that is addressed is: How much has the agriculture sector productivity and labor force increase due to the switch from rain fed agriculture to irrigated agriculture? The author states that agriculture employment presents strong fluctuations due to its demand changes along the cultivation period. Even though agriculture productivity has constantly increase through decades, it has been below the economic growth of the other sectors. Moreover, it is mention that neoliberalization politics have change production and consuming patterns making the rural economically active population (EAP) emigrate to urban centers meanwhile EAP that stays at the rural sector faces poverty and marginality conditions. The main constrain to assess the irrigation agriculture economic impact is the low reliability of employment figures reports that might vary even 100% depending on the source. There is a lack of specific research on the real employment generation of the high level agriculture production.

5.3.2 Social impacts

Involving Local Organizations in watershed management (Ashby, 1988) is a representative document for answering the research question of how irrigation becomes a factor for social structures creation (i.e. Water users associations, etc). The authors talk about three main reasons for involving local organization on water basin management. Firstly, local organizations can often be very effective in generating and securing compliance with rules for the use of common property such as water. Secondly, organizations that involve local stakeholders in the development of management practices and the selection of technologies aim to improve watershed resources. Thirdly, represents a devolution of responsibility (from the government to organizations) to externalize some costs of conservation from the state to local communities. Also, local organizations regulate resources use, provide a forum for resolving conflicts among local stakeholders and provide a channel for the representation of on site -and off site- stakeholders groups in the negotiation of common property resources use. The publication is a case study from the “Rio Ovejas” in Colombia

5.3.3 Environment impacts

Irrigated agriculture represents more and more an important water pollution source. The publication titled “Fight against agriculture water resources pollution” done by Ongley (1997) addresses the effects of agriculture on water quality due to chemicals use and soil erosion which are linked to food production. According to this study, the main difficulty on estimating agriculture impacts on the environment is that pollution causes can not be specifically located or linked to a defined source which makes measurements practically impossible. Moreover, fight against pollution is so expensive that suggests that knowledge on water pollution costs for the different sectors should have priority. Information content in this publication is useful for formulating an answer on how agriculture contributes to hydraulic erosion and soil fertility reduction and how agriculture has increased human contact with chemical substances. However, further research needs to be done making special emphasis on irrigated agriculture –as a difference from rainfed agriculture-. The reviewed publications generally focus on the agriculture impacts and there is a lack of analysis on how irrigation has promoted the cultivated land increment as well as water resources pollution.

Another set or irrigation impacts are mention in many publications related to health especially focused on waste water irrigation (Cifuentes et al, 2000; Ortega Larrocea et al, 2001) and diseases given the water bodies (Ledder and Scudder, 1999). However, studies on how irrigation increases access to water for domestic purposes are seldom found.

5.3.4 Water resources impacts

The irrigation impacts on water resources are definitely very relevant giving a general awareness on water scarcity (Barker et al, 2000; Robledo, 1999). Irrigated agriculture began as a new water user that soon became the biggest. Most publications on this subject are focus on measuring water consumption (Chambouleyron and Morábito, 1980; 1978; 1979) and alternatives for saving water from new technologies to waste-water reuse (Cavallini, Julio Moscoso et al, 2002; Medeiros Leitao, 1999; Blanca Jimenez-Cisneros, 1995; Silva and Scott, 2003; Bahri, 1999). Moreover, integrated water management is often discussed as a solution for mitigating and ensuring irrigation agriculture sustainability (Seckler, 1995; Armando Bertranou, 1999). Rosegrant and Ringler (1999) give an interesting summary on irrigation impact on water resources by addressing water competition among different sectors by reviewing and synthesizing the available evidence of the effects of water transfers from agricultural to urban and industrial areas on local and regional rural economies. The

research question to which, this publication, surely provides an answer is: How irrigation generates competition among sectors for water allocation?

As a conclusion, based on the literature review findings, good research has been done on how irrigation is linked to waste water management and its impact on water competition among sectors. However, a very important gap on information exists on how irrigation development increases the pressure on water resources exploitation and how irrigation affects general water resources use efficiency. This situation is closely related to the lack of water control and measurement on water use in irrigation and irrigated surface. The first step towards assessing the irrigation impacts on water resources is having reliable and accurate data bases on irrigated surface and water consumed by irrigated agriculture. Unfortunately, this step is remains behind in most countries in LA.

6 COMMENTS ON INFORMATION AVAILABILITY

A second step towards the research on irrigation impact assessment will be the definition indicators based on certain methodology. Within this phase, information availability is definitely a constraint and special attention should be paid on this subject. In this section, some general comments on this issue are presented as a result of the literature review exercise done.

Table 6.1 Institutions water sector related in selected LA countries

Country	Institution name	Acronym
Chile	Instituto Nacional de Investigaciones Agropecuarias - Area de Riego	INIA
	Ministerio de Obra Publicas-Direccion de Obras Hidraulicas - Direccion General de Agua	MOP-DOH
	Unidad Asesora del Riego del MINAGRI	UAR/ODEPA
Colombia	Instituto de Hidrologia, Meteorologia y Estudios Ambientales - Subdireccion de Hidrologia	IDEAM
	Instituto de Investigaciones en Geociencia, Minería y Química - Subdireccion de Minería	INGEOMINAS
Ecuador	Consejo Nacional de Recursos Hídricos - Planificación	CNRH
	Corporacion Regional de la Sierra Centro - Planificación de Recursos Hídricos	CORICEN
	Centro de Reahabilitacion de Manabi - Riego, Drenaje y Desarrollo	CRM
	Centro de Reconversion Economica del Azuay, Canar y Morona - Riego y Drenaje	CREA
	Comision de Estudios para el Desarrollo de la Cuenca del Rio Guayas - Direccion Ejecutiva	CEDEGE
	Corporacion de Desarrollo Regional de Chimborazo - Riego y Desarrollo	CODERECH
	Corporacion de Desarrollo Regional de El Oro - Riego y Drenaje	CODELORO
Mexico	Comision Nacional del Agua - Subdireccion General de Operación - Subdireccion General Tecnica	CNA
	Instituto Mexicano de Tecnologia del Agua	IMTA
	Fideicomiso de Riesgo Compartido	FIRCO

	Secretaria de Agricultura, Ganaderia y Desarrollo Rural - Subsecretaria de Agricultura	SAGARPA
Peru	Direccion General de Aguas y Suelos - Direccion General	DGAS

Information availability among LA countries is diverse as the countries themselves. A search among LA countries was conducted on related offices, ministries or information institutes linked with the irrigation sector in order to evaluate how readily available information is. Several publications on statistical data bases for LA were found, among the most relevant are presented in *Table 6.1*. Also, a summary of the regional links, regional institutions and international links, found during the literature review search, is in the irrigation impacts Excel file in separated spread sheets.

Finally, the lowest level of data available is a very important aspect of data bases for estimating costs, benefits, and irrigated agriculture impacts indicators, i.e. country, region, province, basin, irrigation systems, and etcetera. The selection of the study area for estimating these indicators should take this characteristic as the most relevant factor. For instance, basins have been a world-wide water management model which has been predominant in LA countries with significant irrigated area but general census, agriculture and hydraulic data bases (or statistic) do not correspond to the basin boundaries but the political division the so called provinces, states or their minor political level which is the municipality.