Perspectives of different stake holders to implement drip irrigation systems and its consequences for land and water use

A case study in Cànyoles river basin, Valenvia (Spain)

M.Sc. Thesis by Saioa Sese Minguez

May 2012

Irrigation and Water Engineering Group

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A case study in Cànyoles river basin, Valencia (Spain)

Master thesis Irrigation and Water Engineering submitted in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands

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May 2012

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CIDE Centro de Investigaciones Sobre Desertificación

ABSTRACT

Approximately from the nineties of last century irrigation modernization initiatives have been promoted by the European Water Framework Directive in Spain with the aim to achieve water savings. In Cànyoles river basin (Valencia), those initiatives were also noted and derived in a change from the typical open surface irrigation canals that Muslims introduced, to closed pressurized systems. However, how the initiatives are perceived at field level by farmers and the reasons why they adopt the new technology are different to the written promoted ideas. Each stakeholder understands irrigation systems, as well as drip systems, distinctly, which makes it difficult to reach different expectations from the same action. In addition, it is important to be aware of the possible consequences that a technology can bring at field level in order to avoid undesirable effects in other areas in the near future.

Some of the consequences of this irrigation system transformation are organizational changes in Comunidades de Regantes (WUAs), in farmer labour work or in plants responses. Nevertheless, the main shifts are related to the rising of energy consumption and tariffs as well as irrigated land expanded areas, which compete and question the promoted water saving quality of drip irrigation systems.

ACKNOWLDEGEMENTS

Working on this research thesis has been marvellous, but it would not have been possible without the support of many people.

I would like to thank to the people of the study area, as without them this research would have been impossible. Those are Ricardo Vila, Pepe Alcaráz, Isidro Bellver, Antonio Aparicio, Emilio Ródenas, Pepe Barbera, Vicente Blasco, Paco Navalón, Antonio Sanegre, Jose Manuel Galindo, Esteban Micó, Rafael Micó and Antonio Beneito. Thank you all for the explanations given in field and for conversing with me always with a smile on your faces. Thank you to Mari Carmen Carreres, and Asunción Francés, for helping me to find contacts and to clarify some doubts regarding to financial issues. I would also like to thank to Ibana Tormo Baño, which was the only woman showing the field and irrigation systems. Thank you to the farmers that joined and shared their opinions without making an appointment before, I really appreciate your help. I would like to give a special mention to José Barberá, who apart from explaining all the irrigation system transformation in Montesa spent more time in showing me the other actors that make the area so special and enchanting. Thank you all for demonstrating that information is easy to find whenever you find approachable people who are willing to share.

I had a lot of support not only in the field but also back in Valencia. Thank you Luis Bonet for providing me with the necessary data for the study area. Thanks to Pilar Paramo and Carmen Palmero for the technical information and different administration process explanations. Thank you Juan Gutiérrez, who gave me the first insights about the importance of the laws ant their impacts in field. Thank to Jose Antonio Dominguez and to the other members of IGME in Valencia office, who facilitated information about groundwater and aquifers and also invited me to a warm breakfast. Thank you to Guillermo Palau for sharing the ideas and information about the topic in other areas from Valencian Community.

Making maps with GIS was a new challenge for me. I would like to give my gratitude to Antonio Valera and Carolina Perpiñá for their patience, their time and tips to use the software.

The most difficult part of this thesis was to write and organize the information obtained giving a solid structure and making a story out of it. I have to thank to Camilo Robles and Miguel Ángel Campo for supporting me during all the phases from Pamplona, giving me feedback and facilitating the procedures to elaborate the thesis. Thank you Sabina Asins, you were the one assisting me in Valencia, helping me in field and also in writing. I learned so many things from you which are not only academic. I have to thank Saskia van der Kooij for her useful suggestions and remarks. Harm Boesveld, you were the one giving me very good insight, critical view and orientation for the thesis. I appreciate your help when structuring the ideas in order to clearly see the whole picture of the thesis. Thank you all so much.

There are some people that helped me in other ways. Thank you Ion, for encouraging me, for being there, for helping me to make smaller boxes.
Thank you to my parents and my brother for supporting me in all the moments. Mila esker, benetan.

LIST OF ACRONYMS

AEMET	Agencia Estatal de Meteorología
AEUAS	Asociación Española de Usuarios de Aguas Subterráneas
AGUA	Actuaciones para la Gestión y Utilización de Agua
AVA	Asociación Valenciana de Agricultores
BOE	Boletín Oficial del Estado
CAP	Common Agricultural Policy
CAPA	Consellería de Agricultura, Pesca, Alimentación y Agua
CEA	Cuentas Económicas de la Agricultura
CGRM	Comunidad General de Regantes de Montesa
CHJ	Confederación Hidrográfica del Júcar
CIDE	Centro de Investigaciones Sobre Desertificación
CR	Comunidad de Regantes
CSIC	Consejo Superior de Investigaciones Científicas
CULT	Consellería de turismo, cultura y deporte
CVC	Consell Valencia de Cultura
DIS	Drip Irrigation System
DOCV	Diari Oficial de la Comunitat Valenciana
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
EcS	Economic Sustainability
EGEVASA	Empresa General Valenciana de Agua S.A.
ERDF	European Regional Development Fund
ES	Environmental Sustainability
ESA	European System of national and regional Accounts
ESF	European Social Fund
ET_0	Crop evapotranspiration or reference evapotranspiration
EU	European Union
FEGA	Fondo Español de Garantía Agraria
FENACORE	Federación Nacional de Comunidades de Regantes
GIS	Geographical Information Systems
GV	Generalitat Valenciana
IBI	Impuesto sobre Bienes Inmuebles
IDAE	Instituto para la Diversificación y Ahorro de la Energía
IGME	Instituto Geológico y Minero de España
INE	Instituto Nacional de Estadística
INEM	Instituto Nacional de Empleo
IRYDA	Instituto Nacional de Reforma y Desarrollo Agrario
IVIA	Instituto Valenciano de Investigación Agraria
MARM	Ministerio de Medio Ambiente y Medio Rural y Marino
MITYC	Ministerio de Industria, Energía y Turismo
OCAPA	Oficina Comarcal de la Conselleria de Agricultura, Pesca y Alimentación
OP	Operational Program
PHJ	Plan Hidrológico del Júcar
PHN	Plan Hidrológico Nacional
PP	Partido Popular
PSOE	Partido Socialista Obrero Español
RTS	Reglamentación Técnico Sanitaria
SAT	Sociedad Agraria de Transformación
SS	Social Sustainability

STP	Sewage Treatment Plant
STR	Servicio de Tecnología de Riego
UK	United Kingdom
UNCED	United Nations Conference on Environment and Development
US	United States
VC	Valencian Community
WFD	Water Framework Directive
WHO	World Health Organization
WUA	Water User Association

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1.-INTRODUCTION

The *huertos Valencianos*, or Valencian orchards, are very characteristics in the landscapes of any village of the Community. They were usually laid in the surroundings of the rivers, fountains or springs where water is abundant. Sometimes this water was allocated by tunnels or irrigation channels. The main grown crops used to be vegetables and fruit trees. The latter ones were peach trees or plum trees among others, and fig trees or white mulberry trees were placed in the border of the orchards. This next text taken from the novel of Vicente Blasco Ibañez, *Entre Naranjos*, describes an area in Alzira, a village 30 km far from the study area. It pictures a typical landscape of that time, where an orange tree orchard, the river, the sun and irrigation canals act as the main actors in a play:

"Los huertos de naranjos extendían sus rectas filas de copas verdes y redondas en ambas riberas del río; brillaba el sol en las barnizadas hojas; sonaban como zumbidos de lejanos insectos los engranajes de las máquinas del riego; la humedad de las acequias, unida a las tenues nubecillas de las chimeneas de los motores, formaba en el espacio una neblina sutilísima que transparentaba la dorada luz de la tarde con reflejos de nácar".
(Blasco Ibáñez, 1900)

Irrigation has been practiced during centuries. In the study area, Muslims introduced their knowledge during the XI-XII centuries and built infrastructures like weirs or irrigation canals for crop production (Hermosilla, 2003). Nevertheless, what it has been in use for a thousand years is changing now. There are other types of initiatives fostered in the last decades that seek irrigation modernization using technology aiming water conservation or resource sustainability.

The objective of this research is to investigate the process of introduction and expansion of drip technology in the area of Cànyoles valley in Valencia (Spain). The importance of the study is emphasized because the 80% of the world freshwater is used for irrigation. Therefore, if new irrigation technologies will replace traditional systems, is essential to find the effects that those will produce in detail. In this way, water sources exploitation, water consumption, crop change, agricultural productivity, expansion of the irrigated area, energy consumption and irrigation operation and labour will be studied as a consequence of implementing drip irrigation systems. In addition, water heritage is also considered in this rich irrigation area of Valencia.

The structure of this report comes as follows. Firstly, a research set-up is explained in which the objectives, research questions, concepts and methodology are mentioned. Secondly, the background information is defined in order to place the research in context. Then, the results of the research are stated, where village by village the outcomes are described. Thereafter, the analysis and discussion is presented, followed by the recommendations. Finally, the conclusions are presented.

2.-RESEARCH SET-UP

This section aims to make clear the problem and the research objectives of the study case in Cànyoles basin. Moreover, the concepts in which the research is based are developed as well as the methodology used, specifying the methods and the strategy of data management followed.

2.1.-PROBLEM STATEMENT AND RESEARCH OBJECTIVE

In La Costera region, Valencia, drip irrigation systems are replacing traditional irrigation systems with high heritage value in order to, at least at first glance, foster water efficient technologies. It is true that while conventional irrigation technologies have an average efficiency of 30-50%, drip irrigation can reach field application efficiencies of 80-90% (Seckler, *et al*., 2003). However, it is unclear what the exact motives of the stakeholders in many field situations are behind the implementation of drip technologies.

The development objective of this case study is the better understanding of the process of the introduction and spreading of drip irrigation technology from traditional surface irrigation systems, in the upstream area of La Costera region, Spain. The origin of these transformations is related to national and autonomous community level legislation and initiatives and later on to the sustainable water management promoted by the Water Framework Directive (WFD) of the European Union (EU).

To tackle the mentioned objective of the research, the next specific objectives are defined at different levels.

- Human action
  - To identify other reasons, apart from using water more efficiently, to transform from furrow to drip irrigation systems (DIS);
  - To assess water resources management due to the change of irrigation system at basin level;
  - To find out which have been and are the plans concerning to irrigation coming from the directives of the European Union, Spanish government and Valencian Comunity (VC) and if they have been accomplished in the area;
- Infrastructure transformation
  - To describe the impacts caused due to DIS implementation in traditional irrigation systems;
- Natural resources
  - To study the impact that DIS implementation has in agricultural water use and other water use activities;
  - To describe the expansion of the irrigated area using drip technologies;

2.2.-CONCEPTS

For the understanding of the thesis, it is necessary to have a clear idea of the meaning of some concepts. In this section, the concepts in which the research is based are explained. Those are water savings, sustainability, water efficiency and irrigation as a socio-technical approach.

2.2.1.-Water conservation, water savings and drip technology

From all the water that humans use, two thirds are applied for irrigation. That is why one of the water conservation technologies is improving irrigation efficiency, making use of less water to achieve the same yield. With it, as water resources are limited, they are declining. Some authors mention that new water supplies likely will result from conservation, recycling, reusing, and improving water use efficiency (Pimental, *et al.*, 1997, p. 98) rather than from new infrastructures, making use of the main sources.
For this study case, the focus will be on improved water use efficiency in means of water savings. Water saving has been a sound concept in the last years. Seckler (1996) differentiates between dry/paper efficiencies and wet/real savings. The real ones increase the total water availability of the basin. For example, if efficiency is increased on farm level, it does not always mean that there will be more water available at the basin level, but only that the non-used water in the plot will be reallocated somewhere else in the basin.

A measure to promote real water savings could be accurate accounting of basin wide water use; analysing the use, depletion and productivity of water at basin level (Ward & Pulido-Velazquez, 2008). Nevertheless, this is too ambitious as there will be no data to make a complete and representative analysis. Moreover, drip irrigation, which is considered a tool to save water, results in positive water conservation at the farm level, but not necessarily at the basin level (Samani & Skaggs, 2008, p. 289). On-farm adoption of drip irrigation is one measure widely believed to conserve water.

From the farmer's economic point of view the new water conserving technology is good. Nevertheless, basin-level consumptive use of water can increase (Samani & Skaggs, 2008)

Achieving real water savings requires designing institutional, technical, and accounting measures that accurately track and economically reward reduced water depletions. Conservation programs that target reduced water diversion or applications provide no guarantee of saving water (Samani & Skaggs, 2008).

Apart from that, it is essential to know whether farmers are interested in achieving water savings at farm level and basin level. The same happens with policy makers or subsidizers. The vision each actor has of the concepts (water saving, conservation, efficiency, sustainability) is very important as there are totally different interests. For instance, for a farmer, the water reallocated in a river can be wasted water. However, for a water manager or many policy makers that could be a way to use water more efficiently promoting its sustainability. Integrating the sometimes even opposite interest and accomplishing some common objectives is what water management do.

2.2.2.-Sustainability

As it is known, currently the increase of population and water scarcity are two main reasons why the need to conserve water arose (Jackson, *et al.*, 2001). Water conservation consists mainly on reducing the demand of water, saving the latter one as well as energy and reusing wastewater. In other words, it seeks a sustainable way of using water that assures availability of the resource for future generations. However, the concept of sustainability is much broader and it integrates more disciplines. As the European Commission defines, resource efficiency means using the Earth´s limited resources in a sustainable manner.

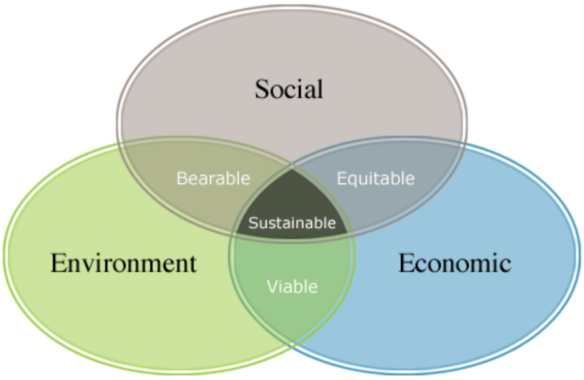

FIGURE 1: PILLARS OF SUSTAINABILITY (HTTP://WWW.GREENTIMES.COM.AU)

For its development, figure 1 will be used. This figure shows how different disciplines intervene to achieve sustainability. Even though traditionally sustainability has been interpreted only from an environmental vision, in the last years different academic disciplines expressed the need to integrate other factors to give a mayor globalist and integrate interpretation to the term. The disciplines will be shortly described below.

Economic Sustainability (EcS) refers to capital maintenance, overall with natural capital as it started to be scarce no long time ago and economist have no much previous experience in valuing it (intangible, intergenerational, and, especially common access resources) (Goodland, 1995)

Societal development cannot be held in inequities. Therefore, Social Sustainability (SS) is essential. Human capital (investments in education, health, and nutrition of individuals) is now accepted as part of economic development, but the creation of social capital as need for social sustainability is not yet recognized. Cohesion of community, cultural identity, diversity, solidarity, comity, tolerance, humility, compassion, patience, forbearance, fellowship, fraternity, institutions, love, pluralism, commonly accepted standards of honesty, laws, discipline, etc. constitute the part of social capital (Goodland & Daly, 1996).

Environmental Sustainability (ES) supports to maintain natural capital; understanding ES thus includes defining natural capital and maintenance of resources or at least "non-declining levels of resources" (Goodland, 1995). More specifically for this case and included on the environmental sustainability, sustainable water management is promoted from the WFD.

Although the three pillars are indispensable for a complete study, the research will focus more in the environment discipline as considered in the European Commission. In the growth strategy of Europe 2020, one of the priorities is sustainable growth, with three goals related to environmental sustainability, climate change and energy: reducing greenhouse gas emissions by 20% compared to 1990 levels, increasing the share of renewable in final energy consumption to 20% and moving towards a 20% increase in energy efficiency (Europe 2020, 2011). Irrigation fits here as drip systems have to deal with the mentioned three objectives.
In addition and included in the environmental sustainability approach, sustainable water management is promoted from the WFD as mentioned before.

In this sustainability interdisciplinary line, Gleick suggests a change of mentality in a longer term which plans meeting present and future human needs with the water that is available, to determine what desires can be satisfied within the limits of the resources, and to ensure that humans preserve the natural ecological cycles that are so integral to their well-being (Gleick, 2000). The research will follow this base where environmental, social and economic disciplines are unified and dependent on each other for a sustainable water management. Nevertheless, even though those environments are indispensable, they revolve around individual´s objectives. Therefore, the focus will be in individual's interests (Samani & Skaggs, 2008, p. 292) that sometimes are contrary but at times there is a common agreement on the objectives. The actors have agreed to implement drip irrigation. Nevertheless the research will try to find out what different motives drove each of the actors to promote it.

The challenge is dealing with the environmental, financial and social concerns and the gap between their interests, considering the different water needs (urban, environmental and agricultural) at distinct levels (farm and basin). All of it, taking into account the transformation to drip irrigation. This is summarized in each individual's priorities, concerns, values and interests', which are all equally valid.

2.2.3.-Complexity of concepts: Water Efficiency

It seems that increasing the efficiency of irrigation systems could, at first sight at least, help to satisfy the human water demand. However, there is a complex water efficiency paradox, as the concept of efficiency in irrigation has witnessed an evolution over time. In this section, different perceptions to interpret the concept "efficiency" will be studied.

Mainly, there are three stages when efficiency is classified: classical efficiency, net efficiency and effective efficiency. These have been studied by more than one author in the last years.

The definitions would be as follows (Seckler, *et al.*, 2003):

Classical Efficiency (CE)

$$CE = \frac{NET}{DIV}$$

Where NET is the water needs to satisfy the crop water requirements and DIV is the total amount of water diverted from a source to achieve NET. Seckler, Willardson, Viets and more authors mention the term with this meaning.

The term can by divided in different levels (Kay, *et al.*, 1997):

- Farm level: applied to fields.
- Schemes: relationship between water delivered to farmers and water received from the source at which project jurisdiction starts.
- Basin level: percentage of catchment yield actually applied to "productive" uses.

When CE is being used, it is indispensable to mention in which level it is defined.

Net Efficiency (NE)

It was developed by Jensen (1977) and, apart from the water for the crop requirements, it also considers the water that can be reused. Therefore, the perspective is from a system level.

Effective Efficiency (EE)
This last definition was developed by Keller and Keller (1995) and here, they also include the pollution factor (considering water quality as well as quantity) in the possible recycling process of the system.

Apart from these three basic interpretations there are authors that have other suggestions to use this concept. Haie and Keller (2008) determine different efficiency concepts and recommend the use of EE as an indicator of performance and fractions for looking at and understanding water flows. They further recommend to stop making use of the CE term.

Moreover, there is another group of authors that believe that efficiency is a too limited concept and they see the need of new ways of describing and evaluating water use. New definitions are proposed that require re-naming irrigation efficiencies to various types of "fractions" including consumptive fraction, reusable fraction, and non-reusable fraction (Willardson, *et al*., 1994).

Efficiency can be also classified from different disciplines points of view. An example of that is the next table, where it can be observed that improving efficiency has distinct meanings depending on the focused category.

TABLE 1: DIFFERENT VIEWS OF INCREASING EFFICIENCY AT FIELD LEVEL (HOWELL, 2001, P. 285)

Improvement category	Options
Agronomic	Crop management to enhance precipitation capture or reduce water evaporation (e.g, crop residues, conservation till and plant spacing); improved varieties; advance cropping strategies that maximized cropped area during lower periods of water demands and/or periods when rainfall may have greater likelihood of occurrence.
Engineering	Irrigation systems that reduce application losses, improve distribution uniformity, or both; cropping systems that can enhance rainfall capture (e.g., crop residues, deep chiseling or paratilling, furrow diking, and dammer-diker pitting).
Management	Demand-based irrigation scheduling; slight to moderate deficit irrigation to promote deeper soil water extraction; avoiding root zone salinity yield thresholds; preventive equipment maintenance to reduce unexpected equipment failures.
Institutional	user participation in an irrigation district (or scheme) operation and maintenance; water pricing and legal incentives to reduce water use an penalties for inefficient use; training and educational opportunities for learning newer, advanced techniques.

Clearly, the best way to improve efficiency would be to integrate all of the categories.

Theoretically, this concept is already broad enough. However, there is still the need to deal with the perception that technicians or farmers have. Therefore, the complexity lays on how each stakeholder refer to the same concept. There can be miscommunications, even if at first sight they use the concept for the same objective (in this case the transformation to drip technologies to increase efficiency). In addition, each stakeholder can be looking for different subsequent effects with the same measure.

Consequently, it is important to recognize the connotation that each stakeholder gives to the concept to understand the context of the study case properly.

2.2.4.-Irrigation as a socio-technical approach

In the article about irrigation technology written by Mollinga (1998), a definition of technology is stated as "the practical ensemble of knowledge and skill by means of which people pursue particular goals in society". With this focus, technology is considered not only the newest innovations created nowadays, but also any other skill or knowledge trying to achieve any purpose in society.

The main approach of this thesis is to think about how people create irrigation technology, how they perceive it, how they apply it and maintain it using irrigation in a constructive way. In real irrigation systems, there are social and technical elements and relationships, and they can only be both at the same time (Mollinga P. P. and Wester P., 2010, p4). This means that irrigation systems are socio-technical systems. There are material and social conditions that determine the system. For instance, the infrastructures for water allocation from the water source to the field will condition how irrigation will work. Moreover, the farmers and the way they use/apply/maintain the infrastructure and water will condition the irrigation system. In addition, the organizations, their structure or their internal way of working can also affect to the system. Finally, the relationship between all the stakeholders and their interest is a very relevant part of an irrigation system.

FIGURE 2: ELEMENTS OF IRRIGATION AS A LABOUR PROCESS (MOLLINGA P. P. AND WESTER P., 2010)

As it is shown in figure 2, and based on the Marxist labour process, there are three elements considered for irrigation. Firstly, the natural resource itself, in this case water. Secondly, the activity or action carried out by humans. The action would be done by farmers that want to irrigate their crops, but also government officials organized in agencies manage irrigation systems and are essential for the systems operation. In the same way, the actions can be done individually or collectively. Lastly, this would be impossible to do without an irrigation physical infrastructure to transfer and distribute water.

To sum up, irrigation technology has a technical facet, but also a social perception, which is crucial when there are projects that water users will apply in field. After all, they are the ones that in fact live with that technology.

2.3.-RESEARCH QUESTIONS

Based on the previous objectives and concepts, the main question to have in mind during the research will be the following one;

What are the reasons of implementing drip technology in the historically traditional surface irrigation systems of the upstream area of Cànyoles river basin, Spain, and its consequences in relation to a sustainable water management in the last twenty five years from a socio-technical approach?

In order to make the objectives researchable, some representative questions are detailed below:

- What are the motives of implementing drip irrigation systems for different stakeholders?
- What are the used water resources before and after DIS implementation for agriculture and other water use activities in the area?
- How have government subsidies influenced the adoption of DIS?
- What are the main field consequences for farmers regarding to irrigation system transformation?
- To what extent DIS facilitated the expansion of the irrigated area?
- What are the consequences of DIS in traditional irrigation infrastructures?

2.4.-METHODOLOGY

In this next section the operationalization of the research topic in the upper area of the Cànyoles river basin will be explained. For that, the methods used and the strategy of data collection and management are explained.

2.4.1.-Research methods

Defining the methods is essential for a research. For this case literature research, field work and Geo-Information tools will be used.

2.4.1.1.- Research sources/literature

Three research sources are used for this study. Firstly, scientific articles and general research, secondly, legislation and thirdly, the historical documents kept in the *Archivo del Reino de Valencia*.

Articles from different scientific journals, information from national congresses and legislation checked out in the official EU legislation, Official Bulletin of the State (BOE) and in the *Diari Oficial de la Comunitat Valenciana* (DOCV) are some of the most used sources for the elaboration of the research. Furthermore, initiatives related to drip irrigation and other activities that include water use, involving the actions of different organizations at different levels have been used (Water Framework Directive, National Irrigation Plans, village level initiatives etc.). This will give an idea of how the transformation to drip irrigation was made.

The linkage that irrigation has with the crops produced and at the same time with the demanding market and competences cannot be avoided. Therefore, it is important to put special emphasis on it, seeking the crop tendencies in the area, as well as the product selling strategies. Searching for the different subsidies that farmers received is also important. For that, the research is based on publications of national public organizations like the *Instituto Nacional de Estadística* (INE), *Generalitat Valenciana* (GV) and its different departments, *Confederación Hidrográfica del Júcar* (CHJ) or *Instituto Geológico y Minero de España* (IGME).

Bibliography is needed in order to place the research topic in context and compare it to other cases in Spain and other countries. Moreover, it is important to keep updated with recent studies, measures and results obtained in different researches.
The *Archivo del Reino de Valencia* is visited to consult different documents dated since the XIII century, as well as information related to irrigation in the area from that century. With this information, a chronology of the history and traditions about the area are considered, emphasizing how it developed during the centuries and why the area is the way it is nowadays. More specifically in La Costera (and in general in Valencia), where there has been a lot of irrigation tradition all over the centuries.

2.4.1.2.- Field work

Field work is the most active function of the research. On the one hand, interviews help to be in contact with people of the area or experts that give the real situation. On the other hand, observation methods are used to capture the surroundings and other factors that sometimes can only be recognized watching.

Interviews are the main tool connecting the research with field. For the case, farmers are the most important unit. However, there are other interviewees as heads of *Comunidades de Regantes* (CRs), administrative workers in different organizations like IGME, CHJ or Government Agencies. The interviews are made in different atmospheres, some in the field, some in offices and others in particular houses. In general, they are face to face and individual interviews, although in some cases more than one farmer is interviewed at the same time. They are semi-structured and informal conversations, which mean that some questions referring to the objectives of the research are prepared but the interviewer is very open to listen to any related story and to experience unexpected events, which is considered a positive characteristic (Annex I). This is a research that is looking forward to follow the water, the people and stories.

Interviews are mainly addressed to find out the motives of the stakeholders to transform to drip irrigation systems, their perspectives concerning water consumption and yield changes, their opinions about the relation between the irrigated area and drip technologies, their awareness of the traditional infrastructure preservation and to check if the subsidies are relevant from different points of view.

For the selection of interviewed farmers some criteria are considered in order to be as representative as possible in the study area. The CRs of the area are identified from literature and checked afterwards in field. From all of them, at least two CRs for each village are interviewed. In some villages it was possible to interview all the CRs. Nevertheless, in the other ones, the CRs with more agricultural area and different water sources (groundwater, river water, springs and treated wastewater) are selected. At least one president of CRs in each village is interviewed, otherwise, the agricultural and environment councillor of the municipality or the secretary of the CRs is interviewed. Apart from them, at least one or two farmers from each CRs are interviewed.

Observation methods are used to perceive the essence of the field. The most relevant observations are captured as graphic information, as it is very helpful when describing the area. The pictures are used to complement the report. With images one can infer how the area looks like, what the conditions of new technology irrigation systems are, the conditions of old irrigation canals and weirs, the climate and lifestyle of inhabitants etc.

2.4.1.3.- Consult of aerial photographs and making up maps by Geographical Information Systems (GIS)

Mapping the area is one of the challenging parts of the research. The idea is to show the basic characteristics of the area in a very graphic way, using Geo-Information tools.
Aerial photographs allow a better understanding of the study area. The main unit of research in this case will be the river basin and more specifically the south-west side of it. It will be considered which maps will be the most relevant and feasible for the research.
The maps aim is to identify the irrigated and non-irrigated areas, the expansion of irrigation in the last years, the different crops and soil types of the area etc.

2.4.2.-Strategy of data collection, management and analysis

Managing and organizing the obtained information is as important as collecting data. The objective of managing the data is to make the reporting task easier. In general, the same three different blocks need to be disposed: literature research, interviews and maps.

One of the key points when writing a thesis is to stress the importance of the data organization. The best way to "digest" the information obtained is to write about it again making a selection of what is most important in order to have the information classified. That is why first, literature is organized in summaries depending on the authors and the topics and second, interviews are gathered in daily reports. The day reports have different parts where the objective of day, a short description of planning of the day, interview notes and graphic information, context of observation and feelings of observation are shown (Annex II). The interview notes are organized in such a way that each paragraph has the topic next to it written to facilitate the identification of the information in the reporting part.
Last, GIS work is done by using data bases, programs and ortophotos provided by *Centro de Investigaciones sobre Desertificacion* (CIDE), as well as by the downloaded layers from the official websites. Those websites are mainly from the *Ministerio de Medio Ambiente, Medio Rural y Marino*[1] (MARM) and from GV. Usually, there is always a space for GIS and cartography, where everyone can consult maps with different layers online and also download some of the layers and metadata when they are georeferenced. For this research, the used metadata was normally in Web Map Services (WMS) format.

To avoid track loss, weekly reports are written to collect the activities fulfilled and to note down what still needs to be done. Those reports have a similar structure to daily reports (Annex II). In addition, a midterm evaluation of progress is assessed during the field work phase.

All this will contribute to an efficient organization making use of all the time available. The three activities compilation is elaborated in the CIDE building in Valencia, which provides the necessary facilities. For the reporting of the research, Wageningen University and Research (WUR) provides a place to work.

[1] After the last general elections of November 2011, this Ministry is now called Ministerio de Agricultura,

3.-BACKGROUND INFORMATION

This section explains the required knowledge in order to understand the research study. It is divided in the next six subsections: the justification of the study area, a description of the area, the evolution of irrigation in the area, legal and political support to drip technology, the water resources used for irrigation and the water management and social capital associated to irrigation.

3.1.-JUSTIFICATION OF THE STUDY AREA

The research area was decided based on three reasons. Firstly, it is a region where drip technology is easily found. The area is devoted to irrigated agricultural activity. There are evidences that traditional irrigation infrastructures existed since the XI-XII century, which means that there was a culture in irrigation. Nevertheless, it is observed that the majority of the irrigation systems are currently drip systems, which assures to find the necessary actors, structures and information to meet the objectives of the research.

Secondly, one of the villages, Montesa, was the pioneer in adopting drip irrigation systems in the Valencian Community. This was due to the facilities given from the Conselleria de Agricultura, Pesca y Alimentación of the autonomous government and also to the enthusiasm and initiatives of the local people to implement the new technology. In addition, there was a close relationship between this village and the Conseller de Agricultura (head of the Conselleria de Agricultura, Pesca y Alimentación) at that time, Jose María Coll Comín. In consequence, Montesa became the pilot area of irrigation modernization in Valencian Community.

The introduction of drip irrigation in this Community was due to the approbation of the Decree 47/1987, focused on the use of water for irrigation. This decree opened the possibility to farmers and associations of irrigators to propose any petition related to:

- the better exploitation of water;
- the improved distribution of water use in the area and in each plot;
- the adjustment of the necessary water delivery or the guarantee of water savings.

Once these ideas were proposed, the Consell of the Generalitat Valenciana would be the organism in charge of choosing and approving the corresponding plan, giving the accorded subsidies and loans for the selected irrigators associations.
Therefore, from that year on, every year there was the possibility of proposing projects for irrigation improvements. In the early nineties, the works for the proposal of the modernization in Montesa started. Specifically, it was in the year 1995, with the Decree 69/1995 (and under the protection of the 47/1987 Decree), when the Plan of Water Use for Irrigation in the Comunidad General de Regantes de Montesa (Valencia) was approved. Its purpose was to achieve substantial water saving introducing drip irrigation technology. Generalitat Valenciana provided half of the total budget for the initial investment.

Thirdly, the upstream area of the Cànyoles valley, which is more than half of the total surface of La Costera region, is considered for the study. Although the ideal research would have been to analyse the entire region, it was decided to do a deeper study in the most rural area. In this upstream area, there is no much research previously done related to the introduction and evolution of irrigation. Usually, researches are focused more in the downstream areas or in zones where urban units are more important and with higher population. The aim is to add information in the areas that are not around the capital of

Valencia, as currently there are numerous studies about the Valencian orchard but no so many in the upstream areas of some Júcar basins and tributaries.

3.2.-DESCRIPTION OF THE STUDY AREA

In the next section the study area is described. This includes the physical environment and economic context in order to set the topic.

3.2.1.-Geographical boundaries and physical environment

The study area is bounded by four villages located in the upstream of the Cànyoles valley: La Font de la Figuera, Moixent, Vallada and Montesa. Those villages are part of La Costera region (Valencia province, Valencian Community, Spain) and they form what previously was called Montesa Valley. It is the steepest side of La Costera and although the population is lowest, it covers more than half of the *comarca*[2]. La Font de la Figuera is the last village of the Valencia province in the south-western border and bounds with the Albacete province in Castilla La Mancha Community. The study area is about 60 km far from the Mediterranean Sea, which encloses it in a typical Mediterranean climate (Figure 3&4).

This climate is characterized by dry and high temperatures during the summer, which is translated into high plant evapotranspiration needs and high plant water consumption, soft temperatures in winters and irregular rains that sometimes turn into torrential, mainly in spring and autumn seasons. In Montesa, there is an agrometeorological station which provides daily data of temperatures, precipitation, humidity, sun hours and wind velocity and direction. The mean annual temperatures vary from 26ºC during the warmest months, July or August, to 8.9ºC in winter (Bonet, 2011). The average annual precipitation in the last eleven years is around 593 mm. Usually, the maximum rainfall is recorded in autumn and the driest period is in summer. The highest precipitation has been 356 mm/day.
According to the Köppen Climate Classification, used in the State-level Meteorological Agency (AEMET, Agencia Estatal de Meteorología), the climate in the study area is Csa, which means that the average temperature in the coldest months is between 0-18ºC and average temperature in the hottest month is above 22ºC, temperate with dry or hot summer (Agencia Estatal de Meteorología & Instituto de Meteorología, 2011, p. 17). In addition, following Papadakis agro-climatic classification, the study area is Subtropical Mediterranean, which is obtained based on the data of Montesa station provided by the *Servicio de Tecnología de Riego* (Bonet, 2011). This classification is characterized pertaining to the effect that climate can cause in plant development. This type of climate is favourable for crops like cereals (wheat, barley), vineyards, and specially citrus, such as orange trees.

[2] In English *comarca* is similar to county for the U.S. or district in U.K.

FIGURE 3: SITUATION MAP, SPAIN, VALENCIAN COMMUNITY AND LA COSTERA REGION (ICIETLANATURE.COM, AND COMARCARURAL.COM)

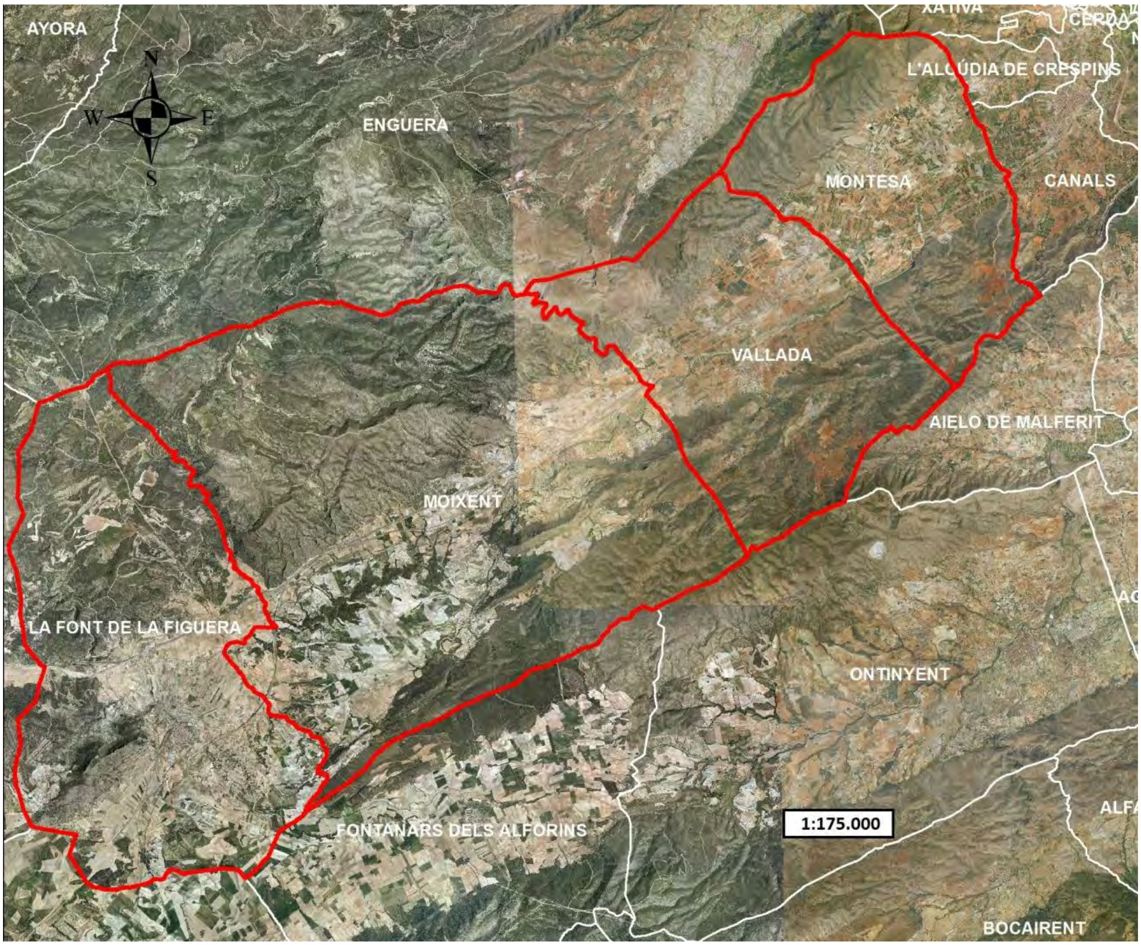

FIGURE 4: AERIAL PHOTOGRAPH OF THE STUDY AREA: LA FONT DE LA FIGUERA, MOIXENT, VALLADA AND MONTESA

The studied valley is located in the union point of the Baetic and Iberian Systems. Those systems are two big main mountain ranges in Spain. The Baetic one is located in the south-eastern of the peninsula and encloses mountains of Andalusia, Murcia and Valencia. The characteristic of those mountain ranges is that they are positioned in southwest-northeast direction. The Iberian System is located in the central region of the peninsula and reaches the Mediterranean Sea in Valencia. The studied valley, Cànyoles valley, has the characteristic orientation of the Baetic system, from SW to NE. However, the northern part comes from the Iberian system (García-Atiénzar, 2009). It is a mountainous valley in its north-west and south-eastern areas and quite plain in the lowland near the river. La Font de la Figuera is at 550 metres of altitude a.s.l. and the mean altitude in Montesa is of 250 metres a.s.l. In the surroundings of the villages, there are different *sierras* (mountain ranges). In the border of the western side *El Capurutxo* (901m) is raised, a mountain in La Font de la Figuera with the particular shape of a hood which gives its name. It connects the valley with Almansa plain and opens the way between the two Spanish Communities. The river basin is surrounded mainly by two mountain ranges, from the northern and southern directions. In the northern side, there are *Sierra de Enguera*, *Macizo del Caroig* and *Sierra Plana*, known as well as *Sierra de la Solana.* This latter one is characteristic due to the impressive *barrancos* (gully) that born there. *Sierra de Navalon* is another mountain range placed behind the *Sierra de Enguera*, and even that is not next to the study area, some watercourses are born there, like the *Barranco del Regajo* and *Rambla de la Teja* that meet before the plain to form the Cànyoles river. In the south, *Sierra Grossa* is raised, with a maximum altitude of 900 metres in Moixent, presenting small valleys formed by the erosion of the Triassic outcrops. The village and inhabitants of Moixent and Vallada are laid in the lowlands of *Sierra Grossa* (García-Atiénzar, 2009). In contrast, Montesa is settled in the northern side of the valley in the *Sierra Enguera*.

The geology of the area in general is a Quaternary plain in La Font de la Figuera and sediments of the Tertiary and Quaternary periods until the boundary of Montesa (García-Atiénzar, 2009). More specifically, in the northern part of La Font de la Figuera there are materials from the Quaternary, Superior Miocene and Facies Wealdense (FW). In the lowest plain of the valley next to the river, there are Tap-Burgadilense (M1) materials from the Miocene as well as Neo-cretaceous materials (Santonense superior and Campaniense Superior, C4-5). In the southern part, where *Sierra Grossa* is situated, and from Moixent to Montesa, there are also Keuper materials (TK) from the Triassic. In the same side in Montesa, there are Wealdense and Albense Continental Arenoso (G1-4) materials (IGME, 1956) (Annex IV).

In the area is important to know how lithology affects water infiltration. For instance, calcareous or limestone allows water infiltration. However, in the Miocene, the base is a porous material and the Burdigalense tap is accumulated above, which is totally impermeable and constitutes the major inconvenient for water catchment. This is due to the fact that the lowlands are usually laid in this tap and the thickness is too wide to drill the surface. In some cases, calcareous loams and limestone from the Superior Miocene are found, which are permeable and allow water to pass through by drilling wells. Normally, the highest water discharges are obtained from the wells drilled next to the *sierras* which are composed by limes from the Cretaceous (IGME, 1955).

Cànyoles River finds its way in the lowest part of the valley of Montesa. The river rises at 900 meters a.s.l. in La Font de la Figuera and it descends among the valley passing through Moixent and Vallada. After Montesa, in Canals, there is a spring called Santos and is the river Santos which gives the most discharge to Cànyoles. Afterwards, in the Cubeta of Xátiva, it converts with the Albaida River. Cànyoles river is a tributary of the Júcar watershed. It is the most irregular river of the *comarca*, contributing less water to irrigation than the other ones. This is interesting to study, due to the fact that there are water shortages in some dry years. Apart from the river, temporary courses such as *ramblas* and *barrancos* only have some discharge in rainy periods. When there are torrential regimes, those water courses drag materials that form their path.

The land uses in La Costera are divided as showed in figure 5. There are no meadow lands as grazing is not characteristic in the place and almost half of the surface of the area is forest. The 35% of the lands are used for agriculture purposes. From that total, 15% corresponds to non-irrigated areas in contrast with the 20% of the irrigated ones. Lastly, there are another 17% of hectares devoted to other uses (urban and industrial areas, roads etc.).

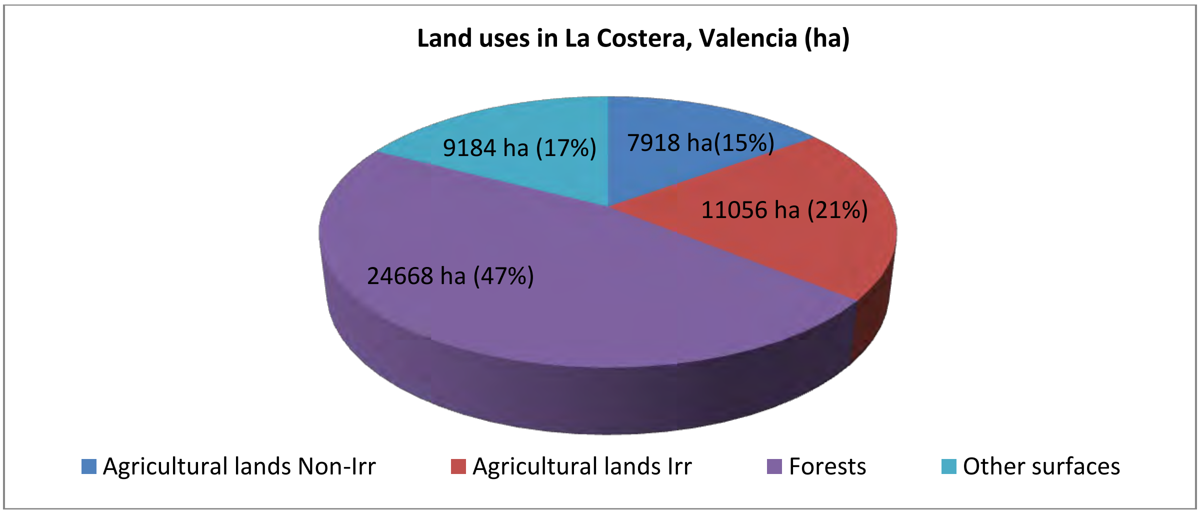

FIGURE 5: LAND USES IN LA COSTERA (CAPA, 2009)

Another way of dividing La Costera region would be in two areas, depending on the size of the typical orchards. On the one hand, the Cànyoles river or Rambla de Montesa, where there are small fluvial orchards (in the upstream area) and on the other hand, the Cubeta of Xátiva, where there are considerably wider orchards (Hermosilla, 2003). This last area has more study tradition and documentation about irrigated areas, as it was the extensive area for that activity.

3.2.2.-Economic context

This section analyses the rural development and social situation of the study area. The region La Costera has a total population of 74.226 inhabitants and a surface of 528 km^2. From that total, the four villages studied represent 65% of the total surface with a total of 11.796 inhabitants (15% of the total population in the region). This implies that the inhabitant's density is quite low comparing to other areas of La Costera, with a mean of 282.6 inhabitants per km^2 (table 2).

TABLE 2: POPULATION, SURFACE AND DENSITY IN THE VILLAGES OF THE STUDY AREA (INE, 2010)

	Population	Surface (km^2)	Density (inhabitants/km^2)
La Font de la Figuera	2.227	84,34	26,41
Moixent	4.753	150,23	31,64
Vallada	3.447	61,5	56
Montesa	1.369	48,11	28,46
Total	**11.796**	**344**	

This is a rural area, where industry and services are the main activities done at full time. The main activity for some years was furniture industry, specialized mainly in wicker or rattan. However, the competence with the Chinese market and the current financial crisis made it go down. Another common activity is the rental of lands for seedling for the consequent transfer to other plots. This activity is specially practiced in Moixent and in small close valleys. Agriculture is practiced at part time, normally during the weekend and free time.

From the economic point of view, it is essential to know the agricultural incomes in the area. The organism in charge of the calculus of the Economic Accounts of Agriculture (EEA[3]) in the Valencian Community is the Conselleria de Agricultura Pesca y Alimentación (CAPA) and the methodology used is the ESA-95[4], the European System of national and regional Accounts. This system describes the total economy of a region, its components and relations with other economies and it is used as a central framework of reference for the social and economic statistics of the EU. The income comes mainly from two sources, plant and animal production. However, there are costs and benefits, directly or indirectly attached to the incomes (services, intermediate consumes, amortizations, subsidies or taxes among others). For instance, fodder took 33% of the total costs in 2008 and phytosanitary products the 8% (to be applied in fruit trees, and especially in citrus) (CAPA, 2009).
This agricultural income varies, but not significantly lately, from year to year. Recently, the latest data show the agricultural income in 2007, 2008 and 2009 was 1728.4 million of Euros, 1827.1 millions of Euros and 1797.3 millions of Euros, respectively (CAPA, 2009). Plant production income covers about 78% of the value of the total agricultural sector in the Valencian Community. The main crop in this autonomous community is citrus. For instance, its value in 2008 represented more than half of the plant production and 39% of the total consumer items. One of the most important income of the Valencian Community is the exported food market, and more specifically the citrus fruits, that gives 82,4% of the total income. The insured production has also decreased in the last years, falling 23.4% in the Valencian province in 2009 (CAPA, 2009).

The importance of agriculture is linked to irrigation and also to the improvements in this sector made in the last years. In Spain, plans like the *Plan Nacional de Regadíos* and *Plan de Choque de Regadíos* caused some effects like the reducing of traditional gravity irrigation systems and increasing of the sprinkle and drip irrigation systems that promote water savings. Drip irrigation systems land has incremented more than 450% since 1989 to 2007, and currently is the most significant irrigation system in Spanish agriculture (Gómez-Limón, 2010, p. 12).

3 The EEA are a satellite account of the European system of national and regional accounts, adapted to the specific nature of the agricultural industry, providing complementary information and concepts (Eurostat, 2011).
4 ESA-95 collects comparable, up-to-date and reliable information on the structure and developments of the economy of the Member States of the European Union and their respective regions (Eurostat, 2011).

TABLE 3: AMOUNT OF WATER DELIVERED IN THE AUTONOMOUS COMMUNITIES OF SPAIN WITH DIFFERENT IRRIGATION SYSTEMS (INE, 2007)

Autonomous Communities	Irrigation technique (thousands of m^3)				
	Sprinkler	Drip	Gravity	Others	Total
Navarra	51.344	50.912	351.752	843	454.851
La Rioja	96.673	23.334	103.108	1.327	224.332
Aragón	614.149	113.085	1.574.904	197	2.302.335
Cataluña	154.167	256.980	1.031.475	2.667	1.445.284
Castilla y Leon	1.083.660	75.694	1.044.766	25	2.204.145
Castilla- La mancha	937.045	736.669	77.868	5.183	1.756.765
Valencian Community	15.269	808.349	688.634	2.744	1.514.996
Murcia	12.211	445.193	83.167	1.232	551.803
Extremadura	406.757	313.289	861.188	-	1.581.234
Andalucía	334.854	2.513.658	861.455	2.409	3.712.376
Remaining Autonomous Communities	217.056	119.625	65.395	6.689	462.758
SPAIN	3.977.185	5.466.678	6.743.712	23.304	16.210.879

As it can be observed in table 3, the Valencian Community uses a high quantity of drip irrigation when compared with irrigation systems at national level. It is the second community (after Andalusia) that has the highest percentage of drip irrigation systems. In addition, these irrigation systems are the most used ones in the community.

The economic crisis of the last years has affected unemployment in general but also to agricultural activity. In the national statistical data, 2% of the active population shows an agricultural unemployment in La Costera (INEM, 2009). It is wise to keep in mind that before this situation, in Montesa, every year 450 immigrants used to go to the field as farm workers to harvest. Nowadays, none of them find a job in the area, as they have been replaced by local hand-labour.

3.3.-INTRODUCTION AND EVOLUTION OF IRRIGATION IN THE STUDY AREA

As professor Martín Retortillo stated, "Nothing must be innovated without a perfect knowledge of the past" (Martín Retortillo, 1960, p. 19). Valencia is very rich in history; therefore, it is essential to know the evolution of agriculture, irrigation and legislation in order to understand how the current situation is reached.

In the study area, there are evidences that in the XI-XII centuries farmers already used water for irrigation, as in the 16th of October 1289, a *Carta Puebla* (letter to the villagers) was delivered to the villages of Montesa and Vallada, where the King Alfonso I rewarded 120 Christians with lands and possessions. In this latin "letter" it is stated: "*possessions et vineas, tam rigadivi quam sicani*", which means there were already irrigated and non-irrigated arable lands. Furthermore, some other activities are mentioned which are totally linked to the use of water like mills or *almazaras* (mills for producing olive oil), or *tintorerías* (dyeing works) (Guinot Rodríguez, 2008). This means that at least in the XI-XII century's Muslims already introduced irrigation in the area. In addition, they used different infrastructures for drinking water demand or for some industries.

Alquerías are the unit for water management at local level, which are totally linked to irrigation (Guinot Rodríguez, 1991; Hermosilla, 2010). In the Cànyoles valley, three out of the four villages studied show archaeological remains of *alquerías.* In Montesa: *Les Alqueries*, in Vallada: *Alquería les Solanetes*, and in Moixent: *Hortes Velles* (CULT, 2011). During the Islamic period, the territorial organization was structured through the relation between the *alquerías* and a castle, which at the same time where related with irrigation systems. The castles used to protect the fertile lands, and the *alquerías* integrated dry and irrigated lands (Glick, 2007, pp. 124-128). In the study area, the ruins of three castles are found. The first one was located in Moixent, conquered by Jaime I who donated it to the *Gran Maestre de la Orden de Santiago*, Fray Pelagio Pérez in 1255 (CVC, 1998). The remains are solely an Islamic square tower and some walls on the outskirts of the village. Near Vallada, there are the ruins of the castle of *Garmuxen*. It was also constructed by the Muslims and donated in 1288 by Jaime II (CVC, 1998).

The most important castle and the best preserved one is in Montesa, which was also erected by the Muslims and conquered by Jaime I. In 1317, the King Jaime II created an Order for the Kingdom of Valencia in this castle. The complete name of the Order was *Orden Militar de Caballeros Cruzados de Nuestra Señora de Montesa*. In 1347, the *Orden* bought castles and *villas* to Pedro IV, seizing almost the entire current Castellón province. The castle was preserved splendidly until 1748, when it was destroyed by an earthquake. The rest of the standing castle ruins are National Monument since the 13th of April of 1926 (Gaceta de Madrid, 1926).

Those evidences assure the irrigation introduction thanks to the Islamic culture. Christians afterwards, maintained those traditional structures because of their good capacity of water distribution and continue using them for agricultural and other purposes. Therefore, in the Late Middle Ages, the irrigation landscapes were actively maintained. Already in the Modern age, Viciana (in 1564) described the landscapes and villages of La Costera, among other villages. It is easy to perceive the abundance of springs, fountains, canals and different crop productions that existed during the previous centuries. For instance, the next lines describe the importance given by Viciana to water. This part is specifically referring to the fertile lands near Xátiva and Canals in the La Costera lowlands:

"There are infinite fountains and water is marvellous for the orchards and fruits (…) water quantity and quality, as well as the orchards make the villages rich and their inhabitants rich. The food that comes from the land is one of the best of the kingdom in healthiness and mildness…" (Viciana, 1564, p. 332).

In fact, in the study area, the descriptions of irrigation structures were a constant in the book of Viciana:

"…in the river that comes from Montesa, there are ten canals and in the exit of the region it carries more water than what it brings, it all comes from the river. There are infinite fountains and water is marvellous for the orchards and fruits" (Viciana, 1564, p. 360).

The names of the villages are also connected to water. It is the case of La Font de la Figuera (Fig's Fountain in English):

"…In the place there is a spring called The Clear Well, because it is very deep and its water is clean and pure. With this water, many orchards are irrigated. In the surroundings there are many marvellous fountains. That is where the name of the village Fuente la Higuera comes from..." (Viciana, 1564).

Certainly, the relevance of water for drinking, for agriculture and overall for the livelihood, create some repercussions among the inhabitants of the villages, such as troubles that once happened in the village of Xátiva:

> It is said that the maestro (builder) of the village promised to build a canal from a fountain/spring called Bellús, in order to bring 8 hilos[5] of water for everyone so that water would reach all the houses. Nevertheless, when the canal was finished it was impossible to make the water reach the high part of the village (as the fountain was high, but not as high to have enough impulse to reach that part), and only the lower part villagers could use it. There were discussions as everyone contributed to the expenses but only half of them obtained the benefit. Therefore, to avoid the scandal, the villagers brought 3 more hilos from another fountain/spring which was higher located. Finally, all houses had access to water which brought peace to the village. They named the last spring Saint Fountain due to its action (Viciana, 1564, p. 332).

Having so much water resources in the area, it is natural that some rules were established. In La Costera, the first written ordinances that regulated the administration in the different canals of the *comarca* are dated from the XVII century (Hermosilla, 2003). It is a century later, in the XVIII century, when owing to the population increase and technological improvements, agricultural areas were expanded and new water resources were explored. In the study area, this resulted in the construction of a reservoir, called *El Bosquet*, in Moixent, ordered by Pascual Caro, uncle of the *Marqués de la Romana* and landowner in Moixent. The reservoir was, and still is, in the south west part of the village, far from the traditional irrigated areas. It was finished in 1775 and transformed previous dry lands into productive irrigated orchards (overall the ones owned by the Marques and Caro) achieving higher economic benefits (Cavanilles, 1795, p. 232).

Information about agricultural areas and irrigation in the study area is also described in other documents of the XVIII and XIX century. At that time, starting from the highest village of the Cànyoles valley, La Font de la Figuera, irrigated land was only located in a district called La Redonda and there were few orchards irrigated with the remaining water of the springs after they were used for the village supply (Madoz, 1850, p. 221). Apart from La Redonda, there were two more *partida*s (districts) with agricultural activity in the XVIII century. Their names were *Carrascal* and *Bobalar*. In the first one they used to grow grapes and in the second one they cultivated wheat and other grains (Cavanilles, 1795, p. 234). According to Cavanilles, Moixent was one of the most recommended villages of the kingdom because of its agricultural growth. Apart from irrigation canals, there was crystalline water in places where in previous years there was no irrigation. It came from unknown fountains and from small springs that were lost in some *barrancos*, so that it was used for irrigation or stored in reservoirs for the same purpose in many other lands. Vallada was part of Montesa until the XVI century, when because of the growth of inhabitants obtained the title of village (Cavanilles, 1795, p. 231). Lastly, Montesa was a mountainous and dry but fertile area. It was full of olive trees and forest of carobs, which were very abundant. Mostly, the agricultural production in the four villages was wheat, barley, oat, rye, millet, olives (for olive oil), vineyards (for wine elaboration), figs, honey, vegetables, corn, carob pods and acorn (Madoz, 1850).

[5] According to Glick, Muslim measurements to deliver water where made time-based. In that way 1 *hilo* would be equivalent to 12 hours in this area of Valencia (Glick, 1970).

During the XIX century, there was no change in the irrigated surface of La Costera. However, there was a change of crops to fruits and vegetable, all of them irrigated (Hermosilla, 2003, p. 60). As first data, the irrigated and non-irrigated lands surface in the XIX century in three of the villages of the study area, are shown in the table 4.

TABLE 4: IRRIGATED AND NON-IRRIGATED LANDS IN MOIXENT, VALLADA AND MONTESA IN 1848 (HERMOSILLA, 2003, P. 55)

Village	Non-Irr. lands (ha)	Irrigated lands (ha)	Percentages (%) in each village	
			Non-irrigated (%)	Irrigated (%)
Moixent	2421,3	56,8	97,7	2,3
Montesa	1609,7	4,2	99,7	0,3
Vallada	1271,4	22,3	98,3	1,7
Total	**5302,4**	**83,2**		

The three villages represent half of the total surface of La Costera (current surface of La Costera 52.826 ha and surface of the three villages 34.418 ha.) (INE, 2010). It is obvious that at that time the irrigated lands where much less than the dry land agriculture areas. Irrigation systems were the same ones as used in previous centuries (furrow irrigation by canals). Moixent was the most important area as consequence of the construction of the reservoir of El Bosquet in the previous century. However, there was still much more dry land rather than irrigated land, as apart from the reservoir there were no other improvements or modifications in the irrigation systems. In this same century (and more specifically in the last third of the century) the idea of studying and planning water resources started, as water could not be used as wished anymore since different activities water needs were increased (Hermosilla, 2003).

At the time, at national level, due to the various particular confusing rules and ordinances related to water use, several Royal Orders tried to arrange rules related to water regulations. Firstly, the Royal Order of 14th of March 1846 established the rules for water use, which meant that royal authorization was required to exploit new sources of water. Moreover, with the aim to promote irrigation in the most suitable areas, the Royal Order of 5th of March 1847 was enacted. This Order stated that the Mayor of the villa was the person in charge of giving information about irrigated and non-irrigated lands, mills and industries (discharges, canals, mill water jumps etc.). In addition, the Royal Order of 21st of 1849 outstands the concern about reaching the maximum water exploitation. This was followed by other Royal Orders, like the one of 20th September 1859, in which it was stated how the State bestowed concessions of water river use, or the Royal Decree of 29th April 1860 which established the base for the bestowment of the works and other water use authorization (Martín Retortillo, 1960).

However, the most significant change was due to the National Water Law of 1866. The accumulation of exigencies for different and new water uses, the diversity of documents (content incomplete, sometimes contradictory or confusing, coming from different periods and governments), the population increase and the augmentation of crop needs required a complete, uniform and precise legislation unified in one general law. All this was expressed in the Royal Decree of the 27th April of 1859, in which a Ministry Committee was named in order to write the future Water Supply Law Project. This project would be the starting point of the Water Law of 3rd of August of 1866. The idea of the law came once the regulation of

water supply in villages was set, as awareness was raised in the need to regulate not only water supply in villages, but also all general water uses. This implied an adequate distribution of discharges, although natural water regime needed to be modified. Importance was given to irrigation and also, taking into account water resource limits, to make the different water uses compatible. Conflicts among irrigators happened at that time, which was another reason why a law was needed (Martín Retortillo, 1960).
Owing to the long tradition of irrigation rules in Valencia, it was not a coincidence that the dean of the Law faculty of the University of Valencia, Professor Antonio Rodríguez de Cepeda, participated actively in the writing of this essential law for the water management cycle (Martín Retortillo, 1960). This Law, which unified the uses and traditions practiced until that time at state level legally, was substituted by the Water Law of the 13th of June of 1879, which maintained the same general principles. The only systematic difference was that the law of 1879 excluded all the uses related to the sea water and beaches, transferring them to the Seaport legislation. In those first laws, the existing local organizations, *Comunidades de Regantes* as well as water rights and local water regulation management were nationally recognized for the first time (Gaceta de Madrid, 1879).

After the legislation was in force, the biggest change in the study area arrived at the end of the XIX century-beginning of the XX, with the revolution of electricity and wells. This period can be considered as a phase between traditional furrow irrigation and drip irrigation systems, when drilling was an usual activity to make quarries, mines and try to find groundwater. This can be appreciated in the text of Blasco-Ibáñez (1900) included in the introduction of this study, where irrigation machines and motor chimneys are mentioned, giving an idea of the change in irrigation activity from Muslim period to the consequences of the industrialization in the XX century.
The agricultural crops and vegetation of the study area were changed. Three different levels could be defined from the agronomical point of view: *Sierras*, high valleys and low valleys. In the first ones, the *sierras*, soil is very rocky and in general it is impossible to cultivate, where pine is the main vegetation. In dry summers this contributes to forest fires, very common in North Mediterranean countries as it is well-known. Apart from pines, and in a lower quantity, rosemary, thyme and gorse are also distinguished (Costa, 1986).
The second ones, the high valleys, were extensively cultivated. The typical planted crops were cereals, leguminous plants (pulses) and vineyards. Some olive trees and dry land fruit trees could be found as well. In the last ones, the low valleys, there were dry and irrigated lands. In the dry lands, there were similar crops to the just mentioned ones. In the irrigated lands of the low valleys extensive and splendid vegetables were grown, forming the orchards. There were already abundant orange trees, adequate to the climate of the area. However, sometimes frost caused terrible loss in yield. At that time, the main problem to expand the irrigated crop surface was the slender water availability, once the surface resources were exploited. National organisms, like *Instituto Geológico y Minero de España*, were aware of that and already gave advice of doing research on groundwater (IGME, 1955).

Later on, and until the third half of the XX century, the expansion of irrigation in dry agricultural lands is noticed, overall in Vallada and Montesa. In addition, the urban and industrial expansion affected the orchards and the disappearance of some traditional structures that used water (mills, canals, hydraulic structures etc.). The reason is the exploitation of the groundwater resources, which leaded to irrigation supported by wells. The fact that River Cànyoles did not have much discharge, contributed to this well based irrigation expansion (Hermosilla, 2003, p. 61).

As water sources changed, the disputes between irrigators arose mainly due to two reasons. On the one hand, the expansion of the irrigated lands due to the new aquifers exploitation, provoked water shortages in the previous irrigated areas. On the other hand, the decrease of the flow in the natural course of the river was related to the aquifers exploitation and affected to the traditional irrigation in La Costera. Relevant crop change at that time was citrus and overall oranges, due to economic reasons (Hermosilla, 2003, p. 62).

The following important step concerning water legislation in Spain is linked to the change introduced with the end of the dictatorial regime of Franco. In 1978, the approval of the Constitution of the new democratic system implied the transfer of most of the administrative competences concerning water management to the 17 Spanish Autonomous Communities. In the Article 148-10 of this Constitution, the projects, constructions and exploitations of the hydraulic resources, channels and irrigation of interest for the Autonomous Community were transferred to the governments of these Autonomous Communities.

With the new democratic system, the necessity to change the Water Law of 1879 emerged. Consequently, on the 2nd of August of 1985 a new Spanish Water Law was promulgated (Boletín Oficial del Estado, 1985). The main difference with the previous one was the change to declare the groundwater and aquifers public, rather than private. Nevertheless, there were some exceptions due to the preservation of past rights and situations given before the law was promulgated. It also defined watersheds as resource management units, indivisible and listed all the functions that the *Confederaciones Hidrográficas* (watershed organisms) had.

At regional level, and making use of the competences delegated to the Autonomous Communities, the Generalitat Valenciana approved the Law 7/1986 (Generalitat Valenciana, 1986). This law regulated the Use of Water for Irrigation in the Valencian Community in order to achieve three principles: high austerity, economy and solidarity. Valencian government offered farmers to render technical and economical help with project studies, subsidies and loans that contributed to the decreasing use of water without decreasing the land productivity. This Community level law would be the one facilitating the introduction of drip irrigation systems in the study area in the nineties of the XX century.

The next step was given as a result of the United Nations Conference on Environment and Development (UNCED), or Rio Conference in 1992. In this conference, the focus was on the state of the global environment and the relationship between economics, science and the environment in a political context. The conference concluded with the Earth Summit. The leaders of 105 nations gathered to demonstrate their commitment to sustainable development. In this line, Europe would support a Convention on Climate Change and a Convention on Biodiversity as signed by more than 130 nations. Modernization of irrigation systems as well as the introduction of technology like drip systems arrives to Valencia by European, Spanish and Valencian initiatives in the late eighties and the beginning of the nineties of the XX century.

3.4.-LEGAL AND POLITICAL SUPPORT TO DRIP TECHNOLOGY

Political support and water management are two of the factors that affect to drip irrigation systems transformation in Spain. In this section, relevant legislation related to the research topic and subsidies affecting to irrigation technology and agriculture will be studied.

3.4.1.-Legislation related to irrigation

There are various organization legislation and actors that affect irrigation in La Costera region. They can be divided in the following levels: European level, Spanish national level and Valencian Autonomous Community level.

Several departments of the European Commission influence to the irrigation transformation and basin management in Valencian Community. On the one hand, the Environment department seeks an integrated river management approach via the European WFD 2000/60/EC of the European Parliament and of the Council, which established a framework for Community action in the field of water policy. To fulfil their objectives they called for the Hydrological Basin Plans (*Planes Hidrológicos de Cuenca*) and in concrete for this case, the *Plan Hidrológico del Júcar*. Apart from that, water quality in both groundwater and surface water and a sustainable development without natural resources degradation are regulated. This is captured in initiatives like Directive 2006/118/EC promoting the protection of groundwater against pollution and deterioration or the Directive 2008/105/EC, which gives a step focusing on the environmental quality standards in the field of water policy (European Commission, 2006 and 2008.). All this, is included in the European Sustainable Development Strategy that was renewed by the Council of the EU in June 2006 in Brussels. This strategy has the conservation and management of natural resources as main purpose. One of its objectives is to improve management and avoid overexploitation of renewable natural resources such as water, air, soil and atmosphere, restoring degraded ecosystems.

On the other hand, in the European legislation of Regional Policy department, where they seek for a balanced development throughout the EU, there are interesting Operational Programs (OP) that affect irrigation in Valencian Community. In fact, one of the four strategic objectives of the Operational Program in that Community for 2007/2013 coming from the European Regional Development Fund (ERDF) is to "develop the environment improvement with the efficient use of water resources, indifferently of the source they come from", which means that, priority is given to the improvement of the existing water infrastructures and to the implementation of the new technologies for water management. As it is mentioned in the third axes of the same document, the fourth objective is: "the improvement of the irrigation efficiency (main use of water resources) to save water in the Valencian Community". It is also stated that the measures will take place "in the existing irrigation areas, assuming no expansion of the irrigation surface" (ERDF Operational Program Valencia, 2009, p.131). Therefore, there is evidence that the initiatives from Europe are enhancing water efficiency using technology to save water. Besides, it is clearly stated that there is assumption of no expansion of the irrigation surface.

In this line, it is useful to have a look to the reform of the Common Agricultural Policy (CAP) and its planning reforms for 2013 and future reforms with horizon 2020. Agriculture and Rural Development department has weighed in irrigation transformation as it is totally linked to the crops. In the next section the subsidies given from Agriculture will be reviewed.

At national level, the government represented by Ministerio de Medio Ambiente y Medio Rural y Marino (MARM) promoted certain plans and programs. The first plans were the *Planes Hidrológicos de Cuenca* 1664/1998 followed by *Plan Hidrológico Nacional* (PHN) approved by the Law 10/2001. From the total budget of the PHN, 32.6% was aimed to irrigation modernization (Rico Amorós, 2010, p. 247). At this point more specific plans in the topic of irrigation arose. Starting with the *Plan Nacional de Regadíos* (2000-2008) 329/2002 (Boletín Oficial del Estado, 2002), for which research and works started in 1994.

The next plan that empowered the previous one was *Plan de Choque de Regadíos* (2006-2008) (Boletín Oficial del Estado, 2006), which also affected to irrigation modernization at national level. It caused some effects like the reduction of traditional gravity irrigation systems and the increase of sprinkle and drip irrigation systems that promote water savings.
Following the PHN, a program called A.G.U.A. (*Actuaciones para la Gestión y Utilización de Agua*) is put forward, based on four concepts: flexibility, quality, water saving and sustainable development, which is mainly applicable to Mediterranean basins, including the study area (MARM, 2008).
MARM is also working in the continuation of the *Plan de Choque de Modernización de Regadíos*, which is called *Estrategia Nacional para la Modernización Sostenible de los Regadíos Horizonte 2015* (Sustainable Modernization of Irrigation National Strategy Horizon 2015). Some of their purposes are to foster water savings improving the water use efficiency and energy, to transfer technology to the irrigation sector, to use non-conventional water resources, to improve the agricultural and rural development and to seek a sustainable irrigation in agriculture that respects the environment (MARM, 2010). Other two related plans are the current *Plan Nacional de Reutilización de Aguas* (2009-2015), which pursues water reuse and the *Plan Nacional de calidad de las Aguas: Saneamiento y Depuración* (2007-2015) that seeks to reach the good environmental status that WFD proposed for 2015 (Boletín Oficial del Estado, 2007 and 2010b).
Besides, MARM have published a report including good environmental practices, based on the EU different area initiatives, encouraging a balanced sustainable development from the economic, social and environmental perspective. It is called *Manual de Buenas Practicas Ambientales en el Sector Agrario* (Ministerio de Trabajo y Asuntos Sociales, Ministerio de Medio Ambiente and ESF, 2003). There are also publications referring to these practices in other sectors. They seek to guide any person or stakeholder related to that sector and to make them aware of the environmental conservation in their every day practices. In the report, incorrect practices and correct practices are mentioned to achieve a sustainable development in agriculture. Several things are explained: some definitions related to agricultural activities, the material resources used in the agricultural activity, the generated spillage and waste etc. It concludes giving some guidelines to manage the resources (energy, water etc.), contamination and spatial management.

At Community level, Generalitat Valenciana and specifically the Conselleria de Agricultura, Pesca y Alimentación is in charge of agriculture, fishery, food as well as water and irrigation. Its objective is to carry out the European plans and programs in the Autonomous Community. In this line, in the late eighties and early nineties, some own initiatives can be observed at this level. Those were the Law 7/1986 about the Use of Water for Irrigation in the Valencian Community, followed by the 47/1987 Decree of the Generalitat Valenciana that enhanced subsidies and loans for irrigation modernization (Generalitat Valenciana 1986 and 1987).
After that, the Law 13/1995, denominated Irrigation Modernization Plan in the Valencian Community encouraged to increase drip irrigated surfaces, modernize historical and traditional systems and foster the new water sources (wastewater or desalinization) among other actions (Generalitat Valenciana, 1995a).

Linked to the mentioned European Sustainable Development Strategy, the Sustainable Development Strategy for the Valencian Community was launched in 2002. In it, water is considered as a strategic resource which deficit could only be improved with the PHN and water saving strategy (Generalitat Valenciana, 2002).

In addition, Valencian orders and decrees in relation with environmental matters like water protection to the nitrates contamination, environmental and land protection or even conservation of wild birds are raised. *Código de Buenas Prácticas Agrarias de la Comunidad Valenciana* (Generalitat Valenciana, 2010*)* is the one protecting the contaminated water from nitrates coming from agricultural activities. This later one is also based in European Directives.
Some of the current Valencian initiatives are the depuration and reuse of wastewater, the planning of alternative energy sources, the analysis of the flooding risks and forest fires, saving of water, assessment of the impacts of urban plans etc.

3.4.2.-Subsidies and training for drip irrigation

For irrigation, as well as for agricultural activity, subsidies play a meaningful role. The majority of subsidies that benefit the agricultural sector are coming from the European Commission in combination with national and autonomous budgets. The most important subsidy sources are the following ones:

Directorate-General for Agriculture and Rural Development of the European Commission
In the CAP framework there are two important financing funds. The first one is the European Agricultural Guarantee Fund (EAGF), from which the most important subsidies are the "direct payments" to farmers, directly granted to them in order to have a basic income support. The second one is the European Agricultural Fund for Rural Development (EAFRD). It finances the rural development programmes with the Member States, like the National Strategic Plans of Rural Development (2007-2013) (European Commission, 2007).

Directorate-General Environment of the European Commission
Apart from the implementation of the WFD, European Commission seeks for the integration of agriculture with environment, developing agriculture and respecting and conserving the environment. CAP is the policy in charge of it and one of the priority areas to protect and enhance the EU's rural heritage is water management and use. As CAP gives direct payments subsidies, farmers are asked to preserve the environment and natural resources during agricultural activities.

Besides, this Directorate promotes LIFE programmes since 1992 that supports environmental and natural projects, some of them related to water. A number of programmes search to advance wastewater treatment in rural areas, some others to save water with more efficient irrigation systems. An example of the latter one has been applied in Spain with OPTIMIZAGUA Life programme. In the same state, there are other projects like "Excellence in irrigation water management" (gEa) during 2005-2007 or the "Sustainable management of water reducing environmental impact using new fertigation methods" (FERTIGREEN) during 2005-2008 (European Commission).

Directorate-General for Employment, Social Affairs and Inclusion of the European Commission
The financial support in this area is coming from the European Social Fund (ESF) which fosters employment for sustainable development of rural environment. One of its programmes is the European Social Fund in Spain (2007-2013) (European Commission)

Directorate-General for Regional Policy of the European Commission
The Regional Policy department has the European Regional Development Fund at its disposal. This fund makes Operational Programmes to achieve a balanced development

throughout EU. For instance the already mentioned ERDF Operational Program Valencia, 2007-2013 (European Commission, 1999).

All the funding of the European Commission are combined with national and Community level initiatives and are compatible with its respective legislations and laws. The EU funding passes through the Spanish government and then to the autonomous communities competences in order to reach the farmers or the subsidizers.

From the Spanish government, the *Fondo Español de Garantía Agraria* (FEGA) manages the funding coming from the CAP for subsidies and rural development programmes. FEGA is an autonomous organism attached to the MARM.
Following the EU principles, MARM searches for sustainable agriculture making use of programs like Programa Nacional para el Fomento de Rotaciones de Cultivo en Tierras de Secano or Programa Nacional para la Calidad de las Legumbres (Boletín Oficial del Estado, 2010a).
Direct payments are distributed by Ministerio de Agricultura Alimentación y Medio Ambiente to the Autonomous Communities. Those subsidies are the ones paid directly to farmers. To opt for them some conditions have to be fulfilled related to good agrarian and environmental status and legal requisites. For good agrarian and environmental status farmers are asked to apply measures to protect and conserve the soil, to guarantee a minimum maintenance of agricultural land surface and to avoid the deterioration of habitats. Apart from that, there are some environmental education and training organized by the MARM about raising awareness on environment.

Generalitat Valenciana works through Conselleria de Agricultura, Pesca y Alimentación (CAPA) to forward the subsidies. Although CAPA is supposed to give a percentage of the subsidies, their current activity, owing the important economic crisis in this Community, seems to be mainly forwarding the subsidies arrived from EU and Spanish government.
Subsidies are found in three different levels: agricultural subsidies, rural development subsidies and subsidies for cooperatives.
In agriculture, the subsidies are for direct payment, agricultural incomes, agriculture sustainability, vineyards, crop protection and measures for improving agricultural competitiveness. The last ones are divided in subsidies for young farmers, early retirement of farmers, citrus tree variety transformation, transformation and restructuration of vineyards, modernization of farm machinery and agricultural infrastructure improvement (Generalitat Valenciana, 2009b).

As for rural development CAPA supports enterprises, rural tourism development and conservation of the rural heritage and village renovation via subsidies.
Some of the current programmes are the Programa de Desarrollo Rural Sostenible 2010-2014, RURALTER-LEADER or RURALTER-Paisaje (Generalitat Valenciana, 2009a).

It is important to recall that the first subsidies regarding to water use for irrigation were published in the 47/1987 Decree of the GV, giving the chance to CRs or other farmers association to ask for a request or project proposal with the general aim of water saving.

3.5.-WATER RESOURCES FOR IRRIGATION

Irrigation has played an important role in improving the diversification of crops and agricultural lifestyles, developing social, cultural and economic aspects. The water has come from different sources. Rivers, springs, fountains, wells, aquifers and most recently reused wastewater are the main ones. In the next section, the relevant sources for the study are explained. Starting from the river water, used for ten centuries and distributed by canals that changed during time (made by wood, brick concrete or even earth channels), followed by wells (which were expanded in the XX century with the evolution of electricity) and lastly reuse of wastewater. This last one is a promoted measure that fits with the sustainable water management philosophy of the EU. In the study area, three main sources are identified for irrigation supply: river Cànyoles water, groundwater and reused wastewater.

3.5.1.-River Cànyoles water for irrigation

Surface water is probably the most ancient water source used by humans, as it is easier to see and calculate its quantity. As mentioned before, Cànyoles is the most irregular river in the area and it is usually dry during summers. However, this was not an obstacle for the inhabitants to use this water to irrigate. Until the XVIII century, it was the main water source and normally it supplied some lands by gravity, after capturing the water in the upstream areas. Despite nowadays, comparing to groundwater, it is the minority resource used for agriculture in quantity. However, it is still in use in some parts of the valley to irrigate. In addition, not only irrigation canals were constructed, but also canals to return the surplus water to the river. Considered its historical importance, it deserves a short description in the study area.

La Font de la Figuera has never used the water coming from Cànyoles for irrigation. The reason is that the discharge where the river is born is very low and it does not reach a minimum of water to irrigate. In the other three villages: Vallada, Moixent and Montesa, the discharge increases because the velocity of the water is incrementing as the altitude decreases, due to secondary water discharges. Therefore, in those last villages, water was used to irrigate the so characteristic orchards near the river.

In Moixent there was tradition to use Cànyoles river water, mainly in the areas denominated Old and New orchards (*Huertas Viejas y Nuevas)*, located in the lowest part of the village. In total there were 500 *hanegadas*[6] or 41.7 ha. The Old Orchards comprises 25 ha (300 *hanegadas*) and the New Orchards 16.7 hectares (200 *hanegadas*). There was a weir where these orchards are placed, just right after the village but they decided to change its emplacement due to problems with the mosquitoes affecting the inhabitants. Currently, it is placed before the village.

In Vallada, there used to be 100 hectares (1200 *hanegadas*) of land irrigated by the water of the river. However, the majority of them have been converted into drip systems now. There is a weir known by farmers, but it cannot be seen as it is surrounded by high, dense vegetation and weeds.

In Montesa, all the irrigators that had the historical rights to river water use are now organized in one CR called the *Comunidad General de Regantes de Montesa*. This covers about 920 hectares (11000 *hanegadas*), and the conversion to drip technologies started only ten years ago, despite the fact that some of the farmers still use surface irrigation. Close to the river, the oldest canals can still be observed in the area controlled by this CR, as well as the remains of an ancient weir abandoned in the river and destroyed by an intense flash-flood. Some years ago, in the 90's they constructed a new weir. Very close to the weir there is a mine, known by the farmers as "The Abandoned Mine". It was dug by hand to carry river water from subterranean canals to fields. This is quite close to Vallada so that the water level is as high as possible and can irrigate more plots in Montesa.

[6] In Valencia, the land is measured in *hanegadas* and 12 *hanegadas* are equivalent to 1 hectare.

Bearing to the chemical conditions of the study area, Cànyoles river basin fulfils the quality regulation for pesticides as well as for nitrates. The last one is confirmed by an evaluation of possible sensitive areas to water contamination by nitrates. It is proved that the concentration is less than 50mg NO3- /L in the sampled wells of the Cányoles river basin (Rubio, *et al.*, 2006, p. 102). However, in the lower course of the river, from Canals to Xátiva, nitrate indicators are too high. That implies that chemical conditions are not accomplished, overall in some aquifers in Xátiva, which could be interesting for future research in this area. In other aspects, like the ecological aspect as defined by the WFD (evaluating the biological, physical and chemical and hydro morphological indicators), there are no data found, as there was no water for the samples taken in the study area or the samples were taken in the downstream area of the river, which makes them no representative. As a whole, the river Cànyoles does not fulfil the conditions to reach the objectives of a good evaluation of a river (CHJ, 2009).

Water coming from the river is limited and variable. With it, only a certain surface can be irrigated and in the case of gravity surface, always at specific levels that are below the water level. Nevertheless, currently, there are other sources and technology that allow farmers to carry water to heights and distances that in some time, were unimaginable to reach.

3.5.2.-Groundwater and aquifers water for irrigation

Nowadays, the main water source in the study case area (for irrigation, industry or village supply) is groundwater captured by wells. There are two groundwater subsystems in which Cànyoles river is included. Those are Caroch Sur (current CHJ mass code 80.147) in the northern side of the valley and Sierra Grossa (current CHJ mass code 80.156) in the southern side (Annex III).

Caroch Sur groundwater subsystem

The Caroch Sur subsystem is isolated in the limits of the Cànyoles valley. This means that there is no connection with any other groundwater system or aquifer at that level, because of the type of lithology found there. The exception could only be in La Font de la Figuera, where there could be connection with the subsystem Sierra Grossa. In the valley, the Tertiary facies “tap” can be found. In general, the groundwater flows in SO to NE direction (MITYC & IGME, 1986, p. 123). This subsystem’s supply comes exclusively from rain and irrigation water infiltration and the water exits are from springs and pumping.

In the “Tap” in facies materials from the Miocene of the Cànyoles river, there are sometimes more mineralized waters. Their dry materials are between 450-850 mg/L and sulphate and chloride concentration is higher than usual, reaching 100 and 80 mg/L respectively (MITYC & IGME, 1986, p. 124). Comparing to the WHO guidelines, this means a good quality as standard sulphate concentration varies from 0 to 630 mg/L in rivers and from 0 to 230 mg/litre in groundwater (WHO, 2004). As for chloride concentration, even if the concentration is higher than usual, it is maintained in the normal range.
The chemical quality of groundwater is characterized by an increase in the concentration of nitrates, right where the irrigation activity is practiced. However, the concentration rarely exceeds the potable limits fixed by the *Reglamentación Técnico Sanitaria* (RTS). There are evidences that organic contamination exists in the area, as there is presence of nitrites, organic matter and other components, but their concentrations are far from the allowance limits (MITYC & IGME, 1986, p. 126).

With this evaluation, water can be used for any activity, and currently supplies urban areas as well as industries. Although, in a greater extent, water is distributed for irrigation activities.

Sierra Grossa groundwater subsystem

The Sierra Grossa subsystem is formed of nine aquifers. Three of them: Sierra Grossa aquifer, Atalaya aquifer and Mortera-Bernisa aquifer are the ones corresponding to the study area. The water uses are similar to the Caroch Sur subsystem. In general, the quality of the water is good. The chemical facies in the valley are bicarbonates with calcium and magnesium (MITYC & IGME, 1986, p. 139). The contamination of the groundwater comes only from the fertilizers used for agriculture and the nitrates are the most spread ones, as their concentration has progressively increased in the last decades.

In general, according to the recent evaluation done in groundwater mass, the study area is in favourable quantitative, chemical and global conditions, as defined these terms in the CHJ (CHJ, 2009).

3.5.3.-Wastewater reuse for irrigation

Even if wastewater reuse sounds as a quite new alternative, there are evidences that the wastewater recycling and reuse already appeared in the Minoan civilization in ancient Greece (Angelakis, *et al*., 1999; Asano & Levine, 1996). Nevertheless, initiatives and administrative plans to support these recycling initiatives have started about two decades ago.

In Spain, treated wastewater was considered as a water source already in the Water Law (*Ley de Aguas*) 29/1985. In the article 101 it is mentioned that for the reuse of water, the Spanish government will establish the need or use conditions, depending on their quality and consequent use. However, at that time, there is no specific regulation followed. Apart from the national level, some of the regional authorities (Catalonia, Andalusia, Balearic Islands) developed their own guidelines concerning wastewater recycling, in the field of irrigation, based on the WHO guidelines of 1989 (Bixio, *et al.*, 2006).

Depending on the use that will be given to the treated water, the level of the treatment varies. In matters of irrigation water, the secondary treatment can only be used in restricted agricultural irrigation applications, such as crops that are consumed cooked. However, usually tertiary treatment is the one that meets the standards for unrestricted irrigation (Bixio, *et al*., 2006). There is still a quaternary treatment that can generate drinking water quality. The most important criteria for evaluation of the treated wastewater, when doing the different treatments are salinity (especially in arid zones), heavy metals, harmful organic substances and pathogenic germs (Kretschmer, *et al.*, 2003). Nowadays, for the reutilization of treated wastewater in Spain, an authorization is needed. This is given by the watershed organism, in the case of Júcar watershed, the *Comisaría de Aguas* included in the *Confederacion Hidrografica del Júcar*.

In the study area, two out of the four villages have the right to use wastewater in agriculture. However, it is only in one of them, in Moixent, where this is a reality. As previously mentioned, the reused wastewater needs a tertiary treatment in order to apply it to the fields. In Moixent, EGEVASA (*Empresa General Valenciana del Agua S.A.*) is the enterprise in charge of it, so that water is ready to use directly for irrigation by the CRs.

The issue in La Font de la Figuera is more complicated. Since 2003, they already have the authorization and subsidy is accepted to construct the reservoir to store the treated wastewater and consequent use for irrigation. Nevertheless, the autonomous government economic situation resulted in postponing the work, leaving the farmers without water for irrigation, as the water used in previous years is currently supplying the village.

3.6.-WATER MANAGEMENT AND SOCIAL CAPITAL ASSOCIATED TO IRRIGATION

As in any other country, in Spain, organizations that manage water use exist. Apart from the government agencies leaded by national or autonomous community level (Ministerio de Agricultura, Alimentación y Medio Ambiente and CAPA), there are other public organizations that specifically aim to manage watersheds in every aspect. Those are called *Confederaciones Hidrográficas* in Spain and are the already mentioned watershed organisms. Moreover, there are Water User Associations (WUAs) or *Comunidades de Usuarios* that are in charge of water management at field level. In fact, the Comunidades de Regantes (CRs) could be translated as Water Irrigator Associations instead of WUAs, which deal with irrigation management at field level.

3.6.1.-Confederación Hidrográfica del Júcar (CHJ)

The *Confederaciones Hidrográficas* were created in the year 1926 acquiring their own autonomy. Spain was one of the first states that managed water from the same common administratively institution at watershed level. That is why they already appear in the 1879 Spanish Water Law. Afterwards, the watershed level management was imitated by other states (Confederación Hidrográfica del Ebro, 2000).

The first institution formed was the Ebro watershed, situated in the north-eastern side of the peninsula and the widest watershed of the state. Those organizations are administratively attached to the government. Nowadays, there are nine of them in Spain and Cànyoles river basin is included in the *Confederación Hidrográfica* of Júcar watershed. This last one was created in 1934 and is responsible to ensure WFD principles in their Hydrological Plans, as well as to regulate all the basins that are in the Júcar watershed. This includes partly, the basins located in four autonomous communities of Spain (Valencian Community, Castilla La Mancha, Aragon and Catalonia) and encloses the Cànyoles river basin in Comunidad Valenciana (Figure 6). The complex system of having two different structured "Spains" (political and watershed) creates most of the times water troubles when the basins cover more than one different autonomous community.

FIGURE 6: WATERSHED ORGANISM BOUNDARIES AND SPANISH AUTONOMOUS COMMUNITIES BOUNDARIES (MARM, 2008)

The watershed organisms have different administrative units and together they have to fulfil various functions, like providing authorizations related to public water and its inspection, giving information about water quality control, droughts and flooding, improving their previous projects, defining new objectives in line with the hydrologic planning, taking actions to improve water demand in order to save water, achieve an economic and environment efficiency of different water uses or giving technical services (Confederación Hidrográfica del Ebro, 2000). The *Confederación Hidrográfica* is not the association in charge of water supply to cities or towns and wastewater treatment. Normally, the municipalities in collaboration with some enterprises give those services.

As it can be appreciated, apart from government agencies there are those specific public organizations linked to the environmental ministry that aim solely water management in each watershed. Furthermore, there is one more level for water users, which are called *Comunidades de Regantes.*

3.6.2.-Comunidades de Regantes (CR)

In the Spanish Water Law of 1985 it is mentioned that the person or organization that uses water has to form a *Comunidad de Usuario* (WUA). The association can use water for different purposes, but if the allocation is for irrigation, then it is called *Comunidad de Regantes* (Water Irrigator Association).

The *Comunidades de Regantes* (CRs), or Water Irrigator Associations, are institutions with long historical tradition. This actor pursued water distribution and organization for irrigation during centuries. They first legally appear in the Water Law in the XIX century. It is true that before the ordinances they were called differently and it is also true that there was not any law to regulate them. Nevertheless, from Muslims period, there were organized farmers that with similar objectives transferring them with customs, culture and rights which passed from generation to generation. Their main purpose? To regulate the water distribution for irrigation.

Comunidades de Regantes can be defined as a group of owners, usually farmers, of irrigable areas and form the basic unit for irrigation management at field level. However, there are other similar associations that have the same function as the CRs have, but are differently named, like for instance *Sociedades Agrarias de Transformación (SAT).* This is usually linked to the irrigator’s rights before the law 1985 or administrative matters. Nevertheless, currently most of the organizations are converting to CRs.

As mentioned previously, in the Water Law of 1879 the Comunidades de Regantes are established for the first time in law and out of the 258 articles, 25 were related to the Water Irrigator Associations. In the current modified Water Law 1985, there are 11 articles from a total of 113 that deal with them (del Campo García, 2000).

All the *Comunidades de Regantes* have to be registered in their respective *Confederación Hidrográfica* and they are also grouped in one national association named *Federación Nacional de Comunidades de Regantes* (FENACORE). They have their own statutes defined in the 22nd article of Spanish Constitution of 1978. In the Júcar watershed, there are 110 legal CRs and in La Costera region 34.

Each CRs have a similar internal structure with different roles. There is a Commission formed by a president, a secretary, some vocals/members (usually from 3 to 5) and a treasurer. They call the General Assembly where all the *comuneros* (users or irrigators) of the association have the right to vote. This is performed at least once or twice a year if there are not extraordinary ones.

Apart from the commission there is a *motorista* (also called the *regador* in other places), who is in charge of the pumps, maintenance works, possible breakages and of reading the cubic meters used in drip irrigation systems. The *motorista* also exists in traditional furrow systems but they work is slightly different, as with furrow systems they open gates or organize the irrigation turns. All of them are members of the *Comunidad de Regantes.*

3.6.3.-Other organizations

Apart from *Confederación Hidrógráfica del Júcar* and the *Comunidades de Regantes* in the study area, other organizations that are also related to water use for irrigation are present.

The *Sociedades Estatales de Agua* (SEA) are one of them. As *Confederaciones Hidrográficas*, they are organizations linked to the government. In that way AcuaMed is responsible of the Mediterranean watershed's hydraulic infrastructures and their construction.

The *Asociación Española de Usuarios de Aguas Subterráneas* (AEUAS) is another organization. This association is private and tries to study groundwater in Spain, as well as to organize training and seminars with the public administration. Unfortunately, it does not cover all the groundwater systems yet, excluding the aquifers situated in the study area. Usually, they focus more in the ones located were the urban areas are, like Valencia and its surroundings and not in the small rural areas.

There is one important institution at state level that does research mainly about agriculture and it is situated in the Valencian Community. Its name is *Instituto Valenciano de Investigación Agraria* (IVIA), in which there is a department specialized in irrigation called *Servicio de Tecnología de Riego* (STR). Their function is to asses farmers with the water needs for crops: when do they have to apply water, how much and how. For that, apart from research, they impart different conferences and speeches for technicians in cooperatives and CRs. The STR publishes all the different data available from agroclimatic stations and offers a service to calculate the time of application of water for drip systems in fruit trees, taking into account the precipitation and the ET_0, depending in the area. For the case, the agroclimatic station closest to the study area is located in Montesa.

4.-RESULTS

In this section, the results of the research are explained. Before describing them, a general view regarding to crops and irrigation in La Costera will be explained, based in the data from CAPA. In La Costera there are 7918 non irrigated hectares and 11056 irrigated hectares (Figure 7). This means that if both table 4 (p 20) and figure 7 are compared, apart from the agricultural surface expansion, there has been a huge expansion in irrigation and water use (the irrigated area in 1848 was 83.2 ha and non-irrigated area 5302.4 ha in Moixent, Vallada and Montesa).

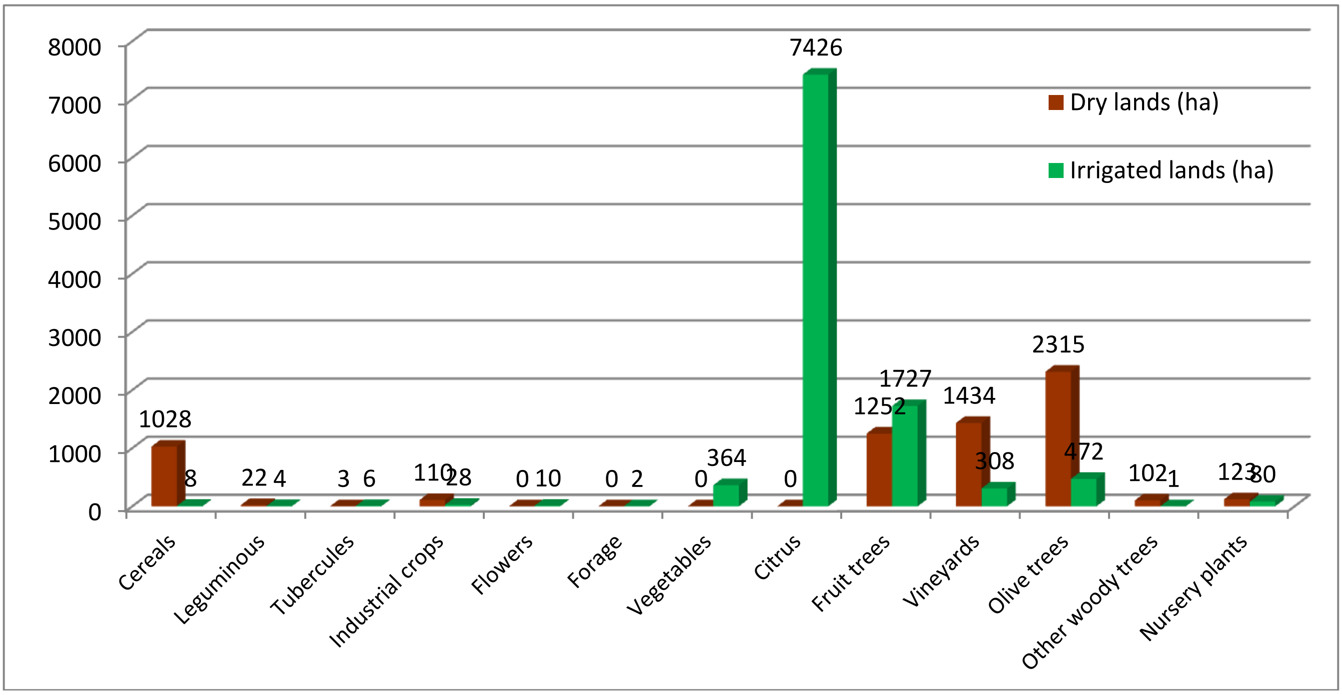

FIGURE 7: CULTIVATED LAND DISTRIBUTION WITH DIFFERENT CROPS IN LA COSTERA (CAPA, 2009)

Currently, there are different crops planted in La Costera region, regarding to the final product destination. Basing on figure 7, it can be concluded that citrus, fruit trees, vineyards and olive trees are the main crops in the area. In a lesser degree, vegetables and cereals are grown. In addition, irrigated lands are more common than dry lands, as there are 6389 ha of dry lands compared to the 10438 ha irrigated lands. It is clear that the main crop is citrus and all its production is obtained by irrigating.

The overall map of the valley can be found in Annex V.

The results section is described village by village, starting from the lowest one and finishing with the highest one. This is considered the best procedure, as there are important differences between them. Each town has a brief introduction and after it, is divided in six subsections: stakeholder's motives to implement DIS, information, communication, subsidies and training, water sources, consequences at field level and expansion, traditional irrigation infrastructures and other issues.

4.1.-MONTESA

Montesa was the pioneer village implementing drip technologies in the Valencian Community (and in Spain together with Murcia). In this village, they already used a similar system to drip technologies in 1990 for strawberries, which was the first modernization of pressure irrigation systems. They implemented this system called BIAFRO in the CR El

Reixach, created in 1989-1990, and as a result the production of strawberries grew. It was a simple model of a current drip system. The area of CR El Reixach, which is located in the north-west part of Montesa, was the first area that used a similar system to drip irrigation. Before, the same surface was agricultural dry land. Later, the strawberry production in the area stopped due to the migration of Valencian people to Huelva (Andalusia). As they knew how to cultivate strawberries and in Huelva the production was cheaper as it was subsidized by the Junta de Andalucía, they stopped producing strawberries in Montesa valley.

However, the wider spread of irrigation technology arrived some years later when the decree 69/1995 Plan of Water Use for Irrigation in the *Comunidad General de Regantes de Montesa* was approved, based on the 47/1987 decree of GV. The main objective was to achieve substantial water savings introducing drip irrigation technology and for that CAPA provided half of the total budget for the initial investment. This project covered the area of the Comunidad de Regantes mentioned above, which is the unification of the three previous CRs placed in the oldest agricultural area. They have the historical water rights of the Cànyoles river and utilized the old canal systems as well as the dam of Montesa for irrigation purposes. The CR was unified in the beginning of the nineties in order to change from furrow irrigation systems to drip systems in 1993. For that, they constructed reservoirs and installed pumps as well as the required pipes for drip systems.
Therefore, the reasons why the first official drip irrigation project was getting started were the next three ones: The initiatives from the *Comunidad General de Regantes de Montesa* (CGRM), their relation with the Conseller of CAPA at that time and his support from administration, and the possibility that GV brought with the decree 47/1987 in subsidizing projects related with water savings. All these reasons made Montesa became the pilot area of drip irrigation systems in the Valencian Community.

Nowadays, farmers from Montesa are organized in the next CRs (Table 5).

TABLE 5: CRS IN MONTESA AND THEIR SURFACE

Comunidades de Regantes in Montesa	Surface (12 hanegadas=1ha)	Irrigation transformation
C General de Regantes de Montesa	920 ha	From traditional furrow irrigation to DIS
CR El Reixach	380 ha	From dry land to DIS
CR Santa Rita	220 ha	Dry land-No transformation
CR La Baseta Roja	25-33 ha	DIS
El Canari	-	DIS

Comunidad General de Regantes de Montesa was the first CR implementing drip technology. Nowadays, they have a combination of three farmers irrigating with surface irrigation and the rest using drip systems. All the members share both costs. The members with DIS also pay for the maintenance of the canals for furrow irrigation and the others also pay the maintenance of the drip systems. They have a total of 920 hectares.
There are two *motoristas,* as it is quite big CRs, who are responsible for the maintenance, possible failures (breakdowns) and reading of the water meters.
CR El Reixach is the other Comunidad de Regantes that transformed all the irrigated area into drip systems. They have 380 hectares and are about 240-242 members. The last ones entered when the plots were measured and valued for the cadastre for the construction of the

drip irrigation system. In general 90% of its surface is covered by monoculture of oranges and the rest of the crops are olive trees and other fruit trees.
Farmers take the water from a well of 140-170 metres depth which provides them with 10.000L/min using two pumps. The reason why they first were organized in CR was to ask for the permission of the construction of the well in the CHJ. They do not pay taxes for the well. Once the application was approved, they obtained the right to construct the well and use water. Consequently, the water user became the owner of the well. The owner of the land where the well is situated does not have any right to that water or the well neither, as the right to use water comes from the state. All the farmers are aware of the use of groundwater for irrigation. However, no one knows about the aquifer itself and how it is recharged.

The costs of the DIS installations were paid by the members of the CRs. Each one paid 55€/ha for ten years (5,5€/ha and year). Therefore, they asked for a loan and guarantee it with their own personal assets. The total loan, which was a common loan, reached 2,4 millions of euros.

“Water is the only thing that joined farmers together. We are not organized in cooperatives, or for selling products. However, to achieve water, people were sure from the beginning that we had to work collectively” (José Barberá, president of Comunidad de Regantes El Reixach).

The pump is at 180 metres underground, water level is at 140 metres and the pump has to impulse water until the reservoir which is 90 metres above (total of 270 metres pumping, see figure 8). They have two reservoirs of 7500 and 2500 m^3 for water storage that were built in the nineties with the irrigation system transformation. They did not level out the land for the irrigation system transformation.

4.1.1.-Farmers and CRs motives to implement DIS in Montesa

The reasons why farmers and Comunidades de Regantes from Montesa show their interest in transforming the traditional system was the water saving quality of the new system, which was supposed to be cheaper. In addition, it would solve the problems that surface irrigation caused like demanding less labour work and to avoid the cracking of the land. Those were the motivations that encouraged them to ask for the subsidy based on the Decree 47/1987.

4.1.2.-Information, communication, subsidies and training in Montesa

European Union wants to achieve farmers to be the environmental defender. However, any measure taken to preserve biodiversity or good practices in agriculture by farmers, are done because of the money. There is neither incentive nor consequent awareness of the environment conservation. In addition, in the village there are a total of only ten recognized farmers with social security system for agriculture activity, as the majority do their work in field as a part-time activity. The information goes from farmer to farmer as most of them are quite old and they do not use internet. Furthermore, it is difficult and slow to change when you are older. Farmers think that the information does not arrive from Europe.
Another way of being informed is via Labour Unions. Farmers general opinion in Montesa is that Labour Unions do not show that are independent as the farmer interests are not entirely recognized by some. Therefore, they think that Labour Unions would not be supposed to receive subsidies from the government. The CRs were members before but after experiencing to be part of it, they left as they saw that the set initial ideas were not supported.

Very recently, 2012, the Consejo Municipal Agrario of Montesa has been established in the municipality, with an informative aim, giving the chance to villagers to participate in agricultural issues (Barberà Ferrer, 2012). This is a council that has to be formed compulsorily, since 1995, by law in every municipality to control the rural areas, plagues, give crop statistics, to construct rural roads and to inform the farmers about interesting issues related to agriculture (Generalitat Valenciana, 1995b).

The main subsidy received for drip systems transformation, as mentioned before, is the support from GV which contributed with half of the project Plan of Water Use for Irrigation in the CGRM in 1995, based on the decree 47/1987.

Apart from that, farmers receive Single Payment from the CAP for agricultural purposes. One can think that maybe with other subsidies, the farmers will cover the investment on DIS. However, it is not the case with Single Payment subsidies. One example is that for olive trees a farmer gets a mean of 550€/year for one hectare, which is very little money taking into account that each farmer has usually less than 1 hectare.
Another example, this time regarding to crop transformation to mandarin trees is that a farmer paid 1600€ for 330 seedling plants (almost 5€/plant). With the subsidy that he got in proportion to his surface, he only covered the seedling plants at the most. However, he had to deal with the other costs like the transport or the planting and maintenance of the crops.

Subsidies played a meaningful role in drip irrigation transformation only in one CRs of Montesa, the CGRM, the first DIS installation. However, in the other cases the farmers invested with their own financial sources and needed to proof to the bank a guarantee that the loan was going to be returned "risking" their possessions (like lands, house etc.) to get a common loan together. Besides, those investments are not compensated with subsidies received for agriculture and crops.

There have been a lot of training courses subsidized by the CAPA region offices or extension agencies called *Oficina Comarcal de la Conselleria de Agricultura, Pesca y Alimentación* (OCAPA). In this region, the corresponding OCAPA is located in Xátiva (45km far from La Font de la Figuera and 20 from Montesa). In addition there were subsidies offered from EU and GV to learn how to use those new systems.
In general, farmers that attended the training programs consider that there has been enough training to know how to irrigate with drip systems and its mechanism. Farmers from the surrounding villages came to Montesa to learn and to be trained. One of the organizations that gave training courses about drip irrigation systems and irrigation modernization is Asociación Valenciana de Agricultores (AVA).

4.1.3.-Water sources in Montesa

The CGRM is the only CRs that has the historical rights to use river water for irrigation in Montesa. Previously, they used the weir located next to a mine near the river to irrigate by gravity. This weir was destroyed in the flooding of 1987 and they constructed a new one (figure 11). Before using drip systems, there were three Comunidades de Regantes using Cànyoles river water for irrigation, which were close to the river. Those are now the ones that constitute CGRM. Currently, after the transformation to drip systems, they still use water from the river. They take this water near Vallada where the new weir is located (highest point) and distribute it by different subterranean canals to the plots from different *partidas* (water intake). Moreover, they store it in one big reservoir (figure 8) fed by five

pumps that propel water from five wells coming from the subterranean canals that come from the river. The subterranean canals cross the valley (Annex V) irrigating the plots from both sides of the river. Pumps are working 8h/day at night during the week and 24h/day during the weekends.
The drip irrigation system in CGRM works by gravity, their highest point is the height of the weir, which is maintained by subterranean canals to cover as many plots as possible.

> How does irrigation by gravity work with drip irrigation systems?
> Farmers leave at least 2 kg of pressure from the water surface until the hydrants, which means that there is a maximum of 20 metres of possible head. After that, they have pressure regulators, but they base the infrastructures varying the pipe sizes. Therefore, depending on the height that the water intake is situated, it will have more or less pressure and depending on that, they have bigger diameter pipes for the ones having more pressure and smaller pipes for the ones having less pressure. Therefore, each plot is irrigated at different pressures, although they have a regulating valve as well as auto compensating drippers of at least 0.7 kg.

On the other CRs, farmers use groundwater to irrigate their lands. In the CR El Reixach they store groundwater in reservoirs. Currently, all the area works with drip systems, but they do not work with gravity as in CGRM. Instead, the water distribution from the reservoir is made controlling water with pressure regulators, so that the water arrives with the same pressure to each plot. There are also some other private wells and reservoirs from farmers in the surroundings of the village. Old wells that supplied with salty water can be found in disuse like Ferri (in Canari zone) and Muller.

The groundwater in Montesa has different characteristics. In the northern side it is freshwater, which indicates good quality, whereas in the southern side of the river water is salty (more gypsum concentration), which means worse quality although the quantity is higher than in the north. The water price in Montesa varies from 0,1 to 0,17€ per 1000L.

There is a sewage treatment plant in Montesa with a maximum allowed spilling of 195.091 m^3/year (CHJ, 2011). This spilling is delivered to Cànyoles river. There are no water reuse plans for the moment as the sewage treatment plant (STP) is situated quite in the low side of the village and a lot of pumped energy would be need.

As for water supply, it is known that there was an early system that provisioned the castle. As an indicator, high capacity cisterns are observed in the castle ruins. Water was collected by different underground tunnels, passages and galleries that were more than 150 metres long so that inhabitants that lived in the castle surroundings used the water for drinking. Most of the galleries are demolished or covered by soil due to the earthquake in 1756. However, one gallery is restored as 30 years ago an organized group of Montesa that wanted to restore the passages won the 2nd prize of the famous national lottery El Niño.
Currently, for the water supply in Montesa village groundwater is used. Water is taken from the well of the CRs El Reixach and before distributing it, water is treated with chlorine. Network of sanitary sewers were constructed in 1965.

4.1.4.-Consequences at field level and expansion due to DIS

Irrigation system transformation brought a series of consequences in field regarding different matters.

First of all, drip systems brought consequences concerning to the way of working of the CRs and farmers crops and yield production (table 6).

TABLE 6: CONSEQUENCES OF DIS IMLEMENTATION ON THE WAY OF WORKING IN MONTESA

Consequence in way of working	
Automatization	The irrigation installations are automatized with drip technology, which means less and different labour work is needed. However, it is curious how before with furrow irrigation systems farmers used to go once every 20 days to field to irrigate. Now with drip systems they have to go to the hydrants to irrigate at least every two days. This happens because it is not profitable to buy the technology to control all of it from a central computer program. The reason that lays behind this is the characteristic smallholding system of Valencia.
In demand system	The change from irrigation in turns (irrigating at night as well) to a system in demand. Farmers can irrigate whenever they want with drip systems. Moreover, irrigation activity is most important from June to October. Farmers irrigate every day about 2-4 hours with drip systems, depending on the soil of the plot. In furrow systems, they used to irrigate every 20 days for 12 hours.
Troubles among farmers	The *motoristas* think that surface irrigation causes more troubles than drip systems as it is easier to steal water and to block the canals. With drip is impossible as the pipes are underground and the system is automatized.
Motoristas work	*Motorista*'s work has changed, they need information about technologies and how pumps work, to control that the new system is working well.
Water savings	With drip the perception of farmers is that they spend less water, but it is important to use water adequately, using less than 3h/day. Water quantity for irrigation depends on the temperature, soil and other factors that vary in different plots, but a good use of water is fundamental. Training is necessary.
Irrigated land expansion	Nowadays there are about 2000 irrigated hectares (24.000 hanegadas) in Montesa and most of the pipes/canals are placed underground. The legislation and initiatives like the Operative Programs in Valencia clearly mention that the transformation to irrigation must be done in the existing irrigation areas, without expanding the irrigation surface (ERDF Operational Program Valencia, 2009, p.131). However, it seems inevitable to expand the area once the water sources and its quantity can permit it. In Montesa there has been expansion of the irrigated area, from dry agricultural lands to drip irrigated lands, due to drip irrigation system transformation. For the expansion, the authorization from CHJ is needed. In some areas, this expansion is clear as it has been made up the hills, where practicing agriculture is more difficult. Farmers constructed terraces in the highest parts to make agriculture possible. However, the terraces are made by soil without concrete nor stones, as these latter ones would have been too expensive. In addition, they took away the vegetation using herbicides in order to avoid the rabbit plagues. Therefore, as those are the steepest sides, farmers have erosion problems. The authorization needed to cultivate and irrigate in the steep areas is decided by the municipality and by the Conselleria in Valencia, as the land they exported to make the terraces came from public low mountains. Usually, the authorization is given easily except in the case of the areas considered *Paisaje Natural Municipal* (protected areas based on environmental, landscape values). Currently, there is enough water to cover all the land with the wells, as it is not a water scarce area.

Yield change	Farmers that transformed from dry lands to irrigated agriculture, noticed changes in yield. A real example is that a farmer owning 0,25 hectares with 30 olive trees in production obtained a yield of 700-900kg every two years (as one is needed for pruning). When the farmer installed drip irrigation system he got a maximum of 2400kg with a yearly production.
Monoculture	DIS brought farmers to monoculture, overall orange, which is a risk due to the possible yield loss of the whole area and also the diseases of the plants and biodiversity loss.
Fertigation	With DIS, there is possibility to fertigate from the hydrants by each farmer.

Secondly, introducing new technology in irrigation has brought new costs to maintain the infrastructures (Table 7).

TABLE 7: COST CONSEQUENCES DUE TO DIS IMPLEMENTATION IN MONTESA

Consequences: new costs	
Electricity costs-water costs	For some of the DIS, new pumps were installed and electricity charges rose. The problem is the high price of them. CRs have to pump at night because the prices are cheaper. The price in 2011 was 0,15€/kwh. However, in September 2011 it raised 17%. In the same way, water meters were installed to control water price per m^3. River water and groundwater used in surface irrigation was not paid, as water was for free at that time. However, due to European initiatives and drip technology consequences, now farmers have to pay for water as well.
Land property taxes	Land property taxes called *Impuesto sobre Bienes Inmuebles* (IBI) *Rústica*, are charged for any owned land in rural areas. This tax is based on the cadastre and each plot has a different value depending on the characteristics. For instance, if the plot is irrigated the cadastral value tends to be higher. However, the update of this value is usually done when the land is sold or modified and it is not a competence of the municipality. That is why usually the data that the CRs have does not coincide with the data gathered in the cadastre. The last update of the cadastre values in Montesa were made in 2001-2002.
Hydrants (figure 12)	Every farmer has to pay for the own-hydrant for DIS. In each hydrant there are pressure regulators and controlling devices. The *motorista* takes care of the irrigation installations until the common hydrant but each farmer takes care of its own-hydrant and its plots.
Maintenance costs	For maintenance work each member has to pay a fix quantity of 7€/year. Extraordinary expenses are charged for extra costs yearly when needed.

Finally, other consequences are found in relation with intermediaries and landscape.
The subsidies have changed in the CAP and the intermediaries take advantage of the farmers with the selling of the products with the fruit calliper/size. If the fruit size is big, it goes for fruit production and if it is small it goes for juice production, which is cheaper than the first option. What happens now is that if the fruit is too small the intermediary does not buy the fruit. Usually the intermediaries are the ones picking up the fruits from farmers plots, and they say that it is more expensive to pay someone to pick the fruits rather than the fruits themselves. Therefore this means more lost in agriculture for the farmer, even if they are the ones receiving the subsidy.
In addition, the intermediaries are the ones that set the price. For instances, there were some farmers in Montesa that sold big calliper peach to Madrid for 0,79€/kg. Now they found that

in Canals (village next to Montesa) they pay more than 2 euro for the same product that goes to a closer national market.
Regarding to the landscape, not much changes have been noticed after irrigation transformation. There have been no fires around and the vegetation is similar before and after the transformation to irrigation.

4.1.5.-Traditional irrigation infrastructures in Montesa

In Montesa, traditional surface system infrastructures exist, some of them are made of concrete and some others are earth canals (figure 10). At least three farmers in the village use the traditional furrow canals. The rest of the canals are abandoned or used to place drip pipes inside. Vegetation is growing next to them and lots are full of weed. However, the gates and the distribution lines can be observed showing their recent use. There are no initiatives to preserve the historical canals of Montesa from the culture department of the municipality. This could lead to a total loss of the traditional systems.

4.1.6.-Other issues

It is essential to be aware of three factors that affect irrigation in Valencia and to all the municipalities studied in the case. The first one is that agriculture is organized in smallholding systems. This means that farmers usually have very small agricultural land (less than half a hectare). This system has a lot of disadvantages in matters of facility in operation and income. In addition, some subsidies are denied to them due to the limited area. The second one is that agriculture is only a part time activity most of the times, which makes the activity not farmers main income. The last one is that farmers are quite old as young people are not attracted to agriculture. Farmers spend their free time working in the field and do not abandon the lands because they were from their family and have a high sentimental value.

In addition, it is important to know how products are sold in the area. In general, the stallholder or intermediary goes to the field, value the fruits and make an agreement of the price with the farmer. After, the intermediaries arrange the harvesting of the fruits. Harvesting workers are usually Spanish and immigrants from Bulgaria or Rumania. If the farmers sell the product later than in season the intermediaries pay less, they do not care about the risk the farmers are exposed to (like frost). The farmers do not store the production in this area. Once the fruits are harvested, the intermediaries sell them to national and international markets in Europe, China or USA.
In the last years new alternatives for selling the fruits in a more straight forward manner arose, trying to avoid the intermediaries and their costs. This is made via internet. An example in Montesa is a webpage called Naranjas Vila (http://www.naranjasvila.com). It is a particular case of a young man (25 years old) that was unemployed because of the economic crisis and decided to create a web-page to sell mandarins and oranges. The added value is that the service guarantees a distribution of the fruit from the harvesting phase to home in a maximum of 72 hours, assuring fresh fruit as well as avoiding the intermediaries.

FIGURE 8: CRS EL REIXACH RESERVOIR (LEFT) AND COMUNIDAD GENERAL DE REGANTES RESERVOIR (RIGHT), MONTESA

FIGURE 9: PEPE, ONE OF THE *MOTORISTAS* OF CGRM OPENING ONE *PARTIDA*, MONTESA

FIGURE 10: EARTH AND CONCRETE CANALS, MONTESA

FIGURE 11: NEW WEIR IN MONTESA CONSTRUCTED AFTER THE FLOODING OF 1987

FIGURE 12: AN HYDRANT TO DELIVER WATER TO FIVE FARMERS WITH DIFFERENT SURFACES, MONTESA

4.2.-VALLADA

As Montesa was the village where drip systems where installed first in Valencian Community, it is natural that close villages were influenced. Currently, in Vallada, three official Comunidades de Regantes are found (table 8). In most of the cases, farmers changed from dry lands (excepting the typical orchards area next to the river) to surface irrigated lands and finally to DIS. These canals that were dug in the soil are at least from the XIII century, which are still in use at times combined with drip systems.

The irrigated area was expanded from the 70's onwards in Vallada. All started with a well drilled in 1965 by the *Instituto Nacional de Reforma y Desarrollo Agrario, del Ministerio de Agricultura* (IRYDA). This institute searched for other purposes different to groundwater. Therefore, they found water unintentionally. This water was used to supply Vallada as well as to irrigate. The installations for furrow system like canals and reservoirs were constructed in 1969 from this well located in the Barranco de Boquella which separates Vallada from Moixent.

TABLE 8: CRS IN VALLADA AND THEIR SURFACE

Comunidades de Regantes in Vallada	Surface (ha)	Number of members in 2011	Water price	Irrigation transformation
CR Pozo Santa Bárbara	196 hectares	231	0,15€/m^3	From surface and dry land to DIS
CR Pozo Virgen de Gracia	380 hectares (south of Vallada, below the river until the old mountain)	450	0,09€/m^3	From surface to DIS
CR Pozo Cànyoles-1	380 hectares with drip and 25 hectares surface	268	0,12€/m^3	From surface and dry land to DIS

Nowadays, only the 6-7% of the total irrigated area in Vallada is done by surface system, the rest uses drip technology.

CR Pozo Virgen de Gracia started to use groundwater in the 70's from the Barranco de Boquella for irrigation purposes. They constructed a reservoir to supply agricultural lands.

The reservoir Virgen de Gracia is located in a place called Molino. From there, water was distributed to Huertas de Arriba (40-50 hectares) and Huertas de Abajo (30-40 hectares) (Upper orchard and Downer orchard, old names of the area). They distributed water with earth canals.
The transformation to drip irrigation in the area started about thirty years later in 2003 and was finished in 2005. The transformation came because they asked for permission in CAPA to open a new well, called Cànyoles-6, in order to have two wells and two reservoirs for the CRs and consequently use more water. For that, they received a subsidy. Once they had the authorization to use water from the new well for irrigation, farmers were obliged to irrigate with drip technology from CHJ (figure 16). In addition, the subsidy received to drill the well for irrigation purposes from CAPA also conditioned farmers to install the same technology.

For the new water rights, as consequence of the water coming from the new well Cànyoles-6, farmers had to pay a value of 4300€/hectare. The members that already had furrow irrigation did not pay, but only the new members. All of them paid general expenses of the construction work but always taking into account the difference of the initial investment of the old and new members.

In CRs Pozo Virgen de Gracia there are 2-3 farmers that still irrigate with furrow systems (figure 15), but it is a matter of time as last signatures and procedures are needed for DIS transformation. From a total of 400 hectares, only 25 do not use drip and they only pay general expenses.

Santa Barbara well supplies with water to Vallada village, to the traditional surface irrigation canals (from 1969 on) and currently to drip systems. Surface irrigation was working until 1996, when the system changed to drip technology. This transformation was undertaken by the farmers without any subsidy. Investments in 1996 reached 1800€/ha as well as other costs. Nowadays, a landowner must pay 7300€/ha to obtain the right to irrigate. The depth of Santa Bárbara well is 74m.

Cànyoles-1 well was drilled in 1977 and in 1979 farmers started to organize and meet in order to arrange furrow irrigation constructions. They started with surface irrigation in 100 hectares and currently, there are around 190 hectares irrigated from the same well.
The furrow irrigation investments were up to 6130€/ha. Afterwards, in 2000 the members decided to install drip systems which cost 12.000€/ha. For this last instalment, CRs Cànyoles-1 received a subsidy of 40% from CAPA. There are two wells providing water to Cànyoles-1 called Solareta with 122m depth and El Tollo with 148m depth.

4.2.1-Farmers and CRs motives to implement DIS in Vallada

The secretary of Virgen de Gracia well says that drip technology is an initiative that comes from farmers, as irrigating is totally voluntary. However, the motives seem to be imposed from CHJ to get the water authorization and from CAPA to get the subsidy, as the condition was to implement drip systems if they wanted to open a new well and achieve more rights for groundwater use in 2003.

CR Pozo Santa Barbara (DIS transformation in 1996), was the first transforming the irrigation system in Vallada. This was due to the influence of the close village Montesa and can be considered an imitation experience.

CR Pozo Cànyoles-1 (DIS transformation in 2000) has a close relationship with Pozo Santa Barbara, consequently, they could see the development of DIS. In addition, they were incentivized by a 40% of subsidy for drip system installation.

4.2.2.-Information, communication subsidies and training in Vallada

According to farmers, information from EU does not arrive. They do not have the Consejo Municipal Agrario that could help people to be informed about problems and possible solutions regarding to agriculture. As mentioned before, the Consejo Municipal Agrario must have existed from 1995 on. It is the Majors fault (PP, Popular Party) as it is its competence. Currently, PSOE is leading the municipality and in its program they say they will form the Consejo, but they did not do it yet. The last asphalted roads in Vallada were the ones that reach to the major and the counsellor plots. Farmers are aware that it is always about people (the Counsellor was at that time president of Valencian Council or *Diputación*).

Both Santa Bárbara and Cànyoles wells are associated to AVA, which is why they are well informed, because of the magazine of the association that is send home by post. Most of the members of the CR are also members of AVA.

Regarding to subsidies as mentioned previously, CR Pozo Virgen de Gracia received a subsidy for the modernization of irrigation system in 2003 from the CAPA. From the total of 2.800.000€, 750.000€ were subsidized (about 25%). The modernization was linked to the permission to open a new well (Cànyoles-6), as the irrigation water had to be delivered only with drip systems. In Santa Barbara no subsidies to foster drip irrigation were received. Farmers dealt with all the costs in 1996. In Cànyoles-1, they received a subsidy of the 40% of total investment from CAPA. The total installation cost 1.9 million of Euros. However, getting the subsidy was very costly and difficult. They applied for it four times, as apparently the first three times the papers did not arrive. There were also other priorities for the budget of the Conselleria at that moment.

Apart from the subsidies related to drip irrigation implementation, the subsidies for agriculture coming from European funding were and are currently offered. Nevertheless, the latter ones are not interesting as the smallholding system of Valencia is an impediment to obtain them. In addition, Single Payments are given to farmers with more than 0.5 ha. Farmers from Vallada know about other subsidies related to terraces. However, due to some problems, they could not get them.

Pertaining to training for drip systems technology, farmers and CRs learned from organized courses in Montesa as they are the ones that know most about drip irrigation.

4.2.3.-Water sources in Vallada

Cànyoles river (figure 13) is dry in summers, therefore it is not possible to use it for irrigation as it is the period in which more water is required. There were two previous CRs that used river water before called Pare Presentat and San Juan, covering a total of 100 hectares divided in 7 *partidas* (table 9 and figure 9).

TABLE 9: OLDEST COMUNIDADES DE REGANTES USING CÀNYOLES WATER IN VALLADA AND ITS PARTIDAS.

Traditional Comunidades de Regantes using Cànyoles water in Vallada	*Partidas*
Pare Presentat	Las Vegas de Policena Vegas Viejas El Juncar El Pla
San Juan	Subirana Huertas Arriba Huertas Abajo

In the old area they used to produce fruit trees and oranges. However, they had a small well with groundwater supply for the summer water demand. Now the majority of those *partidas* have been transformed into drip systems and had joined to other CRs.

Groundwater is the main used water source in Vallada, both for village supply and for irrigation. This is the reason why every CR has the noun "well" (*pozo* in Spanish) in their name. The water source for irrigation has always been the same. Both for surface and for drip systems groundwater has been used since 1970. Farmers ignore how the aquifer is recharged. However, they know that they have high discharges. For example, in CRs *Pozo Virgen de Gracia* there are two wells that bring 8000L/min and 4500L/min.

There is a sewage treatment plant in Vallada as well. The maximum allowed spilling by the CHJ is 339.343m^3/year (CHJ, 2011). The spilling is delivered to Cànyoles river from the canal called *Vegas Nuevas* that flows into Cànyoles river. Water reuse from this plant does not occur, as no application for reuse has arrived to the CHJ, which means there is no authorization.

4.2.4.-Consequences at field level and expansion due to DIS

The observed consequences at field level are the following ones (table 10).

TABLE 10: DIS IMPLEMENTATION CONSEQUENCES AT FIELD LEVEL IN VALLADA

Consequences	
Water savings and efficiency	Farmers think that DIS make them save 20-25% of water consumption comparing to surface irrigation systems. According to their perception, plants produce more, less fertilizer is needed, water infiltrates better in the roots and they take water more easily. Plants cultivated currently have a maximum root of 60cm depth in comparison with the roots that were 5 metres long when DIS were not implemented. Therefore, the water that reaches more than those 60cm is "lost" according to farmer's beliefs. With drip, the leaves of the plant are always terse which does not happen with furrow irrigation, as they irrigate once every 15 days. In addition, as farmer's main income is not agriculture, they are not so much concerned about it. Farmers farm to enjoy, to relax and to sell oranges in a less extent. However, they cultivate to get some benefit.
Irrigated land expansion (Annex VI)	In CR Virgen de Gracia they achieved the permission for the new well. Therefore, the irrigation surface was expanded as there was more water. Authorization was given by CHJ for that water use for irrigation. Cànyoles-1 well used to irrigate 100 hectares during the 80's and nowadays it irrigates 190 hectares, which means that an expansion of the irrigated area is observed. Not all farmers feel comfortable when talking about expanded irrigation lands, but it can be inferred that it happened as although they did not mention it directly they gave the prices for new water rights. This means that there have been more water rights distributed than the ones given the first time with surface irrigation. Therefore, it is assumed that there is more water used for agriculture than before.
Fruit quality and yield	Regarding to the fruits, farmers note a better quality, not in quantity so much as it depends on the flower, bees, rain and fruit set. With drip, plants are supposed to produce more. However, the impression of farmers is that it is debatable. One example of the production increase is that there is one farmer that uses furrow irrigation and irrigates every 12 days (even though normally it is done every 15-20days) produces more than what another farmer produces with drip system irrigating almost every day 2-3 hours with the same crop.
In demand system	Automation goes hand by hand with the in-demand system that replaced the previous in turns system of furrow irrigation. The frequency and irrigated quantity changed (more frequent and less quantity) and so the manner of irrigation for farmers and for plants.
Automation	The automation is another change mentioned in Vallada that conditioned the way of working of farmers in field as well as the *motoristas* work. With DIS implementation, the *motorista* of the CRs is in charge of reading the meters, making reparations and checking if the reservoirs are full of water.
Electricity costs	The major problem farmers find when using DIS is clearly to cope with electricity costs. Electricity charges are too high and those costs are

	drowning them.

Another opinion that farmers from Vallada share with the ones of Montesa, is that the organizations and intermediaries that buy their fruits to sell them to national market or export abuse from them.

4.2.5.-Traditional irrigation infrastructures in Vallada

In Vallada, a little amount of earth canals are still in use. Those are well maintained in order to provide a good irrigation service. However, there is no cultural heritage of water and the majority of earth canals are in disuse and not maintained (figures 14&15).
There is also a weir in the highest point of Vallada but it is not possible to see it due to the bramble patches.

4.2.6.-Other issues

In Vallada, abandoned lands are found. Those lands were not only dry agricultural lands but also irrigated lands. Particularly in the east part of Vallada where the river is quite covered with vegetation and weed and the area where the typical orchards were situated are abandoned. Reaching the orchard plots in the other side of the river is impossible due to vegetation.
The reason why abandoned plots exist is that agriculture is becoming less profitable. The prices of the fuel and insecticide have increased in the last years. Furthermore, in Vallada as well as in Montesa, there is a plague of rabbits (figure 15). Their warrens or holes can be seen next to the fruit tree plots as well as the footprints of wild boars. Besides, the issue of the absence of young farmers affects as they do not seem to show any interest for agriculture, maybe because this activity does not give any benefit security. The smallholding system is also a disadvantage for new farmers. Most of the farmers have less than 0,8 hectares, although there is an exception of one that has 30 hectares, which is the maximum surface owned by the same person. In CRs Pozo Virgen de Gracia there are three farmers with large plots that are part of a bigger organization called MAMUSA S.L. However, the mean surface (without the 3 big farmers) for each members is of 0,7 hectares. The alternatives for young people that inherit lands are to sell them or to abandon them. Nevertheless, there are cases where because of sentimental value lands are not sold and young ones take care of them, which takes up a lot of their time apart from their job.

FIGURE 13: CÀNYOLES RIVER WITH DISCHARGE, VALLADA

FIGURE 14: OLD IRRIGATION CANALS IN DISUSE, VALLADA

FIGURE 15: SURFACE IRRIGATION AND RABBIT TRAILS IN FIELD, VALLADA

FIGURE 16: KAKHIS, OLIVE TREES AND ORANGE TREES WITH DRIP IRRIGATION SYSTEMS, VALLADA

4.3.-MOIXENT

As the research goes upstream, it is observed how the agricultural lands with surface irrigation or dry lands appear, although always drip systems are predominant. In Moixent, it is very clear where the typical orchards were situated. This is the only village of the study area where wastewater reuse is applied for irrigation. This activity is practiced near the village, both with drip and surface systems, but there are also dry cultivated lands while going up the hills, as it would be too costly to bring water so high. Finally, the highest mountain areas in the northern and southern part (Sierra de Enguera and Sierra Grossa) are not cultivated. There are some CRs or other organizations that use water for irrigation in Moixent (table 11).

CR la Rinconada Vieja, also called *Huertas Viejas* (Old orchard) is responsible of the oldest irrigated area of the village, which used Cànyoles river water and water coming from the spring El Bosquet (figure 17). Currently, it covers 25 hectares.

Some authors have found similarities in the extension of the irrigated fields in different study areas. These areas, covering a total of 24 hectares, coincide with the location of historic orchards surrounding the remains of Islamic *alquerías* and are linked to the exploitation of some identified *qanats*[7]. In these areas, located in Andalusia or Alicante, it is possible that Muslims could have designed reservoirs with a fix capacity to irrigate 24 hectares of land (Trillo San José, 2002; Asins Velis, 2009). Orchards of *Huertas Viejas* in Moixent have near the same extension: 25 hectares. This could match with the mentioned theory if the last hectare is considered an expansion due to the past years.

TABLE 11: CRS IN MOIXENT AND THEIR SURFACE

Comunidad de Regantes	Surface	Number of members in 2011	Water price	Irrigation transformation
CR Huertas Viejas/ CR La Rinconada Vieja[8]	25 ha	-	120€/ha (here the price is dependent on the surface)	No. Surface irrigation
CR La Rinconada Nueva/ CR Huertas Nuevas	17 ha	87-88	Free (wastewater reuse)	No. Surface irrigation (only the president uses DIS in 2,5 ha)
CR Pozo de la Solana (including partidas of La Solana and the shady area of Bellús and Vadillo)	227 ha	347 (from which 280 have less than 1,5 hectares)	It raised from 0,15€/m^3 to 0,20€/m^3	From surface to DIS

CRs La Rinconada Nueva can be considered as the second oldest irrigation area of Moixent. It is close to Rinconada Vieja and current irrigation is made with treated wastewater by

[7] *Qanats* are water management systems, similar to galleries, used in arid or semi-arid climate areas that deliver water for irrigation and for human settlements.

[8] Huertas Viejas is the traditional orchard area, as it is located in a lower part of Moixent village. Huertas Nuevas are located lower than Huertas Viejas and in the village they also call *El Regadiu* to the two areas together.

canals and surface irrigation (figures 18&20). There is one exception, the president of the CRs irrigates with DIS his fields. The president, Antonio Sanegre, is a young farmer (one of the few ones) and lives from agriculture. He owns 2,5 ha in Moixent as well as other lands in La Font de la Figuera, irrigated with DIS and also leases other farmers lands. He is autonomous with agriculture social security.

As Rinconada Nueva has a majority of farmers using surface systems and canals, there are physical measures to avoid stealing between farmers. Antonio takes the water from the same reservoir, but he has his own hydrant (figure 21) for drip irrigation system. In general, there are no troubles for water. There are no troubles with the next village downstream, Vallada, probably because there are no droughts in the area.

The CR Pozo de la Solana was created in 1979 when the well with the same name was drilled. This CRs has been special due to their internal organizational and decision troubles, which were translated into a slow organizational progress. However, it must be mentioned, that it was the initiative of a group of farmers from Moixent to form an organization (Sociedad Agraria de Transformacion or SAT) and to drill a well in order to achieve water for their fields.

Before 1979, the areas of Rinconada Vieja and Nueva (El Regadiu) were the only ones with irrigation (about 42 hectares) and the rest of the agricultural lands were placed in dry lands. In 1980 there were already 316 interested farmers in implementing gravity surface irrigation in 200 has. The well was paid by the farmers in relation with the hectares each one possessed (50€/ha). Nevertheless, there were problems as not all farmers could afford the costs. Finally, only 130 members participate in a total of 50 has, paying 2000€/ha (for the whole furrow irrigation system 400.000-500.000 of Euros).
An engineer calculated that the well had a capacity to irrigate 220 has, but the interested farmers had only 50 ha in total. Therefore, the president decided to give double rights of water related to the land to each farmer, giving water rights for 14 hectares to the farmers that owned 7 hectares. As the well is 408 meters depth and water level is at 192 meters from the surface, the pump has to impulse almost 300 metres because the reservoir is located at 100 meters.

This CRs is slightly different to the other ones as it works by votes in proportion to the owned irrigated land. Farmers that own 1,5 has or less have 1 vote, farmers owning from 1,5 to 4 has have 2 votes and farmers that have more than 4 has have 3 votes (there are only 3 persons achieving the last condition in CR Pozo de la Solana)

There was a chance to sell water right titles to irrigate until 2007, as farmers owned more rights than land. However, in that year the organization became a CR officially due to CHJ requisites and the selling of rights was forbidden (in CRs is not allowed to sell water rights). Therefore, currently, some of the farmers still have more water rights, as some thought it was a good idea to save them for their son/daughters, but the rights are not in use

The usual price of water is of 0,15€/m^3, but currently it rose to 0,2€/m^3. If a member uses more than what it corresponds to him/her, the consequence is to pay three times the price, which is 0,6€/m^3. This measure, the fine system, and other internal regulations are agreed in the General or Extraordinary Assemblies of the CRs. If members do not use water, a minimum amount has to be paid anyway, which is 6€/year per member. The payments for water costs are done three times per year and everyone has to pay. The payment of the meters is per member and the general expenses are also paid in proportion to the votes/owned surface.

It is important that the landowner has the right to water, as before this was set, some families cheated saying that the lands were from the respective wife or husband and used only one membership of the CRs. Some others had less water right than land and used more water than the corresponding one. However, this was solved when the president set the fine of paying triple.

The relationship between the members is in general good. Although the president of the CRs has a kind of police role they all get on very well, even when there are fines for water overuse. Usually, farmers pay their receipts as if not, the water delivery is interrupted. The president thinks that the most important thing is to have a good water manager leading a CRs that has knowledge in finances.

Antonio, the president of CRs La Rinconada Nueva thinks that from the Pozo de la Solana they could irrigate much more than what they do. He thinks they could reach the other side of the river, as the aquifer has enough water. However, as the majority of people do not live from agriculture they do not exploit it. In addition, in the beginning they should have put a pump with more power and adequate canals and pipes.

4.3.1.-Farmers and CRs motives to implement DIS in Moixent

According to the president of Rinconada Nueva, DIS are the most interesting alternative for irrigation nowadays. Firstly, because it saves a lot of time that the farmer can spend working in other fields (pruning, tilling etc.) and secondly, because fertigation is possible, which means less labour for the farmer.
For CR Pozo de la Solana, it was the only way to receive water concession from the CHJ.

4.3.2.-Information, communication, subsidies and training in Moixent

According to municipal administrative workers, farmers get information regarding to agriculture and related issues from OCAPA in Xativa. OCAPA sends letters informing farmers with subsidies, suggestions of combating plagues or arranging informative meetings. Some farmer's opinion is that the basic informative work of OCAPA is satisfactory. However, other farmers think that the information arrives very slowly from public administration and even more if the person wants to be informed about current initiatives. Although the OCAPA is in Xativa, usually it is easier to drive to Valencia to obtain the information or applications faster. Valencia is at about one hour by car and they have costs in fuel and time. Moreover, the *Cámaras Agrarias*, which were the ones in charge of the consult work for agriculture and livestock before, disappeared with the national law 18/2005 and had to be replaced with the mentioned *Consejos Municipales Agrarios*. The latter one, as in Vallada, has not been established yet in Moixent.

Regarding to the subsidies, farmers from el Pozo de la Solana did not receive any to directly cover the construction of the infrastructures of drip irrigation. The only subsidy was related to power lines and it was very costly to get them as the papers seem to be lost in Valencia. From the total investment, 30% was returned to them because of the power lines.

Antonio, the young farmer and the president of La Rinconada Nueva, got individual subsidy for his infrastructure. He is the only interested one in DIS in the CRs, as the other members are quite old to change their mentality and prefer to continue irrigating with surface irrigation. He received two subsidies, one for young farmers and another for irrigation modernization. The conditions for receiving young farmer subsidies are the age, to start a new agricultural activity (demonstrating that the person is a landowner) and to take at least 250 hours of training. Antonio did 500 hours of training and courses. He had its own initiative to be trained and to modernize the irrigation system as it is vocational. The courses were received in Montesa, and now he became a specialist in horticulture and fruit trees production. He proposed to the CAPA to install DIS. CAPA accepted and paid the 100% of the technical study and 40% of the installation costs until the hydrant in 1999. Antonio is very informed about subsidies because he is interested and finds the way to reach them. He thinks that Brussels (that is how he refers to EU) does not take farmers in consideration and that associations like AVA do not fight for farmers neither. Besides, they have the pressure from the intermediaries.

In addition, bank loans are given according to the CAPA in order to invest in agriculture modernization. The loans are with 0% of interests and they can be paid back in 5 or 10 years. The CHJ offers some subsidies and technical studies for irrigation reservoirs that are strategically located in order to use them if a fire starts in the surroundings. However, these subsidies were not received in the area. Finally, the subsidies offered for agriculture are for farmers with a minimum number of hectares. Farmers say that the financial crisis is also affecting to the subsidies and that they receive less money than in previous years.

Regarding to the training of DIS, farmers know that Montesa is the "number one" of the area. In consequence, the courses that most farmers took were held in Montesa.

4.3.3.-Water sources in Moixent

From the three studied CRs, it is appreciated that farmers use different water sources for irrigation. Rinconada Vieja, uses water coming from village fountains and from El Bosquet spring. CR Pozo de la Solana uses groundwater resources for water supply. Farmers already used groundwater for surface irrigation and currently, they use the same resource for DIS. Rinconada Nueva depended from water of Cànyoles in Regolf (where the weir is situated nowadays) until the expansion of irrigation was done in 1950.

It is curious how Moixent started to irrigate with treated wastewater. Antonio's grandfather was the president of the Pozo San Juan del Bosquet sixty years ago, the well which currently is used to supply Moixent with water. In the 50's, his grandfather made a deal with the municipality. They accorded that well San Juan would give them water to supply Moixent in exchange of the wastewater for irrigation. Therefore, the municipality constructed a treatment plant to provide farmers with treated wastewater. Currently, there is a new treatment plant, but the deal is still valid. Rinconada Nueva owns a reservoir with a storage capacity of 3000-4000m^3 where water from the treatment plant arrives, as well as the water surplus of Rinconada Vieja. The difference with other reservoirs is that the water surface is green (figure 19), which is caused because of the left nitrogen coming from the treated wastewater. The water surplus is delivered to Cànyoles river. For the wastewater, a tertiary treatment is applied in order to achieve the standard water quality to irrigate. There is an enterprise in charge of it called Empresa General Valenciana de Agua S.A. (EGEVASA) so that water is ready to use when it arrives to the CRs. The STP is situated in the area of La Rinconada Vieja. To reach Rinconada Nueva, the water has to cross the river by gravity. As the source is reused water, the farmers of this CR do not have to pay for it and they only pay for the maintenance of the canals which is almost 7€/member per year. The electricity is not a problem for them. The only one who uses a pump is Antonio, the president, for his DIS

system and as he uses fuel the costs are approximately 1500€/year depending on the price of the petrol.
Farmers think that what they pay in the other villages is too much and they value the deal with the municipality. Even during the summer they do not have water problems as the village is supplied all year long.

CHJ authorizes a maximum volume of 125.513m^3/year from a total spilling of 307.330m^3/year for citrus and fruit trees irrigation purpose in Rinconada Nueva (CHJ, 2011). The surplus is delivered to the Cànyoles river. Farmers can decide when to use the allowed water, for instance, more discharge during the summer and less during autumn.
From El Bosquet spring, some of the high plots are allocated with water and irrigated with DIS. There are also illegal wells.

4.3.4.-Consequences at field level and expansion due to DIS

Several consequences are found regarding to irrigation transformation in Moixent (table 12).

TABLE 12: DIS IMPLEMENTATION CONSEQUENCES AT FIELD LEVEL IN MOIXENT

Consequences	
In demand system	DIS brings an in-demand system. Even with limited use per hectare in Pozo de la Solana, farmers can use their corresponding water at any hour.
Electricity costs and automation	The electricity costs are again the biggest problem for the CRs. The prices have been tripled (raised from 700-900€/month to 2000-2700€/month). They thought about installing a regenerative heat exchanger but the investment is too expensive for them. The measure they take, like in other villages, is to pump at night from 0.00 to 8.00 a.m., which is fine as the system is automatized and no one needs to go to switch on and off the pump every night.
Water savings	Comparing to surface irrigation systems, farmer's perception is that they "loose" less water in the soil, as it directly goes to the plants. However, farmers are not able to give more evidence than that.
Yield change	Currently, with drip irrigation farmers notice a production change. For instance, one farmer that owned a plot of 49 olive trees used to have 55-65kg/ha once every two years (due to pruning). With DIS the farmer gets 90-120kg/ha in the same plot.
Expansion	According to farmers and CRs, there has not been any irrigated land expansion. Their argument is that the used area is delimitated and it is not possible to expand it anymore. In the case of Pozo de la Solana with 227 ha, the calculations for water exploitation from the well were done once, for surface irrigation. When they changed to DIS, they did not change the pump, nor the pumped discharge and each farmer has a limited water use. The CR imposed a fine of 500€ to a member, not for water overuse, but for using his water in lands that were not registered as irrigated. From that day on, and as being a CRs does not permit to expand lands by law (if there is no direct concession from CHJ), all the lands are registered and controlled by the CR itself. In the areas that are covered by Pozo de la Solana (La Solana, Bellús, Pla and Vadillo) no more members are admitted since 2000. In the case of la Rinconada Nueva, the expansion would have been too expensive as the members are irrigating with surface irrigation. Therefore, in the case of having expanded, it would have been for other

	reasons different to DIS implementation.
Fertigation	Drip irrigation permits doing fertigation directly which is very handy.

In Rinconada Nueva not many things changed, as the only person that transformed his irrigation system was the president of the CRs. However, some differences can be appreciated due to the coexistence of both types of irrigation systems. For instance, previously there was one person called *el regador* that was in charge of irrigating the 17 ha of La Rinconada Nueva. Nowadays, the *regador* does not exist and the members are the ones that open and close the gates to irrigate. Farmers do not have turns any more. If farmer A wants to irrigate and sees that farmer B is using the water, farmer A makes a telephone call in order that farmer B can redirect the water to farmer A's plots once he/she has finished irrigating. The members irrigating with furrow systems do not pay for water but only 20€/year and member for canal maintenance. However, in a couple of summers there has been water lack due to the higher water needs in that period.
In particular for Antonio, the way of irrigation has changed. With the drip system he needs to irrigate more often and less quantity. For example, when it does not rain, Antonio irrigates with drip 3h/day, but if it rains 1h/day is enough. The irrigation time goes decreasing from month to month from summer onwards. He stops in November and does not irrigate until February again, when he starts fertilizing. He also has to pay extra costs for petrol charges for the pump work.

To mention a disadvantage of DIS is the high initial investment costs, which farmers do not know if make DIS profitable or not yet. It is very difficult to pay off the initial costs, even when a subsidy is received. There are only 3-4 members with much more surface comparing to the usual members. If farmers use less water it is not in order to save water but to save money.

4.3.5.-Traditional irrigation infrastructures in Moixent

In Moixent, there are some traditional irrigation infrastructures. There was a weir situated at village level (in the area called Mineta del Retor) so that the traditional irrigated orchards were the ones below this point. However, in July and August there was no water and lots of mosquitoes were piled up in the weir area annoying to the villagers. That is why the municipality decided to change the weir of place, constructing a new one (figure 22) before the river arrives to the village and destroying the old one.

There is no water cultural heritage or initiatives to preserve antique irrigation infrastructures in Moixent. The old canals are covered and cemented. In the beginning of the XIX century, in some canals they added concrete to reinforce the old canals, changing the old constructions. Therefore, the value has changed now. There is an abandoned old groundwater canal that Rinconada Nueva used as well. However, there is one infrastructure called La Acequia Mora (figure 23), the Muslims Canal in English, which seems one of the oldest one of the area. It is a canal in disuse that comes from El Bosquet. Previously, the canal was directly connected with the spring of el Bosquet and arrived to the typical orchards placed in the current Rinconada Nueva. Not all the canal infrastructure is maintained. However, one can certainly appreciate how the canal continues at the same level from the reservoir until it arrives to the village. There is a small aqueduct and a tower as well (Torre dels Coloms).

The reason why this is not preserved is that Moixent is not an agricultural village but an industrial one. Therefore, the water heritage is not conserved or at least is not the first priority. There are few farmers that think that the municipality should take care of the old irrigation infrastructures in Moixent. For instance, the infrastructure could be preserved in memory of the Arabs, which started irrigating in the area.

FIGURE 17:EL BOSQUET RESERVOIR, MOIXENT

FIGURE 18: DISTRIBUTION POINT OF CRS LA RINCONADA NUEVA, ARRIVAL OF TREATED WASTEWATER, MOIXENT

FIGURE 19: LA RINCONADA NUEVA RESERVOIR, FOR WASTEWATER REUSE. MOIXENT

FIGURE 20: SURFACE IRRIGATION CANALS AND FURROWS IN LA RINCONADA NUEVA, MOIXENT

FIGURE 21: ANTONIO'S HYDRANT AND HIS PLOTS WITH DIS, RINCONADA NUEVA, MOIXENT

FIGURE 22: NEW WEIR IN MOIXENT

FIGURE 23: PARTS OF THE ISLAMIC IRRIGATION INFRASTRUCTURE CANAL “LA ACEQUIA MORA” IN MOIXENT

4.4.-LA FONT DE LA FIGUERA

This village is different to the other three. It is in the bound of the province and it has distinct characteristics like soil or climate. It is the point where the Cànyoles valley starts.

There are various areas within La Font de la Figuera where fields are irrigated. The biggest agricultural area is located in the lower part of the village. Those plots are the first and highest fields of Cànyoles valley and it is the place where orchards are situated (figure 24). They are found below the road (Cascallars) and are irrigated until the boundary of Moixent. Some cultivated crops are broad beans, artichokes or eggplants. To irrigate, there are two connected reservoirs which are filled with water coming from El Capurutxo spring by gravity. When one reservoir is full, the water starts to go to the second reservoir (figure 27). Before reaching the reservoirs, part of the water arrives to the *lavadero* (typical washing place, figure 26). The first reservoir is located beneath the football and tennis pitches of the village and is about 2,5 meters deep. The second reservoir is beneath the municipal swimming pool bar. The reservoirs can be seen as they have ventilation for air circulation. If both reservoirs are full, water goes to a drain. The water from the reservoirs is used by farmers from the Cooperativa La Viña and the CR del Abovalar. Water arrives to the lower plots after flowing from the second reservoir and crossing the road underground.

In the upper side of la Font de la Figuera, which is not in Cànyoles valley but still in the area of La Font de la Figuera, there is another area called La Foya, which is a smaller irrigated area. It is an humid area. This is observed in the soil type and surroundings. In addition, water from close mountains is accumulated in La Foya plane. Farmers mainly cultivate vineyards (figure 28) in dry lands and with irrigation. As the area is wet is wealthy for agriculture.

There is another area behind La Foya, which is called El Caicó. Here, the main production are vineyards, olive trees, almonds and in a lesser extent apricots. El Caicó is formed by plots with and without irrigation, depending on the land rights. The lack of citrus and orange trees shows the differences of altitude and climatology between this area and the rest of the Cànyoles valley. The soil is limy, what supposes that there is more water as the lithology changes. Some of the *barrancos* are cultivated with terraces for two purposes: to take advantage of the humidity of the *barranco* and to retain the water in the *barrancos* with the crops.

From Capurutxo mountain the reservoir of La Foya and another big reservoir can be observed. This latter one is shared with the farmers of Villena and it is called San Diego reservoir. There is one last reservoir called Pigirri reservoir. It belongs to the municipality but there is one man that has the historical right to use the water coming from there. The right is very old and he does not have to pay for it, as when the right was given, he did not have to pay neither. The man, which is a farmer, has olive trees in irrigation. This can be noticed as he gets more olive quantity and his olives are bigger in size than the ones cultivated without irrigation.

As the research is focused in Cànyoles valley, only the lower part of La Font de la Figuera is studied. The present CRs is only one. Nevertheless, there is Sociedad Cooperativa which works mainly with vineyards, although for water concession issues both organizations cooperate (table 13). In La Font de la Figuera, there are less traditional infrastructures as Cànyoles river has not water at this point and it is usually dry or carries very little discharge.

TABLE 13: CRS IN LA FONT DE LA FIGUERA AND THEIR SURFACE

Comunidad de Regantes	Surface	Number of members in 2011	Water price	Irrigation transformation
CRs El Abovalar	100 irrigated ha	273	0,3€/m^3 (including maintenance costs)	From surface to DIS
Sociedad Cooperativa La Viña	165 irrigated ha	More than 1000	0,15€/m^3	From surface to DIS

CR El Abovalar cultivates in dry and irrigated lands. Apart from agriculture, they also have a very small area to keep the livestock (only ovine). From the total area, 100 ha consist of the irrigated area, in which irrigation is present for more than 60 years. Farmers always have irrigated from the same well, which is 30 meters deep. The crops are mainly orchards with vegetables, lots of corn and fruit trees. First, they irrigated with surface irrigation, but currently they changed to DIS. They received a subsidy of 30% to cover the costs of the irrigation system modernization. The current situation is that although they have the rights and they have been using water for 100 ha for some years, the water level from the well had decreased. To face this situation, farmers from CRs El Abovalar have to buy the water to the Sociedad Cooperativa la Viña (Ajuntament de La Font de la Figuera, 2011). In the Water Sources section, it will be explained how a project is set to achieve wastewater reuse for irrigation in the whole low agricultural area.

A clear characteristic in this CR is that farmers cultivate using herbicides, without any grass or weed. Their parents and grandparents farmers used to do agriculture always taking away the grass and tilling, in order to use at maximum the rain water, as they thought that if weeds appear in the fields, they would “steal” the water and fertilizers to the crops. From older farmers they believe that if they till everything the trees will produce for a longer time, they will give more kg of yield and that they will sell the products more expensive. Another extra reason to “clean” the fields is to use less water, in order to pay less for it.

The Sociedad Cooperativa La Viña is an organization that groups farmers that produces overall vineyards, which are located in the same area than CR El Abovalar.

Traditionally, vineyards were not irrigated. However, there was surface irrigation before implementing DIS during the 90s in the Sociedad Cooperativa to complement to rain water. The initial investment for DIS was about 1000€/ha, in 165 hectares without receiving any subsidy. Farmers take the water from a well. The Cooperative has an Irrigation Section that is responsible for irrigation related issues. From there, the technician tries to foster DIS as he is convinced that vineyards will achieve a higher yield and a better wine will be produced. They do not have a paid *motorista* like in other CRs. There is one farmer that does *motoristas* work voluntarily. Other farmers are in charge of reading the meters as well.

The maximum and minimum costs vary from farmer to farmer depending on the water volume used. For instance, last year's maximum water cost was 3100m^3/ha year with Merlot variety vineyards and the minimum one 6m^3/ha and year. It is important to notice that some farmers cultivate vineyards for their consumption and some others for the cooperative.
From the Irrigation Sector they defend to unify all the irrigation systems in La Font de la Figuera, which they are planning to accomplish as soon as the wastewater reuse project is finished. Farmers in general believe that it is a rich water area, but not enough wells have been drilled to ensure it.

Apart from the water shortage problem that farmers have to deal with in La Font de la Figuera, it is wise to keep in mind other factors like the smallholding system. In the lower fields, there are only 2-4 members that own 2 hectares, the maximum surface owned by the same farmer. The rest usually has 0,1 hectare.
In addition, farmers think that it is a difficult time for agriculture, as they depend in lots of uncontrollable issues like fruit size, diseases, prices, climatology etc. For instance, for calliper Grade 12.5 0,1€/kg is paid and for Grade 13 0,25€/kg, more than double. Besides, farmers have to handle with the rabbits plague.

4.4.1.-Farmers and CRs motives to implement DIS in La Font de la Figuera

The reasons why farmers opt to install DIS are mainly three. Firstly, it is a system that saves water, and in consequence, saves money. Secondly, it is a comfortable system that does not require so much labour as surface systems. Lastly, there were some subsidies given by the CAPA and they returned the 30% of the total invested (only in the case of the CR El Abovalar).

4.4.2.-Information, communication, subsidies and training in La Font de la Figuera

In general, farmers from CRs El Abovalar do not feel like they are informed from EU initiatives and they only know about Single Payment subsidy. In the Cooperative they have more information.

Sociedad Cooperativa La Viña did not receive any subsidy for DIS implementation, which was not the case in CRs El Abovalar. They received the 30% of the total investment. Lastly, and currently, they have signed to receive a subsidy for the reservoir which will collect water from the wastewater treatment plant. However, the project is blocked for now.

In general, farmers from La Font de la Figuera did not receive much training for DIS. Therefore, and according to Antonio (villager living in La Font de la Figuera and president of CRs La Rinconada Nueva de Moixent with 500 hours of training) not being trained and abusing of herbicides as well as tilling to "clean" the plots has brought some consequences. In order that DIS work correctly, the farmer has to let the small roots grow, without tilling the soil. In La Font de la Figuera, farmers always till because it is a traditional way of agriculture, and these customs are difficult to change. After tilling (and breaking the roots) farmers get angry and say that DIS does not work as they get less production.

4.4.3.-Water sources in La Font de la Figuera

Starting with the river water, in La Font de la Figuera, Cànyoles does not carry a drop of water, as the river starts to get considerable discharge from Moixent onwards. Therefore, La Font de la Figuera does not use river water for any activity. The river can only be appreciated when it rains. In fact, people can walk or drive through the dry riverbed. However, the watercourse road clearly remains as probably centuries ago it rained more and there was water flowing (figure 25).

Currently, the irrigation activity has decreased in La Font de la Figuera, but the used one comes from groundwater resources. The Sociedad Cooperativa La Viña is supplied by groundwater taken from a mine, which is stored in two reservoirs. The mine was drilled in the 50's. In the cooperative there is a total of 165ha in irrigation and they irrigate only for complement to rain water without using much water.
In CRs El Abovalar, they theoretically have 100 has in irrigation by using groundwater resources, which are stored in a reservoir with 2,5 million of m^3 of capacity. However, the real situation is that in the last years a water shortage has been noticed in groundwater. The used wells for irrigation are getting dry and the water level is going deeper and deeper, which makes the water pumping not possible for the farmers.

According to the town councillor, there are three wells and respective reservoirs that supply with water to La Font de la Figuera. Those wells were drilled in 1985 and water is extracted 24 hours/day all year long. In the beginning, there was water for everyone, but 25 years later (2010) there is no water for the irrigators. Surely, the aquifers in use by farmers and the municipality are connected, and they do not have other source as the river does not bring any water. In addition, there is a water bottling plant since the 80's that takes the water from a well higher in the mountain. Famers think that this plant also affects directly to the water shortage. Therefore, the water supply and water bottling plant could be two of the reasons why farmers suffer from water shortage at the moment.

There is also a STP in La Font de la Figuera. The maximum allowed spilling is 220.000m^3/year, which is allocated in the river after the treatment (CHJ, 2011). As searching for new aquifers is too expensive, in the year 2001 it was suggested to use water coming from the treatment plant for irrigation purposes. Therefore, farmers could complete the water cycle recharging the aquifers again (Aquifer, reservoir, village supply, treatment plant, reservoir, drip irrigation and goes back to the aquifer again). It is possible that the idea came up because in Moixent part of the treated wastewater is also used for irrigation. Besides, the president of La Rinconada Nueva of Moixent lives in La Font de la Figuera.

With this idea, farmers bought the lands where their new reservoir, called Madronyal, would be constructed (5,5 hectares). In 2003, the irrigators signed all the administrative papers with CAPA, which guaranteed that the project costs would be shared by the CAPA and them. However, the costs for tertiary treatment, which are quite expensive, have to be covered by the farmers.
In October 2011, they had a meeting with the GV where it was confirmed that there would not be any reservoir for them because there was no money available.

At the moment, all the papers are correct, the concession of water is given and recognized by CHJ, and CAPA has approved the construction works, but the farmers still do not have water after nine years. According to the CHJ data, from the wastewater plant, 85.000 m^3 are assigned for 165 has of the Sociedad Cooperativa La Viña de La Font de la Figuera and 75.965 m^3 for 100 has for Comunidad de Regantes de El Abovalar, with the purpose of fruit tree and vineyards irrigation. Up to now, farmers even calculate their water needs (table 14)

TABLE 14: WATER NEEDS FOR DIFFERENT CROPS CALCULATED BY FARMERS LA FONT DE LA FIGUERA

Crop	Water needs (m^3/ha)
Vineyard	1250
Fruit tree	1250
Almond	625
Olives	625
Vegetables	2500

The construction project was presented in 2007 and it had a total budget of 1.593.000€ for the reservoir of the treatment plant with a capacity of 150.000m^3 and a height of 15 metres. However, in the Spanish Royal Decrees and Orders, it is mentioned that if a reservoir is bigger than 15 meters, it has to be controlled from the central government in Madrid. If it is smaller than 15 meters then the control passes to Valencia. Therefore, CAPA ordered another project where the reservoir was of 14 meters in order to control the construction from Valencia. This second project was done by VAERSA, which is a construction group that works for GV projects. This second project was presented in 2009 and required a total budget of 3.143.000€. Consequently, it can be clearly seen that with one meter less of reservoir, the budget increased double.

Farmers think that technicians do not look carefully to the costs, and that it seems that money does not have any value for them. Farmers feel cheated. If they knew that the reservoir will not be constructed, they would have invested on searching other aquifers. They are already fed up and tired of paying such high costs and not finding a solution for irrigation source. Their lands are very fertile but they need water to practice agriculture and get enough yield.

4.4.4.-Consequences at field level and expansion due to DIS

In La Font de la Figuera, the following consequences are found (table 15).

TABLE 15: DIS IMPLEMENTATION CONSEQUENCES AT FIELD LEVEL IN LA FONT DE LA FIGUERA

Consequence	
Electricity costs	Although the electricity charges have increased, farmers have to deal with less electricity costs as there is less water. They already paid electricity with surface irrigation system.
Troubles	Among farmers there are no troubles, because there is no water for anyone and they do not need to pay it. There is no cause to be angry about.
Crop change	Farmers noticed some crop change as consequence of implementing DIS. Changing from vineyards to olives or almonds for instance. However, this can be related to some subsidies which had to do with vineyards pulling up.
Expansion	The farmers of La Font de la Figuera are very determined with the expansion issue. They argue that it is impossible for them to expand the irrigated lands as the allowed water for DIS is admitted for 165 ha in the Cooperative and 100 ha for El Abovalar, and they cannot pass that limit. They firmly defend that they never modified their irrigated hectares and

	that they were very loyal as they are aware that DIS could permit the expansion of land. They know it as they have seen it happen in near villages, which is illegal and they are very proud of not doing the same. If farmers expand lands, DIS would not save water. Therefore, there is no expansion due to DIS implementation

It is important to realise how the DIS opinion changed in farmers from the CR El Abovalar. As mentioned before, they wanted to install DIS because of its benefits in money and labour savings and also the subsidy obliged to do so. However, once the system is or was working they were disappointed with it. Nowadays, farmers think that DIS destroy agriculture, destroy the mountains (due to expansion consequences) and destroy the aquifers.
They disagree with the fact that DIS saves water, as more quantity is needed as irrigation is practiced almost every day. With surface irrigation farmers only have to irrigate once every 15 days. Therefore, there is not so much water savings in m^3. Farmers though that DIS were supposed to save 20-25% but if the lands are expanded water is not saved.

4.4.5.-Traditional irrigation infrastructures in La Font de la Figuera

There is no much traditional architecture about irrigation in La Font de la Figuera, as Cànyoles river has not enough water volume for it. There are no weirs in the area. The only traditional infrastructure related to water is the spacious *lavadero* (public washhouse) of the village (figure 26). In addition, some old canals are covered or abandoned and full of weed.

4.4.6.-Other issues

As in the other villages, young people abandon some of the lands, as it is not profitable to put them in production. Besides, some of the old farmers are thinking about quitting their lands as well because they cannot deal with the costs. The reason is alleged to be largely the intermediaries' responsibilities, as they can control farmers by being their contact with the market. Nevertheless, farmers do not see any alternative.

FIGURE 24: GENERAL VIEW OF CÀNYOLES VALLEY FROM EL CAPURUTXO MOUNTAIN

FIGURE 25: DRY WATERCOURSE AND OLD ABANDONED CANALS IN LA FONT DE LA FIGUERA

FIGURE 26: *LAVADERO*, THE TYPICAL WASHING PLACE IN LA FONT DE LA FIGUERA

FIGURE 27: SECOND RESERVOIR IN LA FONT DE LA FIGUERA

FIGURE 28: FARMERS PRUNING VINEYARDS IN LA FONT DE LA FIGUERA

5.-ANALYSIS

Although in every municipality different results can be found, the analysis will be described for the whole area of the study case in order to give and overall picture of it. The analysis is divided in five sections where DIS will be studied regarding to water sources and savings, agricultural productivity, energy issues, cultural heritage and operation and labour.

5.1.-WATER SOURCES AND WATER SAVINGS

Regarding to the relation between DIS and local water sources and water savings, the main found effects are the clear increase of groundwater quantity for irrigation as well as the decrease use of river water. Moreover, the water savings at field level due to DIS implementation are combined with the expansion of the irrigated area.

In general in the study area, an increase of groundwater exploitation has been noticed in the last years when DIS were implemented. At the same time, the river water use has been decreased from three out of the four municipalities that owned historical rights, to only one, Montesa. The reason why this happened is the low river discharge compared to other rivers like Albaida, and the possibility of using groundwater with drip systems. Installing these systems brought the possibility to use pumps as part of the pressurized systems. The river water was not enough for this purpose and farmers knew that groundwater is a more reliable and secure source that assures irrigation for drip systems. In addition, farmers did not have any problem for further groundwater quantity use from public entities, even though the subsidies restricted land expansion. There is only one municipality exception, the case in La Font de la Figuera, where the river never had enough discharge for irrigation use. Here, the groundwater level decreased in the last years and at the moment they are facing the problem of lack of water. Furthermore, they do not have the river source alternative and still, they are waiting to the agreed support of the CAPA to construct a reservoir for the reuse of wastewater. This water table depletion problem is an effect of the water bottling plant and the three wells that supply with water to the village. Apparently, all the aquifers from where water is taken are connected, but the municipality has more priority for water than the irrigators, which at the moment do not have water to allocate to their fields.

Both CAPA and CHJ provided support by giving subsidies for technical projects and implementation of DIS, restricting the expansion of land as mentioned previously. Nevertheless, at the same time, they gave groundwater concessions to CRs for irrigation to use them in non-irrigated areas, which seems quite contradictory. For instance, in the Plan Hidrológico del Júcar there is no mention of specific discharges or data of minimum environmental discharges in the rural areas. Therefore, it is unknown how public administration controlled the water source availability and the assurance of minimum use for every water activity in Cànyoles valley when the water concessions were given. Probably it has to do with the low population density and the fact that the valley is in a rural area, which supposes less importance than other agricultural areas located nearer to urban areas.

Apart from that, groundwater quality, which is the main source, is different in the two systems Caroch Sur subsystem (north of the valley) and Sierra Grossa subsystem (south of the valley). Generally farmers are not very aware of the water quality conditions. Only some farmers like the presidents of the CRs or the town councillors have knowledge on this issue. Although they know water is fresh in the north part and more salty in the south part of the valley it is not a big issue until the moment and gives no problem for irrigation or water supply. That is why the majority of farmers are not aware of the salty water issue.

Furthermore, there are evidences of the increase of organic contamination in groundwater, mostly nitrates (MITYC & IGME, 1986), due to agricultural activity, which theoretically is better managed fertigating with drip systems. In fact, fertigation can be a way of doing an efficient fertilizer management. To achieve so, three factors have to be taken into account: crop and site specific nutrient requirements, timing nutrient delivery to meet crop needs and controlling irrigation to minimize leaching of soluble nutrients below the effective root zone (Hartz & Hochmuth, 1996). Most of the farmers of the study area are trained to use drip. However, controlling every action that humans take is not achievable and in this case, how farmers manage fertilizers is not checked.

Apart from river and groundwater use, in the study area there is also wastewater reuse for irrigation in one municipality, Moixent. However, the use is mainly for surface irrigation, not for drip systems, which means that there is no relation with DIS implementation and wastewater reuse for irrigation in the area. The system works by gravity and gives no problem in water availability all year long. In fact, it is proved that in relation to energy consumption, drip technology use is best with groundwater source and surface water is best to use in gravity irrigation systems (Jackson, *et al.*, 2010). This allows having a balance in water consumption and energy consumption. In addition, wastewater reuse for irrigation is an alternative source that helps to achieve the mentioned objectives that seek for a sustainable growth in Europe 2020 (Europe 2020, 2011). As stated before, some authors believe that new water supplies will come from conservation, recycling or reusing (Pimentel, *et al*., 1997, p. 98).

This research did not seek for the accurate quantification of water savings as a consequence of DIS, but searched for evidences that verified the saving or not saving of water with DIS at field level. Based on farmer's observations, it can be said that there have been water savings after the implementation of drip systems at field level (in plots that previously were surface irrigated). Nevertheless, the irrigated land expansion issue has to be taken into account. As a consequence, it is quite questionable that the total quantity of water used has decreased at basin level due to DIS.

The research also had to deal with the different connotations given to the concept water savings by different stakeholders. Firstly, there is the lack of verification if water saving quality is related with DIS. There are many cases that verify it, as the government is promoting DIS with that aim. Nevertheless, it is also true that some current research studies in Spain evidence the contrary. It is the case of a Ph.D. research in Lleida University that verified the lack of relation between irrigation modernization and water savings in the Corb basin (Cots Rubió, 2011) or other researches in the CSIC in Zaragoza with similar results. Public entities are totally sure that DIS would consequence in water savings, as they understand water savings as less m^3 of water for the same ha. Farmer's opinion based on interviews is that drip irrigation saves about 20-25% of water compared to surface, because the water goes directly to the plants roots and not so much is "lost" in the soil compared to surface irrigation. Therefore, the characteristic of water saving attached to drip systems is internalized in society, although training have to be assured in field irrigation management. Despite farmers believe in this water saving idea, their main concern related to DIS is the decreasing of the cost of the water rather than the used quantity. In consequence, water saving (and drip*)* meaning for farmers is mainly cost saving (being aware that the highest costs are related to electricity) and the water saving concept remains vague, what leads to misunderstandings among stakeholders.

To sum up, there has been change in water source for irrigation, more groundwater dependant, and higher quantity of water used. In general in Cànyoles valley, there is enough groundwater for farmers' irrigation up to now, as there has been no problem with water shortages after introducing DIS and expanding some of the areas. The only exception is La Font de la Figuera. However, there might be shortage consequences in a future caused by the exploitation of the groundwater and less recharging of the aquifers (drip systems replaced surface systems), as it is happening in La Font de la Figuera. In addition, there is a misunderstanding of what policy papers mean with water saving and what farmers understand with water saving due to different interests.

5.2.-AGRICULTURAL PRODUCTIVITY

Is drip irrigation system transformation affecting to agricultural productivity? Farmers say that in theory, with drip irrigation systems the production per surface would have to increase comparing to the surface irrigation systems. However, after implementing it, there is a variety of opinions about the topic. What is clear is that irrigated lands produce more than non-irrigated lands, and farmers know it. There are different cases where this is verified and in some of them, the productivity increase reaches even double of the production in the same plot with the same amount of trees.

Supposedly, the promotion of irrigation aimed to transform traditional irrigated systems to drip systems. Nevertheless, farmers knew that with drip systems less water would be allocated to the surface irrigated plots (with an adequate management) and that irrigated land and crops produced more than non-irrigated ones. Therefore, taking the opportunity of drip systems initiatives, non-irrigated lands or other non-agricultural lands (mainly low-mountain areas) were converted into irrigated agricultural lands. Farmers probably wanted to make more profit using the same or more water. Maybe this could be the reason why sometimes farmers do not feel comfortable when talking about expanded irrigation lands.
In addition, drip systems eased the shift to high value crops like summer fruit trees or citrus and guide agriculture to monoculture in some areas. Farmers affirm that orange trees were already cultivated with surface irrigation before the transformation to drip systems. However, in some of the dry lands where previously vineyards or almonds were placed, nowadays irrigated dependent crops like mandarin or peach trees are cultivated. Therefore, in one way drip systems helped to shift from dry lands crops to irrigated dependent crops in the study area. There is also a particular area in Vallada where farmers believe that drip systems had influence in the fruit quality, which can be noticed in the taste.

The fact is that in order to increase the yield, farmers expanded the irrigated area and thus utilize more water than used with only surface irrigation systems previously. In contrast, the CR statutes do not permit to expand lands by law (if there is no direct concession from CHJ). Moreover, all the irrigated lands are registered and controlled by the CRs themselves. The reviewed literature and policy clearly state that drip is implemented mainly for water saving reasons. This excludes the possibility of irrigation expansion. Some of the found documents are the ERDF Operational Program Valencia of the European Commission, or the subsidies that support drip transformation. In other legislations like in the Royal Decree 678/1993 for improvement and modernization or traditional irrigation systems, it is stated that "works that aim expansion of irrigated area would be excluded or instead, the maximum resources allowance of the respective watershed organism will limit the works". This means that there is a water and land limitation from GV. However, the watershed organism, in this case CHJ, is involved in the expansion decision. That is why in some given subsidies of the

study area that prohibited expansion, this happened legally, as CHJ gave the authorization for the expansion dependent on the water conditions of the area.
Therefore, there is a clear contradiction between the drip system policy objectives (water saving and funding subsidies that fostered DIS implementation strictly without expansion) and the actuation in field, as rather than using less water, farmers use the same or even more water. However, what is not clear is the real measure and assessment of GV and CHJ to allow farmers to expand the irrigated area. This could be due to the fact that the study area is a rural area far from the urban points of Valencian Community, where usually there is less control of the water sources condition, even though in the highest village, La Font de la Figuera, there are already some problems with the decreasing of groundwater table affecting to irrigators.

It is not easy to identify the legal or illegal situation of the irrigated lands. Nevertheless, the majority of farmers affirm it was legally done by concession of water rights (given by CHJ) or well construction permits. In addition, the plot maps from two CRs in Vallada, 2006 and 2008, certainly show the expansion plans of irrigated area (Annex VI). It is important to recall that in order to irrigate, the lands compulsorily need to have their own respective water rights. For the expansion, the used extra water is coming from groundwater as explained in the section above.

Analysing the data obtained in the results section, this next table is elaborated to have an approximation of the expanded area. The data are dependent of the interviewed CRs, which are the most important ones in the area.

TABLE 16: TRANSFORMED AND EXPANDED IRRIGATION AREA IN CÀNYOLES VALLEY

	Montesa (4CRs)	Vallada (3CRs)	Moixent (4CRs)	La Font de la Figuera (2CRs)
Irrigation transformation from surface-drip (ha)	920	380	230	265
Irrigation expansion from drylands to drip (ha)	410	?		0
Surface irrigation in the studied CRs (ha)		25	40	not quantified
Others (ha)		576		
Total irrigated area	1330	981	270	265
Drylands in the studied CRs (ha)	220			not quantified
Total studied area (ha)	1550	981	300	265
Irrigation expansion (%) (from drylands to drip)	30	?		0
Irrigation transformation (%) (from surface to drip)	70	>40	85	100

It is appreciated that there are differences regarding to irrigated area expansion in the study area with a slight progression. While the two lower municipalities are exposed to irrigated expansion, the upper ones had not expanded even a hectare of the irrigated area. It is the case in La Font de la Figuera, the highest village of the valley, where there have been strictly no expansion mainly due to their water shortage problem. In Moixent, no evidences were found to assure a percentage of expansion. Nevertheless, the reason why they did not expand in the studied CRs can be attributed to the internal problems that the main CRs had for water rights organization. In Vallada, it is unknown how many hectares have been transformed or expanded from 576 ha of two CRs. However, it is a mixture of both (table 16). Montesa is the municipality where most expansion has been noticed, a 30% of the total irrigated area . At the same time, a progression is noticed in the surface irrigation transformed areas. This progression can be due to the already mentioned lack of groundwater sources in La Font de la Figuera and due to some organizational problems in one of the biggest CRs in Moixent as well as the closeness to the pilot area, Montesa.

It seems that when drip systems were promoted in the nineties, they were fostered or advertised as water saving technology but also as a productivity increment technology. Nevertheless, some years after farmers adopt DIS, this higher yield is not clearly noticed in the study area when comparing to the surface irrigation systems. Therefore, DIS could increment production only depending in some conditions like the crop or the soil type of the area. Furthermore, DIS can induce irrigated area expansion depending on the situation or context. In a context where there is water enough to expand the irrigated area and no institutional problems (not only local in CRs but also strict legislation or policy restrictions) then drip systems facilitate the expansion. It is in this case when the productivity is raised, when the transformation is from dry lands to irrigated lands.

5.3.-ENERGY ISSUES

In this section, the relation between the transformation of irrigation system to drip and its relation to energy issues will be analysed. Two main issues are found: the energy or electricity prices and the energy consumption increase.

As stated in the results section, the highest cost demanding factor farmers have to face at the moment are electricity costs, mainly for pumping water. It is found that at the same time that DIS are installed, electricity costs rose. Implementing drip systems does not have a direct relation with electricity costs increase, but the systems have influence as they brought the opportunity to farmers to acquire more wells permission and water concessions. This means that more water is used for irrigation and as the water is coming from groundwater sources, more energy for pumping is needed and thus, more money to pay it. Nevertheless, the biggest influence in electricity charges is related to the disappearance of the special irrigation rates in Spain in July of 2008, due to the liberalization of the Electricity Market. From that date on, the charges per kW increased from year to year. The only solution for CRs is to pump at night, on the hours where electricity costs are cheapest. Still, these costs are making farmers think about the profitability of agriculture in the area.

It can be said that in general in Spain, irrigation modernization increased water efficiency but it also contributed to the increase in energy consumption in the last years (table 17). In the case of Cànyoles valley, with drip irrigation systems, the consumed energy per hectare is also higher than with previous irrigation systems. This is due to the groundwater exploitation related to DIS implementation and the irrigated area expansion (more water used, more water need to be pumped). It is important to point that this happens because groundwater is the principal water source in the area.

TABLE 17: VARIATION OF CONSUMED WATER AND ENERGY FROM 1950 TO 2007 FOR IRRIGATION IN SPAIN (COROMINAS, 2010)

Year	Used water (m3/ha)	Used energy (kWh/ha)
1950	8250	206
1970	8000	480
1980	7750	775
1990	7500	1088
2000	7000	1435
2007	6500	1560
Increase 1950-2007	**-21%**	**657%**

Instituto para la Diversificación y Ahorro de Energía (IDAE) is a public entity attached to the Ministerio de Industria, Energía y Turismo of Spanish Government. After the first Energy Saving and Efficiency Action Plan 2008-2012, they elaborated the next Energy Saving and Efficiency Action Plan 2011-2020 where energy for irrigation is studied under agriculture section. The energy is used for pumping water extraction and/or distribution for irrigation and their aim is to optimize energy efficiency. For 2020, the plans ought to maintain irrigated land but want to decrease energy consumption in a 30% (implementing modernized technology), by optimizing the storage, transport and water delivery in field (IDAE, 2011). For that, subsidies will be offered for energetic audits in different CRs irrigation systems. In addition, the already mentioned National Strategy for Sustainable Irrigation Modernization, Horizon 2015 (MARM, 2010) also has the objective to try to diminish energy consumption in irrigation. However, none of the stated plans are going to take action in the Cànyoles basin for the moment.

Consequently, DIS implementation contributed to the increase of the electricity consumption due to the possibility of expanding the irrigated area that it brought. This ended in more water pumping needs. In addition, due to the liberalization of the Spanish Electricity Market, the farmers have to deal with very high costs of electricity, which questions the profitability of their systems.

5.4.-CULTURAL HERITAGE

As presented in the results section, there are traditional irrigation infrastructures that verify the existence of irrigation practiced in Islamic period and later periods in Cànyoles basin. Besides, there are ancient infrastructures related to water like fountains, underground canals, reservoirs or *lavaderos* which show the role of water and its relevance during centuries, giving the characteristic charm to the Valencian rural areas. In this section the relation between drip system transformation and ancient water related infrastructures will be analysed.

The most important consequence in Cànyoles valley is that the canals that were in use before the irrigation transformation (mainly concrete and earth canals) were directly affected with drip systems implementation. It is as simple as DIS infrastructures replaced the other infrastructures. This implies that the canals are abandoned or in disuse. Some of the farmers, specifically in Moixent, think that the municipality would have to take care of the old infrastructures of the area. The abandonment is caused by the convenience and use that is given to the infrastructure. For instance, the *lavaderos* are the best conserved water relate infrastructures in the study area, due to the current use by elder villagers, mainly women, who still clean some of their clothes there. It is true that some canals are currently in use for

surface irrigation systems, which are maintained and cleaned once in a while by farmers. Nevertheless, those are only few ones. In addition, some of the drip pipes are placed inside the old canals. As for the ancient weirs, only the one in Vallada remains. However, it cannot be reached nor seen due to the amount of grown weed around.
Therefore, there is a general non conservation attitude towards the old irrigation infrastructure from the public administration. The found motives are the lack of funding of the municipalities and the fact that agriculture is not the first activity of the area. Therefore, water heritage is neither a first priority for administration

There is a special infrastructure that deserves more attention than others in Cànyoles valley, although it did not experience a substantial change due to DIS implementation. It is probably one of the oldest ones and as mentioned in the result is the Acequia Mora in Moixent. It is located next to an Islamic tower and a part of a small aqueduct is still standing. The fascinating thing is that it is a very large canal that is maintained at the same level and it can be appreciated how it was constructed in ancient times. After so many centuries, this piece of history still remains near Moixent without planning any conservation action. In addition, El Bosquet spring and its surroundings, dated in the XVIII century, have importance for the village.

Therefore, for ancient canals it can be said that DIS replaced them leaving them in disuse and abandoned. There is little awareness of possible heritage and there are no initiatives for preservation.

5.5.-IRRIGATION OPERATION AND LABOUR

DIS has also influenced the irrigation operation and labour work in field.

Firstly, farmers have to adapt to a different irrigation system which has different characteristic compared to surface irrigation: it is automatized and it works in demand. This means that they change the irrigation frequency and water quantity delivered to the field. Normally, farmers are very happy to have an automatized system which requires less labour work, but some farmers prefer to go to the field and see how water arrives to their plots rather than pressing a button and leaving the system working alone. They see the advantage that the plants receive more water and less is allocated in the soil. However, the less allocation of water on soil can have consequences in aquifers recharge. In addition, drip systems cause less troubles among farmers due to the in demand system compared to the in turns system of surface irrigation. This also means that there is less necessary contact between them and probably less information exchange.

Secondly, the automation and in demand system have consequences in the motorista's role of the CRs. For their "new" work (change from working *before* water with surface irrigation to *after* water with drip[9]), there are no special trainings organized. Therefore, motoristas have gain knowledge by themselves about the new technology. For instance, how pumps work, how to repair new pipes and the understanding of the general pressurized system. Nevertheless, despite the lack of training motoristas made the drip systems function well.

[9] In surface systems, motoristas were the ones telling farmers when to irrigate which meant there was communication and direct relationship. In drip systems motoristas responsibilities are to read the meters, to make reparations and to check if the reservoirs are full of water, without necessary direct relationship with farmers.

Finally, training workshops for farmers assure a good management and operation of the system as well as for instance, fertigation management. An example of it is observed in the study area. In three out of four municipalities trainings were commonly taken by the majority of farmers. Nevertheless, the farmers in La Font de la Figuera did not receive much training. As a result, they combine the traditional tilling practiced with surface irrigation systems or in dry lands in plots with drip irrigation systems.
If they had knowledge about drip systems, they would have known that once drip irrigation is applied, the crops tend to have shorter and important roots were farmers till. Therefore, when they till, they are destroying roots and consequently, crops will produce less. The curious thing is that farmers think that lack of water and production decrease has been caused because of drip systems, when the reality is that they do not have knowledge about the system.
If there is no training about the system that is being used, then the system is not working correctly as it should and it results in damaging crops in this case.
It is worth recalling that these farmers from La Font de la Figuera transformed their irrigation systems mandatorily and supported their traditional irrigation systems. Therefore, the willingness of farmers and their traditions are also a concerning aspect when it comes to irrigation transformation decisions.

It can be said that drip irrigation systems in the study area productivity contributes to sustainability from an economic perspective, less sustainable in terms of water use and use of natural resources.

In summary, drip irrigation systems brought changes in the way that farmers deal with irrigation, changing the frequency and the quantity delivered and adopting to an automatized in demand system. Motoristas role, very important in every CRs, has also changed for which they have to acquire knowledge without any training help. However, it seems that the motoristas effort to gain that knowledge was enough to make the drip systems work properly. As for farmers operation, the introduction of drip systems without training leads to a non proper use of the system and poor results.
With it, drip systems contributed to sustainability in the study area from the economic point of view with crop productivity. However, in in terms of water use and use of natural resources DIS did not lead to sustainability in environmental perspective. As for social sustainability, these systems brought some consequences in the way of irrigating which are not clear if they increase the sustainability in the basin yet.

6.-DISCUSSION

In this section, a critical view of the research will be explained. Some issues like concepts connotations, water sources, energy issues or land abandonment will be elaborated.

In the research set-up section it is already mentioned the challenge of the thesis with the dealing of some of the concepts. What is found is that each concept is understood differently, from different perspectives and connotations from every stakeholder. Furthermore, it is found that the concepts look at the topics from different domains. For instance, water savings can be considerate from the environment point of view, or economic point of view. Other concepts look at irrigation and water from other focuses, like water productivity[10], irrigation energy balances, ecological, water or energetic footprint or virtual water or energy consumption (Corominas, 2010). For instance, virtual water is more used when it comes to exportation of products and water footprint is used to interpret water from a socio-environmental point of view. Therefore, there is not a perfect term that looks at irrigation from different perspectives, nor a term that every stakeholder is going to consider in the same way. It is the existence of complex situations which affects to different people, problems and interests.

With reference to groundwater exploitation, on the one hand, it is not clear if the responsible organizations stick to policy papers verifying the possibility to expand and controlling the irrigated areas of all the rural areas of Valencian Community and their sources. On the other hand, although farmers mentioned the expansion was legally done, it is difficult to affirm that the given water concessions are so. Therefore, it is unclear what the real actions of farmers and administrative workers have been.

Regarding to abandoned irrigation infrastructures, it can be discussed if it is worth to preserve them, making use of them for irrigation, rural tourism purposes and other aims or to destroy or abandon them. It is a matter of need or desire to preserve objects with historical value, which could be useful for touristic, historical or educational purposes. Here, once again, different interests emerge depending on the stakeholder. From some engineers or politicians point of view preserving those infrastructures could be a waste of time and money. Nevertheless, for the societal point of view historically and culturally it might have consequences.

There are some of the results that although they are relevant they stay in a backburner for the conclusion. This is the case of land abandonment in Cànyoles valley. Land abandonment is a problem found in every municipality. It has been practiced mainly by young people but also lately from experienced farmers. The reasons seem to be the high costs needed for agriculture and the opportunist role of intermediaries, who take advantage from the gap between field and market. This makes agriculture not to be profitable for them. The land abandonment could have serious consequences for farmers in the study area and for agricultural incomes.

There are differences before doing the field work phase and after doing it. It is important to recall the opportunity to study cases to come up with what at first glance could be unexpected results. Furthermore, every case is contextualized and it is important to have a wide variety of cases to achieve consistent research for science.

[10] More information about water productivity can be found in Playán & Mateos (2006) or Seckler *et al.* (2003).

For this case, energy consumption has been an unexpected finding. The fact is that at field level, water consumption has decrease with DIS. However, that supposed an increasing of the energy consumption for well exploitation. One of the sustainability growth objectives for Europe 2020 is to reduce the energy consumption to a 20%. Therefore, is it sustainable to reduce water consumption at field level and at the same time to increase energy consumption? Therefore, it remains the issue of finding the balance between two natural resources consumption, water and energy.

7.-FINAL CONCLUSIONS

From the case study and following the analysis, some clear conclusions about the irrigation system transformation are found. The conclusions are context dependent. The main characteristics of the area are the smallholding system way of farming, the general consideration of agriculture as a part time activity, the few discharge of the basin and the location of the area which influences to the control from public entities.

Regarding to water sources with DIS implementation in Cànyoles valley, a transformation to a more groundwater dependent irrigation activity is found for drip systems. In addition, the decrease of river water is found when drip irrigation systems are used. Water savings are accomplished at field level comparing to surface irrigation systems. Nevertheless, at the same time the water consumption has increased at basin level due to the irrigated land expansion.

As for crop change, it can be mentioned that DIS implementation leads to a change to high value crops like summer trees or citrus. Furthermore, the productivity increased and even doubled with drip systems in expanded irrigated lands. What is not clear is the change of productivity from surface irrigation systems to drip irrigation systems.
The expansion of the irrigated area is a consequence of implementing the new systems in Cànyoles valley. An expansion of drip irrigated systems has been observed in 30% of the irrigated lands studied in Montesa, the pilot area of drip systems in the Valencian Community, as well as in the next village, Vallada, with a lower percentage. However, this has been possible due to some context dependent conditions like enough water resources to expand the irrigated area, no institutional problems (nor local like in CRs nor strict legislation or application of policy restrictions). If that is the case, then drip systems facilitate an expansion of the irrigated area.

Energy problems were not expected until the field work phase, when it was discovered that DIS contribute to a higher energy consumption due to the possibility of expanding the irrigated area (more pumping needed). Moreover, drip systems partly contributed to the increase of electricity charges.

Traditional irrigation systems with historical value and cultural heritage are likely to disappear as a consequence of the transition to drip systems. There seems to be little concern of this happening in Cànyoles valley.

With reference to irrigation operation and labour, DIS causes less troubles than surface irrigation systems among farmers due to the in demand and automatized conditions. However, this leads to a less contact among farmers and to a more individualistic way of farming. Farmers and motoristas have to be responsible for gaining new knowledge concerning to drip technology. There are no special trainings for motoristas offered, but they managed to learn how to make the drip systems work properly. Therefore, special trainings for motoristas are not necessary for this irrigation transformation. The contrary can be affirmed for farmer's trainings. The introduction of drip systems without farmers training leads to a non proper use of the system and non-desired results.

To sum up, drip irrigation systems have brought several impacts regarding to water source exploitation, water consumption, crop change, agricultural productivity, expansion of the irrigated area, energy consumption, irrigation operation and labour as well as traditional irrigation infrastructures. All these consequences do not bring a balanced sustainability to the Cànyoles river basin.

To finish the conclusion section, what remains to express is that as noticed during the thesis, everything is context dependent: the time when the transformation occurs, the history and past events, the area conditions and characteristic and most importantly the person or people that are looking to the issue. An example could be the water saving concept. From public administration DIS are equal to water savings, assuming a straight forward relation. However, the context (crops, land, climate, water source, culture/traditions etc.) is not taken into account and the objectives have lack of specification. In addition, other stakeholders understand drip irrigation differently, as for instance some farmer's view of saving money or some others view of an imposed system. This is very well resembled in the following quote from "El Libro Blanco del Agua en Espana" (MARM) which summarizes the essence of the research.

"Vistas distintas, todas verdaderas, distintos intereses, todos legítimos. Necesidad de equilibrios, de unificaciones, de prioridades, de acuerdos, de ponderaciones. Lo tecnológico, lo jurídico, lo económico, lo ambiental, lo antropológico (...), no existe el camino único que recorra el territorio del agua" (MARM, 2000).

8.-RECOMMENDATIONS

After studying the successfully implemented DIS in Cànyoles valley, a following up and improvement plan is missing, in order to identify future possible problems and seek preventions. The improvement lines could be related to water sources investigation and optimization, renewable energy sources research or sustainability study of old irrigation systems among others.

Concerning to groundwater, a quantitatively and qualitatively investigation would be desirable as well as a clarification of the legislation in means of irrigated land expansion.
Groundwater is the most abundant water source in Cànyoles valley. The irrigated agriculture is dependant of it and with DIS implementation, rather than saving it, its use has been increased in new expanded irrigated areas. In the near future, this could suppose the depletion of groundwater level, as with drip systems aquifers are not as much recharged as with surface irrigation systems. With it, the availability of water in the basin would decrease and could create serious consequences. In addition, Júcar watershed is expected to be one of the watersheds with the most severe impacts in Spain due to climate change for 2030. The temperature will rise, which means that plants will need more water for evapotranspiration, rainfall will decrease and there will be less water quantity available (due to the higher evapotranspiration of plants/forests, the fewer run-offs and less river discharges) (Gómez-Limón, 2010).
The qualitative investigation could help to avoid water contamination. Even though drip systems provide a better fertilizer management due to fertigation possibility, less water is allocated in the soil and therefore, groundwater could be contaminated by higher concentrations of fertilizers in less water volume. The primary groundwater pollution in the area can be due to nitrate or salt pollution. Therefore, a special emphasis is deserved for those two elements.

Another idea would be to do a study of the applicability of potential alternative resources, investigating the possible sources, their potential and limits. Some initiatives could be wastewater reuse or more rainwater catchment systems such as traditional *aljibes* (cisterns). As described previously, there is already one municipality (Moixent) reusing wastewater for irrigation purposes, which is a very valid alternative as a renewable source. However, these sources lack of promotion and facilitation for farmers to spread out.

As for traditional abandoned systems, a study of the sustainability and the cultural and historical value for society as a whole of the old systems could be fostered. Surface irrigation has been practiced for centuries, and it could be beneficial for the basin water management as it could recharge aquifers and find the balance with drip irrigation systems using different water resources. In addition, those infrastructures are a sign of how irrigation systems lasted so many centuries and could be an example to follow as they are not dependant on pipes or non-renewable energy sources (by gravity or mills). If it is studied that the infrastructures have high historical value, then a recovery plan could be set, reconstructing some parts and making them work again. This could later on be used for fostering rural tourism and history knowledge in the area, for instance including it in a walking rural path which follows the irrigation systems. In fact, there are already some paths promoted by municipalities that cross some of the interesting areas[11] (Taller de empleo Moixent Turístic Etnològic, 2010). This could contribute to the remembrance of the Islamic culture, which started irrigating in the area.

[11] Some of those areas are El Bosquet reservoir or different parts like Regolf or Vaillo in Moixent.

Another recommendation is to investigate the way to decrease the energy consumption or to investigate the way to balance water and energy. In addition, the study of renewable energy alternatives could be pursued. Aside the governmental initiatives (IDAE plans), other proposed measures or alternatives are found for saving energy consumption in irrigation like (Rodríguez-Díaz, *et al*., 2011): the determination of optimal pump curves, irrigation network sectoring (grouping hydrants with similar energy requirements), improving energy efficiency of the pumping systems (installing smaller pumps) or using the less consumptive water source for each kind of irrigation system among others. Currently, some alternative renewable energy sources are already being investigated and tested for irrigation as exposed in the 1st National Sustainable Irrigation and Renewable Energies Congress (Pamplona, October 2011). Their aim is to optimize water and energy consumption and to decrease costs. These renewable energy sources would also help to achieve the objectives of Sustainable Growth of Europe 2020. Some alternatives are:

- ✓ Electric energy production with **biomass** of energetic crops or organic agricultural waste (pruning, fruit stones, shells etc.) (Iribarren, 2011; Lafarga, 2011);
- ✓ **Biofue**l use (from cereals or oleaginous crops with biodiesel and bioethanol) (Echeverría, 2011; Lafarga, 2011)
- ✓ **Photovoltaic** pumping systems (Abella, 2011)
- ✓ Medium potency **Eolic energy** for auto consumption in agricultural use (with storage place and also selling advantage) (Nistal Ruiz, 2011)
- ✓ **Hydroelectric small centres** (use of height difference of water in the canals with selling possibility and no impact in environment) (Trillo, 1996)

Some of the alternatives permit to farmers to be independent of the enterprises that provide electricity and even to make some profit of it. Therefore, farmers would not need to face the electricity costs problem. In any case, the electricity charges of the enterprises should be readjusted and negotiated in particular to agree on special prices for CRs.
The new measures not only need to find economic and social solutions, but also have to look to the current environmental problems. For instance, the presented renewable energy investigations would also help to fight against the climate change, contributing to avoid CO_2 gas emissions. CO_2 emissions are an indicator of water sustainability, as climate change directly affects to agriculture and irrigation. Energy consumption decrease would also help to achieve the objectives for Climate Change.
Therefore, the challenge is to study the best alternatives for each context and to put them in practice in order to find a balance between water and energy consumption.

Investigation about increasing productivity using the same crop quantity and water volume should be promoted in research institutes and universities. In other words, research of reducing water demand and consumption without decreasing yield could be fostered. In that way, farmers would not need to expand the irrigated areas to increase yield.

After interviewing stakeholders, it is found that different understandings exist between policy papers and farmers. Therefore, it could be studied how to approach interests in field (by farmers and CRs) and governmental institutes like GV or CHJ, as farmer's opinion is that they do not feel considered. An idea to cover that gap could be to organize participative workshops so that public administration can understand and consider the main concerns of farmers. In addition, CRs could be empowered as they are the main representatives of farmers, by having a space in the CHJ to approach legislation, current research and farmers view. This rapprochement would facilitate to change the way humans perceive water from a natural resource for humans use to a natural resource that has to be respected. Fostering awareness of decreasing individual water consumption and demand could be more effective than providing new irrigation systems or could at least supplement them. The focus of water savings at basin level has to find a balance between technology, water and human's way of acting, and this latter one is essential when supporting sustainable water consumption.

To sum up, to achieve a following up and improvement of DIS implementation in field the next recommendations for future research are suggested: investigate groundwater qualitatively and quantitatively, clarify the legislation regarding to irrigated land expansion and its possible consequences, study the applicability of potential alternative resources like wastewater, study the sustainability and the cultural and historical value for society as a whole of the old irrigation systems, investigate how to balance water and energy consumption as well as the application of renewable energy alternatives, investigate how to increase productivity maintaining the crops and water quantity (or reduce water demand and consumption without decreasing yield) and research the rapprochement of interests and knowledge of farmers and governmental institutes.

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