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ADAPTATION TO CLIMATE CHANGE OF ITALIAN AGRICULTURAL SYSTEMS: THE ROLE OF ADAPTIVE GOVERNANCE AND SOCIAL LEARNING

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Adaptation to climate change of Italian agricultural systems: the role of adaptive governance and social learning

Dedicate to…

my newborn child Carlo Khiem Virdis

my beloved husband, Salvatore Virdis

my parents, Don Tran Nguyen and Thi Liem Tran

Declaration

I, Nguyen Thi Phuoc Lai, declare that the PhD thesis entitled *"Adaptation to climate change of Italian agricultural systems: the role of adaptive governance and social learning"* contains no material that has been submitted previously in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Date Signature

"Your work is to discover your work and then with all your heart to give yourself to it". Buddha

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Abstract

Agriculture sustainability in the changing climate world is a difficult issue for both research and policy communities. While scientists are still struggled with CC knowledge uncertainties. Policy makers are stuck in understanding CC impacts in order to develop and implement policies to ensure an optimal level of adaptation. Several questions emerged in this context for policy makers are who and what adapts, what they adapt to and which levels they need to adapt.

Through an empirical study at Oristano (Italy) with the 4 representative Italian agricultural systems, this research aimed to examine the local farmers' adaptation capacity in the context of climate uncertainty. The research was designed flexibly in 4 phases as guided by the Grounded Theory Methodology. Participatory and bottom-up approach adopting methods such as interviews or questionnaires, meetings and workshops developed during the 3 years to trigger the interactions with/among stakeholders, engage their participation and open new space for social learning occurrence.

The results provided an insight understanding about farmers' perceptions, their knowledge, attitude and practices in coping with climate uncertainties, and importantly scenarios of adaptation to CC of Italian agricultural systems. It also highlighted several theoretical frameworks, that have significant implications for research and policy, on emerging social learning processes and forming local adaptive governance for CC adaptation at local levels.

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There are two mistakes one can make along the road to truth…

not going all the way, and not starting. -Buddha

1.1.Background

The background of this research lies in the emergence of sustainable agriculture development in the world of changing climate. Many studies showed that Climate Change (CC) has effected several sectors in Europe in different ways and to different extents (Aaheim et al., 2012) and how the amount and quality of water available to meet human needs are also limited. In addition, has been demonstrated how CC and a growing human population has led to a gap in freshwater supply and demand. As it has been already resulted in a number of water-policy successes stories, growing demands on freshwater resources are indeed creating an urgent need to link research with improved water management strategies (Ecological Society of America, 2001). FAO estimates an increase of about 11% in irrigation water consumption from 2008 to 2050 while this is expected to increase by about 5% from the present water withdrawal volumes for irrigation. Although this seems a modest increase, much of it will occur in regions that are actually suffering from water scarcity (FAO, 2011).

Agricultural sector depends heavily on climatic factors and water availability (Olesen and Bindi, 2002), directly depends on climate conditions like rainfall and temperature, and is thus adversely affected by CC (Aaheim et al., 2012). The CC demonstrated several impacts in agriculture like decreased food and livelihood security (Ericksen et al., 2009). Projected climatic changes will thus affect crop yields, livestock management and the location of production (Nardone et al., 2010; Olesen and Bindi, 2002; Olesen et al., 2011). The increasing likelihood and severity of extreme weather events will considerably increase the risk of crop failure as well as soil and depleting organic matter, the major contributor to soil fertility (EC, 2009).

Agricultural sector is also the largest consumer of freshwater: about 70% of all freshwater withdrawals go, by far, to irrigated agriculture (UNESCO, 2009). Water scarcity may limit agricultural production and economic development in many regions, it also put pressure on food markets and increase the gap between population growth and water use demand (Larson et al., 2009; Schlüter et al., 2010). As a result in many regions as well as Europe the current trends in agriculture reveal differences between the Northern and Southern countries.

Agriculture represents 10% of the European Union total GDP, and it plays an essential role in the European culture and environmental protection strategy. As agriculture occupies a great part of the territory and helps maintain the lifestyle and economy of many rural areas, a majority of Europeans (about 90%) regard agriculture and rural areas as important for the future (EC, 2010). However, European agriculture is exposed and vulnerable to climate changes in the last decades (Reidsma et al., 2010). In particular, the Mediterranean region is one of the most imperiled regions in the world concerning present and future water scarcity and CC impacts (IPCC, 2012). According to simulation models of Olesen et al. (2011), the Mediterranean will experience an increase in average temperature double the global temperature rise, a significant increase in heat waves, and a strong decrease in precipitations. In Mediterranean region agriculture is limited by water availability and heat stress, and irrigation become fundamental in countries due to expected high evapotranspiration rates and restricted rainfall (Olesen and Bindi, 2002). The demand for water for irrigation is projected to rise in a warmer climate likely increasing the competition between agriculture and urban as well as industrial users of water (Arnell, 1999). More water will be required per unit area under drier conditions, and ,due to more severe heat waves, peak irrigation demands are also predicted to rise (UNESCO-WWAP., 2012).

However, CC is a complex issue and uncertain, makes future impossible to be predicted for any planning and management (Ensor, 2011). A common approach to studying the future in the context of CC is to attempt to define a number of possible futures, called *scenarios* (Audsley et al., 2006). Scenario approach is presented in the literature as a means for engaging stakeholder groups to explore CC futures and to advise policy making for adaptation responses (Cairns et al., 2013). The development of changing scenarios for agriculture requires considerations in population, economic, technical, climate and social changes, because these changes may amplify or reduce the impacts of CC itself (Abildtrup et al., 2006). This implies the need to handle a large number of interdependent factors and involve a large group of stakeholders because human-induced CC is likely to present new, and to a large extent unpredictable, challenges to societies (Næss et al., 2005). More, CC impacts often manifest in local contexts, where weather variability is a major source of risk and where multiple factors interact in generating vulnerabilities (Berkhout et al., 2013). Local scenario uncertainties are highest, as well as climate variability and long-term CC

(Liverman and Merideth, 2002) show that vulnerability and its causes are location-specific. For this reason, local adaptation is increasingly considered as a necessary complement to cope with CC and water scarcity by scientific and political communities (Smit and Olga, 2001).

However, a difficult question emerged in the local context is how can various agricultural systems best adapt to CC or how can their adaptation planning proceed in the face of future uncertainty?

1.2 Research objective

The question of agriculture sustainability in the changing climate world is so difficult for both research and policy communities. UNFCCC (2009) and IPCC (IPCC, 2007a, 2007b1) have made efforts to promote the adaptation to CC through initiatives and plans at different scales. Many EU member states have prepared national adaptation strategies. However, policy makers are still stuck in the challenges of understanding CC impacts in order to develop and implement policies to ensure an optimal level of adaptation. Several questions emerged in this context for policy makers are, for examples, who and what adapts, what they adapt to and which levels they need to adapt. While scientific community is still struggling with CC knowledge uncertainties, limits of scientific understanding, such as what knowledge is lacking or what temporal or spatial scale mismatches, exist among disciplines (Ascough Ii et al., 2008). Although the use of scientific climate information and knowledge for decision making has been studied across regions in many different sectors, including agriculture, water, and disaster response (Dilling and Lemos, 2011), climate scientific knowledge usability is often influenced by contextual factors, uncertain and complex characteristics of climate change. The complexities and uncertainties are not only based on multifaceted interactions of biophysical variables, but it is even more derived from an amalgam of biophysical and socio-cultural factors (Deppisch and Hasibovic, 2013). In the context of scientific-policy uncertainties, social learning emerged as an promising propriety for understanding climate local impacts and preparing for adaptation. These processes are considered as a promising thinking for solving complex problems (Bommel et al., 2009), towards systemic and adaptive governance (Ison et al., 2013) building a valuable framework for participative reflection (Roux et al., 2010) and integrating local and scientific knowledge for better adaptation at local scale (Reed et al., 2007).

Through an empirical study at Oristano (Italy), this PhD research aimed to examine the local farmers' adaptation capacity and adaptation processes in the context of climate uncertainty and complexity. By focusing on the role of social learning processes in enhancing adaptive capacity, the study tried to answer the following research questions:

- What are the relationships between agro-ecological practices, conflicts of interests and social context in a situation of complexity and uncertainty of climate change, and how do they interactively deal with their different frames?
- What are farmers' perceptions of CC and are they adapting to climate change?
- Which are farmers' knowledge and attitude towards in defining CC adaptation practices?
- What are adaptation scenarios of agriculture systems and which roles of different stakeholders in the process of identifying adaptation scenarios to CC?

Finally, the research aimed to discuss about how to realize a local governance of CC adaptation in a situation of diverging frames, within and between institutions, organizations, scientists, societal actors, in the context of conflicts between agricultural activities and the environmental conservation. How knowledge generated by scientific research can prepare/benefit farmers to develop agriculture and reduce unavoidable detrimental CC impacts.

A multidisciplinary approach is proposed to consider the different aspects and interrelationships between factors such as climate, crops, pests, soils, social environment and economic viability of agricultural production. The PhD research has particularly been integrated into the research line 2 of the project Agroscenari[1] coordinated by Nucleo Ricerca Desertificazione of the University of Sassari (NRD-UNISS). The specific aim is to produce specific scenarios for adapting representative cropping systems of the Italian agricultural systems through the integration of agronomy and economic analysis, using participatory approaches to engage with stakeholders.

[1] Agroscenari: project funded by the Italian Ministry of Environment aiming to identify ways of adapting to CC of the main Italian agricultural production systems and assess their sustainability (www.agroscenari.it).

1.3. Climate adaptation in agriculture: the role of social learning and adaptive governance

Adaptation in agriculture to CC is important for understanding climate impacts and vulnerabilities at local scale and for the development of CC policy (Smit and Skinner, 2002). Agricultural adaptive capacity is not only dependent on socio-economic conditions, but also on farm specific conditions (Reidsma et al., 2010), different farm types and locations, and the economic, political and institutional conditions (Bryant et al., 2000; Smit and Skinner, 2002). Governance of adaptation requires knowledge of anticipated regional and local climate effects (Meadowcroft, 2009). In agriculture it varies depending on the climatic stimuli to which adjustments are made by farmers and it requires also appropriate awareness and actions at the local scale where the impacts of CC manifest and the responses need to be undertaken (IPCC, 2007a; Shaw et al., 2009).

However, like many other complex systems, main features of agricultural system that the literature highlights are uncertain and change, because of many socio-biophysical factors that influence the adaptive capacity of agriculture systems, which may occur as difficult to manage knowledge and foresee systemic transformations (Nilsson and Swartling, 2009).

To foster the local adaptation capacity in the CC context, a range of approaches based on social learning theories are proposed in the recent literature (e.g. Collins and Ison, 2009b; Pahl-Wostl, 2008b). The concept of social learning is originated from the cognitive learning theory of Bandura (1977), organization theory of Argyris & Schon (1978) and policy and development studies of Dunn (1971). Social learning have been increasingly used as a holistic approach to address the complex and uncertain issues, such as environmental and natural resources management (e.g. Berkes, 2009; Folke et al., 2005; Hoverman et al., 2011). However, so far little understanding exists concerning how social learning can be detected in practice and what impacts different kinds of participatory approaches yield on learning outcomes and decision-making (Armitage et al., 2008; Garmendia and Stagl, 2010).

In this study the author tried to prove the role of social learning processes in local adaptation to CC by interpreting that social learning as a change in understanding and practices that becomes situated in groups of farmers of practices through social interactions. Adaptation at farm level is crucial for CC adaptation in agriculture, and this depends on the actions of individual farmers or groups of farmers, the majority of those practicing agriculture. Social learning processes for understanding ecological, social and economic dimensions seems to offer such an approach that not only accounts for uncertainty and change (Ensor, 2011) and but also focuses on increasing the knowledge and adaptive capacity of farmers or groups of farmers. Social learning for enhancing adaptive capacity in agriculture means the processes of social interactions that trigger changes in knowledge and practices contributing to development adaptation strategies. They are the processes for governing dynamic complex systems in situations of inherent and unavoidable uncertainty that have capacity for continuous learning and adaptation (Folke et al., 2005). It is a form of adaptive governance in which the role of continuous learning is central and learning to learn can be identified as a potentially important strategy (Nilsson and Swartling, 2009).

1.4.Potential application of Research's finding

This research makes a number of contributions. Firstly, using a Knowledge, Attitude, and Practice (KAP) surveys, the study provides an overview understanding of Italian farmers' perceptions, knowledge, attitudes and their adaptation capacities in the context of CC in order to help researchers and policy makers in identifying appropriate research policy making approaches in studying and formulating adaptation strategies of Italian agricultural systems. Secondly, using a theoretical framework of systematic, holistic and participatory approaches, the research will examine the role of social learning and adaptive governance to address the difficult policy and practice problems of CC where facts are uncertain, values in disputes, stake high and decisions urgent. Thirdly, the research will provide to the output of Agroscenari with series of adaptation options to CC of Italian agricultural systems from a social science perspective. Finally, the research brings to the International Project "CADWAGO- CC adaptation and water governance: reconciling food security, renewable energy and the provision of multiple ecosystem services (www.cadwago.net)", lesson learnt from Italian case study in Adaptation to CC of Italian agricultural system which will be synthesized and could be used within the adaptation of key European policy processes and governance actions that have a global impact.

The findings of this research will benefit farmers, intermediate organizations, researchers, policy makers and whom that involved in the research and development of CC adaptation strategies for agriculture. The examination of the roles of social learning and adaptive governance in this study will provide a more holistic and systematic understanding and approaching to the uncertain and complex CC issue. The novel process of participatory research (Elden and Levin, 1991; Park, 1992) using the grounded theory(Glaser and Strauss, 1967) method involved a systematic methodology by integration of multiple methods in this study will open a new vision for researchers and policy makers in conducting research practices and decision-making process dealing with environment and climate change.

The analysis of farmers' knowledge, attitude and practices will provide policy makers at all levels with a local example picture drawing behavioral change and specific adaptation actions of local stakeholders, coloring what they know and need to know about the issue and highlighting the role and responsibility of each actor playing in the complex agro-environmental systems. This implies that the policy making process could usefully acknowledge the relevance of the integration of farmers' knowledge and attitude in CC adaptation. The adaptation policies/strategies at regional and national levels could then be designed to support the creation of new spaces or platforms for dialogue between farmers, researchers and policy makers in order to promote the generation of hybrid knowledge (Nguyen et al., 2013) for the emergence of more sustainable and long-lasting strategies.

1.5. Ethical and legal considerations of the research

1.5.1 Ethical considerations

Ethical considerations in CC concern the balance of responsibility for action and question of justice arising in relation to impacts on people who have little or no role in creating problem (Gardner, 2006). CC raises the issues of "double disadvantage" at both global local levels (Walker, 2010): the poorest will tend to be disadvantaged by the climate impacts, despite having the least responsibility for the emissions and resources to mitigation and adaptation. In order to enable all the voices to be heard and to adjust to each other's perspectives, this study ensured the participation of multi-stakeholders at the case studies. A stakeholder map has been built and criteria of stakeholder selection carefully made before conducting interviews and deliberative workshops. The study targeted farmers, fishermen, service providers, agricultural technical advisors, local and regional policy makers with a special consideration on gender, and vulnerable groups. Semi-structured interviews were made in order to understand their stakes. These actors were engaged in the deliberative workshops in order they have a chance to interact, share and build a common consensus among themselves to enhance transparent and efficient decision making process. Scenarios of adaptation at the case study will be inputs for developing sustainable development strategies of not only policy makers but also local stakeholders. Sustainable development means that intergeneration equity will be enhanced and those unborn and young generations will be enabled to inherit ecological services at least at resilient and healthy. With the scenarios created, local stakeholders will be able to make wise decisions on their production practices for both maintain daily livelihoods and environmental conservation; policy makers will be fostered to engage policies of intergeneration equity in CC agenda.

The research also provided the attention to environment and bio-diversity. Given the risk that CC will accelerate and exacerbate the existing problems of biodiversity loss due to human action. The participatory field experiment's outcomes contributed to develop sustainable farming practices at farm level, e.g. reduction of nitrate pollution from livestock farming and agricultural inputs.

The study was developed based the trust-based relationship (Lange and Gouldson, 2010): the research objective and the data collection purpose were informed to stakeholders; privacy was respected during the interviews by not asking private questions or insisting when the interviewee did not feel comfortable to answer. The field experiment was designed and followed together with farmers and since the research outputs will support policy making, engagement of farmers in the field experiment helped to avoid the independence between the upper policy making levels and the lower policy implementation level.

1.5.2. Legal considerations:

The study also examined the effectiveness of the Nitrate Directive at the case study areas, so that it would touch the sensitivity of the high political level. However, since this research was done within the framework of the Project Agroscenari, the endorsement at this aim was obtained at both national and local governmental levels. Furthermore, the field experiment contributed to the effective implementation of the Nitrate Directive. The involvement of farmers in the field experiment, interviews, focus groups and workshops aimed to enhance their understanding on the impact of the Nitrate Directive and their improvement of farming practices for sustainable agriculture. Since fair processes are more significant to stakeholders than fair outcomes (Gross, 2007), it is necessary to consider the knowledge partnership interface and the opportunity for people affected by a decision to participate and make their views heard, basing decisions on hybrid knowledge, and non-biased behavior by outsiders and decision makers.

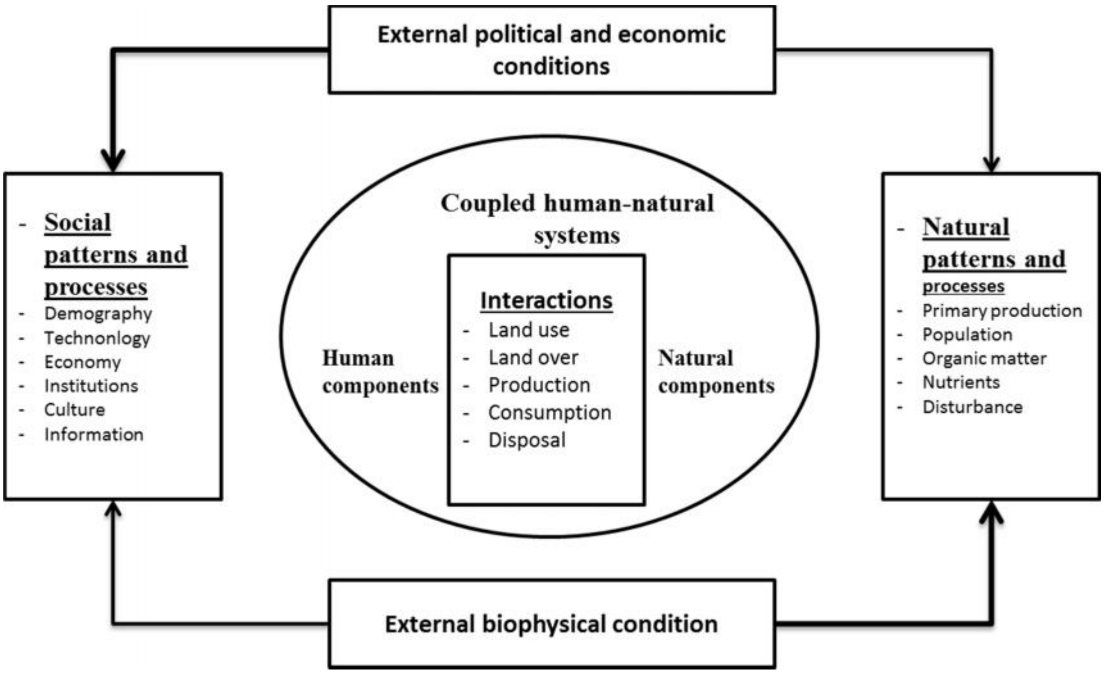
Chapter 2: THEORETICAL FRAMEWORK OF THE RESEARCH

Chapter structure

- Agricultural systems as a coupled human natural system
- System thinking and CC adaptation
- Sociological perspectives on CC adaptation
- Adaptive governance and social learning for adaptation of agricultural systems
    - Envision and reflection
    - Co-creation of knowledge
    - Changing behaviors and actions resulting from understanding

2.1. Agricultural systems as a coupled human environmental system

“A system is more than the sum of the parts. It may exhibit adaptive, dynamic, goal seeking, self- preserving and sometimes evolutionary behavior”(p.12, Meadows, 2008). Anderies *et al*.(2004) defined socio-ecological systems as social systems —in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non -human biological units. They are also considered as “perpetually dynamic, complex system with continuous adaptation” (Redman et al., 2004, p. 163). In this research, the author considered agricultural systems as a coupled human-natural system (Nguyen et al., 2013) as they exist in the intersection of coupled human and natural systems (Yu et al., 2012). There are many complex interactions between human and ecological components within these systems (Figure 1) such as land use/land cover, production, consumption and disposal (Redman et al., 2004).



Source: Redman *et al*. (2004)

Figure 1. Conceptual model of a coupled human-natural systems.

An agricultural system is an grouping of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system (McConnell and Dillon, 1997). It is driven by changes in both ecological and social patterns and processes that drive the agricultural system. The ecology theory explaining agricultural growth emphasizes human-environment relationships and their influence on agriculture (Ali, 1995; Paudel and Thapa, 2004; Thapa and Rasul, 2005). Many other cultural ecologists such as Turner II and Brush (1987), Arcury (1990) and other environmental sociologists (e.g. Duncan, 1961) consider agricultural systems as a function of constraints imposed by the physical environment and the human capabilities to reduce and modify those constraints. These scholars highlighted the human activity patterns occurring within the domain of human biology, especially demography, social organization, and technology. Many recent studies on the evolution of agricultural systems involved the dynamics and complexity of socio-ecological patterns (e.g. Hall et al., 2011; Yu et al., 2012). Agricultural systems are complex outcomes integrated by human activities and natural processes, its dynamics not only represent an element of global environment change, but also reflect the human dimension adaptation to global change. When social and ecological factors are linked, the overall agricultural system is complex and adaptive system involving multiple entities and interactions between entities, as well as being embedded in the whole system. Although it contains or consists of nonliving things, the agricultural system change, adapt, respond to event. It can be self-organizing, and often are self-repairing over at least some range of disruptions, resilient and evolutionary (Meadows, 2008).

As it includes the different entities and subsystems, an agricultural system is considered complex and dynamic taking in account of the course from production to consumption, institutions and politics concerned agricultural research and policy (Table 1). It is a mixture of political, economic and social activities which, because of increasing population pressures and disparate degrees of economic and political development, has become increasingly sensitive to any instabilities. As human population increases, the increased demand for food and natural resources has led to an expansion of agriculture causing large-scale land-cover change and loss of habitats and biological diversity. Although about half the world's population now lives in cities but depends on connections with rural areas worldwide for food (Chapin et al., 2009). In the climate changing world, agriculture systems display very little elasticity. Change that affects land, water and ecological services available for cultivation, instability of agricultural product prices, the cost of fertilizer, the availability of capital for technological innovation, etc., has as much or more impact on the agricultural system even whether there is sufficient precipitation.

Entities	**Examples**	**Potential problems**
System resources (services)	Water resource Ecological services	Uncertainty Uncertainty/complexity
System beneficiaries	Farmers using ecological services Farmers using irrigation	Resource use conflicts Water pollution/ overexploitation
Public infrastructure provider	Executive and council of local users' association Government bureau	Internal conflict or indecision about which policies to adopt Information loss
Public infrastructure	Irrigation systems Road systems	Wear out over time
Institutional	Rules (formal enforceable principles such as laws, directives, etc.) Norms (attitudes, values, and cultural traditions)	Inefficiency of rules, conflict with local socio-ecological contexts Different stakes and interests
External environment	Weather, economy, political system	Sudden changes as well as slow changes unnoticed/ Crisis

Table 1. Entities involved in agricultural systems.

2.2 System thinking and CC adaptation

As defined by Theodosius Dobzhansky (1968) "adaptation is the evolutionary process whereby an organism becomes better able to live in its habitat or habitats". Adaptations are processes of adjustments made by natural and human systems within entities and systems (Eisenack and Stecker, 2012). It refers to capacities of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Gallopín, 2006; Walker et al., 2004) by which a specie or individual can create or improve its chance of survival in both a specific current state of environment and a dynamic evolutionary future state of environment.

In the context of climate change, .the system that is effected by CC is called exposure unit and that is the target of an adaptation is called the receptor (Eisenack and Stecker, 2011). Receptors can be both biophysical entities (e.g. crops) and social systems (e.g. farmers), depending on the objective of analysis. In this research, the author specifically refer to the adaptation of agricultural systems –individuals/collective groups of farmers as receptors and farming systems as exposure units. According to IPCC TAR (2001) (Chapter 18). "adaptation to CC is any adjustment in ecological, social, or economic systems in response to actual or expected climatic *stimuli*, and their effects or impacts". Adaptation here refers to changes or transformations in processes, practices or structures to reduce potential impacts or to take advantages of opportunities related to changes in climate. It is a process that can take the most diverse forms depending on where and when occurs and on who/what is adapting (Smith et al., 2000). Adaptation of agricultural systems refers to change in behavior, organization and practices of individuals or collective groups of farmers to adapt to changes in meteorological variables and its impacts are defined as changes in biophysical variable associated with climate change. In sum, it is a process of adaptation of social systems to changes in natural or environmental systems. In the world of changing climate, adaptation is overwhelmed by the complexity of ecological and socio-economic elements as the main features of socio-environmental systems are the multiple interrelationships and interdependencies.

System thinking emerges in this context as an active cognitive endeavor to conceptually frame reality of these complexities. Systems thinking is a holistic approach to analysis that focuses on the way that a system's constituent parts interrelate/ interconnect and how systems dynamically work over time. It starts when people see the reality through other people's eyes and the reality is seen and interpreted by multiple perspectives (Reynolds, 2010).

Systems thinking is traditionally taught in eastern religions such as Buddhism, by the underlined notion of interconnectedness of humans with the environment (Midgley and Shen, 2007; Shen and Midgley, 2007), that claim that the boundaries between self and others, as well as self and environment, are blurred or even non-existent (Davis et al., 2009). With some variations, these ideas of system thinking also present in the Western philosophy (e.g. Churchman, 1968).

The philosopher C. West Churchman describes the system approach in term of systems thinking: "A systems approach begins when first you see the world through the eyes of another" (Churchman, 1968p. 231). He also talks about the interconnectedness with the environment in Churchman (1979, p. 5-6)

> "Fallacious, all too fallacious. Why? Because in the broader perspective of the systems approach no problem can be solved simply on its own basis. Every problem has an

> "environment," to which it is inextricably linked. If you stop x from growing (or declining), you will also make other things grow (or decline), and these changes you have created may very well be as serious, and as disastrous, as the growth of x."

The central idea in the systems thinking of Churchman is every decision has consequences, and not only in the system in focus but also in other systems. His approach focuses on the need to make proper representation of the interrelationships between entities supposed relevant to a situation and problem should be solved by viewing "problems" as parts of an overall system, rather than reacting to specific part.

Contemporary western science has been defined a systematic approach as a methodological approach to answering complex issues of environment because systemic problems arise from the interrelationships and interdependencies of entities in a system. Thinking about complex issues associated with the environment in terms of systems provides a powerful framework for understanding and getting a grip on the issues. For an example, Donella H. "Dana" Meadows, as an environmental scientist, states:

> You can understand the relative importance of a system's elements interconnections, and purposes by imaging them changed one by one. Changing elements usually has the least effect on the system. If you change all the players on a football team, it is still recognizable a football team. (It may pay much better or much worse- particular elements in a system can indeed be important) (Meadows, 2008, p. 16).

CC has become a boiling topic for a range of physical, social and social-ecological domains in the last decades. It has not been only transformed from a purely scientific concept to a highly relevant socio-political problem, but also has gained a remarkable degree of complexity (Deppisch and Hasibovic, 2013). The literature emphasized the complexity in understanding CC nature (Collins and Ison, 2009b; Hallegatte, 2009) because it involves integrating many independent disciplines using tools and models from the roots of systems theory (von Bertalanffy, 1969). Understanding CC may be developed based on the interactions occurring among the living and nonliving components (Maturana and Varela, 1991) by using the systematic approach (Churchman, 1968).

The recent climate research trend, therefore, must lean towards the integrated multi-disciplinary approach in understanding CC and its impacts (Dickens, 1992) and the investigation of co-evolution of coupled human-environmental systems (Reenberg et al., 2008). The literature showed that environmental scientists have integrated models in predicting and building future scenarios of uncertain and complex environmental change (e.g. Allen and Lu, 2003; Ascough Ii et al., 2008). These models take into account from biological and atmospheric sciences to economics and social sciences to acquire further knowledge and understanding of different types of uncertainty (Berkes, 2009; Blackmore, 2007; Gibbons et al., 1994; Nguyen et al., 2013; Olsson and Folke, 2001). However, their responses may also have negative and positive indirect impacts, because of complexity and dynamics of the systems such as socio-ecological change triggered by climate variables, that might only be anticipated by seeing them in broad ecological, social, and economic contexts (Ingwersen et al., 2013). Because there are aspects of the dynamics of climate systems that are difficult to predict, adaptation emerged as important to lessen the impacts

System thinking in the context of CC helps provide an integrated approach for adaptation, consistent with trends in CC research to evaluate CC impacts holistically. Systems thinking is invoked as an holistic approach towards assuring comprehensiveness and opening a frame for practices (Reynolds, 2008; Reynolds, 2010). System thinking deals with couple human–environment systems (Ison et al., 2011) and contributes to a comprehensive vulnerability analysis by avoiding the artificial divide between a physical and a social emphasis. Adaptation of agricultural systems will not only refer to the evolution of biophysical components because of multiple potential stable states with surprise and inherent unpredictability being dominant in these components (Holling, 1973). But adaptation is also seen in the context of the ability of individuals, groups of farmers to resist disturbances and reduce climate impacts on their cropping/production systems (Briguglio L, 2006). The concept of a coupled human-environmental system in agricultural systems emphasize the interrelationships between biophysical and social elements of the systems and adaptation is a co-evolution process of interdependent human-environmental systems to absorb disturbance (Berkes, 2003, 2007; Olsson et al., 2004) and retain the same function, structure, identity, and feedbacks (Walker et al., 2004) to adapt to changes.

2.3. Sociological perspectives on CC adaptation

The Darwinian concepts of 'evolution', 'natural selection' and the 'survival of the fittest' was also entered into early sociological discourse. The Darwinian were addressed in some aspects of nature and society by the three classical sociological founders like Durkheim, Weber and Marx. Many of the other conservative sociological thinkers in the nineteenth century also applied Darwinian principles to human context. For an example, Herbert Spencer, an English social philosopher, who proposed an evolutionary doctrine which extended the principle of natural selection to the human realm (Hannigan, 1995). However, the Dominant Western Worldview (DWW)[2] and the paradigm of Human Exemptionalism (HEP)[3] were mainly cemented mainly into their thinking. Their explanation of the human society context was only based on assumptions that the world is vast, and thus provides unlimited opportunities for human according to DWW; or socio and cultural environments are crucial context for human affairs, and biophysical environment is largely irrelevant according to HEP (Dunlap, 2002). Or they explained social phenomenon only in term of other social factors such as human innovative capacities plus an aversion to earlier excesses of biological and geographic determinisms. This led sociologists to ignore the biophysical world (Dunlap, 2002; Dunlap and Marshall, 2007).

In the 1970s, the two sociological scholars Riley Dunlap and William R. Catton, Jr. began recognizing the limits of what would be termed the HEP. They tried to define environmental sociology through a series of works (e.g. Catton and Dunlap, 1978a; Catton and Dunlap, 1978b; Dunlap and Catton, 1994; Dunlap and Catton, 1979; Dunlap and Catton, 1983). Catton and Dunlap (1978a) suggested a new perspective that took environmental variables into full account. In the "Environmental sociology a new paradigm" they mentioned the work of Schnaiberg (1972) that *"the study of interaction between the environment and society is the core of environmental sociology*". and they argued it is necessary to study the effects of environment on society and the effects of society on the environment. Catton and Dunlap (1978a) suggested a "new Environmental Paradigm"(Catton and Dunlap, 1978a) or "new Ecological Paradigm" (NEP) (Dunlap and Catton, 1979, p. 250) that acknowledges the ecosystem-dependence of human societies to replace HEP. The NEP recognizes the innovative capacity of humans, but says that humans are still ecologically interdependent as with other species. The NEP notes the power of social and cultural forces but does not profess social determinism. Instead, humans are impacted by the cause, effect, and feedback loops of ecosystems.

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[2] The view is human-centered. It basically says that humans are superior and humans have dominance over nature. It has a belief that humans have primary obligation to humans and that's it. It says that humans should have unrestricted use of natural resources for the benefit of just humans.

[3] The paradigm that humans are different from all other organisms, all human behaviour is controlled by culture, and free will, and all problems can be solved by human ingenuity and technology.

The influence of the environmental sociological notions in the late 1970s and the early 1980s came to be strong since the explosion of attention of global warming and global environmental change from 1988 onward (Buttel, 1996). However, environment is an enormously complex phenomenon plus socio-cultural evolution processes, open to various conceptualization and operationalization (Dunlap, 2002; Luhmann, 1989). This leads to diverse disciplines of sociological works (Dunlap and Marshall, 2007). Thus, environmental sociology today has dual perspectives: the realist and the constructionist. For the climate change, realists see global warming as a real environmental problem that is revealed by science, something that is going on because of the way society interacts with environment (Leahy, 2007). While constructivist perspective, which comes from a sociological tradition – society is socially constructed (Berger and Luckmann, 1967), demonstrates that environmental problems do not simply emerge from changes in objective conditions, scientific evidence is seldom sufficient for establishing conditions as problematic, and the framing of problems is often consequential (Yearley, 2005). According to the constructionist approach, there is no reality of environmental problems. Different people have their own differently constructed and equally valid interpretation of the environment (Leahy, 2007) and environmental problems are not simply revealed by science and then taken up by a concerned public (Franklin, 2001). Constructivist perspective highlights the crucial roles played by environmental activists, scientists, policy makers and other actors (Yearley (1991) cited in Dunlap and Marshall, 2007). Table 2 shows the differences between these two approaches.

Due to the different approaches and theories-based of these two perspectives, the constructionist-realist debate (mostly realist critics on constructionist approaches) has been lasted for a decade (Buttel, 1996; Dunlap and Marshall, 2007; Hannigan, 1995). However, the debate has recently begun to settle and questions emerged in this context for both proponents and opponents are why social constructionism emerged as a way of dealing with environmental matters and how it might continue to make a useful contribution (Hannigan, 1995). Subsequently, it has become common to find sociological research in recent decades that involves investigations of socio-environmental interactions and sometime involving examinations of perceptions and definitions of environmental conditions held by different interests (Dunlap and Marshall, 2007). Sociological approaches become crucial in the context of a changing climate in which they could contribute to investigate how changing environmental (climate) conditions in interactions with social factors (production, population, technology, market, etc.) that produces social impacts and also how social impacts affects environmental conditions as well as establish a social setting for preparing adaptation to uncertain situation of climate change.

<table>
<tr>
<td colspan="2">Realist approaches
(Duncan, 1961)
Global warming as a real environmental problem caused by the way society interacts with the environment.
The role of sociologist:
- Follow the lead of natural science in identifying the problems
- Understand why society is producing this problem
- Evaluate the social barriers to dealing with the problem
- Measures to stop the problem (e.g. reduce gas emissions, deforestation, etc.)</td>
<td rowspan="2">Constructionist approaches
(Franklin, 2001; Hannigan and Routledge, 1995)
There is no one “reality of environmental problems. Different people have their own different constructed and equally valid interpretation of the environment (Berger and Luckmann, 1967). Understanding of environmental problem is constructed in specific social contexts.
The role of sociologist:
- Investigate how environmental is understood by different sections of the population,
- how environmental issues are constituted as social problems and
- how people respond to these discourses of environmental problem
- Consider the claims made about natural conditions rather than assuming that some if these claims are true</td>
</tr>
<tr>
<td>Reformist approach
(Hawken et al., 2000)
- “Natural capitalism doesn’t aim to discard market economics”
- The problems as steering from ignorance and old fashioned technologies
Solutions:
- Make small reforms to the economic and political structures to deal with environmental problems
- Need to steering the markets in more creative and constructive directions
- New technology to reduce the economy’s dependence on fossil fuels should be invested
- Citizens should change their lifestyle, but government interventions (regulations, taxes, etc.) is central</td>
<td>Radicals approach
(McLaughlin, 1993; Pepper, 1995; Trainer, 1995, 1996, 1998)
- Growth as an environmental problem
- The combination of parliamentary democracy and capitalism is a problem for environment
Solutions:
- Much more drastic change in society is necessary : a radical restructuring of politics and the economy
- Refers to as Neo-Marxist or political economy perspectives (Lawrence, 2004; Robbins, 2004)
- A sustainable society with 3 equal economic structures: capitalism in the private sector, socialism in the public sector, and anarchism in a large community</td>
</tr>
</table>

Table 2. Current sociological approaches to CC (reviewed from Leahy (2007).

2.4. Social learning and governance for adaptation of agricultural systems

It seems to be extremely important to include system thinking and sociological perspectives into environmental research framework, or at least to provide potential levels-of-linkage which could be basic starting points for interdisciplinary environmental analyses. Recent environmental, economic and political demands are also requiring better understanding of the linkage between the ecological and human social systems, especially in the context of the development of management strategies for a sustainable world (Müller and Li, 2004). Agriculture systems are considered as a complex human-environmental system with simpler artificial ones to sustain select highly productive crops and unseen social system created by human society. It presents interdependences among production elements such as cultivation, fertilizers and pesticides; all foreign ecological elements of the natural environment and social conflicts.(Lichtenberg, 2002). The development of effective CC adaptation strategies for complex, adaptive socio-ecological systems such as agricultural systems, requires an in-depth understanding of functions and behavior of interdependent social-ecological systems (Kroll et al., 2012; Ohl et al., 2010) - both the dynamic nature of the systems themselves and their changing environment in which they operate. This understanding also includes the human dimension that reflects properties of complex adaptive systems, such as a diverse set of institutions and human behaviors (Smajgl et al., 2011), local interactions between actors, and selective processes, that shape future social structures and dynamics (Folke et al., 2005; Olsson et al., 2004). Theorists working within the interactionist perspective expressed that addressing environmental problems need to be created and defined the problems. Dunlap and Catton (1994) specified that environmental problems are socially constructed through the development of societal recognition and definition of environmental conditions. The construction of an environmental problem requires to address these questions: *"How are environmental problems created?"*, *"what factors are included in the process?"*, *"how is a problem legitimized?"* and *"who and what groups play a role in the process"* (Hannigan, 1995). To understand the behavior of a complex system we must understand not only the behavior of the parts but how they act together to form the behavior of the whole. It is because we cannot describe the whole without describing each part, and because each part must be described in relation to other parts, that complex systems are difficult to understand.

Interdependence theory (Agnew et al., 1998; Kelley and Thibaut, 1978) focuses on the idea of relationship interaction and provides a rich framework for characterizing the human–environment relationship how the structure of a relationship will affect. Davis *et al*. (2009, p. 174) argues that human and the natural environment have a reciprocally dependent relationship and they may affect each other:

> Whether or not individuals feel ‘‘close’’ or ‘‘connected’’ to nature, they are interdependent with nature in the sense that the wellbeing of nature can affect the well-being of individuals (and vice versa)..

In fact, environmental problems or environmental sustainability depend on human activities. World Commission on Environment and Development mentioned in "Our Common Future" (1987), page 24, para 27 as follows:

> Human has the ability to make development sustainable – to ensure the it meets the needs of the present without compromising the ability of future to meet their own need.

Human behavior is crucial important for the process of adaptation to CC which relies on how people perceive and understand the complex system around them in order to changing in their daily behavior and practices.

The fundamental theoretical insights arising from the above section are that systems thinking is a way of thinking based upon a critical understanding of how complex agricultural systems by considering the whole part rather than the sum of parts. System thinking is used to frame reality – understand and manage complex situations through learning to adapt. Adaptation of CC of agricultural systems can defined as a co-evolution process (Collins and Ison, 2009b) entails several phases of learning from perceiving, practicing and transforming. According to Gibson (1986) perception lies on the conception of visual learning that learning is a process of turning the perceptual system to become more sensitive to information present in the stimulus. Learning is a process that influences the way farmers think, feel and act. Learning is made not only through interacting with environment but also with people, in this sense it is specifically called "social learning".

Social learning refers as the "learning taking place in groups, communities, networks and social systems that operate in new, unexpected, uncertain an unpredictable circumstance, it is directed at the solution of unexpected context problems and it is characterized by an optimal use of the problem solving capacity which is available within this group or community"(Wildemeersch, 2004). Or in another definition "social learning refers to the collective process that can take place through interactions among multiple interdependent stakeholders who are given proper facilitation, institutional support and a conducive policy environment" (SLIM, 2004) Figure 2.

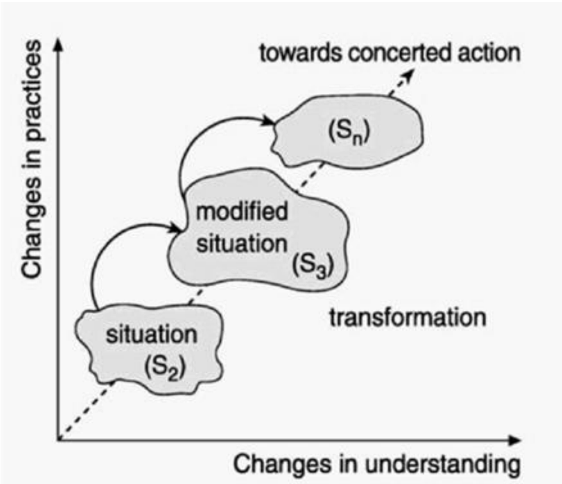


Figure 2. The Social Learning for the Integrated Management and sustainable use of water framework conceptualising transformation of practice through emergence of understanding. (SLIM, 2004).

Social learning may trigger the deliberative paradigm offering as its main empirical point of reference a democratic process, which is supposed to generate legitimacy through a procedure of opinion and will formation that grants publicity and transparency, and inclusion and equal opportunity for participation (Habermas, 2006). In the uncertain and complex CC agricultural context, social learning is emergent property of the process that helps to establish structure and empower individual farmers and groups and other stakeholders to enable adaptation capacity to transform a situation. This is a new form of adaptive governance, in the sense that refers how the farmers behave and practise in adaptation to CC in the way of the self-organizing interaction, shared learning, and communication that is at the heart of collaboration (Kallis et al., 2009). Social learning helps to open the framework of framing the reality and the framework of practice (Reynolds, 2010). It is a process of integrating the three sociological perspectives in finding a way for adaptation to climate change: the functionalist perspective is to understand and frame the reality of interdependences and complexities of the agricultural systems; the conflict perspective is to frame stakeholders and stakeholding and mediate the conflict; the interactionist perspective focuses on the differences of people' attitudes and actions, and the different between science/policy and public perception of climate change.

This approach seeks to implement systemic change within the community and arrange an new adaptive governance through a process which underpinned by the following courses:

2.4.1 Envision and reflection

Social learning is a process of iterative reflection that occurs when farmers share their experiences, ideas and environments with others (Brown et al., 2005). Visualizing and reflection process that engages farmers and stakeholders in perceiving, capturing a vision and interpreting their environment around them and how knowledge and opinions are shaped by those around them. The process involves critical thinking triggered by a questioning process to discover their possible and preferred future and to uncover the beliefs and assumptions that underline their visions (Tilbury, 2007). Critical thinking leads to a deeper understanding of multiple stakeholders' interests, their knowledge (knowing) and the influence of media in their daily life. It also helps contextualize socio-environmental contexts within farmers ambitions and attempting to overcome the situation. Perceiving the CC threats to agricultural systems seems to trigger learning and knowledge generation and opens up space for emerging collective action for adaptation to climate change. The envision and reflective process can be depicted as a series of learning. The cycles provide a framework for continuous reflection on their actions and ideas, and the relationships between their knowledge, behavior and values. To reflect on themselves and their practices, they need to catalyst that can help them see what would otherwise be invisible to them (Keen et al., 2005). The process will help to "formulate the problem "system" as a composite of all stakeholders' version of the problem by combining expertise from outside with insider expertise from local communities" (Ison et al., 1997, p. 261).

2.4.2. Co-creation of knowledge

Social learning is the process by which individual farmers acquire knowledge about different aspects of their social environment. The process of co-creation of knowledge which provides insight into the causes of, and the means required to, transforms the situation. Social learning explores the new modalities of knowledge production in the contemporary science and research (Gibbons et al., 1994) through the participation of multiple stakeholders. In the last decades many social learning models have been examined in different specific local contexts with the aim of integration of different sources of knowledge for understanding and management of complex and uncertain environment issues (e.g. Allan et al., 2013; Armitage et al., 2011; Corburn, 2003; Edelenbos et al., 2011). Participation in and for understanding the CC issues towards concerted actions for adaptation is an important way of recognizing the value and relevance of "local" or context-specific knowledge and knowing. If properly undertaken, this knowledge integrated with scientific knowledge will be hybrid knowledge to enhance convergent understanding the complex issue among diverse stakeholders (Nguyen et al., 2013) (Figure 3). Co-creation of knowledge takes place during the interactions among farmers, with other stakeholders like technical advisors, researchers and policy makers in interviews, participatory experiments, meetings or workshops. systems. In most uncertain and complex contexts the value of different sources of knowledge (i.e. local and scientific) is pivotal to problem identification, framing and analysis. There are thoughts to be substantial contributions to social–ecological understanding, trust building, and learning where the complementarities between formal, expert knowledge, and non-expert knowledge are recognized (Dale and Armitage, 2011; Nguyen et al., 2013) .This process can engage more stakeholders in becoming part of the process of adaptive governance and decision making.

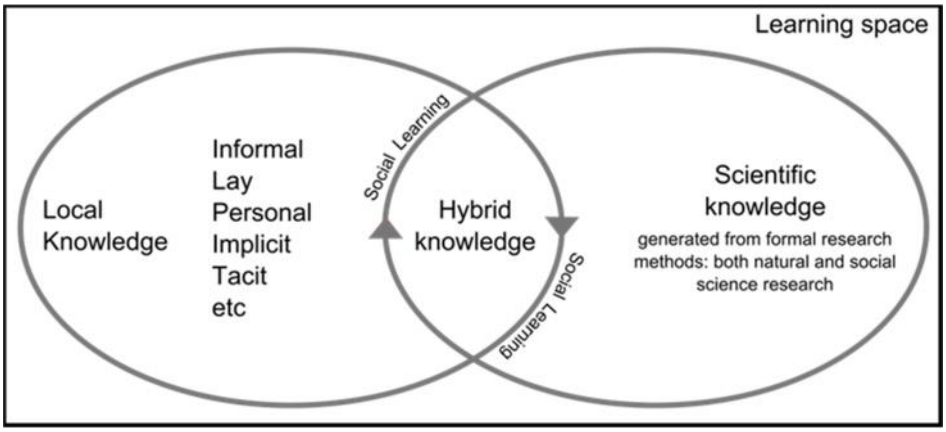


Figure 3. Conceptualized "hybrid knowledge generation" through the social learning process.

(Nguyen et al., 2013)

Recent literature highlights the interrelations between particular ways of knowing (epistemologies) and governance processes. Many studies have examined how forms of grounded local knowledge are linked to political and material claims - to resource control and environmental management (e.g. Corburn, 2003; Hall et al., 2009). Scholars such as Ison (2010), Snyder and Wenger (2010) and Wenger (2010) suggest that a community of practice, which is formed by members' common interests with a friendly informal atmosphere, within which the participants may feel free, to sharpen their skills and broaden their horizons, will mobilize social resources to optimize the knowledge within the context.

2.4.3 Changing behaviors and actions resulting from understanding

Social learning is thus an integral part or constitutive of concerted action. The change in something through action ('knowing') and leading to concerted action. Social learning is thus a feature of knowing and doing and at the same time an emergent property of the process to transform situation (SLIM, 2004). The transformation of agricultural management systems towards adaptive governance is based on the outcome of social learning process in which multiple perspectives and interactive are taken into account and hybrid knowledge about the complex environment is co-produced towards concerted actions for practice. Because the self-organizing properties of complex agricultural systems and associated management systems seem to cause uncertainty to grow over time, understanding should be continuously updated and adjusted, and each action viewed as an opportunity to further learn how to adapt to changing situations (Carpenter and Gunderson, 2001; Tidore, 2008). Social learning is flexible community-based learning system tailored to specific places and situations they are supported by and work with various organizations at different levels.

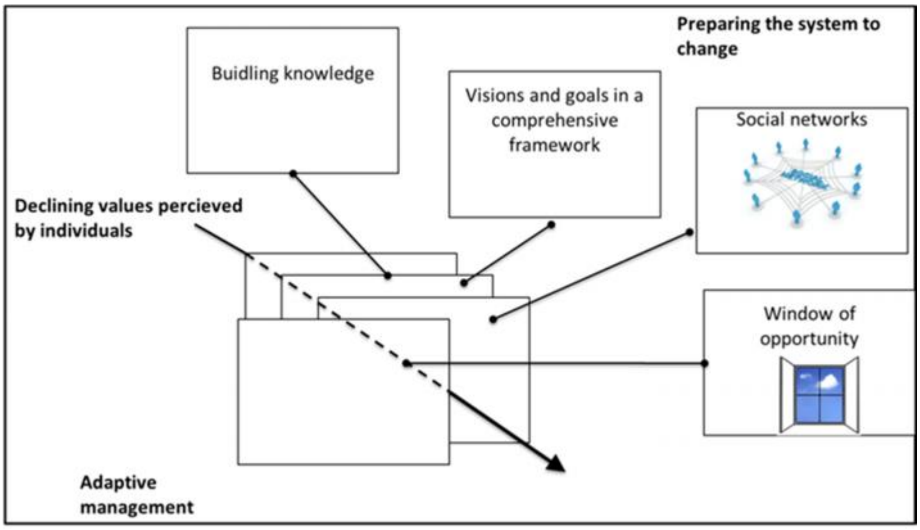


Figure 4. Transformation towards adaptive governance, adapted from Folke 2005.

The flexible structure allows for learning and ways to respond to and shape change in behaviors and actions through processes of co-reflection, co-production of knowledge to prepare the system for change. This is a transformation of the system towards adaptive governance (Figure 4). Aadaptive governance will be presented in “good practice” initiatives/ good adaptive options/strategies, and plays a role in mediating individual and collective perspectives/ knowledge/ experiences at different levels and scales (Sairinen et al., 2010) (Box 1).

Box 1: Practices to be changed for an adaptive governance (Sairinen et al., 2010)

- control →discussions,
- technocratic approaches → societal
- hierarchical processes → collaborative
- communication to explain → mutual learning

Adaptive governance is a model that incorporates actors across multiple levels of social organization, recognizing that many different actors in and outside of community play roles in decision making. Adaptive governance can build opportunities for learning and capitalize on the self-organizing capacity of social networks, such as local farmers or community governments (Meek et al., 2010).

Chapter 3: RESEARCH METHODOLOGY

Chapter Structure

- Grounded Theory Methodology (GMT) background
- Justification of methodology
- Selection of case study
- Research design
    - Phase 1: Understanding of historical, socio-cultural and institutional analysis (Semi-structured interviews and meetings)
    - Phase 2: Knowledge, Attitude and Practice survey (KAP) surveys (semi-structured interviews and questionnaires)
    - Phase 3: Theoretical and concept research (literature reviews and desk work)
    - Phase 4: Scenario development (data analysis and stakeholder meetings)

3.1 Grounded theory methodology background

The Grounded Theory was firstly presented in the book "The Discovery of Grounded Theory" by Glaser and Strauss in 1967 (Glaser and Strauss, 1967). Grounded theory is not supposed to be a theory in fact it stand for method. Grounded theory is referred to as a Grounded Theory Method (GMT). The book symbolizes a method to develop theory this method is based on the systematic generating of theory from data, that is gained scientifically from social research. The GMT was designed to construct a new theory that is useful for the area of study that light up a particular phenomenon. This GMT is a valuable qualitative method for the reason that it facilitate to grow the building blocks for generalizable empirical research (Zarif, 2012). GMT has become a 'global' phenomenon. Studies have been conducted using the methodology in a wide range of disciplines including sociology, nursing, anthropology, health science, business and management (Glaser 1995 vol 1, 2)

The GMT was continuously developed over the years by these two sociologists independently of each other. According to Dey (1999, p.2) there are 'probably as many versions of grounded theory as there were grounded theorists". The separate pathways od Glaser and Strauss were developed and divided as recognized as two schools of thought of GMT in 1980s: "the Straussian" and "Glaserian" (Dey, 1999).

In the book "Basics of Qualitative Research: Grounded Theory Procedures and Techniques", Strauss and Corbin (1990) defined the GMT as a qualitative research method that uses a systematic set of procedures to develop an inductively derived GT about a phenomenon, emphasizing that GMT is an analytical approach based on grounding the analysis in the data that have been gathered and inductively reaching conclusions from these data. However, Glaser (1992) suggested this did not extend understanding of grounded theory but had gone on to develop another method entirely - full conceptual description.

According to Melia (1996), it is not clear whether these two schools of thought are actually different, or whether they are just expressing a similar idea in different ways. Onions (2006) has discussed about the different approaches and point views of these two schools in the Table bellowed which were identified from original texts and later literature

(Borgatti, 2005; Chiovitti and Piran, 2003; Cutcliffe, 2005; Glaser and Strauss, 1967; Glaser, 1992; Strauss and Corbin, 1990, 1998; Walker and Myrick, 2006).

GLASERIAN	STRAUSSIAN
Commencement with broad wonderment (an empty mind)	Having a general idea of where to begin
Emerging theory, with neutral questions	Forcing the theory, with structured question
Development of a conceptual theory	Conceptual description (description of situations)
A basic social process should be recognized	Basic social processes need not be recognized
The researcher is passive, exhibiting disciplined restraint	The researcher is active
Theoretical understanding (the ability to recognize variables and relationships) comes from interest in the data	Theoretical understanding comes from methods and Tools
The theory is grounded on the data	The theory is interpreted by an observer
The credibility of the theory, or verification, is resulting from its grounding in the data	The credibility of the theory comes from the rigour of the method
Coding is less rigorous, a constant comparison of incident to incident, with neutral questions and categories and properties evolving. Take care not to “over-conceptualized” recognized key	Coding is more rigorous and defined by technique. The nature of building comparisons varies. With the coding techniques. Labels are cautiously dexterity at the time. Codes are derivative
Date reveals the theory	Date is prepare to divulge the theory

(Onions, 2006)

Increasingly there is a trend in the literature to categorize Glaser and Strauss as the first generation of grounded theorists and the development of the second generation of GMT (Morse et al., 2009). The second generation of grounded theorists have written about their interpretations of Glaser and Strauss’s grounded theory methods and have in many cases used the original work as a launching pad for their own iterations (Charmaz, 2006; Morse et al., 2009).

A later version of GMT called constructivist GT, rooted in pragmatism and relativist epistemology, assumes that neither data nor theories are discovered, but are constructed by the researcher as a result of his or her interactions with the field and its participants (e.g.Bryant, 2002; Charmaz, 2000, 2006). Constructivist grounded theory can be traced from the work of Strauss (1987) and Strauss and Corbin (1990, 1994, 1998) underpinned by their relativist position and demonstrated in their belief that the researcher constructs theory as an outcome of their interpretation of the participants' stories. Strauss and Corbin's focus on the provision of tools to use in this process confirms their constructivist intent. Following Strauss and Corbin (1990, 1994, 1998) Charmaz (2000) is the first researcher to describe her work explicitly as constructivist grounded theory.

> "by adopting a constructivist grounded theory approach, the researcher can move grounded theory methods further into the realm of interpretive social science consistent with a Blumarian (1969) emphasis on meaning, without assuming the existence of a unidimensional external reality" (Charmaz, 2000 , p.521)

The construct are " grounded" in the specific set of data the study bring together and consequent research can be tested the effectiveness of the construct (Charmaz, 2006). As in other constructivist methodologies, a constructivist GT arises from interaction between the researcher and participants, the researcher's perspective being part of the process. Ontologically relativist and epistemologically subjectivist, constructivist grounded theory reshapes the interaction between researcher and participants in the research process and in doing so brings to the fore the notion of the researcher as author.

Charmaz, a student of Glaser and Strauss, has emerged as the leading proponent of constructivist grounded theory (Charmaz, 2000). Opposing our argument that there is a discernible constructivist thread in the strategies of Strauss and Corbin, Charmaz (2000) has argued that in their development of "analytic questions, hypotheses [relational statements], and methodological applications" (p. 513), they assume the existence of an external reality.

According to the literature review of Mills *et al* (2006), there are a number of scholars drew on the work of Charmaz (1995b, 2000) in formulating their argument for assuming a constructivist approach to their own studies in many different disciplines such as education, psychology, occupation and environmental medicine, etc.

> "Data do not provide a window on reality. Rather, the 'discovered' reality arises from the interactive process and its temporal, cultural, and structural contexts" (Charmaz, 2000, p.524).

According to Charmaz, a constructivist approach to grounded theory is both possible and desirable. There are the possibilities for meaning by focusing on the data that can be constructed. Charmaz (1995b) has used grounded theory to elicit multiple meanings. Following Charmaz, researchers need to go beyond the surface in seeking meaning in the data, searching for and questioning tacit meanings about values, beliefs, and ideologies. There is an underlying assumption that the interaction between the researcher and participants "produces the data, and therefore the meanings that the researcher observes and defines" (Charmaz, 1995b, p. 35; emphasis in original). To enrich these data, Charmaz (1995b) has positioned the researcher as co-producer, exhorting them to "add a description of the situation, the interaction, the person's affect and perception of how the interview went" (p. 33). Researchers need to immerse themselves in the data in a way that embeds the narrative of the participants in the final research outcome. In constructivist GMT, it demonstrates the value that the researcher places on the participant as a contributor to the reconstruction of the final grounded theory model and researcher plays the role of co-knowledge producer (Munhall, 2001). With an emphasis on keeping the researcher close to the participants through keeping their words intact in the process of analysis, Charmaz has striven to maintain the participants' presence throughout. A key point is creative writing as a form of expression that has the potential to communicate how participants construct their worlds (Mills et al., 2006).

While many grounded theorists have recently produced more constructivist framings utilizing GMT have ranged from positivist to social constructivist, these works are shifting toward more constructivist assumptions/epistemologies (e.g. Charmaz 1995a, 2000). Together with Charmaz (2000:510), situation of Clarke (2005) is the part of these shift.

> "Situation analysis is part of these shifts. I seek with Charmaz (2000:510) to "reclaim these tools from their positivist underpinnings to form a revised, more-opened practice of grounded theory methods as flexible, heuristic strategies. Charmaz emphasizes that a focus on meaning making further interpretive, constructivist, and, I would add, relativist/ perspectival understandings" (Clarke, 2005, p. xxiii)

Situation analysis is considered as the postmodern turn of the GMT. The postmodern turn has occurred across the disciplines in the social science through other sites of knowledge production such as media, film, architecture and so on. Its perspectives view all knowledge (including the natural and social sciences and humanities, "lay" knowledge of all sorts, and knowledge for all sites globally as socially culturally produced (e.g. Berger and Luckman 1966, McCarthy 1996). Situation analysis of Clarke (2005) was developed to answer the question how the sociology of knowledge concerning the relations of knowledge to the sites of their production and consumption practices – aspects of "ecologies of knowledge" (Clarke, 2005). This scholar has regenerated and updated a very popular and epistemologically sound approach to qualitative analysis called GT to focus on the complexities and differences of the modern society.

Situation analyses provides the three main approaches:

1. Situation maps that lay out the major human, nonhuman, discursive, and other element in the research situation of concern and provoke analyses of relations among them;
2. Social words/arenas maps that layout the collective actors, key nonhuman elements, and the arena(s) of commitment within which they are engaged in ongoing negotiations, or mesolevel interpretations of the situation; and
3. Positional maps that lay out the major position taken, and not taken, in the data vis-à-vis particular discursive axes of variation and difference, concern, and controversy surrounding complicated issues in the situation.

3.2 Justification of methodolody selection

Agricultural system is complex and adaptive system involving multiple entities and interactions between entities, as well as being embedded in the whole system. A pivotal question is how to accommodate and synthesize different perceptions of the farming systems and the 'soft' and 'hard' components of the system. Participatory bottom-up, qualitative research can provide a more direct reflection of the on-the-ground reality that farmers face in making management decisions in adaptation to climate change. However, for any proposed adaptation measure, there are biophysical impacts that need to be evaluated, trade-offs to be made in present and future costs and benefits. Social research, by nature, is unable to adequately quantify these impacts and trade-offs.

The application of GMT in this research for the following reasons:

- According to the initial investigation, the researcher found that there is the emergence of adaptation as a focus of CC policy action and assesses current approaches to adaptation policy development and research. There are numerous explanations for the increasing interest in adaptation as a response to climate change. First, the experience of climate negotiations throughout the 1990s eroded confidence in the ability of mitigation to stabilize or moderate climate change. Second, it is widely recognized that CC is already occurring in some regions where populations are vulnerable so that adaptation at local level becomes important. A growing community of policy makers and researchers is evolving to provide support to identify what adaptation policies are required to moderate or reduce the negative effects of climate change, and how they can be best developed, applied, and funded. However, there was a lack of theoretical foundation which help as basis for understanding the actual adaptation to CC at specific local socio-ecological levels in many countries. Adaptation to CC is considered as relatively new research and policy attention in Italy as the country hasn't developed the national strategies of adaptation to climate to guide the operation at the local level. Therefore, the researcher believed there was enough ground and applying GMT to explore the actual adaptation situation to CC of Italian agricultural systems in Italy through investigating knowledge, attitudes and practices of stakeholders as phenomenon within their real-life contexts, especially when the boundaries between the phenomenon and its contexts were not seen as being clear, nor were they thought to be clearly defined between the practices of adaptation to CC and the Italian agricultural systems.
- GMT provides a systematic method involving several stages. This is used to "ground" the theory, or relate it to the reality of the phenomenon under consideration (Scott, 1996). GT is derived from the phenomenon under study. This contrasts with the hypothetic-deductive method, where theories are generated from cyclical testing and refined from previously constructed hypotheses. In GT studies, theory emerges from the systematic examination of the phenomenon.
- Constructivist Grounded Theory Methodology (Charmaz, 2000, 2006) is a widely cited research approach based upon symbolic interaction with a focus on interaction, action and processes (McCreaddie and Payne, 2010) which prepare for occurrence of social learning processes. It is the reason, it was chosen to apply in

this research. Constructivist GMT was used to the research to co-produce knowledge by integrating codified knowledge (e.g. scientific) with existing knowledge (e.g. lay/ local knowledge) developed by experiences. "Constructivism assumes the relativism of multiple social realities, recognizes the mutual creation of knowledge by the viewer and the viewed, and aims toward interpretive understanding of subjects' meanings" (Charmaz, 2000, p. 510) This is considered as a root in cognitive process that lays on the ways knowledge is created in order to adapt to uncertain and complex world of climate change.

- Situation analysis approaches of Clarke (2005) is the best suit in understanding the complexities and uncertainties of local environmental change through the socio-economic processes in the climate changing context. Recent research on CC argues that local material and symbolic values have to date remained underrepresented climate change science and policy (Adger et al., 2009; Hulme, 2009; O'Brien, 2009; O'Brien and Wolf, 2010; Adger et al., 2011). The context places that have been identified as at significant and immediate risk from the impacts of CC (Wolf et al., 2012). Using situation analysis will help to understand interdependences of human and non-human elements in the local socio-ecological context, stakeholders and stakeholding on CC as well as controversies of CC adaptation and relevant agri- environmental policies. This aim to also explore integral social relationships and the behavior, knowledge and practices of farmers' groups where there has been little exploration of the contextual factors that affect their lives and production in the context of climate change.
- "All is data" (Glaser) not only interviews or observations but anything is data that helps the researcher generating concepts for the emerging theory. Grounded theory gives flexible guidelines rather than rigid prescriptions (Charmaz, 2006). It offers sharps tools for generating, mining and making sense of data so that it helps to answer the research questions. Certain research problems indicate several combined and sequential approaches. In this research case, the research aim was to explore perceptions, attitudes, knowledge and practices of farmers of several farming systems on climate change, semi-structured interviews, distributed questionnaires, joined meetings, workshops organized within the Agroscenari project were carried out to collect as much as possible data and information to interpret the phenomenon.

3.3. Selection of case study

The research aimed to examine the adaptation of Italian agricultural systems to CC with emphasizing the roles of social learning and adaptive governance. The main criteria to select the study site were: 1) location of the site must be in Italy and among the case studies of the Agroscenari Project as the research was chosen to be carried out within the framework of this project; 2) the site must present a range of diversified farming systems representing Italian agricultural systems.

Other criteria were developed for a better understanding of local sociological, political and economic development processes, which directly or indirectly reshape agri-environmental system functions according to the guideline of Ohl et al. (2007). They include: demography, vulnerability, agri-environment relevant policy, local conflict.

1. Demography: one the crucial factors influencing land use types and intensity and urbanization processes. It also determines the waste production and release from intensive production activities and domestic activities, or declines wetlands due to agricultural expansion or decrease of water retention potential due to the combined effect of climate variability and agricultural production transformations.

2. Vulnerability: Questions referring to environmental and social vulnerability incurred by the co-evolution of natural and social systems are crucial in the face of environmental changes. Sustainable development will not be a realistic goal unless a social group and/or an economic sector vulnerable to loss of ecosystem services or decline of production activities. Vulnerability can be perceived as both susceptibility and sensitivity to impact or as adaptive capacity to cope with the effect of disturbances in the context of climate change.

3. Agri-environmental relevant policy: The site where is applied agri-environmental relevant policy was selected for this research. Policy refers to social objectives formulated by a governing body and includes specific measures to attain these objectives (e.g. directives, regulations, subsidies, incentives, etc.). Objectives and measures may have adverse side effects on the ecosystem. Attention was be given to (a) questions concerning the dynamic efficiency and ecological effectiveness of policies and measures that are directly aimed at halting the vulnerable agro-ecosystems and (b) the relation of policy implementation and innovations that are relevant for agro-ecosystem conservation.

4. Local conflict:

Local conflicts are often embedded in the socio-economic profile of the local population (age, sex, employment). In this research are referring to local conflicts related to the use of natural resource and environment (e.g. the impacts of agricultural pollution on other economic activities) that lead to agro-environmental dilemmas.

Oristano was selected as the case study of the research. The details of case study are found in the Chapter 4. The site is met all criteria set by the author (Box 2).

Box 2. Met criteria of the case study of Oristano

1. Location: Oristano locates in Sardinia, Italy and one of five case studies of Agroscenari Project
2. Farming diversity: There are a range of farming activities in Oristano: intensive dairy cattle farming, extensive dairy sheep farming, pig farming, rice and cereal production, horticulture, etc.
3. Demography: Oristano in 2007 was the third most populated Province in Sardina after Cagliari and Sassari.
4. Vulnerability: Arborea (Oristano) has been recognized as Nitrate Vulnerable Zone to pollution (ZVN) of agricultural origin by the Regional Agency of Environmental Protection (ARPAS) and it has been designated as the only NVZ in Sardinia (Regione Autonoma della Sardegna, 01/2005) under the ND
5. Agri-environmental relevant policy: A system of natural wetlands still exists between the reclaimed land of Arborea and the sea shore, and a parts were declared Sites of Community Interest according to EU Directive 92/43/EEC, and also as Ramsar sites under the Convention on Wetlands of International Importance. The Nitrate Directive has been applied to implement at Arborea since 2005.
6. Local conflicts: Environmental use conflicts presents in this area: conflict between dairy cattle farmers and fishermen are evident due to water pollution of the animal waste.

3.4 Research design

The research was designed flexibly as guided by the Grounded Theory Methodology. Grounded theory has no specific methodology the simultaneous collection and analysis of data is a phenomenon specific to grounded theory, is a process necessary for the approach. Participatory and bottom-up research approach adopting methods such as interviews or questionnaires, meetings and workshops were developed during the three research years to trigger the interactions with and among stakeholders, engage their participation and open new space for social learning occurrence. However, methods with strong stakeholder engagement have rarely been used in studies of CC and agriculture production. Interviews provide insights from local actors to better understand the forces at play in building adaptive capacity to CC (Lereboullet et al., 2013) .

The research was divided within 4 phases as shown in the Figure 5

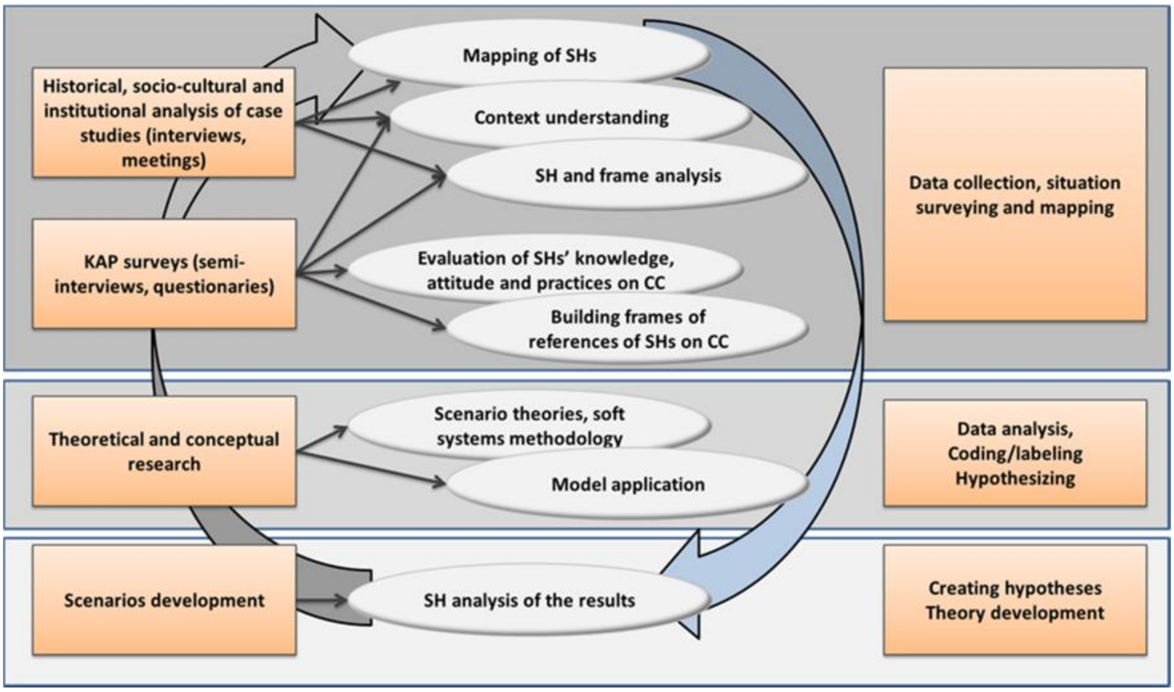


Figure 5. Research design conceptual model.

3.4.1 Phase 1: Historical, socio-cultural and institutional analysis.

The aim was to obtain an understanding of the situation's origin and the state of understanding and practices in the initial interactions among stakeholders. The process of understanding historical, socio-cultural and institutional context was developed according to the guidelines of the SLIM framework (SLIM, 2004). The four variables explaining the situation and the issue include:

- History: Acknowledging and understanding the history of a situation is essential in developing policy responses appropriate to the specific circumstances at play, and the framework to propose places significant emphasis on it. Any given resource problem exists in a historically based social, cultural and institutional setting which 'frames' the issue. Historical differences mean that the configurations, roles and values of stakeholders vary between and within cultures, and it follows that a policy or management practice.
- Stakeholders and stakeholding: Stakeholders are those who, from their perspective, have a 'stake' or a material interest in the situation. Stakeholding expresses the idea that individuals or groups actively construct and promote their stakes in relation to those of others. Through social interactions, new stakes can emerge and help to transform the issue as well as the relationships among stakeholders (Tidore, 2008).
- Ecological constraints: The term' ecological constraints' was used to define an observer's understanding of the relationship between people and their biophysical environment. Ecological constraints are a set of identifiable and quantifiable factors that are perceived to influence agro-ecosystem functions. Scientific knowledge is often accorded primacy in defining agro-ecological constraints which then reflect the experience and understanding of researchers and experts: they are therefore 'epistemologically' grounded. Just like scientists or experts, however, individual users build their own understanding of the agro-ecosystem and of their role in it through their relationship with it within a given system of interest.
- Facilitation: Facilitation in relation to natural resource management is understood as a combination of skills, activities and tools used by a facilitator (defined in the broadest sense) to support and guide learning processes among multiple interdependent stakeholders. Its main role is to bring about systemic change in complex situations for achieving concerted action.
- Institutions and policies: This variable relates to the nature and role of institutions in agri-environmental management such as established law, custom, usage, practice, organisation or other element in the political or social setting.

Since interaction, debate, negotiation, dialogue, joint research and the development of a 'platform' or social spaces to enable interaction are important characteristics of the processes of understanding historical, socio-cultural and institutional context, twenty interviews with farmers, fishermen, intermediate organizations and local authorities were carried out. Four open questions were posed:

(1) What is your activity and what is your role?

(2) How was your activity performed in the past compared with the present?

(3) What do you expect for the future? and

(4) What do you think are the main issues to be managed and addressed in your area?

Two workshops were organized:

(1) The first workshop was organized in July 2010 with 43 participants: 20 from various universities and research centres, covering several disciplines such as agronomy, hydro-geology, economics, ecology and climatology, were involved in Agroscenari –5 regional and national policy makers, 8 technical advisors and members of farmers' unions and 10 farmers). Participants were invited because they were recognized by our research team as the main stakeholders operating in Arborea around the nitrate issue.

(2) The second workshop (18 participants: researchers, technical advisors and regional and province authorities) was organized in September 2010. The participants, apart from researchers were invited because they were responsible for local implementation of the ND. The aim was to collectively reflect upon and exchange information about the evolution of nitrate pollution in the study area following ND implementation.

3.4.2 Phase 2: KAP survey

A KAP (knowledge, attitude and practice) survey is a representative study of a specific population to collect information on what is known, believed and done in relation to a particular topic. This method has been popularly used in the health care sectors. Recently, KAP is used in other sectors, for examples: for evaluating knowledge, attitudes and practices of farmers on biodiversity conservation and agricultural management (Stuart et al., 2011), agricultural land management (Yonas et al., 2010)..

A KAP survey was applied and conducted in several communes of the province of Oristano, Italy. The KAP survey was aimed to gather information about CC topic which includes questions about general perceptions, knowledge and adaptation practices and belief. These data were analyzed quantitatively and qualitatively according to the objectives and design of the study. Figure 6 shows the communes where the survey was conducted. Oristano and Arborea is the two communes in which the interviews were mainly carried out

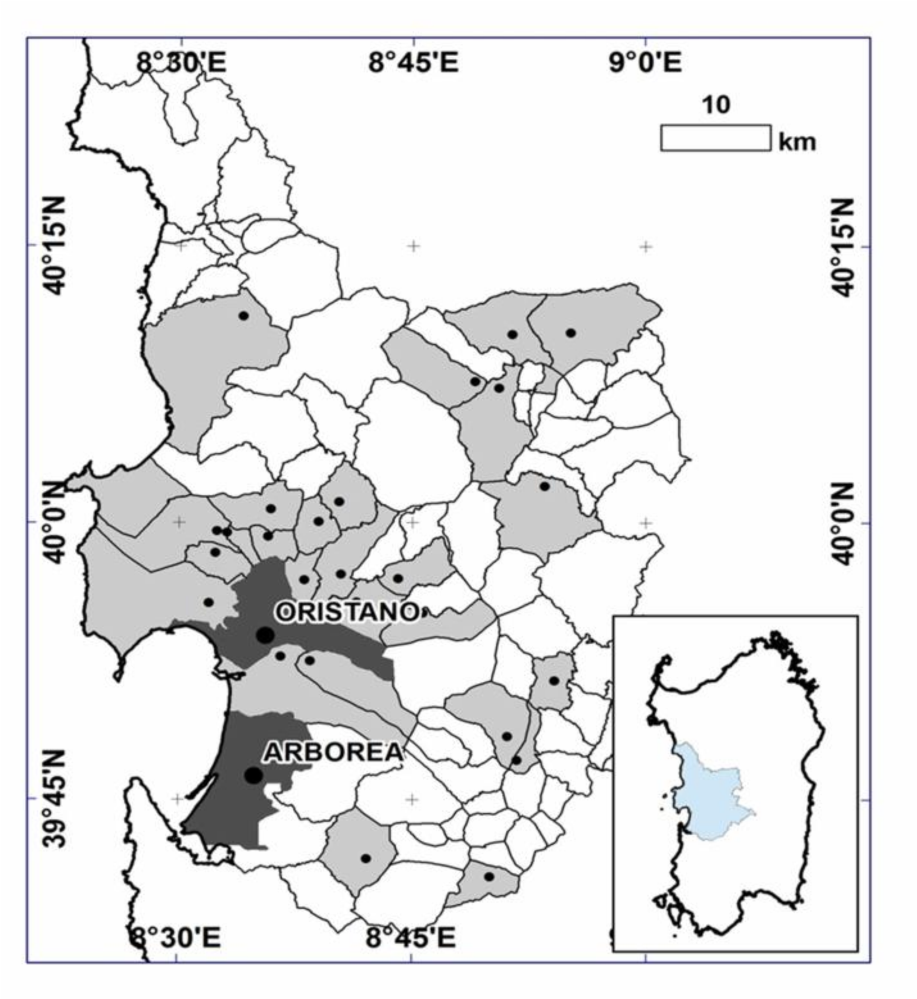


Figure 6. Map of interviewed communes .

When employing grounded theory techniques, the researchers continues to conduct interviews and questionnaires until there is repetition in expression of themes and little new content is expressed (Charmaz, 2006). The survey designed repetitively into 2 steps:

- Step 1: Twenty five semi-structured interviews (9 dairy cow farmers, 7dairy sheep farmers, 3 rice farmers, 4 horticulture farmers and 2 meat cow farmers) evaluating knowledge, attitudes and practices of farmers in perception of CC and adaptation to climate change. Farmers interviewed were randomly selected from the list of farmers provided by the Farmers' Union of Oristano.

  Checklists of these interviews include the following open questions:

To evaluate knowledge and perceptions of farmers, these questions were used:

(1) Respect to today, how was your production activity and your land in the past?
(2) Which have been changes in your activity and your land in the last 30 years?
(3) What has determined the change and evolution in your activity?

To understand their attitudes toward the socio-environmental changes, these questions were deployed:

(1) What do you think about these changes? Which are your prospective for future?
(2) For you, who should "manage" the changes in your land/territory?

At the end, these questions were asked to understand what they had done or are willing to do in order to adapt to the changes.

(1) What did you do/ will you do to manage the "changes" in your production activities
(2) Where did you seek/ will you seek information for planning your activity?

The information of twenty five semi-structured interviews was transcribed. One part of the interviews was analyzed using narrative analysis while all information was coded and translated as indicators for the questionnaires survey at the second step.

- Step 2: One hundred thirty eight farmers were randomly selected for 4 agricultural systems in Oristano (including: 27 dairy cow farming, 42 dairy sheep farming, 40 horticulture and 22 rice production proportional to the farmer numbers of each agricultural system. Questionnaires were distributed randomly to farmers by Arborea Cooperative, Confagricoltura Oristano and Consorzio Bonifica Oristano.

  The questionnaires were divided into 2 parts to acquire the following information: (i) personal and farm level information of respondent, (ii) perceptions, knowledge attitudes, practices of respondents about CC using Likert Type questions.

  Most farmers in Oristano are male, so that the percentage of female in the sampled population answering the questionnaires is very low (Table 3).

  Farmers interviewed by questionnaires have an age range from 20 to 70 years old. However, the dominated sampled population has a range from 40-60 years old. This means that lack of young generation participating in farming activities, except horticulture sector. This sector is considered as new in this area and also attractive to young farmers, around 50% of farmers having age from 30 to 50 years old participated in this activity according to sampled population (Table 4).

Farming System	Female	Male	Total
Extensive dairy sheep farming	1	41	42
Intensive dairy cattle farming	2	25	27
Horticulture	2	38	40
Rice production	3	19	22
Others	2	5	7
Total	10	128	138

Table 3. Number of farmer interviewed and gender.

Farming System	21 – 30	31 - 40	41 - 50	51 - 60	61 - 70	71+	Average Age
Extensive dairy sheep farming	3	4	16	9	7	1	49.0
Intensive dairy cattle farming	4	2	9	6	5	0	47.8
Horticulture	2	11	11	11	3	0	45.8
Rice production	2	2	10	5	2	1	54.4
Others	0	2	2	2	0	1	49.4
Total	11	21	48	33	17	3	49.3

Table 4. Age of interviewed farmers.

The sampled population of farmers showed that more than farmers have an education background of secondary school (more than 50%) and high school (around 25%). Several farmers have university degrees but the percentage is absolutely low (7%) (Table 5)

Farming System	n.a.	Elementary	High school	Secondary school	University degree	Total
Extensive dairy sheep farming	2	5	7	27	1	42
Intensive dairy cattle farming	5	5	2	14	1	27
Horticulture	3	3	9	23	2	40
Rice production	0	0	11	8	3	22
Others	0	0	1	3	3	7
Total	10	13	30	75	10	138

Table 5. Level of education of interviewed farmers.

The main water irrigation sources of farming activities in Oristano are: (1) from public authority (Consorzio Bonifica Oristano) and (2) from the wells. The sampled population showed that most daily cattle farmers (more than 90%) and rice farmers (more than 95%) mainly use water for their farming from the provision of Public Authority. While dairy sheep farmers and horticulturists use water for their farming activities and irrigation from both two sources. More than 50% of dairy sheep farmers and 40% horticulturists still use irrigated water from wells (Table 6).

Total cultivated area of the sampled population varies from 5 ha to 100 ha. However the horticulturists have their cultivated area ranking mainly from 5-30 ha, while total cultivated area of farmers from other farming systems (e.g. dairy sheep farmers, rice farmers) have a range from 10 ha to 100 ha, and dairy cattle farmers from 20 ha to 100 ha (Table 7).

Farming System	n.a.	Public Authority	Wells	Total
Extensive dairy sheep farming	0	20	22	42
Intensive dairy cattle farming	0	25	2	27
Horticulture	2	28	10	40
Rice production	0	21	1	22
Others	0	6	1	7
Total	2	100	36	138

Table 6. Typology of water sources used for irrigation (IWSC: Irrigation and water supply commission of Oristano, "Consorzio di Bonifica dell'Oristanese").

Farming System	Total cultivated area (hectares)									n.a.	Total
	1-2	2-3	3-5	5-10	10-20	20-30	30-50	50-100	100+		
Extensive dairy sheep farming	0	1	1	0	4	8	11	5	3	9	42
Intensive dairy cattle farming	0	0	0	2	1	5	8	5	2	4	27
Horticulture	2	0	1	4	14	6	2	1	0	10	40
Rice production	0	0	0	1	4	3	3	7	2	2	22
Others	0	0	1	2	1	0	0	2	0	1	7
Total	2	1	3	9	24	22	24	20	7	26	138

Table 7. Total cultivated area of each farm which has been interviewed (the lower limit of each class not included within the class itself).

The questionnaires were distributed randomly, however the sampled population represents all farm dimensions of dairy cattle farming system and dairy sheep farming from small, medium and large. Farms interviewed have total number of animals varying from 50 animal to 750 (or more) animals (Table 8).

Farming System	Number of animals								n.a.	Total
	<= 50	51-100	101-150	151-200	201-250	251-500	501-750	751+		
Extensive dairy sheep farming	2	6	7	7	5	10	1	2	2	42
Intensive dairy cattle farming	4	1	7	1	3	10	1	0	0	27
Total	6	7	14	8	8	20	2	2	2	69

Table 8. Total number of animals of each farm which has been interviewed (the lower limit of each class not included within the class itself).

The part 2 of the questionnaire was designed using a Likert scale. The questionnaires aimed to elicit responses that indicate degrees of support for or opposition to statement regarding the indicators on perceptions of CC extracted from the semi-structured interviews. The questionnaires was used by a five point Likert Type scale ranging from "strong disagree" to "strongly agree". Likert Type scales are commonly used in measuring behavior in psychological sciences (Likert, 1932). Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them, and so tapping into the cognitive and affective components of attitudes. Likert-type or frequency scales use fixed choice response formats and are designed to measure attitudes or opinions (Bowling, 1997; Burns and Grove, 1997). These ordinal scales measure levels of agreement/disagreement. A Likert-type scale assumes that the strength/intensity of experience is linear, i.e. on a continuum from strongly agree to strongly disagree, and makes the assumption that attitudes can be measured. Respondents were offered a choice of five pre-coded responses with the neutral point being neither agree nor disagree. Likert surveys are nowadays increasingly used to measure environmental responsible behavior (e.g.Sharma and Mark, 2002; Smith-Sebasto and D'Costa, 1995). Here, the respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements while responding to a particular Likert questionnaire item. The range of Likert Type captures the intensity of their feelings for a given item. However, the result of analysis of multiple items reveals a pattern that has scaled properties (Jamieson, 2004; Likert, 1932). Numbers assigned to Likert-type items express a "greater than" relationship; however, how much greater is not implied. Because of these conditions, Likert-type items fall into the ordinal measurement scale. Descriptive statistics recommended for ordinal measurement scale items include a mode or median for central tendency and frequencies for variability (Boone and Boone, 2012).

3.4.3 Phase 3: Theoretical and concept research

In the Grounded Theory Methodology, data suggests a theory, from which a host of points of view can emerge; each new perspective must be sampled to further ground the theory from all the different perspectives. Each new perspective can create a new theory thereby necessitating a theoretical sampling of each new perspective of each new secondary theory. Although the research tentatively selected the theoretical framework on social learning and adaptive governance at the beginning of the research, this theoretical framework was applied for directing the research approach rather than providing a hypothesis for the research question at the specific case study.

The research was followed Glaser (1998) by using theoretical coding, when they had finished the second phase of this research (through KAP surveys: semi-structured interviews to explore farmers' knowledge and perspectives; questionnaires to examine the consistence of information provided) which was selective coding, it has been tried to connect and explore the relationship between categories and their properties in order to develop the hypotheses leading to a theory. This was done according to the collected data and its analysis, and the memos which were created continuously during field work.

3.4.4 Phase 4: Scenario development

According to Glaser methods mentioned in Charmaz' book (2006) theoretical coding is a conceptualization of "how the substantive codes may be related to each other as sub-hypotheses/ hypotheses to be integrated into theory". Scenarios of adaptation to CC will be developed from the hypotheses generated from the theory generation process. Exploratory scenarios (as also known "descriptive scenarios"), which were selected to be used in this study, are developed from the present and explore trends into the future (what might happen in the future) (Börjeson et al., 2006). Since the scenarios created through this study will be mainly presented to a nonscientific audience (farmers, cooperatives, technical advisors and policy makers), qualitative method with some quantitative indicators , using a narrative element (storyline) to convey the main scenario massage, is selected to develop the scenarios.

Four main sources of information were used to provide the needed insight in the dynamic development of the four agricultural systems in the period covering approximately the last 30 years: a historical data on evolutions of the four systems, farmers' interviews, a questionnaires survey; and an interactive workshop.

Chapter 4: INTRODUCTION TO CASE STUDY

Chapter Structure

- Geographic characteristics of the study area
- Demographic and cultural characteristics
- Socio-economic sectors
- Weather and climate characteristics
- Environmental issues
    - Complex agro-ecologic Arborea and nitrate pollution issue
    - Management of irrigation water

4.1. Geographic characteristics

The research study area is located in the province of Oristano in Sardinia, Italy. (Figure 2, map). The province consists of 88 communes with the total area of 3040 km2 and the total population of 168,582 habitants. Orsitano is located in the center of Campidano Oristano plain and along the west coast of Sardinia. The province possesses 62 km2 of wet land (lagoon), 29 km2 of lakes and 104 km of river length. The main economic activities in this province are agriculture, aquaculture, agri-tourism, etc. Agriculture is the dominated livelihood of the local population. The main agricultural systems are intensive dairy cattle farming, extensive dairy sheep farming, horticulture, intensive rice and cereal production.

The farmers interviewed as part of this study took place in Arborea and surrounding communes. Arbore is a land drained and reclaimed in the 1920s to be devoted to agricultural production, mainly irrigated crops. A system of wetlands still exists in the area between the reclaimed land and the sea shore, and some were declared Sites of Community Interest according to the European Commission directive 92/43/EEC, and also Ramsar sites according to the Convention on Wetlands of International Importance. Many different activities take place in Arborea (dairy cattle production, agriculture, industries, tourism, etc.) and this imply the existence of a great number of interdependent stakeholders acting on the same area. Arborea is one of the most productive agricultural sites in Sardinia, and the productivity of its diary system is one of the highest in Europe (Manca, 2009). Water nitrate pollution of agricultural origin has been recognized as the most serious environmental problem in Arborea which has been, in fact, designated as the only Nitrate Vulnerable Zone (NVZ) in Sardinia (Regione Autonoma della Sardegna, 01/2005) in accordance to the ND implementation.

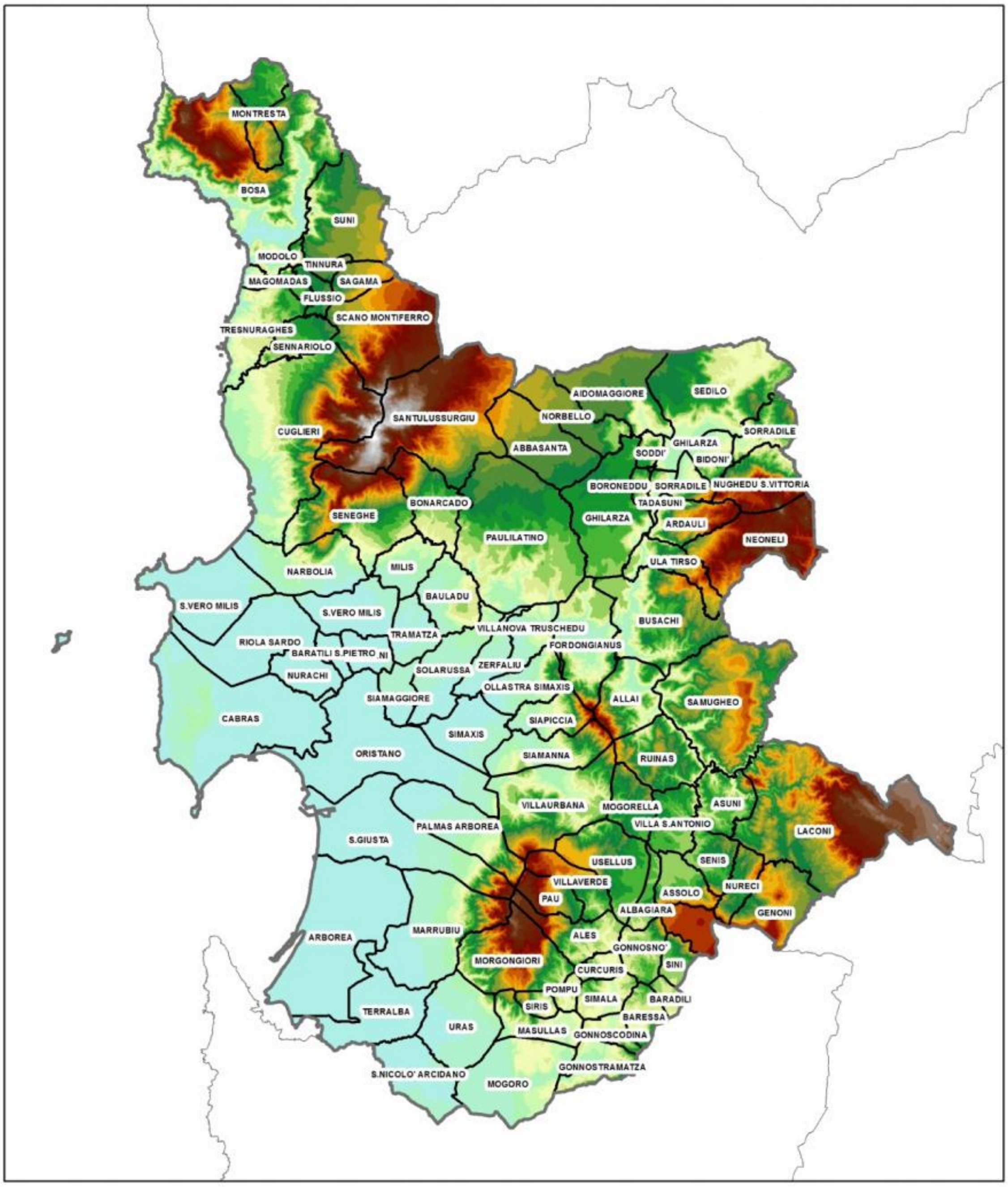


Figure 7. Case study map.

4.3. Demographic characteristics

The province of Oristano extends in an area equal to 3040 square kilometers, equal to 12.6% of the whole Sardinia Region and consists of 88 communes corresponding to 23.3% of the total number of municipalities of the Region plus further 47 villages for a total of 135 inhabited localities. Municipalities can be divided into three broad categories according to three altimetric ranges: those that are located at altitudes between 2 and 100 meters above mean sea level, those that lie between 101 and 300 meters and finally those that are located at a height of between 301 and 554 meters (Table 9).

No. of municipalities	Min Altitude	Max Altitude
31	2	100
33	101	300
34	301	554

Table 9. Number of municipalities classified by elevation ranges.

It is a province characterized by poor resident population centers distributed in small or very small towns: only 4 of these towns are exceeding 5,000 inhabitants. Taking into account the whole number of people, all the municipalities of the province can be divided into three main categories:

- 65 municipalities between 95 and 2.000 people
- 19 municipalities between 2.001 and 5.000 people
- 4 municipalities between 5.001 and 31.169 people

Oristano in 2007 was the third most populated Province after Cagliari and Sassari, while the fifth in term of territorial extent and the first in term of no. of municipalities (Table 10).

Provinces	No. of Municipalities	Population density people/km²	Surface Km²	No. of resident people
Cagliari	71	121	4.596	555.409
Carbonia Iglesias	23	88	1.495	131.074
Medio Campidano	28	68	1.516	103.727
Nuoro	52	41	3.934	161.929
Ogliastra	23	31	1.854	57.960
Olbia Tempio	26	43	3.397	147.387
Oristano	88	55	3.040	168.381
Sassari	66	78	4.281	333.576
Total	377	69	24.090	1.659.443

Table 10. Municipalities, their extent and population in 2007.

Based on the above mentioned indicators the population density per square km is equal to 55 inhabitants, below the regional average (69 inhabitants/km3), and the fifth if compared with the whole regional ranking.

According to ISTAT demographic data, population dynamics between 1991 and 2001 indicate a situation of depopulation. The sharp drop down in natural-residents, which is equal to -2.5%, is not compensated by the total migratory flow that represents only 1,2% of the population. The provincial growth is therefore negative (-1.3%) that is clearly contrasting with the positive figure +2.8%, the regional rate growth.

The resulting population dynamics is hence characterized by the increasingly intense concentration of human resources in working age, and in particular of the young population, along the coast and within hinterland of the town of Oristano mostly along the main arterial road which connects the north and the south of the island. 19% of the provincial population lives in the capital Oristano which recorded an increase of 5.8%. Oristano represents the gravitational pole the entire province. Its attractive force is determined by the central position, even at a regional level, by the presence of an industrial area, railway station and finally by the commercial harbor.

Along with the overall decrease in the total number of population of the province, there is an increase in the number of households, which rose from 55,714 units in 1991 to 59,847 in 2001 (an increase of around 7%). This increase is justified by the strong growth of single person households followed by a decrease in larger families. The trend is coming out from the progressive aging of the population and by a more widespread tendency to the formation of new small families.

4.4. Socio-economic characteristics

The Gross Domestic Product (GDP) is the total value of final goods and services produced within a country or within a specific territory in a certain period of time (usually a year) destined for final consumption. It is considered the measure of the wealth produced in a country. Moreover Added valueis the aggregate that allows you to appreciate the growth of the economic system in terms of new goods and services made available to the community for final use. It is given by the difference between the value of production of goods and services obtained by the individual branches of production and the value of intermediate goods and services consumed by them (raw materials and services rendered).

	Agriculture, forestry and fishing	Industry			Services	Total	Added value per capita (euro)
		Industry excluding costruction	Construction	Total Industry			
Sardegna	907.6	2827.7	1721.7	4549.4	24505.0	29962.0	17893.1
ITALIA	27655.2	261331.9	86203.6	347535.5	1035895.8	1411086.5	23238.3
Nord-Ovest	5367.8	104376.1	27115.3	131491.4	319791.0	456650.2	28251.1
Nord-Est	6945.6	77844.9	20185.2	98030.1	219235.8	324211.5	27831.1
Centro	4431.2	41500.1	18065.1	59565.2	240088.0	304084.3	25336.7
Sud/Isole	10910.6	37610.8	20838.0	58448.8	256781.0	326140.4	15599.2

Table 11. Added value at current prices by sectors of economic activity in 2011.

The distribution of the added value by sector is similar in Sardinia and the rest of Italy. The structure of the regional production system, as well as the national one, is characterized by a high share of added value in the services sector, 82% of the total. The lower the incidence of the industrial sector (9.5% in industry excluding construction and 6% in construction). The lower level is represented by agriculture (3%) (Table 11).

Regarding the Province of Oristano, in 2011, the province has produced 9% of the regional added value for a monetary value equal to about 2.5 billion euros. In per capita terms the wealth amounts to about € 16 per capita, lower than the regional figure. The percentage breakdown of the added value by sector provides a first indication of the territorial vocation of the province as well as the major determinants of wealth. The agricultural sector will remain an important economic sector and strategic for the local economy, with approximately 7% of the total added value, a percentage higher than all other provinces of Sardinia as well as of national level (Table 12).

	Agriculture		**Industry**				**Services**		**Total**		**Added value per capita (euro)**
			Industry excluding constructions		**Construction**						
	Values	%	Values	%	Values	%	Values	%	Values	%	
Oristano	190	7,1	173	6,5	148	5,5	2.149	80,8	2.660	100,0	16.048
Sardegna	908	3,0	2.828	9,4	1.722	5,7	24.505	81,8	29.962	100,0	17.893
ITALIA	27.655	2,0	261.332	18,5	86.204	6,1	1.035.896	73,4	1.411.086	100,0	23.238

Table 12. Added value at current prices by sectors of economic activity for the province of Oristano. Figures in millions of euro and percentage composition in 2011.

In 2012, the total number of firms registered in the Province equals 14,742. This figure decreased if compared to previous years. However, regarding the sectorial breakdown of active enterprises in 2012, it is clear the important role of agriculture, as already emerged in the analysis of the added value: the farms are in 2012 about 4,700, 35% of the total (Table 13).

Economic activity	**2011**		**2012**	
	Values	**%**	**Values**	**%**
Agricoltura	4834	35,58	4759	35,03
A01 Coltivazioni agricole e produzione di prodotti animali, caccia e servizi connessi	4748	34,95	4675	34,41
A02 Silvicoltura ed utilizzo di aree forestali	33	0,24	32	0,24
A03 Pesca e acquacoltura	53	0,39	52	0,38

Table 13. Active businesses by economic activity, 2011 and 2012 – AGRICULTURE.

In summary, agriculture continues to be an important economic vocation for the province, both for its ability to generate added value and for the level of diffusion of the industrial firms related to it. This seems to be, at present, the only "productive" sector on which it would be desirable to think about interactions with the industrial sector and tourism.

4.5. Weather and climate characteristics

The province of Oristano, in its basic features, is characterized by wet winter, uneven rainfall patterns, dry summer and constant wind frequency. Such dry summer subtropical climate, is also known as the "Mediterranean" climate because the land that borders the Mediterranean Sea is a type locality for this climate. According to Aschmann (1973) rainfall periods are concentrated to at least 65% of the total in the period between November and April and temperatures below 0° C are recorded during the year for a period of time not exceeding 3% of the total and not more than 262 hours.

Averaged over the period under consideration (1959-2011), the lowest average max and min temperatures occurs in January with the values of 14.1° C and 5.5° C respectively, while the average is highest in August respectively with values 31.0° C and 18.1° C (Figure 8).

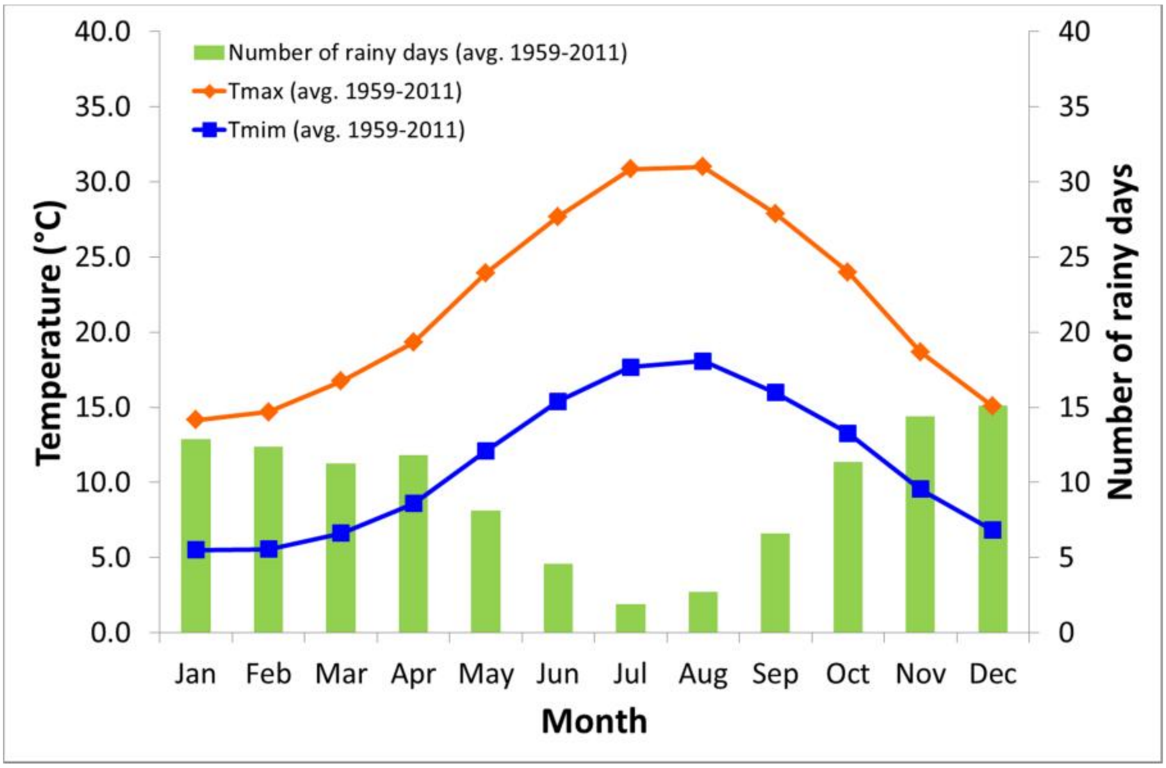


Figure 8. Average maximum and minimum temperatures averaged over the period 1959-2011 and number of rainy days for the same period. Data source: Santa Giusta Meteorological Station. Own elaboration.

As shown in Figure 9, the rainfall is concentrated in the autumn and winter, even if in spring rains are not uncommon. Summer is instead characterized by the almost total absence of precipitation. It is also clear how the rainfall is not, for the area, poor in absolute terms, but unevenly distributed, making necessary the restoration of soil water content for agricultural practices. In winter, however, the water is dispersed in part because they exceed the water retention capacity of the soil and are not useful for agricultural purposes.

Yearly deviations of rainfall values, however, are such that the amount of rain in some years may exceed twice or be less of the half than the average. Deviation of 25-30% from the average must then be considered as normal.

The hourly rainfall intensity reaches high levels, especially in the first phase of the rainy season, the beginning and the end of the rainy season is also quite irregular. December is generally the wettest month.

The average duration of dry periods is such that agricultural development is conditioned by the possibility of using water for irrigation.

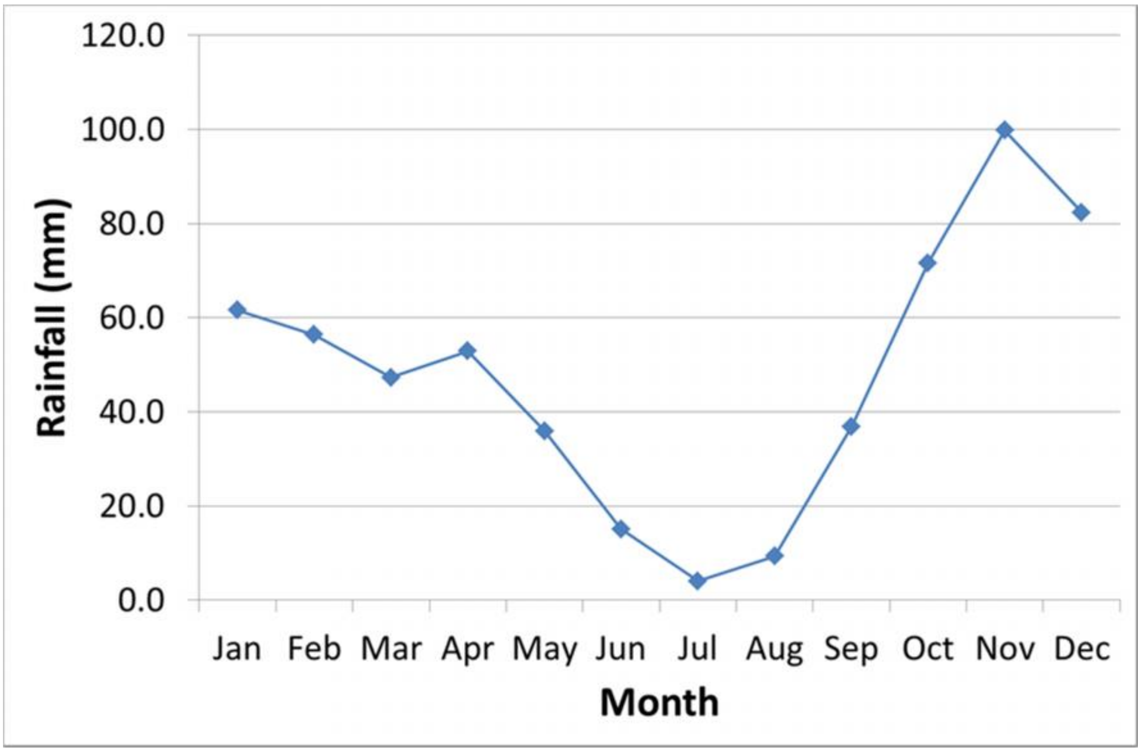


Figure 9. Trend of average rainfall averaged over the period 1959-2011. Data source: Santa Giusta Meteorological Station. Own elaboration.

4.6. Agricultural systems in Oristano

The agricultural systems of the Province of Oristano are distributed in according to the diversity of climates, soils and the morphology of the province. They are divided into 3 main macro systems:

- Irrigated farming systems locate mainly in the plain area in high Campidano. They include rice production, horticulture, forage cropping systems and cereal production. Animal husband activities are mainly intensive dairy cattle farming based irrigated forage systems (mainly in Arborea district) and semi-extensive dairy sheep farming. Irrigated water is provided and managed by the Land Reclamation Oristano (Consorzio di Bonifica di Oristano), an organization that manages the irrigation infrastructure and water supply for irrigation.
- Rainfed farming systems locate in the hilly and mountain areas of the province where there is the lack of irrigation resources. The main cropping systems in the hilly areas are "dry" cereal and forage crops that depend mainly on rain water. However semi-irrigated horticultural and forage farming can be found in the open fields where farmers use ground water from wells for irrigation. Livestock raising in these areas is both extensive and semi-extensive dairy sheep farming based on permanent pastures and grazing areas. In the mountain areas, the main agricultural systems are extensive beef cattle, sheep and goat farming based on permanent grazing areas.
- Tree crop farming systems well spread in the whole province. The crops include olive, vine grapes and fruits, etc. The characteristics of these production activities are family-run, small and fragmented area located. There are also some forestry activities in the mountain areas due the territory is a widespread presence of both natural and planted forests.

4.7. Environmental issues

4.6.1. Complex agro-ecological Arborea and nitrate pollution issue

Arborea was drained and reclaimed in the 1920s for agricultural production, mainly of irrigated crops. A system of natural wetlands still exists in the area between the reclaimed land and the sea shore, and a parts were declared Sites of Community Interest according to EU Directive 92/43/EEC, and also as Ramsar sites under the Convention on Wetlands of

International Importance. Many different activities take place in Arborea (including dairy cattle production, cropping, industry, aquaculture and tourism) and this implies multi-stakeholders acting in the same area. Arborea has become one of the most productive agricultural sites in Sardinia, and the productivity of its dairy cattle system is considered one of the highest in Europe (Manca, 2009). The forage cropping systems for the dairy livestock are based on the double cropping of silage maize, Italian ryegrass *(Lolium multiflorum)* for hay or a winter cereal for silage, representing over 80% of the irrigated land, the remaining land being used to grow Lucerne (*Medicago sativa*) and horticultural crops. The business as usual (BAU) fertilization practice before the implementation of the ND was designed to achieve maximum dry matter yield, particularly from silage maize. The fertilization scheme included the disposal onto the farmed fields of the entire produced amount of slurry and farmyard manure, which approximately corresponded to an average of 300 kg ha^{-1} of N from slurry (about 70% to maize, 30% to the winter crop) and a supplementary fertilization with mineral N to fulfil crop requirements at the beginning of stem elongation for each crop. The total N therefore rates ranged from a minimum of 350 to a maximum of over 650 kg ha^{-1} $year^{-1}$.

Water nitrate pollution of agricultural origin has been recognized by ARPAS as the most serious environmental problem in Arborea, and it has been designated as the only NVZ in Sardinia (Regione Autonoma della Sardegna, 01/2005) under the ND. The nitrate pollution problem initially was considered to be mainly associated with the highly intensive dairy cattle farming systems (170 dairy cattle farms and 35000 cows in 5500 ha), shallow water table and sandy soils (more than 90% of sand).

The implementation of the ND has resulted in a series of obligations related to the distribution of organic effluents (slurry and manure) such as a maximum N rate of 170 kg ha^{-1} $year^{-1}$ from organic fertilizers, a ban on the spreading of organic fertilizers during winter from the 15^{th} of November to the 15^{th} of February and compliance with the GAP Code. The prescribed maximum N rate is less than the N requirements of the intensive forage cropping systems that supply the dairy farms (e.g. maize and ryegrass), while the high annual output of animal effluents at each farm exceeds the ND's prescriptions. This has meant that the farmers on the one hand have to purchase mineral nitrogen fertilizers to meet the total N crop requirements, thus increasing production costs and, on the other hand, when the farm size is insufficient for effluent spreading they have to pay for transporting the excess manure and slurry or they have to rent land outside the NVZ. This situation clearly is unsustainable and has given rise to controversies about whether the measures envisaged by the legislation are appropriate to achieve the goals of reducing nitrate pollution of agricultural origin, and to maintain profitability of this important dairy sector.

The implementation of the ND has resulted in intense polemical discussion and controversies in various public fora (Soru, 2006), with among farmers, fishermen and environmentalists taking divergent positions. The main challenge for policy-makers is to discover ways to bring about a convergence between the economic goals of the intensive livestock farming system, compliance with the necessarily stringent standards for the distribution of animal effluents under the ND, the maintenance of downstream production activities such as aquaculture, and environmental protection of the vulnerable wetland system surrounding the agricultural areas.

Previous and on-going studies (e.g.Magni et al., 2008; Sechi et al., 2001) on environmental pollution has been carried out in Arborea and its surroundings by a large number of local research institutions and universities. Various scientifically-based attempts to identify alternative land use options have been made in order to solve the nitrate problem. Moreover, no clear evidence has been found of a correlation between water pollution and the downstream farming and livestock activities, and scientific knowledge has not been sufficiently disseminated to local stakeholders in order to mediate the controversies.

4.6.2. Management of irrigation water

Similarly in the whole island of Sardinia, irrigated water in Oristano is managed by ENAS (Ente Acque della Sardegna). ENAS sells water to Consorzio di Bonifica (Land Reclamation authorities) and these water supply authorities will supply water to farmers. Therefore the cost of water sold to farmers includes the original cost made by ENAS plus costs of energy and labour for management of the distribution network. Since the region of Sardinia provides irrigated water subsidies to farmers through projects carried out the Consorzi di Bonifica, these local water supply authorities fixed a price of irrigated water per hectare of 200 euros (which includes all costs minus subsidies from the region authority) for all kinds of crops.

In Oristano there are still many farmers using irrigated water from wells who are dealing with the problem of water scarcity probably due to CC or droughts, however water supplied by Consorzio Bonifica Oristano hasn't reached to most farmers where irrigation infrastructure systems are not available.

According to Sardinian regional law, the Consorzio Bonifica is responsible for agricultural irrigation, but not land reclamation. However, within the Consorzio Bonifica Oristano there is no representative of farmers in management and monitoring of irrigation systems.

Chapter 5: STAKEHOLDERS AND FRAMES

This result has been published in:

- Nguyen.T.P.L., Seddaiu. G., Roggero. P.P. (2013). Hybrid knowledge for understanding complex agro-enviromental issue: nitrate pollution in Italy. International journal of agricultural sustainability. http://dx.doi.org/10.1080/14735903.2013.825995
- Allan, C., et al., 2013. Integrating local knowledge with experimental research: case studies on managing cropping systems in Italy and Australia. http://www.agronomy.it/index.php/agro/article/view/ija.2013.e15/493.

Full information on the theoretical framework, methods, results and discussions of this chapter will be fully found in the above two publications. In this thesis, only the stakeholders and their frames associated with the complex agro-environmental issue at the selected study area of Arborea are present briefly in the next pages.

"The path is made by walking". African proverb

5.1 Stakeholders

The stakeholders of the Arborea system were identified by their possession of attributes based on the idea of what a "stake". These attributes have been used to develop a stakeholder map in order to capture who are the stakeholders in the system of interest of the case study and which is their frame as interpreted by researchers. The nitrate issue is a concern for several actors as reported in Figure 10.

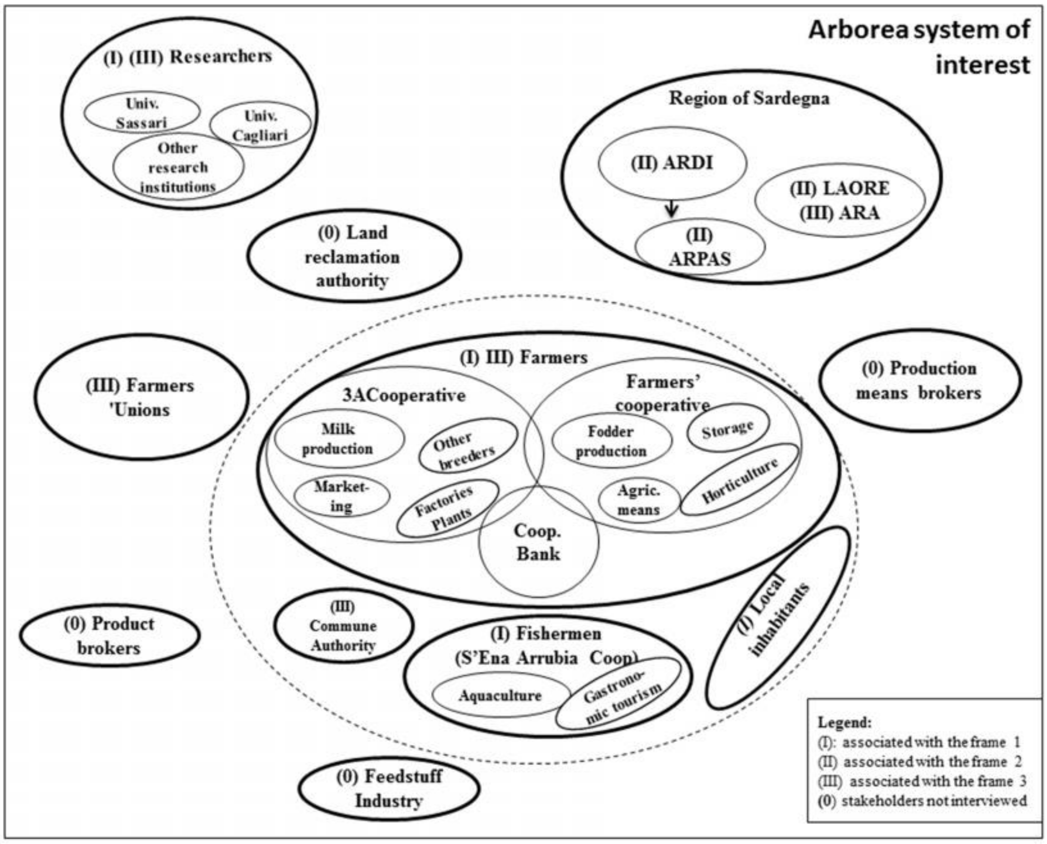


Figure 10. Stakeholder map.

The map is constituted by two groups of insiders and outsiders. Insiders are local economic groups such as fishermen, farmers, who are experts in the area settings, know from personal experience how things work and are focused on solving practical problems related to the nitrate pollution issue. The outsiders, i.e. policy makers and researchers, possess their frameworks and theories to design and carry out research/policy about the problem in hand.

5.1.1 The insiders

Fishermen: The most vulnerable segments of the population residing downstream to the Arborea. The S'Ena Arrubia Cooperative was founded in 1953 by 35 members, today only 19 remain because of the crisis of the aquaculture sector. One of the reasons for this situation is in part related to the economic losses because of occasional fish mortality associated to the downstream water pollution of livestock and agriculture origin. Fishermen directly blamed livestock and agriculture activities to be one of the main causes of the crisis. In an interview with the S'Ena Arrubia Cooperative, one of the members said "Water today arrives in ponds not clean and polluted because of fertilizers used" or "we are in a vulnerable position because our activities are in downstream of the system and suffer from pollution caused by agricultural inputs and animal husbandry discharges". Furthermore, fishermen claimed the role of CC as another constraint for their activity (one fisherman said: "because of high temperature, the fish mortality in summer is higher. And there is also a pre-existing cause between pollution and high temperature leading to an increase of temperature in the ponds") that it is interdependent to water pollution and to the low intake of fresh water.

Fishermen are quite resigned for the future of the their activity since they feel to have low political voice, as they explained: "we do not have much political and economic weight as we are fewer than farmers. Therefore, we never have the chance to talk about aquaculture at political level".

Farmers: The dominated population in Arborea. Most of farmers own intensive dairy cattle farms. The majority belong to both the Farmers' Cooperative (Coop Produttori) and the Milk transformation Cooperative (Coop 3A). The interviews with farmers revealed that there is a range of competencies amongst bovine farmers in relation to husbandry techniques and agronomic practices but many of those interviewed are professional, highly skilled and have good relationships with local and, some of them, also with regional policy makers. For some farmers, there is clear evidence that the area of Arborea is vulnerable to nitrate pollution because of the sandy soils and the shallow water table. These farmers consider the ND as a good opportunity to reduce nitrate pollution and to trigger an improvement in the farming practices, as one farm owner said "for me, all interventions done under the ND are useful. I consider myself fairly sensitive to this issue, but I am only one among few sensitive people here in Arborea". Indeed, not all farmers are sensitive and aware about endangered agro-ecosystems and emergence of system conservation. Most of them put their economic interest as a priority, as the cooperative president remarked: “Some farmers regardless the ND obligations continue to throw the extra-animal wastes directly in the channels. The cooperative has promoted an internal initiative to better manage the livestock effluents”.

However, some other farmers do not consider their farming activity neither as a direct cause of nitrate pollution nor as having negative impacts on the aquaculture activities, as one farmer stated:

> The fishermen have no the ability to make investments, and to look ahead, but instead they just complain. They should better try to adapt to environmental changes. .

Farmers blamed the lack of innovation of fishermen and the ecological characteristics of their area rather than their own farming activity. On the contrary, most of farmers have a high attitude toward technological innovations and they believe that there are opportunities to improve their farming practices to address the nitrate issue, for instance reducing the irrigation for maize. At the same time, there is uncertainty about the long term impact of the ND application on crops productivity. In fact, they claimed that reducing the amount of organic fertilizers it would decrease the soil organic carbon content and, thus, the soil fertility.

These uncertainties and worries encouraged farmers to seek research for a derogation of the ND for their local specific context. Therefore, farmers supported the experimental research in order to analyze the effects of the ND and to obtain information potentially useful to both improve their farming techniques and possibilities for applying nitrate derogation.

Arborea commune: it has been considered the commune authority as an insider since it is responsible for the implementation of political and administrative related- issues of all socio-economic sectors in the commune. It is interesting to highlight that none of the interviewed representatives of the commune raised the issue of nitrate pollution in the area, but they emphasized the strategic role of the dairy cattle farming system since it contributed to the socio-economic development and leaded to positive changes of society in term of employments. For example, one interviewee stated: “today, milk and dairy products of Arborea are sold by the cooperative not only in Italy but are also exported abroad. The strength of the products is the high quality of products as livestock farming is very advanced in Arborea". Although the commune authorities did not explicitly mention the nitrate problem and the impact of the ND prescriptions, they talked about the crisis of the livestock farming system as one of them remarked: "The cow milk producers are still experiencing a crisis because of the rising of production costs ".

5.1.2 The outsiders:

Regional policy makers: Regional Department of Environmental Protection (RDEP) is the authority responsible for environmental political issues at regional level, which includes nitrate pollution management. To implement the ND, RED strives to draw up every 4 year action programmes containing mandatory measures concerning the storage and application of liquid manure, natural and chemical fertilisers for NVZ. The Regional agency for environmental protection (ARPAS) is the technical agency that supports the RDEP in sustainable management of natural and human ecological systems. The ARPAS provides technical and scientific assistance to the local administrative authorities in: i) controlling origins or sources of environmental pressures driven by human activities ii) monitoring environmental conditions and iii) supporting the regional government in defining the responses to cope with the pressures and improve the environmental status. The ARPAS strongly supported the field experiment for assessing the effectiveness of the ND application.

Intermediate technical organizations: They are technical advisors in agricultural farming and environmental monitoring. They represent not only agricultural interests of the farmers but also various regional political interests.

- Sardinian regional agency for Agricultural Policies Application and Rural Development (LAORE) is an interface organization between research and agricultural development. It involves actively in implementation of ND in Arborea in promoting "good practices" to reduce the environmental impacts of agricultural activities and nitrate pollution from livestock raising activities.
- Farmers unions (Coldiretti, CIA) represent farmers' voices and provide technical support to farmers to ensure agricultural development and environmental conservation.

These organizations are actively supporting the experimental research on the nitrate issue in order to find future solutions from the point of view of improving production, controlling environmental pollution and reducing production costs in term of purchasing mineral fertilizer as well as effluents transport, and particularly to ask for the derogation of the ND for the area of Arborea.

Researchers: Several past and going researches on environmental pollution have been carried out in the Arborea and its surrounding by a large number of local research institutions such as the two Sardinian Universities, the Institute for Coastal Marine Environment of the National Research Council and some regional research Centres (e.g., Centre for Advanced Studies, Research and Development in Sardinia; International Marine Centre). These researches focused on creating scientific knowledge/information through experiments, investigations and monitoring rather than understanding local socio-political elements of the issue. They are independent to each other and were mainly concentrated on specific sectors. Understanding the impacts of land use activities on surface and ground water quality (Cau and Paniconi, 2007; Ferrarin and Umgiesser, 2005) and on several organisms in the marine and lagoons water (Magni et al., 2008; Sechi et al., 2001) are the centre of these researches. The studies were occasionally developed to answer some specific ecological problems, such as the fish morality in July 1999 and August 2004 and other anoxia events in the lagoons and coastal marine ecosystems. Some attempts of indentifying alternative land use options in order to solve the nitrate problem were also made such as shifting intensive agriculture and dairy farming activities away from the coastal plain where adverse impacts on aquifers and lagoons have been documented (Cau and Paniconi, 2007).

Another study on the N volatilization losses before the slurry distribution (Atzori et al., 2009) was done. The mean annual N volatilization coefficient of 41% of N excreted in lactating dairy cow bedded-pack barns was estimated, which is higher than the 28% suggested by Italian regulations. This means that the actual N loads from animal effluents are likely to be lower than those assumed by the ND prescriptions.

Despite the numerous researchers have interests in Arborea, no concrete evidences were obtained so far to directly correlate the dystrophic events, causing fish and other organisms mortality as well as water pollution.

5.2 Interpretive frames

The stakeholders in the case study of Arborea were identified by attributes based on the idea of what is 'at "stake'. These attributes were used to develop a stakeholder map (see Figure 3) in order to capture the identity of (i) stakeholders in the system of interest and, (ii) their frames of reference. The main stakeholder groups were found to be fishermen and farmers, who are experts in the use of the natural resources of the area, who know from their personal experience how inter-dependent natural and socio-economic cycles work in terms of their own farms, and who are focused on solving practical problems related to the nitrate pollution issue. The majority of farmers belong to the Farmers' Cooperative (www.produttoriarborea.it) which is responsible mainly for purchasing inputs, technical assistance and product marketing, and to the Milk Processing Cooperative (3A, www.arborea.it), which processes and sells milk products. Most farmers in Arborea belongs to Farmers' Unions which provide technical and administrative support to farmers to ensure, for instance, access to EU and national and regional subsidies and the development of agri-environmental measures through negotiation with the regional government. Other important stakeholder groups include policy makers and researchers, whose frameworks and theories support the evolution of policy and the design and implementation of research about the nitrate issue and agricultural development more generally. Among the decision makers and implementers, the Regional Agency of Hydrographical District (ARDI), ARPAS and Regional Agency of Agricultural Policies Application and Rural Development (LAORE) and Regional Animal Husbandry Association (ARA) were found to play an important role in ND regulation and implementation at local scale. ARDI has a technical and operational role for protecting water ecosystems and for water-related policy measures. ARPAS provides technical support to the Sardinian government in the control of the application of agri-environmental measures at farm scale and in monitoring water quality in wells, channels and wetlands. LAORE and ARA are intermediate organizations positioned between research and agencies for agricultural development, policy makers and farmers.

The definition of the nitrate issue that emerged from the information collected through the semi-structured interviews and the interactive workshops, can be described according to three main frames:

- The first frame is called “vulnerable agroecosystems”. It was mainly associated with fishermen, some researchers and about 10% of farmers interviewed and involved in the workshops. In terms of this frame, intensive dairy cattle farming system is considered to be the main source of nitrate pollution and as potentially harmful to other economic sectors like aquaculture and to Arborea’s agro-ecosystems. For example, some of the interviewed fishermen pointed to the role of livestock practices on downstream water pollution as follows: *“nowadays the water that flows into the aquaculture ponds is not clean but polluted because of the excessive fertilizer rates*” and “*we are in a vulnerable position because our activities are located downstream of the system and suffer from pollution caused by agricultural inputs and animal husbandry discharges*”. According to them, although the dairy sector is an important activity that contributes to the socio-economic development of the area, these economic values should not be prioritised others, like social and environmental values. The fishermen believed that because of the importance of dairy activities to the area, farmers had gained political and economic power; as one fisherman said: “*we do not have much political and economic power like farmers. Therefore we never have chances to talk about the future of our activity at political level”.* Within this frame, ND is considered useful to reduce nitrate pollution, to preserve vulnerable ecosystems and protect other traditional economic activities in the area such as aquaculture. One farmer in this category said “*I consider myself fairly sensitive to the nitrate pollution problem and I think that the ND has been useful to avoid the irrational use of the animal effluents*”.
- The second frame, “political and technical management”, was articulated by decision makers and implementers of ARDI, ARPAS and LAORE. The main emphasis in this frame is put on the political and legal measures as well as on technical strategies to reduce nitrate pollution, such as, for example, the action programmes governing the storage and application of organic fertilizers. Intensive dairy cattle farming is accepted as a part of the socio-economic development in the area but responsibility if placed on farmers to fulfil the obligations required under the ND. Thus farmers should be prepared to for instance, reduce stocking rates. As one official of the ARPAS stated: *“it is necessary to obtain an equilibrium between dairy and aquaculture sectors, however, we need to fulfil the objectives of the Sardinia Region in controlling and monitoring the nitrates*”. In addition to legal controls, technical approaches, like monitoring and modelling techniques for assessing environmental impacts, are considered the main

means for improving water quality. For example, when discussing the issues regarding a possible request for ND derogation, one representative of ARDI remarked: *“.... to produce scientific documents supporting the nitrate derogation request, we can hypothetically propose a project, however this project must contribute to Action programmes and nitrate controlling home-works as well as to new techniques and technologies for nitrate monitoring*”.

- The third frame, “the livelihoods of the majority of the population in the area”, was strongly associated with dairy cattle farmers, farmers’ unions, agriculture extension agencies, some researchers and the local political-administrative organisations. According to this frame, the dairy cattle system is a major provider of livelihood, as the vice mayor of Arborea commune stated: *“The dairy farming has positive effects on the territory including creating jobs. For example, the milk processing factory (3A Cooperative) produces 90% of the total Sardinian dairy cattle milk ....”*; and *“nowadays milk and dairy products of Arborea are sold not only in other regions of Italy but also abroad”.* This frame separated clearly environmental interests and economic development, emphasizing the dairy farming system as an important livelihood and employment opportunity for the majority of the local population. Stakeholders within this frame believe that it was important to find convergent solutions for agro-ecosystem conservation and livelihood. Members of this group of stakeholders strongly believe in collaboration with NRD’s research group to find more sustainable options for nitrate management at farm and field scale. The environmental impact of the dairy cattle farming system is recognized within this frame but the ND was not considered a desirable policy measure for reducing nitrate pollution since it affects the traditional livelihood of a large part of the local community.. For example, some farmers claimed “*we are trying to abide by the ND prescriptions, however, economically not everyone can adapt to these changes*”. Local knowledge and farmers’ everyday experiences are seen as important sources of information that needs to be integrated with scientific experimental knowledge in order to comprehend the complexity of the nitrate issue as well as to elaborate more suitable agronomic practices and environmental protection measures. Stakeholders in the third frame, especially farmers and agricultural extension agencies, emphasized the importance of understanding local ecological conditions when proposing suitable agri-environmental measures. As many farmers remarked: ”*our soils are being extremely exploited due to* *the intensive dairy farming activities but it is important to acknowledge the sandy nature of our soils, that strongly influences the vulnerability to nitrate pollution*".

Chapter 6: FARMERS' PERCEPTION AND DECISION MAKING IN ADAPTATION TO CC

Chapter Structure

- Introduction
- Theoretical framework: Perceiving the environment and adaptation to climate change
- Methods
- Results
  - Farmers perception of climate variability and change
    - Farmers' perception of CC from their narratives
    - Farmers' perception of CC from Liker Type questionnaires
    - Farmers' experience about climate impact on farming systems
    - Farmers' perception of climate impacts on farming systems
  - Farmers' adaptation to climate uncertainties
  - Analysis of long term changes in climate
    - Inter-annual rainfall (1959-2011)
    - Mean inter-annual rainfall (1959-2011)
    - Annual mean monthly temperatures (1959-2011)
- Discussion
  - Factors influence farmers' perceptions
  - Farmer's decision in adaptation to climate change
- Conclusion

"Knowledge begins with perceptions…" (Gibson, 1986)

6.1. Introduction

CC is raising significant issues for European agricultural adaptation strategies. Although it presents both challenges and opportunities to agricultural systems (EC, 2009), agriculture development will continue to deal with surprise. European agricultural will face serious challenges in the coming decades, such as competition for water resources (Koutroulis et al., 2013), combating invasive exotic plant species (Bardsley and Edwards-Jones, 2007), rising costs due to environmental protection policies, and uncertainties in the effectiveness of current European policies as adaptation strategies (Olesen and Bindi, 2002).

As farming activities depend on climate condition, such changes in climate and bio-physical factors are perceived by farmers through their daily to daily interaction with environment. The emerging reality of CC potentially increases the level of farmers' concern about the issues of agricultural sustainable practices in term of mitigating emissions of carbon dioxide, nitrous oxide and methane as well as adapting to the impacts of CC (Fleming and Vanclay, 2010). However, farmers' decision about managing their farming activities in the framework of the "so called sustainability" are plagued with uncertainty. They need to undertake continual adjustment to their practices to adapt to uncertain future because predicting the future is regarded as impossible (Audsley et al., 2006).

Farmers' decision are traditionally made based on the aim of maximizing the profit they achieve from the farming activities taking into account the factors of markets, subsidies, grants and restrictions. But in the world of changing climate, their decisions have to be taken considering the factors of climate uncertainty. CC involves uncertainty about the current state of the environment and there will be further uncertainty about future state of the environment (Dessai and Hulme, 2007). Uncertainty leads farmer perceive their farming activities as unpredictable. Farmers may feel uncertain about investment on their activities. Unpredictability may push farmers to adopt/not adopt agricultural practices, introduce/not introduce new changes in technologies, remain at the same place where they are or abandon farming activities.

Understanding farmers' perceptions of CC will help to understand their behaviors in adjustment they have made/ will make in their farming practices in order to response to consequences of CC (Tambo and Abdoulaye, 2013). In this research, it has been analyzed how farmers' decision making is shaped in the context of changing climate. Using empirical data from a local case study in Oristano (Italy) it has been sought to answer the following questions. (1) What are farmers' perception of climate change? (2) How does farmers' perception influence their farming decision? Factors that influence perceptions of farmers and the complex relationship among CC perception and practices of adaptation to CC at farm level were also discussed. Finally, the research suggests several implications for European adaptation strategies.

6.2. Theoretical framework: Perceiving the environment and adaptation to climate change

Perceived CC has been identified as the main motivator for adaptation (Frank et al., 2011; Tompkins et al., 2010), and the more dramatic climate-related stimuli are important for motivating adaptation responses in human systems (Berrang-Ford et al., 2011). Human systems are adapting and will have to adapt to climate change. Adaptation of CC is as a co-evolution process (Collins and Ison, 2009b) entails several phases from perceiving, practicing and transforming. Perception of CC is a process by which individuals learn and interpret their sensory impressions in order to give meaning to their environment under climate conditions (Kellman and Massey, 2013). Many studies emphasize the role of proximity and common sense perception in people' interpretation of the physical world around them (Bickerstaff, 2004; Bickerstaff et al., 2003). The perceptual adaptation is a complex, adaptive and co-evolved process with continues to be closely connected to many other systems such as ecosystems (Johnston et al., 1998). The indirect theories of perception (e.g. Rock, 1983) emphasized the importance of cognitive process in enriching and making sense of visual stimuli. Although the direct theory of perception (Gibson, 1986), where information is picked up directly from the environment and percepts are not mediated by any cognitive processing, it lies on the conception of visual learning that learning is a process of turning the perceptual system to become more sensitive to information present in the stimulus. In Gibson's book "*the Ecological approach to visual perception*" he argued that knowledge begins with perception and perception of the environment would be a subset of a broader class of perceptual experiences. Scientists who study perception and sensation have long understood the human senses as adaptations. The process of adaptation to CC (Figure 11) is a consequence of perceiving process affected by socio-cultural experiences so that adaptation process involves the creation of knowledge (Nguyen et al., 2013), individuals assess the salience, credibility, and legitimacy of available of information (Cash et al., 2002).

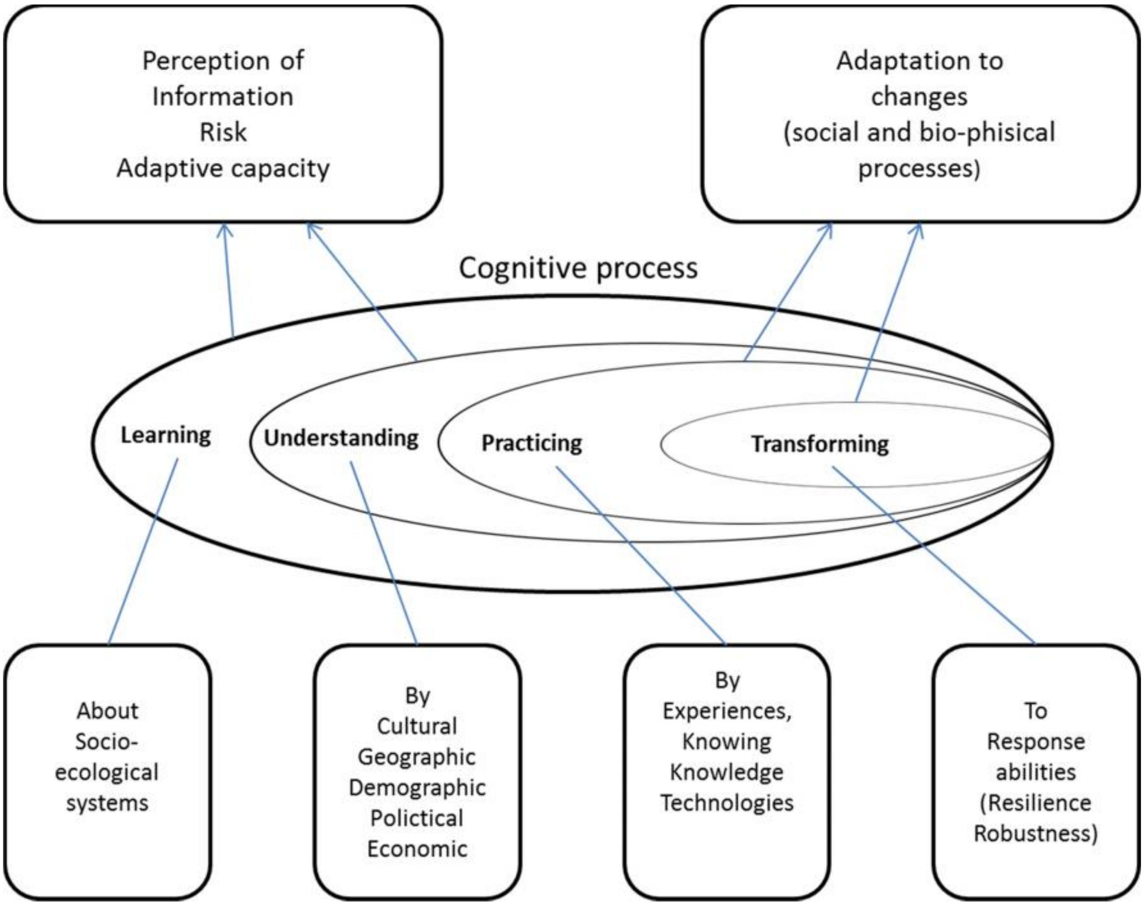


Figure 11. Conceptual model of perceptual adaptation to climate change.

In agriculture, perception plays a crucial role in farmers' choices of their farming activities. Their daily decision is based on the perception they construe. Farmers' adaption to CC could be explained by several factors: experiences with climate pressures, key climate extreme events and socio-political and economic conditions, knowledge and information that in combination persuaded farmers of the need for action. Farmers not only adapt to information about CC but also by their direct experience with impacts of CC leading to their production loss. According to (Frank et al., 2011) the process of adaptation is resulted by the perceiving process that includes perceptions and evaluation of information, and also by perception of one's own capacity to adapt, or self-efficacy. Perception determines the acceptability of adaptation measures posed by policy domain, despite the fact that all adaptation made by human systems and occurred within a social context. (Tam and

McDaniels, 2013). According to Ivrin Rock theory, adaptation made within the context of the everyday world are more complex. Space, time, body schema, auditory and visual adaptations are ongoing processes that take place throughout the day. There is an increasing study of human adaptation to CC based on the perception of environment in which they interact that leads to their decision making (e.g. Buys et al., 2012; Grothmann and Patt, 2005; Ratter et al., 2012),

In this research, it has been tried to emphasize the necessity of environmental epistemology and to pay attention to psychological and epistemological factors in the study of farmers' perception of CC and their adaptation. Studies of farmers' perception of CC must rely more and more on the systemic approach (Collins et al., 2007; Ison et al., 2013; Ison et al., 2011; Pahl-Wostl et al., 2010; Prell et al., 2008) as perception concern about the complex dynamics of human bio-pyscho-socio-cultural change (Laszlo and Krippner, 1998).

6.3. Research methods

The research examined farmers' perceptions and adaptation to climate changes of farmers of four main farming systems in Oristano including intensive dairy cattle farming, extensive airy sheep farming, horticulture and rice production.

Step 1: Semi-structured interviews (n=25) to evaluate: (1) Farmers' perception of CC and variability including climate extreme events and climate impacts on their farming systems , (2) Farmers' practices to respond to climate/ weather extreme events. A total of 25 interviews were made comprising 9 dairy cow farmers, 7dairy sheep farmers, 3 rice farmers, 4 horticulture farmers and 2 meat cow farmers. They are all male, aged between 35 and 55 years as women do not participate in the farming activities in Oristano.

Farmers' perceptions were sought by means of open ended questions on their observations/experiences of long-term changes in climate and weather. The questions were posed to interview:

(4) Respect to today, how was your production activity and your land in the past?
(5) Which have been changes in your activity and your land in the last 30 years?
(6) What did you do/ will you do to manage the "changes" in your production activities?

Farmers' narratives were recorded and transcribed. The use of narrative analysis (Lejano et al., 2013) aimed to focus on the ways farmers made and used stories to interpret their world and link the past to the present. Although there was no question specific problems related to climate or weather change, farmers still talked about weather and climate. Farmers expressed about temperature such as it has become warmer, cooler, more extreme, or no change noted. They could also report any other characteristics noted or say they did not know. Similarly, rainfall could be perceived as wetter, drier, more extreme, no change noted, other characteristics noted or admit to having no knowledge. Additional questions were asked on the manner in which changes occurred and farmers' perceptions of these changes.

Step 2: LikertType questionnaires (Likert, 1932) (n=138, 42 shepherds, 27 dairy cattle farmers, 40 horticulturists, 22 rice producers and 7 others) to evaluate farmers' agreement levels on climate indicators coded from semi-structured interviews. After transcribing the semi- interviews, open coding was involved. The researcher continued to conduct Likert survey using these indicators in order to obtain the repetition in expression of themes. The questionnaire aimed to evaluate the levels of agree or disagree of farmers (1: strongly disagree, 2: disagree, 3: uncertain, 4: agree, 5: strongly agree). Numbers assigned to Likert-type items express a "greater than" relationship; however, how much greater is not implied. Because of these conditions, Likert-type items fall into the ordinal measurement scale. Descriptive statistics was made for ordinal measurement scale items include a mode or mean for central tendency and frequencies for variability (Boone and Boone, 2012)

Step 3: Analysis of long-term changes in climate using meteorological data to understand the complex differences between farmers' perceptions of their exposure to climate variability and change and actual meteorological observations, rainfall and temperature data obtained from the Santa Giusta Meteorological Station (Oristano) were analyzed. Rainfall and air temperature are routinely measured at various stations distributed across Oristano. Trends of the recorded rainfall and temperature data over the last 53 years (1959–2012) were analyzed to determine how scientific observations and farmers' experiences interrelate and to understand the factors influencing community experiences

6.4. Research results

6.4.1. Farmers' perception of climate variability and change

Farmers' perception of CC from their narratives

The semi-structured interviews showed that although the term of "*climate change*" wasn't mentioned when approaching farmers, most farmers spoke about climate year to year variation, and about a large majority of farmers interviewed believed that they had made personal observations of environmental change, especially change on their farm and their land that linked to climate change. Farmers perceptions of CC have been classified into four groups of reference.

(i) Changing seasons: About 90 % (22 over 25) of farmers interviewed thought that CC is occurring with an evidence of changing seasons in the last 20 years. For examples, a dairy cattle farmers expressed "*In the years of 80s, the seasons were very good, from the 90s today , seasons are irregularly changing……"* Similarly a dairy sheep farmer remarked "*twenty years ago we had been sowing in October because after that the rain period began, nowadays in November it does not rain, but it's very cold and frozen".* Or another dairy cattle farmer remarked "*Before it was raining in autumn but nowadays no…."* Majority of farmers expressed that the irregular changes of seasons causes many delays/changes in their farming calendars especially sowing and harvesting. This group of farmers, moreover, believed that their farming activities have been affected by CC and in an extreme case, it can lead to the loss of crops and production, like a rise farmer explained *"two years ago the temperature was occasionally lowered in August (below 15 degrees) when the rice plant was in bloom, consequently there was a big failures of rice seeds and stems, especially the long-cycle varieties provided lowered yields or loss of yields".*

(ii) Increased temperature and droughts. About 70% (17 over 25) of farmers interviewed perceived that temperature has been increased in the last 20 years. They also supposed that droughts have been more frequent and dense in the last 20 years, for examples: A horticultural farmers stated "*nowadays the weather is much hotter in summer. Summer seems longer and winter is discreet in the last couples of years*". Another diary sheep farmer expressed "*There have been several "crazy" years in 2001, 2002 and 2003, the years of severe droughts*" Or "*Since the 80's we* *had 2 or 3 drought extreme events (e.g. 1988-1990 and 2002-2003) that did not allow us to plant…",* explained by a rice farmer. Actually many farmers expressed the same perception and they experienced that the increased temperature and droughts has seriously impacted their production activities. Many sheep farmers stated that "*we lost many sheep during the droughts periods (e.g. 2001-2003). Because of the high heat waves, many animals were sick and died"*

(iii) Increased unpredictable rain. Over 50% (13 over 25) of interviewed farmers (most of them are dairy cattle and sheep farmers) talked about unpredictable rain during the last 10 years. Most of dairy cattle farmers complaint that in the last years the rain period has not started in the right season, for examples some of them said "*Nowadays there is no water when we need. When we don't need, it rains a lot to destroy the forage*", or "*in the last 4-5 years it has rained a lot, but the raining seasons started very late*". Some dairy sheep farmers also expressed their concerns about unpredictable rain, as one farmer explained "*my father told me that it had been raining regularly and frequently in the past. Rainfall was better distributed during the year. Raining season used to start in September and end in April or May. In the last two years, it starts in December"*. Many farmers in these two category groups confirmed that raining season in the past had been between September and May, but today it is irregular and occasional, as one farmer added "*before it had been raining on a regular basis from early September until May, in the last few years it has rained too early or too late, for an example in 2007 it rained from August to November in an irregular manner"*.

(iv) Climate is always the same. Around less than 10% (2 dairy cattle farmers over 25) of interviewed farmers didn't speak about climate issues. When they were tried to lead into the discussion of climate issue, one farmer said "*climate is always more or less the same. Thirty years ago there was the same climate of today: it is a cyclic phenomenon*". Another farmer explained " *every 4-5 years there is always an extreme change in climate and in the last years of 50s it was hot similar today. There is no different in climate respect in the past of 30-50 years ago"*. These farmers were sceptical with climate change.

Farmers' perception of CC from Likert Type questionnaires

Figure 12 and Table 14 shows that majority of farmers of all farming typologies (90% of shepherds, 93% dairy cattle farmers, and 84% horticulturists and 70% rice producers) agreed/strongly agreed that seasons are changing and it is difficult to be predicted.

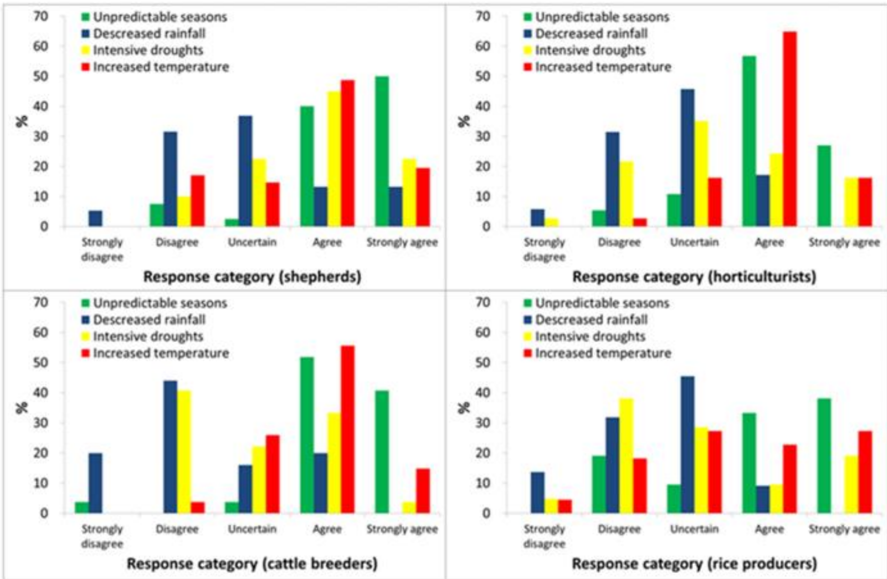


Figure 12. Farmers' perceptions of CC quantified by % response.

Most of them expressed their perceptions of increasing rainfall. High percentage of dairy cattle farmers disagreed that rainfall has been decreased in the last decades, while the three other farmer groups felt into the status of uncertainty with the statement. Majority of shepherds and horticulturists were in tendency of agreement that there has been increased intensive droughts, whereas high percentage of dairy cattle farmers and rice producers disagreed with the statement. Majority of farmers, especially shepherds, horticulturists, and dairy cattle farmers showed their strong agreement that there has been a rise in temperature during last decades. However, about 50% of rice producers were still in the status of uncertainty or disagreement with the statement.

		% Response			Mean	Mode
		Disagree	Uncertain	Agree		
Extensive dairy sheep farming	Unpredictable seasons	8	3	90	2.8	3.0
	Descreased rainfall	37	37	26	1.9	2.0
	Intensive droughts	10	23	68	2.6	3.0
	Increased temperature	17	15	68	2.5	3.0
Horticulture	Unpredictable seasons	5	11	84	2.8	3.0
	Descreased rainfall	37	46	17	1.8	2.0
	Intensive droughts	24	35	41	2.2	3.0
	Increased temperature	3	16	81	2.8	3.0
Intensive dairy cattle farming	Unpredictable seasons	4	4	93	2.9	3.0
	Descreased rainfall	64	16	20	1.6	1.0
	Intensive droughts	41	22	37	2.0	1.0
	Increased temperature	4	26	70	2.7	3.0
Rice production	Unpredictable seasons	19	10	71	2.5	3.0
	Descreased rainfall	46	46	9	1.6	2.0
	Intensive droughts	43	29	29	1.9	1.0
	Increased temperature	23	27	50	2.3	3

Statements were measured in a five-point Likert-scale, subsequently dropped to a three-point Likert-scale: disagree (=1), uncertain = neither agree nor disagree (=2), agree (=3);

Table 14. Descriptive statistics to Likert-type statements designed to quantify farmers' perceptions of climate change.

Farmers' experience about the climate extreme events

Box 3 shows the climate extreme events over 30 years according each group of farmers. Each farmer group has different memories about climate extreme events. There is no incidences among events indicated by the 4 groups. This is because each farming system have its own production calendars and their experiences are usually associated with risks to their production activities such as production losses, increased managerial costs or inputs. However, all farmers, at the same time, indicated the drought event in 2003 and they expressed that this event had heavy impacts on all farming systems.

Box 4: Climate extreme events indicated by farmers

Extensive dairy sheep farming
Drought (1998, 1989, 1994, 1995, 2000, 2003, 2004, 2007, 2012)
Excessive rain (2012, 2013)
Snowing (2007, 2008)
Icing (2007)
Frequent rain (2000 - 2013)
Horticulture
Drought (1983, 1988, 1980, 1990, 1992, 1994, 1995, 1996, 1998, 2003)
Flooding (2010)
Excessive rain (2007)
Hail (1994, 1996)
Icing (2001)
Excessive rain (2011, 2012, 2013)
Flooding (1991,1994, 2013)
Extreme hot (2003, 2010)
Extreme cold (2012)
Rice production
Drought (1984, 1989, 1990, 1991, 1992, 1995, 1998, 2000, 2003, 2009)
Hail (1994, 1996)
Excessive rain (2012, 2013)
Icing (2001)
Intensive dairy cattle farming
Drought (1998, 1990, 1991, 1999, 2003, 2005)
Excessive rain (2012, 2013)
Flooding (1994)

Farmers' perception of climate impacts on farming systems

Farmers were asked about changes in their farming activities in the last decades. Farmer were willing to share about problems they have been facing related to both climate and non-climate factors. These factors and their impacts on each farming systems in Oristano.

To identified climate impacts that farmers face, all information of the interviews were underlined, coded and categorized according to the core categories and sub-categories in the above tables. Most farmers repeated about the same factors causing their systems vulnerable, with emphasizing climate variability of change.

With 90% of respondents indicating that the threats of droughts, excessive rains, unpredictable rains, extreme cold has the strong influences on their farming systems. These have extreme negative impacts on farming activities such as the loss of production, increased water use, irrigations, increased production inputs and service expenses, etc., Farmers also indicates other threats like animal diseases, plant diseases strongest influence on livelihoods, and demand constant labour and herbicides or pesticides to treat them. According to them, the problems of animal and plant diseases could be a result of increasing temperatures or climate instability (Table 15).

Climate/non-climate factors	Risks			
	Intensive dairy cattle farming	**Extensive dairy sheep farming**	**Horticulture**	**Rice production**
Non-climate factors				
Economic crisis	Increased costs of production inputs Decreased product prices/competition with extra-EU productions	Increased costs of production inputs Decreased product prices/competition with extra-EU productions		
Increased animal disease	Increased veterinary/medicine cost	Reduction of milk production Increased veterinary/ vaccine medicine costs Low production		
Climate factors				
Extreme hot and droughts	Increase water use/ irrigation costs/ volumes Increased animal diseases	Increased expensed for animal food Lower production of fodder/ pasture Low new animal births/abortion Lack of water use	Plants diseases/ inserts Increase production input and treatment Cost of phyto- drugs/ parasites/ pesticides Increased water use/irrigation costs Crops are burned by the hot Poor fertilized soil	Loss of production/yields Plant protection costs Reduction of cultivated areas Increase irrigation cost
Unpredictable rain	Delayed harvesting Loss of hay Low quality and quantity of harvesting (products)	Cropping calendars Increased expenditure for food for animals Animal disease (e.g blue tongue) Animal death outbreaks Soil erosion	Cost of management Plant diseases/inserts Difficult to program seeding irrigation and harvesting	Difficulties in programming irrigation and cultivation Increased management costs
Excessive cold	Increased cost of forage Loss of capital and production reduction	Difficult to prepare soils and land Very slow growth of pastures and reduced production Loss of livestock/crops		Increased land preparation costs
Excessive rain	Increased animal effluents damage to structures	Soil erosion Loss of harvesting		
Changing seasons	Higher costs of crop management	Increased non-native weeds Increased plant diseases/ insects	Increased treatment cost Increased labor costs and crop management	Increased treatment costs Loss of production Insufficient income

Table 15. Climate and non-climate risks to farming systems.

6.4.2. Farmers' adaptation to climate uncertainties

Table 16 shows the variety of strategies adopted by the majority of the interviewed farmers to cope with variable climate events during the last decades (i.e. droughts in 2001, 2002 and 2003 and extreme rain event in August 2008, etc.). These farmers also explained that during the last 4-5 years the weather was so uncertain that it was impossible for them to plan their activities. Most of them increased the use of weather reports and forecast to enhance their capability to react. An average of 15% of farmers interviewed, especially rice and dairy sheep farmers, said that they did not perform any additional action to adapt to a changed climate as they don't perceive any new impact of climate on their activities.

Actions were taken	Farming system	Proportion of farmers
Adopt new agronomic practices	Horticulture Rice	60% (3/5 farmers) 25% (1/4)
Change/diversify crops	Horticulture	80% (4/5)
Improve irrigation systems	Horticulture Dairy cattle	100% (5/5) 55% (5/9)
Improve animal health by enhancing veterinary services, hygiene in stables	Dairy sheep Dairy cattle Beef cattle	42% (3/7) 88% (8/9) 100% (2/2)
Change/improve the diet of animals	Dairy cattle Dairy sheep	66% (6/9) 42% (3/7)
Follow daily weather forecast in order to take the action on the spot	Horticulture Rice Dairy sheep Dairy cattle	60% (3/5) 75% (3/4) 57% (4/7) 20% (2/9)
Do nothing	Rice Dairy sheep Dairy cattle	25% (1/4) 29% (2/7) 1 % (1/9)

Table 16. Range of actions that were taken by farmers to cope with climate variability.

Most of the interviewed farmers expressed willingness to adapt to climate change. When explicitly were asked how would they respond to CC and uncertainty, if any, most farmers told that it is important to adapt at farm level and that their response would be based on investments in technologies, infrastructure and knowledge. A minor proportion of farmers continued to maintain a skeptical and passive attitude toward CC issues. Table 17 synthesizes the range of strategies that farmers indicated as relevant in the future for CC adaptation.

Actions farmers think to take	Proportion of farmers
Improve infrastructure (farm structure, stables, barns, sheds)	Dairy cattle (8/9) and dairy sheep (4/7)
Adopt new technologies (i.e. air conditioning systems for animals, video surveillance systems to control animal health performance)	Dairy cattle (8/9)
Ensure right use of water at farm level	Most farmers: horticulture (4/5), rice (4/4), dairy sheep (2/7), dairy cattle (7/9)
Enhance the interaction with technical advisors, colleagues, neighbors	Dairy cattle (7/9). Around 50% of dairy sheep, horticulture. Most rice farmers didn't mention this option.
Participate to social networks to enhance knowledge/information and adaptive capacity	Most dairy cattle, rice and horticulture farmers are using web and social networks for daily work and think they are useful to enhance adaptation ability (markets, prices, inputs). 6/7 dairy sheep farmers do not use these services and do not think they are useful.
Follow daily weather forecast in order to take the action on the spot	Most farmers of all categories (20/25 of total) indicated the daily weather forecast as useful for daily planning.
Do nothing	4/25 farmers (dairy sheep and rice) declared that they will not do anything to cope with climate change.

Table 17: Actions that farmers think to take in a worse situation of climate uncertainties.

6.4.3. Analysis of long-term changes in climate

According to the projected scenarios of temperature and precipitation for Oristano created within the Agroscenari for the period of 2021-2050 are:

- temperature increases in all seasons, with values more intense especially during the summer both minimum and maximum values, and up to 2.5 ° C for the maximum temperature;
- decreases in precipitation, in the winter season (within 5%), the highest in spring (about 20%) and in summer (about 40%).

These scenarios were constructed using various scenarios of greenhouse gas emissions, A1B, A2, B1.

However, by quantitative analysis of statistical climatic data obtained from Santa Giusta Meteorological Station (Oristano), the climate variability for the period of 1959 to 2012 was observed as follows:

Inter-annual rainfall (1959-2011)

Daily rainfall data recorded at Santa Giusta meteorological station from 1959 to 2011 were transformed firstly into monthly and then into annual mean rainfall. Annual rainfall values were then normalized with respect to mean and standard deviation of the whole investigated period, respectively μ=573.6mm and σ=139.0 mm. Occurring trend has been finally calculated through moving average with a period of 5 years (Figure 13).

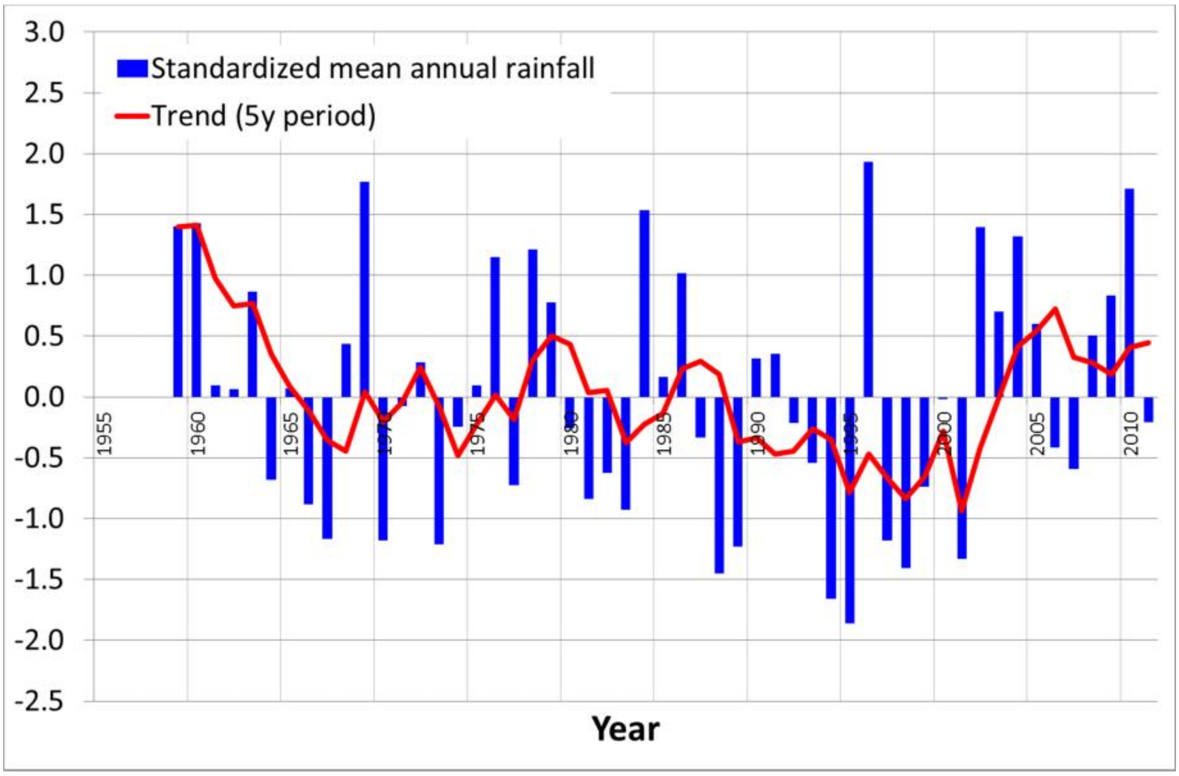


Figure 13. Inter-annual variability of rainfall in Oristano (1959-2011). Data source from Santa Giusta Station (OR), own elaboration.

As reported by ARPAS (2013) between 1870 and 1980 the rainfall of Sardinia had a marked temporal variability from one year to another, but didn't show any evident trend. In the last two decades of the twentieth century, however, the rainfall showed a long-term deficit ARPAS (2013). At least after 1959, this behavior has been observed also at the Santa Giusta station were between 1976/77 and 2000 it is evident such deficit period (Figure 13).

Mean inter-annual numbers of rainy days (1959-2011)

To analyze the frequency of rainy days for the 40-years period, the same methodology of the rainfall analysis has been applied.

Although there is a tendency of decreased annual rainfall, Figure 14 shows average inter-annual numbers of rainy days from 1959-2012. In general, there are three periods: the first one spans the years 1959-1977 where the annual number of rainy days is in general above the average of the investigated period; the second one spans the years 1977-1995 and is characterized by a frequency that is below the average of the investigated period; the last one spans the years 1995-2012, characterized by a marked increase of rainy events.

As can be seen from the Figure 13 and Figure 14, the decreasing trend were more marked on the cumulative analysis of rainfall that on the frequency, which indicates a substantial reduction of the intense events.

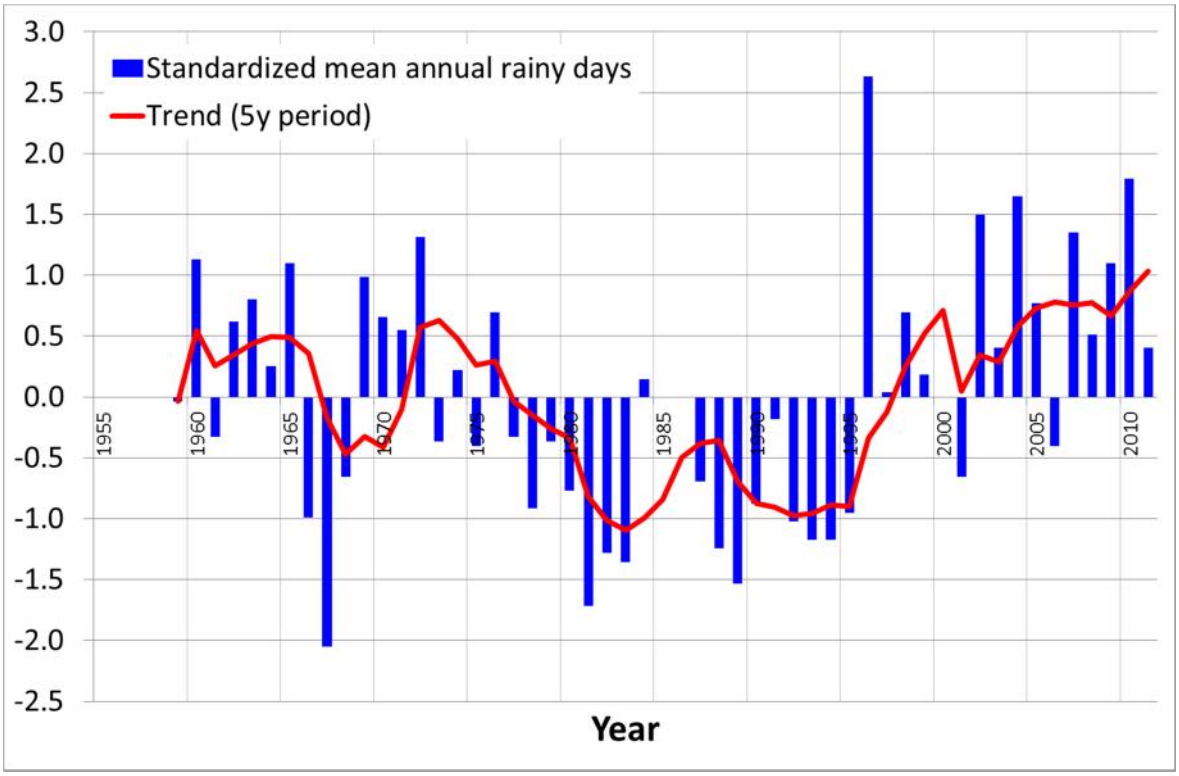


Figure 14. Mean inter-annual numbers of rainy days (1959-2011). Data source from Santa Giusta Station (OR), own elaboration.

Annual mean monthly temperatures (1959-2011).

Important studies were done for the whole Sardinia by ARPAS (2013), which analyses a period from 1880 to 2012. The temperature anomaly from the climatological period of 1961-1990 (the one used as reference by the World Meteorological Organization - WMO) shows signs of global warming. It can be observed that the average temperatures of Sardinia island have suffered a first increase between 1910 and 1930 and a second more pronounced increase, since 1980. This second growing trend is still in progress and has brought the temperatures of Sardinia to about +1.4 ° C above the 1961-1990 climatology. This trend is also recorded at the meteorological station of Santa Giusta (Figure 15).

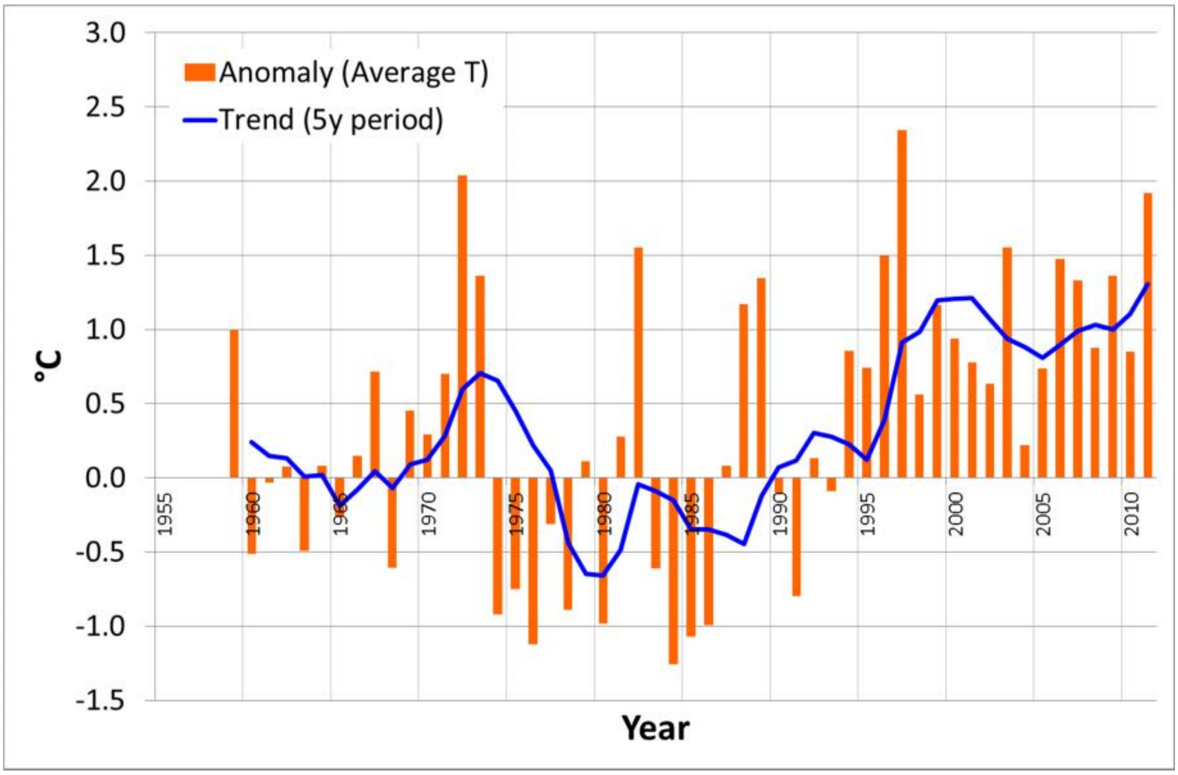


Figure 15. Annual mean temperature anomaly in Sardinia from 1959 to 2012. Data source from Santa Giusta Station (OR), own elaboration. According to the suggestion proposed by ARPAS (2013) to values after 2002 has been applied a corrective coefficient to account for the different response to the minimum and maximum temperatures between mechanical thermometers (bimetal), prevailing up to that year, and electronic (thermocouple), used later.

Figure 16 shows the monthly minimum and maximum temperatures for the same period 1959–2012. Over 52 years, it is possible to observe a generalized positive trends for the maximum temperature from 1980 while a general stability or slightly positive trends for minimum temperature (Figure 17).

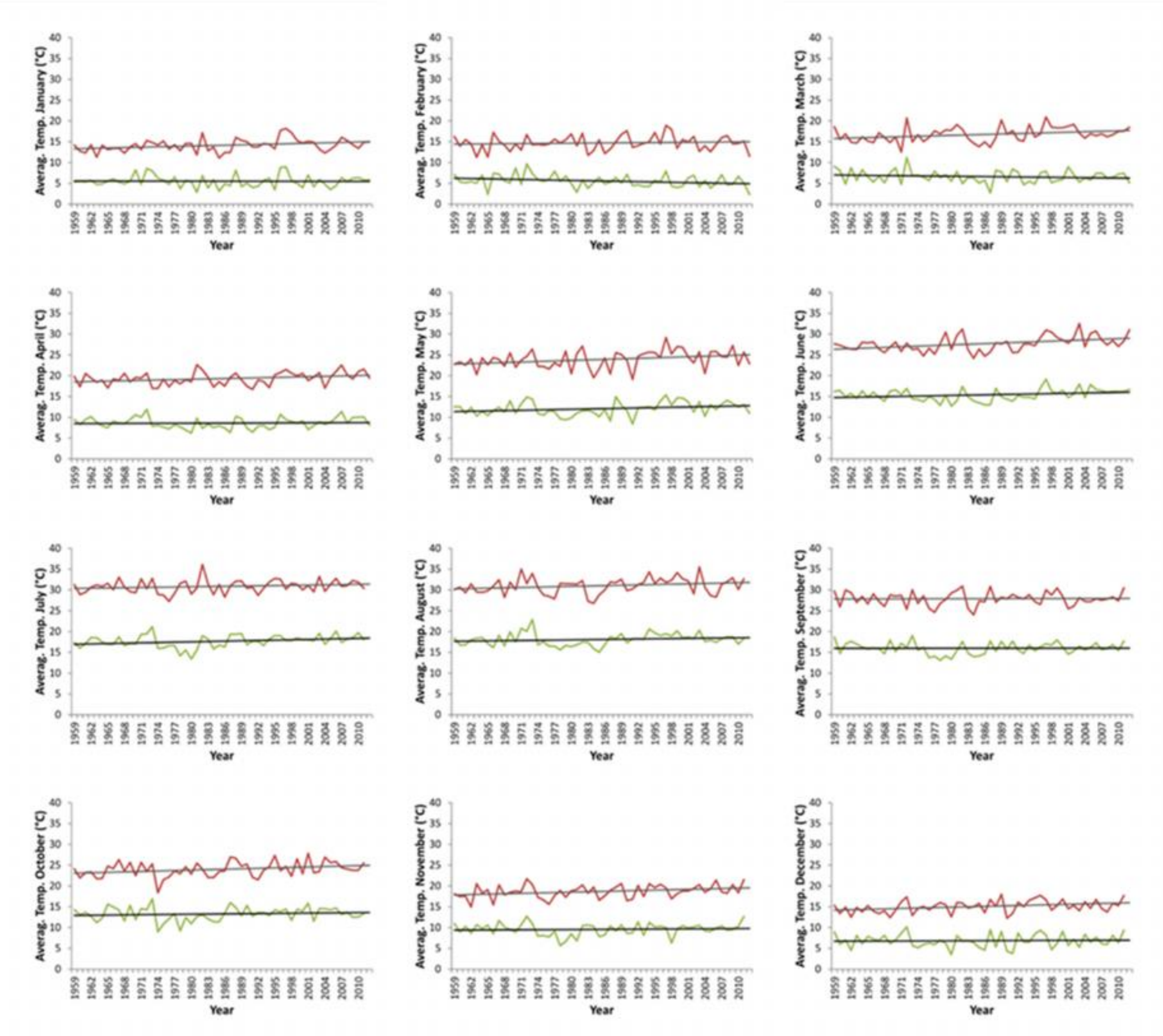


Figure 16. Mean daily maximum and minimum temperatures from Jan-Dec (1959-1960). Data source from Santa Giusta Station (OR), own elaboration.

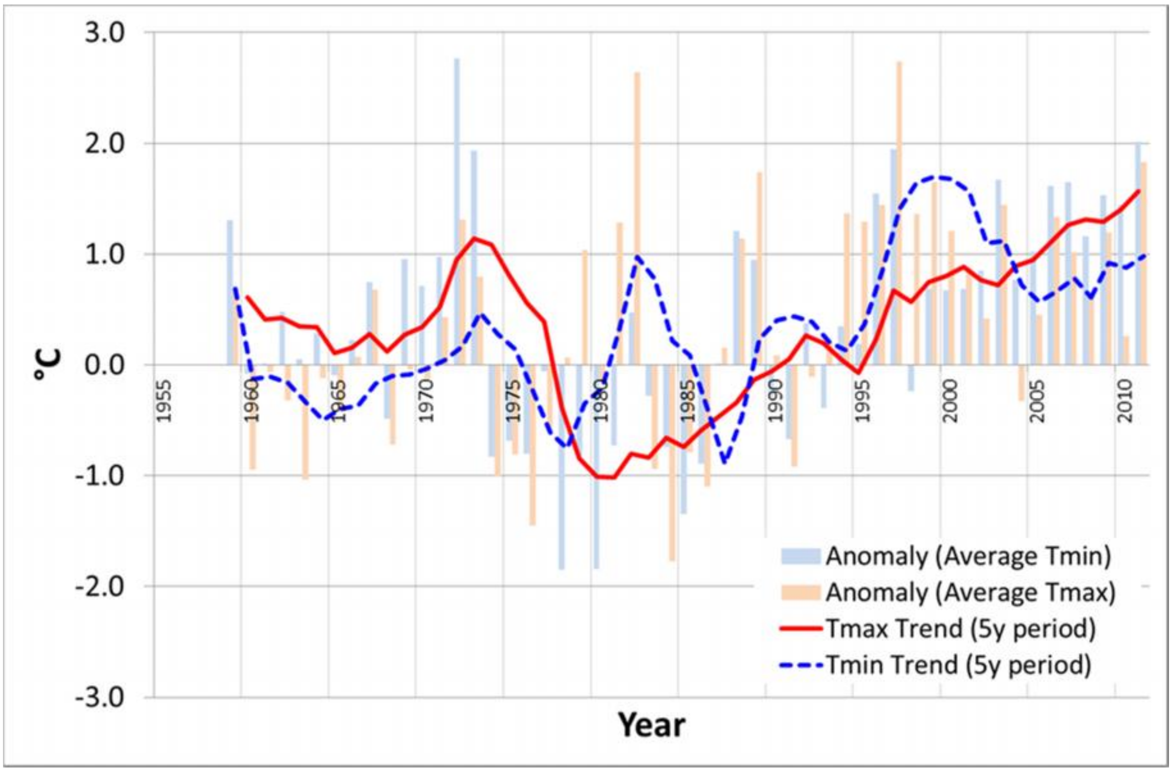


Figure 17. Annual mean temperature anomaly for Tmax and Tmin in Sardinia from 1959 to 2012. Data source from Santa Giusta Station (OR), own elaboration.

6.5. Discussion

6.5.1. Factors influence farmers' perceptions of climate change

The above results showed that there are different perceptions among farmer groups. The differences are shown in farmers' perception of vulnerability of farming systems, climate/weather variability and events. Farmers' perceptions are constructed based on their own attitudes, motives, interests, experiences and expectations in each social cultural background and situation setting (Gandure et al., 2013). These interactions between humans and weather are mediated by a host of social, economic and cultural factors and regions with a similar statistically described climate may have quite different cultural assessments of climate (Hulme et al., 2009). For an example, the study of Kiriscioglu et al (2013) in southern and eastern Nevada showed that the urban people perceive the ecological impacts due to the hazards to water environments higher than the rural people while the rural people perceive the benefits and equity due to the five hazards to water environments higher than the urban people.

Farmers in this study have perceived changes in climate overtime. According to them temperature nowadays has been increased and this is very in line with temperature trend observed by the local meteorological station. The increased or decreased temperature is a "touchable" phenomenon as farmers can personally feel by themselves. Experiential processing often involves feelings and simple heuristics (Marx et al., 2007). Gibson (1986) emphasized the close link between haptic perception and human senses. A personal feeling is an emotion derived from one's current internal status, mood, circumstances, historical context, and external stimuli. In the case of changing climate, human emotions at the perceptual layer may be classified into only two opposite categories: pleasant and unpleasant (Wang, 2005). Many farmers in this study saw themselves in a symbiotic relationship with nature and climate and most interviewees expressed strongly their experiences with hotter weather and frequent droughts from their personal feelings and historical context.

Not only increased temperature, farmers have also perceived unpredictable seasons and extreme weather events in the last 30 years. Most of them spoke about the impacts of changing seasons and extreme weather events on their farming activities. High percentage of shepherds and horticulturists agreed that there has been an increased intensive droughts in the last 3 decades, while majority of dairy cattle farmers and rice producers were uncertain or disagreed with this statement. Extensive sheep farming mainly depends climate conditions with low inputs and investment on pastoral land so that it is quite vulnerable to extreme climate/weather events such as droughts. Intensive dairy cattle farming has a larger investment in farm infrastructure (e.g. structure, stables, barns and sheds) and technologies (e.g. air conditioning systems for animals) and usually works with a lot of food production. For this reasons, dairy cattle farmers haven't perceived there has been increased intensive droughts as their farming system is more robust to resist with extreme climate events. In addition, water availability is one of factors explaining perceptions or non-perceptions of droughts. Most dairy cattle farmers and rice producers use water supply from public authority, while around 30-40 of shepherds and horticulturist still use ground water from their production. However, all four farmer groups in this case highlighted the drought event in 2003 when it was considered as extremely exceptional heat-wave during the summer in Europe (Schar et al., 2004). In Europe, not only warmer conditions have been observed in the last two decades, but also changes in extreme weather events (Reidsma et al., 2010). Extreme climate/ weather events often induce greatest damages and risks to agricultural activities (Niles et al., 2013) which are easier perceived by famers. Farmers perception of risks are not only biophysical, but also economics as these risks have direct impacts on their farming systems (Howden et al., 2007). Farmers with production losses and risk concerns are more likely to perceive more clearly weather stimuli. The lack of experience with major climate impacts can cause farmers to easily forget or see CC as a low probability events with few risks (Weber, 2006).

Farmers also expressed their experiences associated with changing in rainfall, rainy frequency which affected their production activities. Although meteorological statistics showed that rainfall has decreased and there are an increasing of number of rainy days in the last decades, the farmers had perceptions that rainfall has been increased. The farmers misinterpreted between rainfall and rain frequency as like other environmental phenomenon, rainfall is not easily observed and perceived by human senses without appropriate instruments. In addition, the farmers' production activities in this case study are not mainly dependent on rainwater harvesting but public irrigation systems from river/lake water sources. By seeing an increasing of rain frequency during the last decades, most farmers have perceived that there is an increased precipitation or they were uncertain whether there was a change in rainfall. Most dairy cattle farmers and rice producers have perceived that rainfall has been decreased in the last decades. This can be justified by the fact that more than 90% of farmers of these two farming systems only use irrigated water from public supply. While around 70% of shepherds and horticulturists are in the state of uncertainty and disagreement that there was an increasing in rainfall. This may be because about 30-40% of these farmers still use groundwater from wells for irrigation and production.

Farmers' perceptions of rainfall in this case are different from farmers perceptions of in many other regions where their agricultural activities are dependent on rain water harvesting (e.g. Biazin et al., 2012; Gandure et al., 2013; Simões et al., 2010) or water ground (e.g. Sjögersten et al., 2013). The perceptions of farmers are derived from and reinforced by farmers' farmers' daily sensory observations of experienced physical conditions and their local memory (White, 1985). Despite there is a trend of decreased rainfall according to the actual meteorological observation, the farmers in this case study didn't show their worry about water availability for their production. The biophysical conditions of the case study area are characterized as wet and fertilized, for this reason the farmers didn't have sensation of decreased rainfall and seem to be biased towards their local biophysical conditions. More, these farmers traditionally experience with dry weather, this could influence their perception of precipitation when they saw the increased rain frequency out of rainy seasons. This might be due to the lack of weather/climate information/knowledge communication (Sjögersten et al., 2013) or local social processes of information communication of climate uncertainties (Marx et al., 2007; Raymond and Robinson, 2013) in the area. The ways in which farmers perceived change in climate is very critical for them to respond to climate risk. Farmers expressed the damages made by unpredictable rains or increased rain frequency and what they already did to cope with this phenomenon. Perceptual knowledge of farmers is a very important element in farming planning and management especially in context of uncertainties (Ondersteijn et al., 2006).

6.5.2. Farmers' decision in adaptation to climate uncertainties

Adaptation is one of the key policy options for reducing the negative impact of CC (Adger et al., 2003; de Loë et al., 2001; Reidsma et al., 2010; Yegbemey et al., 2013). The aim of this study was to examine how farmers' perception is translated into agricultural decisions and factors that influence farmers' adaptation to CC from the perspectives of local knowledge and practice. Results indicate that most farmers are capable of autonomously adjusting to farm risks caused by climate uncertainties; however, they were more likely to respond to short-term risks and build contingency plans/practices to future changes which have a direct impact on their farm operation rather than longer-term risks related to climate change. Farmers' perception of CC plays an important role in choosing adaptation strategies at farm level (Adger et al., 2009; Jones and Boyd, 2011). Perceived CC risks and socio-cognitive processes will have a direct impact on motivating farmer's responses to CC (Frank et al., 2011; Grothmann and Patt, 2005; Niles et al., 2013). Adaptation to CC has been facing constraints from physical, to institutional and to psychological (Grothmann and Patt, 2005). Adaptive capacity of farmers is influenced by experiences, knowing, knowledge and technologies. Farmer's decision to adopt one or more adaptive actions is also influenced by various factors such as socio-economic and demographic factors (Yegbemey et al., 2013). For instance, farmers who had experiences in technology investment, knowledge buildup, were more active in adopting new farming practices to reduce negative impacts of climate change. In fact, there was the high percentage of dairy cattle farmers and horticulturists who have adopted or have thought to adopt new agricultural practices and technologies to adapt to climate uncertainties. Farmers of these two farming typologies are more younger than shepherds and rice producers. In addition intensive dairy cattle farming and horticulture are considered as "technology innovated" and "economic dominated" sectors in the area.

Adaptation in agriculture also varies depending on the climatic stimuli to which adjustment are made, different farm types and locations, and the economic, political and institution condition (Bryant et al., 2000). The result also showed that depending on each farming systems, farmers have adopted or have thought to adopt different farming practices. There are differences of practices applied by shepherds, cattle farmers, rise producers and horticulturists as these farming systems have different farming typologies and farming calendars.

"Decision theory is concerned with identifying the values, uncertainties and other issues relevant in a given decision, its rationality, and the resulting optimal decision"[4]. However, in the context of changing climate, farmers face difficulties in making decision for their farming activities simply because CC is uncertain and complex issue that cannot be foreseen (Abildtrup et al., 2006; Audsley et al., 2006). Farmers perceive their environment and make decisions can result in mal-adaptations attributed to problems in perception, cognition and the lack of information (Etkin and Ho, 2007; Mubaya et al., 2012). Jones and Boyd (2011) argued several social barriers to adaptation to CC including cognitive behavior, normative behavior and institution structure and governance. Cognitive behavior to CC adaptation relate to how psychological and thought processes influence how farmers react in the face of existing or anticipated climate stimuli (Adger et al., 2009; Jones and Boyd, 2011; Lorenzoni et al., 2007; Wolf et al., 2012). Differences in perceptions of climate variability and self efficacy in adopted practices were found in this study amongst shepherds, cattle farmers, rise producers and horticulturists. Farmers of these 4 farming system categories have different characteristic of socio- cultural background, and institution settings. For examples, shepherds are historically Sardinian native, aged from 50-over 06 years. Shepherds are less organized in cooperative structure for organization of their production activities and marketing, but they work independently and individually.

[4] http://en.wikipedia.org/wiki/Decision_theory

They are quite modest to invest technologies and innovation in their farming activities. While dairy cattle farmers are originally from Veneto who were poor and immigrated in Oristano during the years of 1930s. They are used to invest in technologies and knowledge to improve their farming activities. They are well organized in cooperative structure for technical share and marketing of products. The differences in perceptions and adaptation capacity of these two groups of farmers are due to their different cultural norms and settings (Jones and Boyd, 2011). The lack of information and engaging in the interaction processes with institutions/ organizations and communities of practices can be considered as major barrier for adaptation (Raymond and Robinson, 2013). Dairy cattle farmers seemed to be more active in adopting measures and practices to adapt to the climate variability as their organization in cooperative permitted them to interact among themselves and share knowing and knowledge. In addition, the Cooperative plays a large role in determining the processes that govern and regulate access and entitlement to key assets and capitals needed to adapt to existing or anticipate climate stimuli.

6.6. Conclusion

As the challenges and opportunities posed by CC become increasingly apparent, the need for facilitating successful adaptation and enhancing adaptive capacity within the context of sustainable development is clear. Social environments can limit adaptation actions and influence adaptive capacity at the local level. Perceived CC is considered as the main trigger for farmers' adaptation responsiveness and preparedness and for better risk management in farming decision making. It is well known that human perceptions drive practices far beyond scientific evidences, hence the collected data can support the understanding of the current choices and attitudes of the variety of farmers in this Mediterranean farming district. The study highlighted that while all farmers cited climate in their answers despite not directly enquired, they usually misinterpreted "weather" and "climate" change phenomena. However, this seems not to constrain their willingness and capacity to adapt.

The narratives and Likert data showed that almost all farmers strongly perceived weather/climate changes in the last decades and coped with them by mastering the ability to adapt. Farmers proved to have a strong attitude to adapting their practices to variable climatic factors but this baseline capacity was not sufficient to distinguish the concept of climate vs. weather, which is a basic step to design an effective CC adaptation strategy. Farmers are expected to cope with the impacts of long-term CC and at the same time maintain their income. The implications for this is that investments are needed in enhancing the farmers' perception and response-ability in addressing uncertainty and unpredictable changes that had never experienced before. The integration of scientific and lay knowledge appears as a promising strategy to enhance the shared understanding of the climate scenarios and challenges to develop a strategic responsive strategy also at political level.

Chapter 7: FARMERS' KNOWLEDGE, ATTIDUTES AND PRACTICES OF ADAPTATION TO CLIMATE CHANGE

Chapter structure

- Introduction
- Conceptual framework
  - KAP model
  - Relationship between farmers' KAP and adaptive capacity
- Study design
  - KAP study design
  - Interview techniques and questionnaire surveys
- Results
  - Farmers' familiarity and awareness about climate change
  - Farmers' attitude to CC
  - Farmer' behaviors and actions in adaptation to climate change
- Discussion
  - Social construction of farmers' knowledge of climate change
  - Farmers' attitude-relevant-knowledge and behavior to CC adaptation
  - What drives farmers' adaptive capacity?
- Conclusion

"Knowledge is a treasure, but practice is the key to it." Lao Tzu

7.1. Introduction

Agriculture is one of important sectors in Europe as its added value to GDP is relatively high (15%) in many regions, however its productivity depends heavily on climatic factors (Aaheim et al., 2012). It is the first vulnerable sector to CC in many large European countries (Biesbroek et al., 2010). Both adaptation and mitigation can help to reduce the risks of CC to agricultural systems. Mitigation has global benefits while the benefits of adaptation are largely local to regional in scale but they can be immediate, especially if they also address vulnerabilities to current climate conditions (IPCC, 2007b1). As adaptation is increasingly recognized as an important component in responding to climate change, adaptation measures are slowly emerging at different scales of governance (Juhola and Westerhoff, 2011). However, like many other complex human-environmental systems, adaptation to CC of agricultural systems are limited by the realities and constraints introduced by bio-physical world and social systems. According to Adger (2009), limits to adaptation are not only constructed around three dimensions - ecological and physical limits, economic limits, and technological limits, but also endogenous and emerge from "inside" society. Social construction of adaptation limits include ethics, knowledge, risk, and culture (Adger et al., 2009). Social construction of CC adaptation limits concerns the sociology of knowledge of climate change. "Reality" and "knowledge" of CC is justified by the fact of their social relativity (Berger and Luckmann, 1967). Knowledge of CC of farmers differs from knowledge of CC of scientists. Social value that each individual hold, knowledge they construct and relationships among society will be translated into action of adaptation to climate based on the ways how they frame the reality. Perceptions of risk, knowledge and experience are important factors at the individual and societal level in determining whether and how adaptation takes place (Adger et al., 2009). Humans have lived with climatic variability for a long time and developed management decisions to cope with climate variability (Dovers, 2009; Heltberg et al., 2009; Smit and Wandel, 2006), challenges to adaptation is not new. However, understanding of the specific CC challenges for agricultural sector is prerequisite to research based support for adaptation in policy and practice (Matthews et al., 2008). Many recent researches on investigating CC challenges within the constraints of the broader economic–social–political arrangements (Blennow and Persson, 2009) at multi-scales in supporting a governance of environmental decision making and robust CC adaptation strategies have made during last decades across many regions in the world (e.g. Conway and Schipper, 2011; Juhola and Westerhoff, 2011; Kiem and Austin, 2013).

Similarly, this study aimed to understand the adaptation challenges within the constraints of socio-cultural settings of Italian agricultural systems. The study focused on understanding social construction of CC adaptation through the investigation of CC knowledge, attitude and practices of farmers of the four farming systems (extensive dairy sheep farming, intensive dairy cattle farming, horticulture and rice production) at a case study in Italy.

The conceptual framework of KAP model were applied to investigate farmers' behaviour related to climate change. It examined (i) how and what knowledge farmers constructed about CC and CC adaptation, (ii) how and what attitude farmers hold about CC and adaptation under their specific social value and interests, (iii) whether practices to climate variability taken by farmers are influenced by their constructed knowledge and attitudes.

7.2. Conceptual framework

7.2.1. KAP model

Bandura (1977) discovered his social cognitive theory (the cognitive formulation of social learning theory) considering the importance of an individual's knowledge and attitudes in influencing behaviour and behaviour change, as well as recognizing the impact of external factors such as social and environmental influences on individual behaviour. The constructed knowledge of an individual affects his attitude, while his constructive attitude affects his practices. In the last decades many empirical research applying social cognitive theory to study human behavior through the diagnosing individuals' knowledge, attitudes and practices towards a concerning issue. KAP model (Knowledge, Attitude, Practice) emerged as a conceptual framework to study human behavior in a specific issue. United Nations agencies and the World Bank use KAP as an evaluation methods. KAP measures changes in human knowledge, attitudes and practices in response to a specific issue or intervention (FAO, 2012). The KAP model was developed in the 50's and was originally designed to research family planning until today (e.g. Donati et al., 2000). In human health research, many studies have been applied KAP model to evaluate population's knowledge, attitude and practices towards a disease (e.g. Khan and Khan, 2010; Zhao et al., 2012).

Conventional thinking in the field of education is that knowledge affects the learner's attitude directly, and the attitude is transformed into behavior. The KAP model has been also applied in education field from 1960's focusing on cultivating individual's cognitive, affective, and psychomotor, for examples in the medical and health education field (e.g. Marzuillo et al., 2013; Nunes, 2009; Roelens et al., 2006), in vocational training (e.g. Chien-Yun et al., 2012), in livestock health management (e.g. Grace et al., 2009).

KAP model has been increasingly applied to understand population's awareness and understanding levels of environmental and CC and their behavioural gaps in addressing adaptation to these changes by many international organizations, such as in CC knowledge and adaptation (e.g. UNFCCC)[5], identifying perceptions and needs for the use of climate information by health actors (WMO, 2011), water waste management (UNEP, 2010), population's knowledge gaps about CC as recommended by UNDP[6]. KAP model has been used in exploring climate-related knowledge, attitudes, and practices for building appropriate adaptation strategies taking into account socio-cultural and economic aspects of a local context in which CC is affecting the daily lives of local communities. Usually, the model has its aim to examine the linear relationship between knowledge, attitude and practice as well as the factors of social-environmental context that influence the construction of individual's knowledge. Based on the assumption that there is a relationship between knowledge and behavior, many KAP survey data is often used to plan activities aimed at changing behavior (Launiala, 2009). In environmental psychological research, environmental knowledge has long been assumed to underlie pro-environmental behavior (Hines et al., 1986; Truelove and Parks, 2012). Many studies in CC adaptation and mitigation has cited lack of knowledge on how to change behavior to reduce or adapt to CC (Aitken et al., 2011; Lorenzoni et al., 2007). However, a number of other studies has also emphasized individuals and communities' constructed knowledge of climate (incl. knowledge and knowing) with underlining multiple factors ranging from socio-cultural to environmental, economical, and structural factors (Artur and Hilhorst, 2012; Hulme et al., 2009). The SLIM framework (SLIM, 2004) also suggested that changes in practices depend on changes in understanding (knowledge) that leads to transformation of situation

[5] http://unfccc.int/files/meetings/cop_11/climate_talk_series/application/pdf/cop11_kiosk_deyal.pdf
[6] http://www.undp.org/content/undp/en/home/presscenter/pressreleases/2011/05/26/survey-points-to-need-to-fill-knowledge-gap-among-cambodians-about-climate-change.html

constructed by the four variables of stakeholding, facilitation, institutions and policy and ecological constrains through social interactions.

7.2.3. Relationship between farmers' KAP and adaptive capacity

IPPC has defined "adaptive capacity as the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies"(IPCC, 2007b1, Chapter 17.3.1). Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing conditions (Smit and Wandel, 2006). In another word, adaptive capacity is an individual or a community's capacity in structurally reorganizing their activities to diminish present threats and enhance their ability to address future risks (Reenberg et al., 2008). There it is associated with factors such as institutional structures, resource distribution, social ressource, and perception of risk and impacts, etc. Adaptation is seen as a continuous process of learning and reflection (Folke, 2006) towards adjustments by individuals and the collective behavior of socioeconomic systems (Denevan, 1983; Hardesty, 1986). Adaptation can take place at number of scales, from local to global, and making use of capacities of each group of actors (Adger, 2001). Knowledge, attitude and practice are factors driving adaptive capacities of individuals or a group of people. Changes in behavior lead to changes in an individual and changes in individuals' relationships with others and/or their practices with their environments (Blackmore, 2007). CC awareness is a crucially important factor influencing the capacity of farmers to cope with and adapt to climate changes (Howden et al., 2007; Marshall et al., 2013). However, Füssel and Klein (2006) used the four metaphorical names to characterize the different assumptions on adaptive behavior on climate impacts, as follows: "the "dump farmer" who does not react to changing to changing climate condition at all, the "typical farmer", who adjust management practices in reaction to persistent CC only, the "smart farmer" who uses available information on expected climate conditions to adjust to them proactively; and the "clairvoyant farmer", who has perfect foresight of future climate condition and faces no restrictions in implementing adaptation measures", p. 307. Social cognition of CC drives much the process of adaptation to climate and the capacity of an individual to adapt to change are triggered by social capital (Grothmann and Patt, 2005). Nelson et al (2010) augured that the adaptive capacity of an individual is his capacity of converting existing resources such as financial, natural, human, social or physical. Smit and Pilifosova (2001) cited that "the determinants of adaptive capacity related to the economic, social, institutional and technology conditions that facilitate or constrain the development and deployment of adaptive measures". While Grothmann and Patt (2005) recalled the role of cognitive factors (knowledge and attitude) in adaptation. They argued around knowledge and attitude that build credibility and trust of farmers in climate adaptation, motivation of adaptation (what farmers want to do) and their adaptive capacity (what they could do).

7.3. Study design

7.3.1. KAP survey design

Although KAP survey is commonly used in social research, and it is, nowadays, increasingly used in investigating CC adaptation by international organizations, there are several doubts about the validity of this research method. Bulmer and Warwick (1993) noted that most KAP surveys have often failed to include adequate efforts to study the reliability and variability of their data as well as to obtain measurements of the intensity of the options or attitudes recorded.

To avoid these deficiencies, the KAP survey has been designed according to grounded theory techniques. Twenty-five face to face semi-structured interviews were conducted with general opened questions posed to encourage farmers to tell us about their daily life's activities including CC and their adaptation. Data and information of the semi-structured interviews were coded and transformed into closed-end questions and explicitly opened-end questions for the questionnaire surveys to explicitly evaluate farmers' knowledge, attitude and practices. This is the point of saturation (Charmaz, 2006). A survey of 138 questionnaires was conducted as presented in Figure 14 in order to obtain the repetition in expression of the topics raised by farmers during the semi-structured interviews. The design of questionnaire survey was based on the hypothesis that there is a linear relationship between knowledge, attitude and practices. Both the semi-structured interviews and questionnaires were carried out in the same areas and within farmers groups of the four representative farming systems: intensive dairy cattle farming, extensive dairy sheep farming, horticulture, and rice farming. The repetition of the surveys aimed to enhance the reliability and variability of the data as well as to obtain the major representative options and attitudes of farmers.

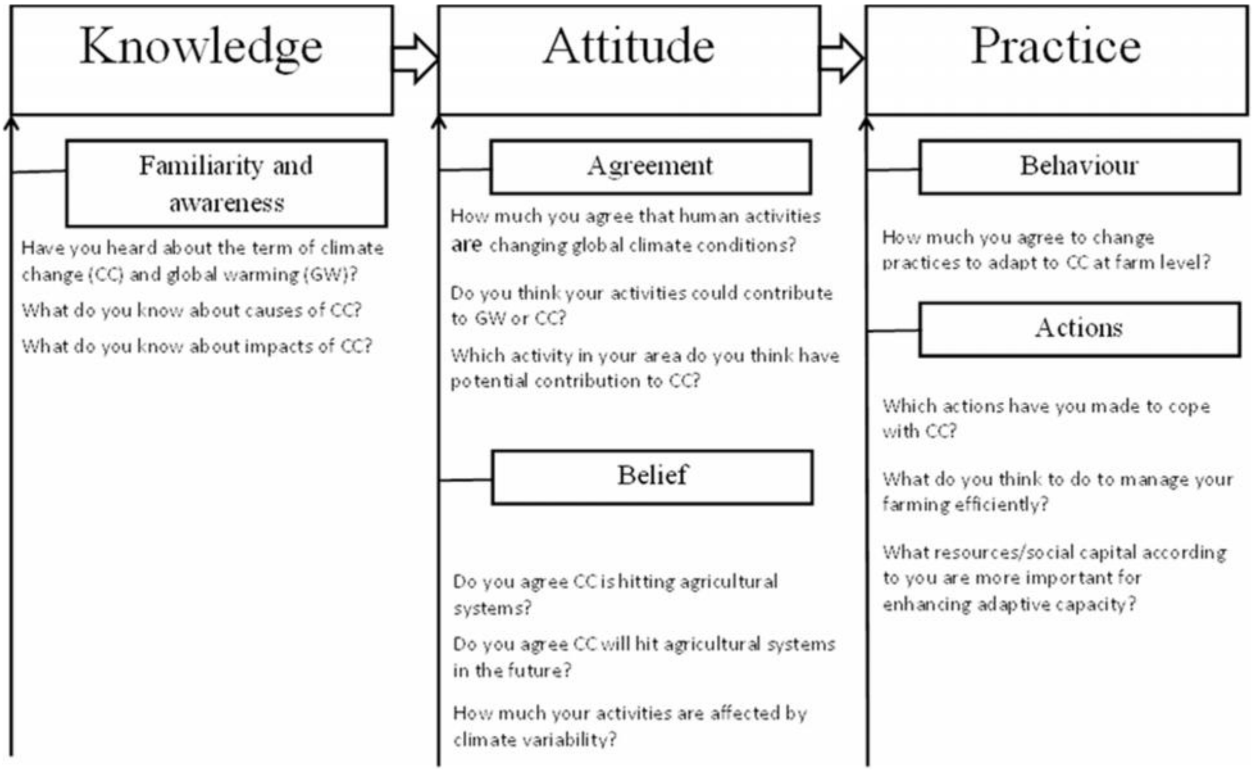


Figure 18. Conceptual framework of KAP survey.

7.3.2. Interview techniques and questionnaire surveys

25 farmers were randomly selected from the lists provided by Arborea Cooperative (dairy cattle farmers' cooperative) and Coldiretti Oristano (Farmers' Union of the province) for the semi-structured interviews. Each interviews lasted 40-60 minutes and happened at their farm. The interviews were made flexibly with a general checklist:

- What are farmers' observation about changes in their area and their land
- What and how they know/familiar with these changes
- What they think about these changes
- What and how they have done/will do to manage these change

Grounded theory analysis (Strauss and Corbin, 1990) was used to identify, analysis, and report themes within the interviewed data. The aim was to search for the themes that emerges as being important to description of the situation and to understand relationship between themes. After transcribing the interview, information was coded into core themes, and second level of themes. Figure 14 summarized core themes, sub- themes coded from the interview data. The closed-end and opened-end questions in the Figure were made based on the statements of farmers as explanation for each theme based on the dataset. These questions were developed to apply in the questionnaire survey in order to quantify the levels of repetition of the sub-themes and the relationship between them.

7.4. Results

Table 18 reported the characteristics of farming systems, historical, socio-cultural characteristics and organizational structures of the four investigated farming systems.

Farming systems	Farming characteristics	Geographical location	Historical and socio-cultural characteristics	Organizational structure
Intensive dairy cattle farming	- Intensive dairy cattle raising - Irrigated forage systems :silage maize, Italian ryegrass, triticale, alfalfa.	Plain areas, mainly Arborea	Started in 50s during the establishment of Arborea district after the land reclamation by Veneto families who immigrated in Arborea Most farmers have origins from Veneto Age of farmers: 23-63	- Most farmers are well organized and interacted in Arborea Cooperative. Cooperative is responsible for both production, transformation and marketing. - Family-enterprises - Use of internet, social networks - Technology investment
Extensive dairy sheep farming	- Extensive dairy sheep raising - Permanent or temporary pastures in rotation with autumn-winter forage (winter pasture and hay or grain production)	Hilly and mountains areas, spread in many areas Busachi, Sedilo, Tramatza, Oristano, etc.	Main tradition ancient farming activity. Locally origins or from inland mountainous areas, Age of farmers: 23-76	- Most farmers work individually Few belong to Cooperativa Allevatori Ovini (CAO) - Family-enterprises - Traditional farming techniques
Horticulture	- Irrigated vegetable farming, mainly artichoke, watermelon, melons industrial tomatoes.	Plain areas, Mainly Oristano, Arborea, Cabras,	New farming activity after the crisis of cereal cultivation in 80-90s Sardinian origins from many parts of the island. Age of farmers: 23-65	- Most farmers are members of Farmers 'Union (Coldiretti), product direct sales under trademark of Coldiretti - Mainly one member/family enterprise - Internet and social network
Rice cultivation	- Irrigated wet rice farming	Plain area, mainly Oristano, Cabras	Started in the years of 50s. It becomes one of important farming activities in Oristano nowadays. Sardinian origins, mainly came from the south. Age of farmers: 22-80	- Most farmers are members of Co.Ri.Sa.(Cooperativa Risicoltori Sardi) for products marketing - Family enterprises - Use local technical newspapers and internet

Table 18. Historical, socio-cultural and organizational settings of the 4 farming systems.

7.4.1.Farmers' familiarity and awareness about climate change

The questionnaires survey (n=138) showed that 98,5% farmers are familiar with the term of CC and 93,5% of farmers heard about global warming. Table 19 and Table 20 are the lists of causes and effects of CC indicated by farmers according to their knowledge. High percentage of shepherds and horticulturists indicate that pollution is one of the main causes (75% for shepherds and 67,5% for horticulturists) and rise temperature is one of the main effects of CC (75% for shepherds and 67,5% for horticulturists).

Causes indicated by farmers	Farming systems (% respondent)			
	SH	HO	RI	DC
GHG/Carbon emissions	52	67,5	37,5	42,5
Agriculture and animal husbandry	5	10	7,5	2,5
Pollution	75	67,5	35	35
Natural process	18	27,5	17,5	7,5
Natural resources overexploitation	27	45	17,5	27,5
Deforestation	43	65	15	47,5
Increased population	14	22,5	12,5	10
Technologies/infrastructure	20	40	7,5	12,5

Note: SH: dairy sheep, HO: horticulture, RI: rice farming, DC: dairy cattle

Table 19. Causes of CC indicated by farmers (n=138).

Effects indicated by farmers	Farming systems (% respondent)			
	SH	HO	RI	DC
Rise in sea level	25	32,5	50	50
Rise in temperature	73	67,5	15	15
Increased natural hazards	34	42,5	17,5	17,5
Disturbed ecosystem	39	47,5	5	5
Loss of biodiversity	11	25	5	5
Loss of production	16	27,5	5	5
Danger of animal and human health	25	0	0	25

Note: SH: dairy sheep, HO: horticulture, RI: rice farming, DC: dairy cattle

Table 20. Effects of CC indicated by farmers (n=138).

However, low percentage of rice farmers and dairy cattle farmers talked about pollution as a cause of CC (35% for each) and rise in temperature as a main effects of CC (15% for each). More than half of shepherds (52%) and horticulturists (67,5%) specified GHG/carbon emission as one of main causes of climate change, while a minority of rice farmers (37,5%) and dairy cattle farmers (42,5%) considered this cause. It's also very interesting to observe that very low percentage of farmers of all categories indicated agriculture and animal husbandry as one of main activities contributing to climate change. And only shepherds and dairy cattle farmer indicated that CC can endanger animal and human health (25% for each).

7.4.2. Farmers' attitude to CC

A description of the extent that farmers were in "agreement or disagreement" with CC status, causes and impacts in their area is provided in Table 21. Most farmers in this survey have homogeneous attitudes towards their belief on CC impacts on their farming as well as impacts of their activities on the environment (the descriptive results were not divided into 4 categories of farmers for this reason). Farmers mostly agreed that human activities are the main cause of global climate conditions, but they rarely agreed that their farming activities could contribute to climate change. A majority of farmers tended to agreed that CC is hitting / will hit their farming systems and their farming activities have been negatively affected by climate change.

	Mean	SE	Mode	Range
How much you agree that human activities are changing global climate condition? 1=strongly disgree, 2=disagree, 3 neutral, 4=agree, 5=strongly agree	3,56	1,03	4,00	5,00
Do you think your activity contribute to climate change? 1=yes, 2=no, 3=i don't know	2,65	0,68	3,00	3,00
Do you agree CC is hiting agricultural systems in Oristano? 1= yes, 2=no, 3= I don't know	1,58	0,76	1,00	3,00
Do you agree CC will hit agricultural systems in Oristano? 1=yes, 2=no, 3= I don't know	1,30	0,53	1,00	3,00
How much your activities have been affected by climate variability? 1=not affected, 2= i don't know, 3=affected, 4=negatively affected	3,20	0,86	4,00	4,00

Table 21. Level of farmers' agreement on climate change, its cause and impacts (n=138).

Figure 19 showed the level of farmers' agreement on the potential contribution of local activities to climate change. A majority (approximately 57-67%) of farmers agreed and strongly agreed that urbanization and vehicle/transport could contribute to changing climate. While a minority of farmers agreed that their local farming activities could contribute to CC (the agreement was ranked in descending order from 24,6% for dairy cattle farming, 15,5% for dairy sheep farming, 11,6% for rice farming, 10% for cereal farming, 8% for horticulture and 5,8% for aquaculture). High percentage of farmers stayed neutral or disagreed or strongly disagreed with the facts that local farming activities could contribute to changing climate.

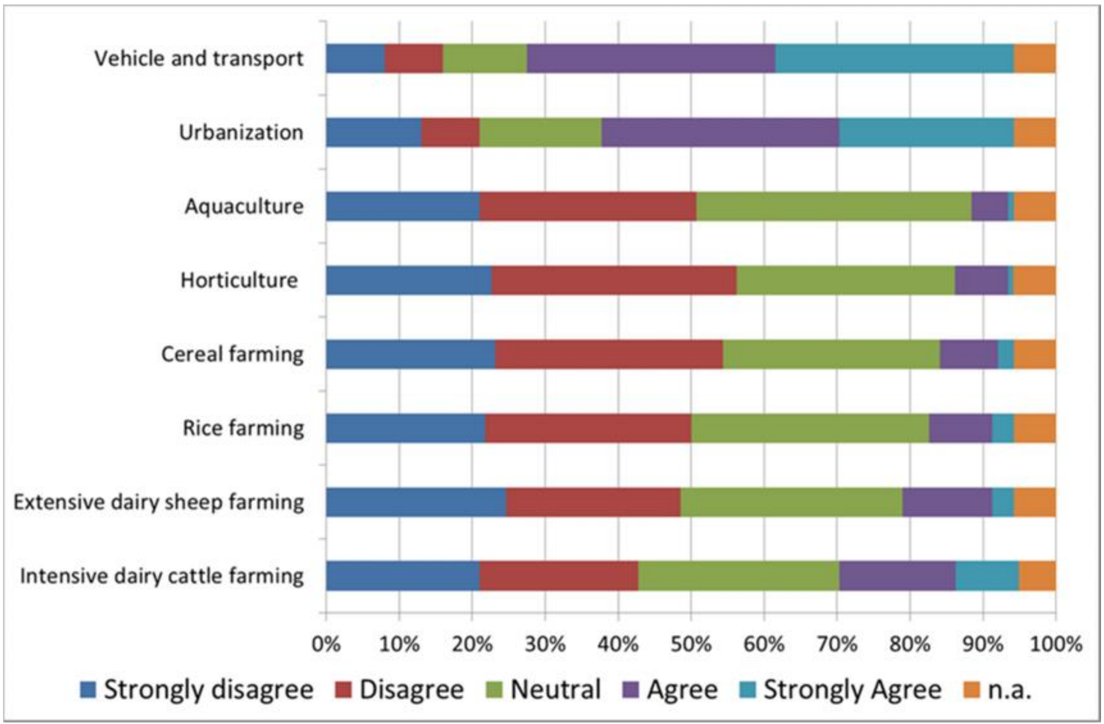


Figure 19. Farmers' attitude on contribution of their local activities to CC (n=138). Statements are ranked in descending order by total level of agreement, n.a= not answered.

7.4.3. Farmer' behaviors and actions in adaptation to climate change

A description of farmers' behavior in adapting to CC is presented in Table 22. Farmers tended to agree that adaptation at farm level is necessary to cope with climate uncertainties. However, no farmers from the two categories of dairy cattle farming and rice farmers strongly agreed or strongly disagreed with the fact.

	Mean	SE	Mode	Range
How much you agree that it 's neccessary to change farming pactices to adapt to CC? 1=strongly disgree, 2=disagree, 3=not sure, 4=agree, 5=strongly agree	**3,7**	**0,9**	**4,0**	**5,0**
Intensive dairy cattle farmers	3,6	0,6	4,0	3,0
Extensive dairy sheep farmers	3,6	0,9	4,0	5,0
Rice farmers	3,6	0,7	4,0	3,0
Horticulturists	3,7	1,0	4,0	5,0

Table 22. Farmers' behavior in adapting to CC at farm level (n=138).

When asked to indicate practices/actions that they have adopted in the last years to deal with climatic variability, the results showed most farmers have taken some actions in responding to CC (Figure 20). The leading group of farmers with the highest level of adaptation is the intensive dairy cattle farming. A majority of farmers of this group has taken actions in farming/management practices, improving knowledge/networking and investing in infrastructure. Around 70-80% of farmers focused on improve animal health, ensure right use of water, improve animal diet, improve farm structure and irrigation systems. Over 50% of farmers also paid attention in interactions with technical advisors, colleagues and participation in social network to enhance their capacity of adaptation as well as following daily weather forecast to know meteorological information for planning. Horticulturists also showed that they have fairly adapted to climate change, especially in ensuring right use of water and improving irrigation systems (over 50%). Nearly 50% of horticulturists have also changed/diversified crops.

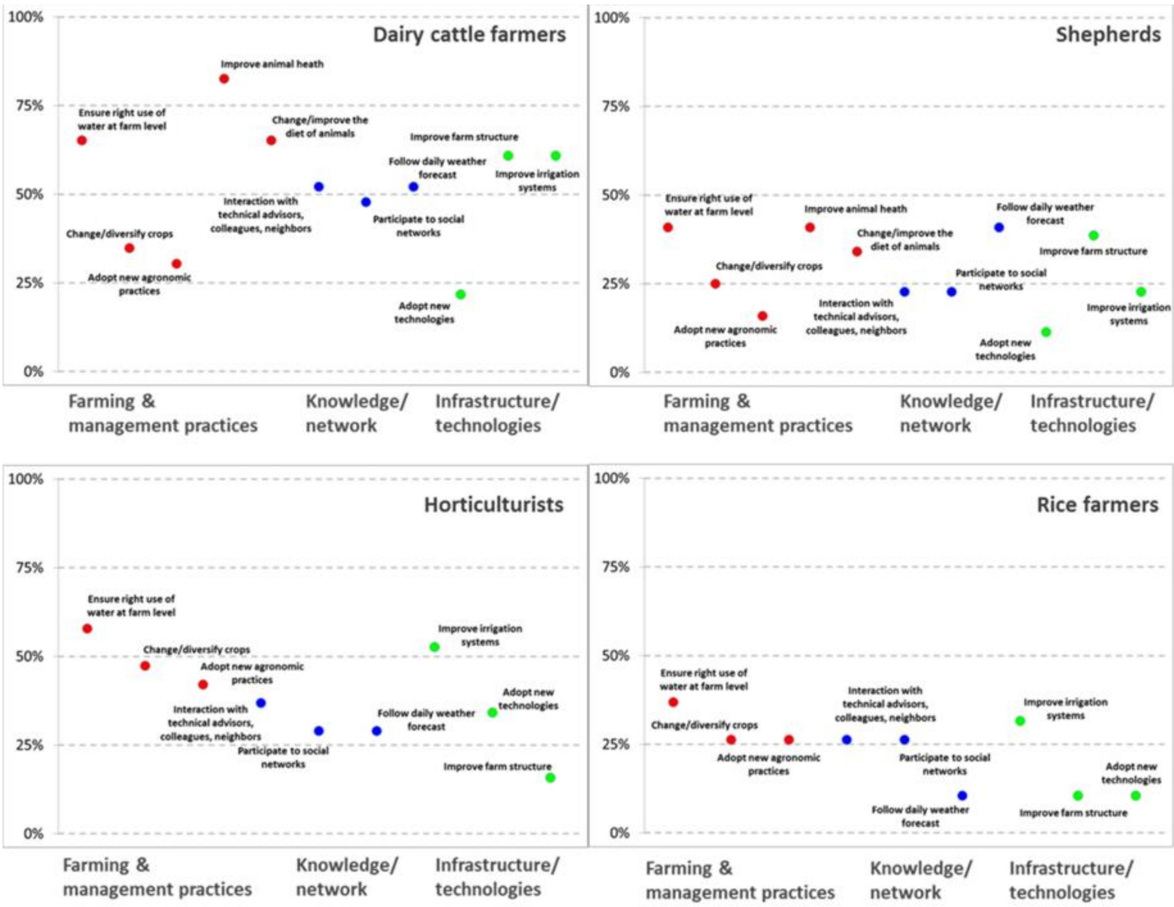


Figure 20. Descriptive results of farmers' adaptation levels and options.

While shepherds and rice farmers showed very low adaptation levels. Ensuring right use of water is the most important practice among others but still a minor percentage (around 30-40%) of these farmers have adopted. A minority of these farmers (25% or less than) interacted with technical advisors/colleagues and participation in social networks. However, seem shepherds considered following daily weather forecast is important for planning their activities as around 40% farmers indicated this options.

7.5. Discussion

7.5.1. Social construction of farmers' knowledge of climate change

Individuals and communities construct their ideas of climate differently (Hulme et al., 2009). Although most farmers of all farming systems in this study knew about climate change, but each group has its own way of interpretation of CC causes/ effects and adaptation. This interpretation was not made based on their knowledge obtained from media communication and other sources, but from their daily experiences and perceptions (Hulme et al., 2009). For an example, rise temperature is one of the main effects of CC according to knowledge of shepherds and horticulturists, (but not for rice and dairy cattle farmers) because the extensive dairy farming is mainly dependent on the rainfed forage cropping and pasture systems and the horticultural cropping is subject of heat waves. In fact, engagement with CC is a "personal state of connection" with the CC issue on cognitive, affective, and behavioral dimensions (Lorenzoni et al., 2007). The cognitive dimension relates to an individual's knowledge about climate change, its causes, impacts, and adaptive practices (Sutton and Tobin, 2011). However, knowledge is sometime biasedly developed and distributed (Behbahani et al., 2012; Dolfsma et al., 2008) based on interests. Rice paddy farming are well-known considered one of the most important source of CH4 emission. The IPCC (1996) estimated that rice production contributed about 5-20 % of the total emission from all anthropogenic sources. But a minority of rice farmers in this study indicated this cause of CC according to their knowledge. In addition, Arborea has been designated as the only one ZVN in Sardinia for nitrate pollution from agricultural origins and intensive dairy cattle farming effluents (Nguyen et al., 2013). But low percentage of this farmer group highlighted pollution as one of CC causes. Knowledge about CC provides an individual with the basis for understanding how it will affect them, their values and interests (Bord et al., 2000). It seems farmers in this study have clear knowledge about causes and effects of climate change, and for this reason they defended their stakes by avoiding talking about the causes of CC concerning their farming activities, (e.g. agriculture and animal husbandry as one of main activities contributing to climate change) or willing to share about climate effects that directly affect their farming activities. Farmers' knowledge about CC is a social construct because it depends on what farmers choose to believe based their interests, values and social-cultural settings. The four farming systems in this study have each own socio-cultural and geographic settings. The different knowledge shared by different four groups of farmers and the homogeneous awareness within each group has demonstrated the fact. According to Berger and Luckmann theory (1967), all knowledge derived from and maintained by social interactions. Farmers interact with their colleagues within their group. Each farmer group interact with the understanding relating to their respective perceptions of reality and through interaction their common knowledge of reality becomes reinforced.

7.5.2. Farmers' attitude- relevant -knowledge and behavior to CC adaptation

According to many scholars (e.g. Kallgren and Wood, 1986) increases in knowledge are associated with greater influence of attitude and behavior, for example attitudes towards to environmental protection. The findings in this study showed that knowledge about CC that helped to engage most farmers in believing CC as well as impacts of CC on farming systems. Knowledge about causes and effects is vital for generating the motivation to engage in adaptive strategies an individual is likely to choose from (Kroemker and Mosler, 2002). Knowledge about causes and effects of CC that pushed most farmers in this study having negative attitudes about the potential contribution of farming activities on environment and CC although most farmers strongly agreed that human activities is the cause of global climate change. A majority of farmers in this study denied or doubted about potential contribution of the local farming activities to climate change. Certain behavior is adopted in certain locality and condition (Syamwil, 2012). Socio-culture as the way people behave in reality. Socio-culture is the resultant of all things that influence farmers' cognitive perception, belief or experience and views on bio-physical and non bio-physical environment surrounding them (Kollmuss and Agyeman, 2002; Syamwil, 2012). However, knowledge - a construct in socio-cultural settings, is a structural property of attitudes that is a function of the number of belief, experiences and point views (Krosnick et al., 1993). Thus "the so-called attitude relevant knowledge" is a socio-cultural construct (Holbrook et al., 2005; Wood et al., 1995). Attitude relevant knowledge influence behavior, decisions and information processing under specific conditions (Fabrigar et al., 2006). Most farmers in this study have quite homogenous attitudes towards CC local impacts, potential contributions of local farming systems as well as homogenous behavior towards to adaptation to CC at farm level. However each group of farmers had their own choice of actions and responses to CC as well adaptation levels based on their own adaptive capacity which driven by both external (e.g. socio-cultural, economic) and internal forces (e.g. motivations, interests) of each farmer group .

7.5.3. What drives farmers' adaptive capacity?

There is a good reason in predicting a relation between attitudes and behavior, but the empirical evidence for this has not always been supportive. Many studies in the literature were provided evidence of an inconsistency between what people say and what people do (Manstead, 2001; Wicker, 1969). Knowledge may change and improve farmer's attitude of CC or contribute to a change in their behavior towards it, but there is a vast gap between knowing about climate change, interpretation and adapting to it. This research results showed that there are different adaptation levels to CC of the four farming systems. Farmers' adaptive capacity didn't not link with farmers' knowledge of CC and attitudes to climate change. Although shepherds and rice farmers had knowledge about climate causes and effects as well as positive attitudes towards adaptation at farmers levels, the study showed that these two groups have very low levels of adaptation to climate variability. In behavioral context, farmers interact with each other in their own group locality and context (social resources) and form a structure of their actions (Syamwil, 2012). Table 15 showed us the different socio-cultural and organizational settings of the 4 investigated farming systems. The leading group of farmers having highest adaptive capacity is the intensive dairy farming system, who is well structured in an institutional and organizational group. This group can be called as the "smart farmer" who used available resources to adjust to their farming activities proactively and had capacity of converting existing social-economic resources in adaptive capacity. However, the other farmer groups cannot be considered as "the "dump farmer", but maybe the "typical farmer" as they came from a different socio-economic conditions and institutional and organizational contexts. Grothmann and Patt (2005), Nelson et al (2010) and Smit and Pilifosova (2001) are factual when they argued that an individual or community's adaptive capacity is triggered by social capitals. The intensive dairy cattle farmers knew how to use existing knowledge systems and socio-organizational networks to enhance their adaptive capacity. For them, interactions and networking are important in taking actions of adaptation to climate variability, while the other farmer groups reacted individually based on daily meteorological information and declarative knowledge about climate change. Strong interaction and networking with the dairy farming group and with other intermediate technical organizations has facilitated the occurrence of social learning within this group of farmers (see Nguyen et al., 2013) that facilitated the co-production of procedural knowledge on adaptation strategies and practices (Albert et al., 2012), built credibility and trust of farmers in climate adaptation, motivation of adaptation and their adaptive capacity (Grothmann and Patt, 2005; Lebel et al., 2010)

7.6. Conclusion

The application of KAP model in this investigation was to capture what and how farmers construct their knowledge about climate change, their attitude and respond to climate variability. The results demonstrated that i) most farmers hold declarative knowledge about CC rather than procedural knowledge, ii) farmers' attitude- relevant - knowledge of CC is a social construct, and iii) their adaptive capacity is influenced, positive or negative, by social capitals such as external (e.g. institutional, organizations) and internal (e.g. socio-economic resources, knowledge, technologies). Farmers' declarative knowledge of CC did not directly influence their adaptation practices, but drove their attitudes towards CC causes and impacts.

Farmers' behavior in CC adaptation is a complex issue that cannot be visualized through one single framework. The farmers' adaptation levels are mediated through many factors such as their existing institutional and organizational capacity. A question emerged in this context is "what kinds of knowledge (Blackmore, 2007) are required for adaptation to CC at farm-level". This study results suggests that in the further researches it is necessary to understand the different perspectives of farmers of both social and technical, and what kinds of knowledge farmers hold and need in order to enhance adaptation capacity at local levels. This implies that research and policy on local adaptation to CC requires considerations. Firstly, integration of environmental psychological discipline into empirical researches in order to examine consistency or inconsistency of knowledge (incl. knowledge and knowing), attitude and behavior of farmers on CC adaptation. Secondly, facilitating social learning spaces within each group of local actors in order to enhance the sharing and co-production of both declarative knowledge (e.g. on CC causes and impacts), procedural knowledge (e.g. on alternative adaptation practices) in order to develop shared sustainable CC adaptation strategies at both policy and farm levels.

Chapter 8: ADAPTATTION SCENARIOS TO CC OF AGRICULTURAL SYSTEMS

Chapter structure

- Introduction
- Theoretical context
  - Adaptation problems and scenarios of adaptation to CC
  - Analytical framework
- Methods
- Results
  - Spatial and temporal evolution of the agricultural systems at Oristano
  - Socio-economic, climate and environmental changes
  - Farmers' prospective about future farming activities
  - Farm level possible adaptation strategies and adaptation agenda for RDP
- Discussion
  - Adaptation scenarios of Oristano farming systems
  - Different attitudes looking into the future
  - Driving forces of changes in adaptation scenatios
- Conclusion

"Every generation thinks it has the answers, and every generation is humbled by nature".

Phillip Lubin

8.1. Introduction

CC induces a range of uncertainties for agriculture including internal and external factors of the coupled human-environmental complex systems (Zhu et al., 2011). Agriculture system, as couple human-environmental complex system, is interrelated with the socio-economic and natural environment and faces increasingly the problem of managing its multiple functions in a sustainable way (Ewert et al., 2009; Reidsma et al., 2010). In the context of climate change, adaptation seems an urgent strategic approach (UNFCCC, 1992) for all sectors. European Commission also recognizes CC adaptation is an important means to complement climate protection measures. According EU Adaptation Strategy adopted in April 2013, most adaptation initiatives should be taken at the regional or local levels due to the varying severity and nature of climate impacts between European regions.

Adaptation of agricultural systems to present and future climate uncertainties requires the construction of future adaptation scenario that allows to take into account the complexities of socio-ecological systems and that address uncertainties of each specific local context. Scenarios analysis is increasingly being used to cope with uncertainty in the CC context (Berkhout et al., 2013; Hallegatte, 2009). Because all decisions at different levels are choices about the future in the face of uncertainty, scenario analysis has become popular approaches in societal and organizational planning (Duinker and Greig, 2007). March et al. (2012) cited that "scenarios analysis is a part of the methodological toolkit of science-governance policy interfaces in environmental matters" which has been extensively used in agriculture assessment (Ewert et al., 2009). Scenario-generation methods combine a set of behavior that include quantitative or qualitative, or mix qualitative and quantitative, subjective and objective methodologies (Bañuls and Turoff, 2011; Harries, 2003; Höjer et al., 2008). Scenarios that generate information useful to farmers requires a clear understanding of their frames and decision-making contexts (Berkhout et al., 2013). Farmers' frames are their perceptions and interpretation of the context, viewpoint or set of presuppositions of relevant issues or situations (Bullock and Trombley, 1999). The way in which farmers frame CC issues emphasizes the vulnerabilities, uncertainties and opportunities that can help to make sensing about the CC issues (i.e, impacts on their farming systems) and open the window for searching adaptation strategies. Adaptation strategies and processes of adaptation both involve a variety changes to local practices and social organization (Reenberg et al., 2008). The analysis of scenarios for decision making on CC adaptation at farm level should take into account how CC is framed by farmers mediated by their interests, experiences and internal/external forces. According to Smit and Skinner (2002), adaptation strategies at farm level can be classified into several dimensions such as (i) farming practices, (ii) farm management, (iii) technological developments and (iv) government programs and policies.

This chapter aimed to explore different scenarios of adaptation to CC of the four examined agricultural systems (intensive dairy cattle, extensive dairy sheep, rice farming and horticulture) in Oristano (Italy) which can be developed by analyzing farmers' frame of references about CC and their decision contexts taking into account socio-economic capitals, institutional and organizational factors.

8.2. Theoretical context

8.2.1. Adaptation problems and scenarios of adaptation to climate change

A wide range of theoretical and empirical research has dealt with human adaptation to exogenous and endogenous stressors in the climate changing world (Artur and Hilhorst, 2012; Berkhout et al., 2006; Chikozho, 2010; Collins and Ison, 2009a; Grothmann and Patt, 2005). Although adaptation research is assuming greater prominence on the scientific agenda, this interdisciplinary field is still characterized by an evolving epistemological base (Eisenack and Stecker, 2012). The scientific knowledge on CC impacts, adaptation is still fragmented. CC is a "wicked" problem (Rittel and Webber, 1973) challenging adaptation with dilemma in the sense that they are involved many actors with different interests at different levels of decision-making and no clear and common perception of what actually constitutes the adaptation problem (Hofmann et al., 2011). The term 'wicked' in this context of adaptation to CC is used, not in the sense of evil, but rather as an issue highly resistant to resolution. As a "wicked" problem, adaptation to climate change, is socially complex - an interacting issue evolving in a dynamic social context, has no clear solution, involves changing behaviors and organizational governance (Australian Public Service Commissioner, 2007).

Ritchey (2011) cited that the traditional steps of resolving a problem are "understand the problems, gather information, synthesize information and wait for the creative leap, work out solutions and the like." (Rittel and Webber, 1973, p.161). Or traditional wisdom for solving complex problems is followed the linear model 'waterfall' (Conklin, 2003). However, for "wicked" problems, especially in the social complexity , this type of scheme does not work (Conklin, 2003; Rittel and Webber, 1973). "Wicked" problem could not be solved by the same tools and processes that are complicit in creating them (FitzGibbon and Mensah, 2012). Resolving "wicked" problems required approached that short on explicating the complex interconnections of the multiple causes, consequences, and cross-scale actors of the problem. Scenario analysis has emerged as a mean of characterizing the future and its uncertainties involving "wicked" issues (Rounsevell and Metzger, 2010). Some specific tools have been suggested to respond to complex issues like CC adaptation, including scenario planning that is called Resolution Scenario Mapping - a knowledge-based, highly interactive group process for analyzing contingent events and possible outcomes (Horn and Weber, 2007).

Scenarios of adaptation to CC are not making forecasts or predictions, but prospective futures or future paths. Scenarios of adaptation will facilitate our understanding of how systems works and evolve (Kowalski et al., 2009). They are useful for learning about complex systems like agriculture systems, for policy decision making and for enhancing the resilience of environmental and CC policies.

8.2.2. Analytical framework

Many recent researches aimed at generating scenarios for decision making on environmental and CC has been concerned with methodologies/approaches that take into account the complexities of socio-ecological systems including environmental factors, social factors and feedbacks of spatial and temporal scales and with identifying the driving forces of change (e.g. Kok et al., 2007; Pahl-Wostl, 2008a; Toth, 2008; Zhu et al., 2011). Scenario analysis are based on a consistent set of assumptions about the key relationships and driving force of change, which are derived from the understanding of both history and the current situation (Kowalski et al., 2009) or consistent stories about ways that a specific system might evolve in the future (March et al., 2012). The recent literature showed that scenario analysis for dealing with uncertainties in the context of environmental and CC has been widely used with the excessive development of different definitions, methodologies, approaches, methods, types and categories (e.g. see the research reviews of March et al. (2012), Zhu et al. (2011) and Höjer et al (2008). Different typologies of scenarios for the studies of future have been suggested by Börjeson et al.(2006). (Figure 21).

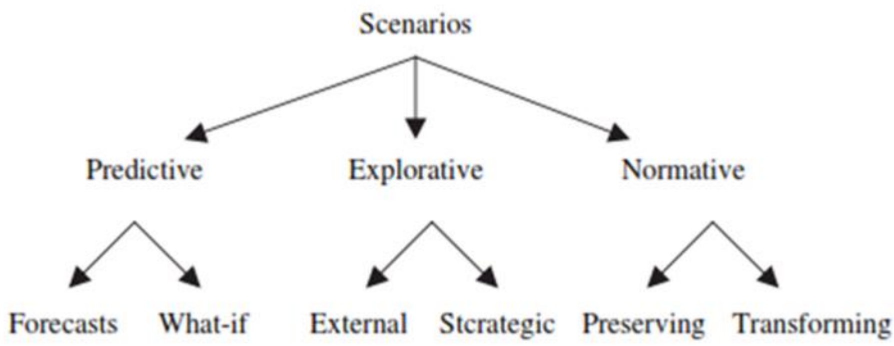


Figure 21. Scenario typology with three scenario categories divided into six types .Source: Börjeson et al.

These typologies of scenarios have been distinguishably used in the literature of CC research (Berkhout et al., 2002; IPCC, 2004). Each typology and type is used to address a specific question about the future, for examples, (i) predictable scenarios aim to predict what is going to happen;(ii) exploratory scenarios are to explore the future from a variety of perspectives; and (iii) normative scenarios are oriented towards certain milestones/targets (Höjer et al., 2008; Kowalski et al., 2009). However, the outcome of any scenarios can be influenced by several factors such as the degree of stakeholder participation, whether scenarios include narrative, descriptive, qualitative and/or quantitative elements, modeling and etc.(Kowalski et al., 2009).

CC adaptation of agricultural systems are directed by structural and organizational changes of farms in the socio-economic conditions as well as change in the bio-physical environment causes by climate change. Therefore, the scenarios about CC adaptation of agriculture systems are "statements of what possible, of prospective rather than predictive futures" (Bazzani et al., 2005, p.167). These scenarios respond to the question "What can happen with agriculture systems?" (Börjeson et al., 2006). They explore the future of farms from a variety of perspectives. In exploratory scenarios , the future is a social construction about which diverse opinions exist, typically they include a narrative element- a storyline and some quantitative indicators (Berkhout et al., 2002). Storylines are the qualitative and descriptive component of a scenario, which create images of future worlds. Exploratory scenario storylines typically adopt a co-evolutionary stance in which multiple assumptions about different development pathways lead to potentially very different outcomes over long-term time horizons. Although this is the most common use of exploratory scenario storylines, they can also be used to identify different development pathways that lead to similar or converging scenario outcomes (Rounsevell and Metzger, 2010).

8.3. Methods

Exploratory scenarios (as also known “descriptive scenarios”), which were selected to be used in this study, are developed from the present and explore trends into the future (what might happen in the future) (Börjeson et al., 2006). Since the scenarios created through this study will be mainly presented to a nonscientific audience (farmers, cooperatives, technical advisors and policy makers), qualitative method with some quantitative indicators , using a narrative element (storyline) to convey the main scenario massage, is selected to develop the scenarios.

Four main sources of information were used to provide the needed insight in the dynamic development of the four agricultural systems in the period covering approximately the last 30 years: a historical data on evolutions of the four systems, farmers’ interviews, a household survey; and an interactive workshop.

Secondary data, originating from Censimento Agricultura 2010 has been a valuable source of information as regards maps of agricultural development trends as well as changing trends of climate variability in the study area. The maps of agricultural development trends have been built to analyze the evolution of the agricultural systems in 30 years (1980-2012).

Twenty-five farmers were interviewed with the aim of acquiring information on climate changes impacts on environmental, social-economic and agricultural production in the study area, prospective futures of farmers and important resources for adaptation of the agriculture systems to climate change. One hundred thirty eight household questionnaires were, consequently conducted to validate farmers’ statements made during the interviews using open-ended questions or Likert type questionnaires to measure the levels of agreements and/or to rank the priorities of the issues. The interviews and questionnaires were integrated in the same survey of the studies mentioned in Chapter 6 and 7.

An interactive workshop was organized at the regional level on 19 July 2013 with the participation of regional policy makers, intermediate organizations, researchers, representatives of relevant communes, public water authorities, enterprises and farmers. The objective was to (i) explore different knowledge and perspectives on developing the regional Rural Development Programme with the integration of climate issues in agenda, (ii) discuss about vulnerabilities (weaknesses) of the different production systems in Oristano and (iii) debate on the adaptation capacity of each system.

8.4. Results

8.4.1. Spatial and temporal evolution of the agricultural systems

8.4.1.1.Dairy cattle farming

Figure 22 and Figure 23 show the spatial and temporal evolution of the dairy cattle farming system in Oristano in 30 years (1982-2010). It is evident that the number of dairy cattle farms has significantly decreased in 30 years, but their dimensions might be amplified as the number of animals considerably increased in the period of between 1982-1990 and kept stable until 2010.

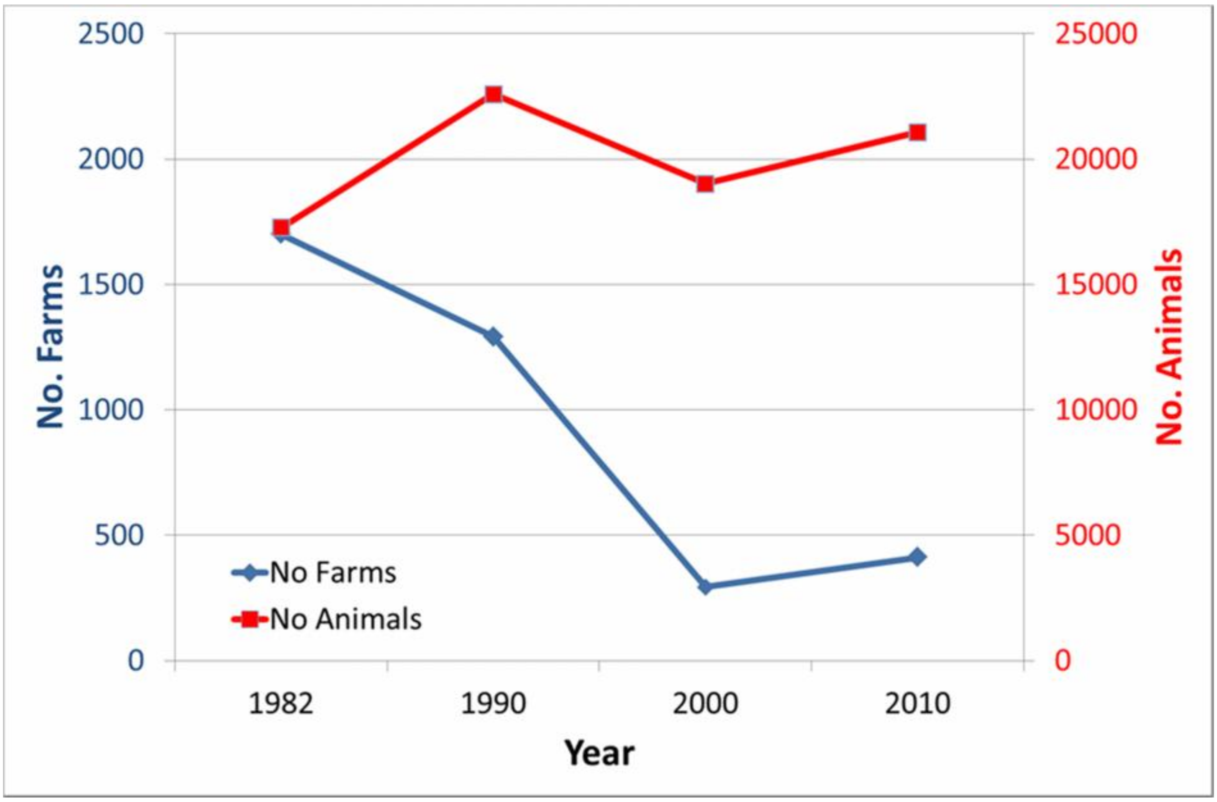
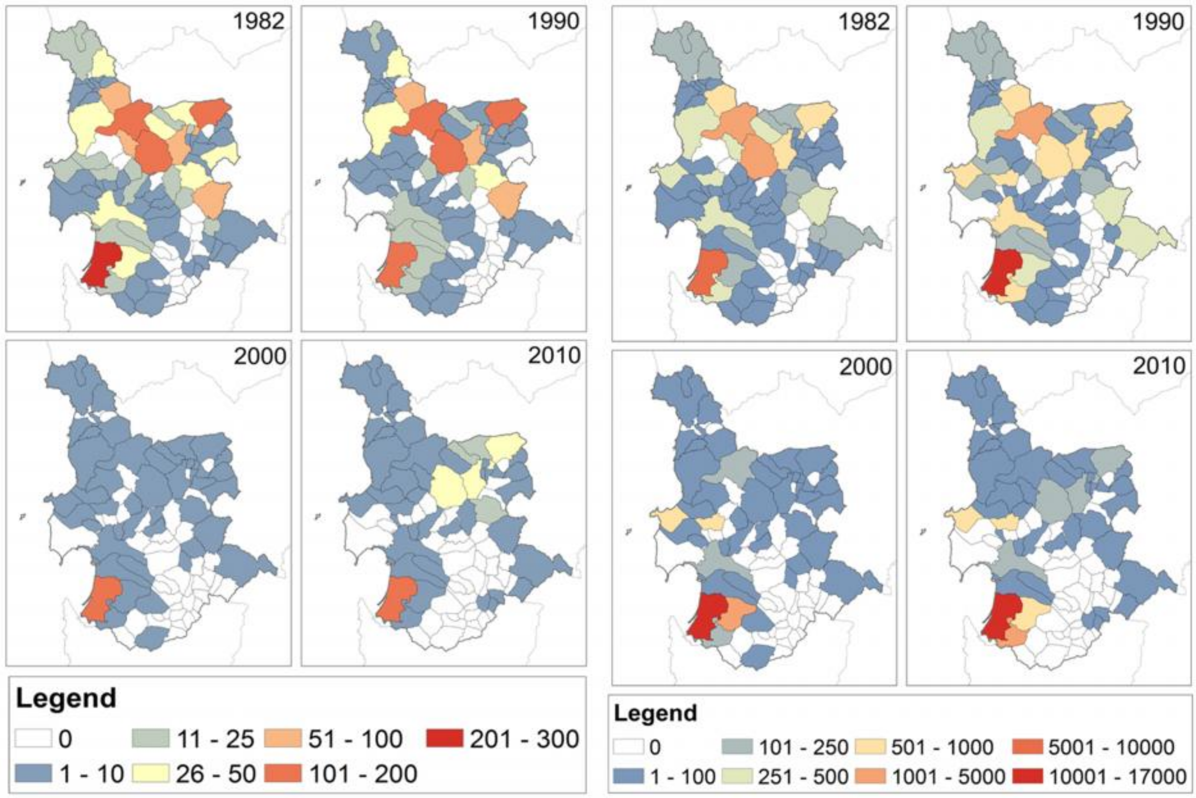


Figure 22. Temporal evolution of dairy cattle farming system (1982-2010). Data source: Censimento Agricoltura 2010, own elaboration.

In 1982, the dairy cattle farming activity covered almost the whole province of Oristano, with a large farm number of about 1700 farms. The high concentration of farms was in the hilly mountainous area of Northern Oristano (e.g. Paulilatino, Santulussurgiu, Ghilarza, Sedilo) and Arborea. Arborea also had a high number of dairy cattle farms of around 230 farms during such period. The farm number was gradually descended down to a number of 1290 farms in 1990, rapidly decreased to the lowest number of 290 farms in 2000 and slightly re-increased in 2010 up to 420 farms. While dairy cattle farming activity has been disappeared in a majority of communes, especially in the hilly mountainous areas, or remained with a minor number of less than 10 farms/commune and 20-50 farms/commune in Paulilatino, Ghilarza, Sedilo, it highly concentrates in Arborea commune of over 160 farms (see Figure 23).



(a) Map of evolution of dairy cattle farms (1982-2010) (b) Map of evolution of dairy cattle numbers (1982-2010)

Figure 23. Spatial evolution of dairy cattle farming. Data source: Censimento Agricoltura 2010 , own elaboration.

Although dairy cattle farms were expressively dropped away in 30 years, the number of dairy cows has been increased from around 57300 animals in 1982 to about 64000 in 2010. The dairy cows in Arborea have been amplified from approximately 14300 animals in 1982 up to 34400 cows in 2010. It is evident that the dairy cattle farming, nowadays, is more intensive, larger-sized and mainly concentrated in Arborea and its surrounding communes such as Terralba and Marrubiu.

8.4.1.2. Dairy sheep farming

The number of dairy sheep farms was stable between the period of 1982-1990 and has dropped remarkably from 1990 to today (approximately 1360 farms), while number of dairy sheep significantly increased between 1982-1990, remained quite stable between 1990-2000 and started increasing again from 2000 until today (approximately an increased number of 15860 dairy sheep). (see Figure 24).

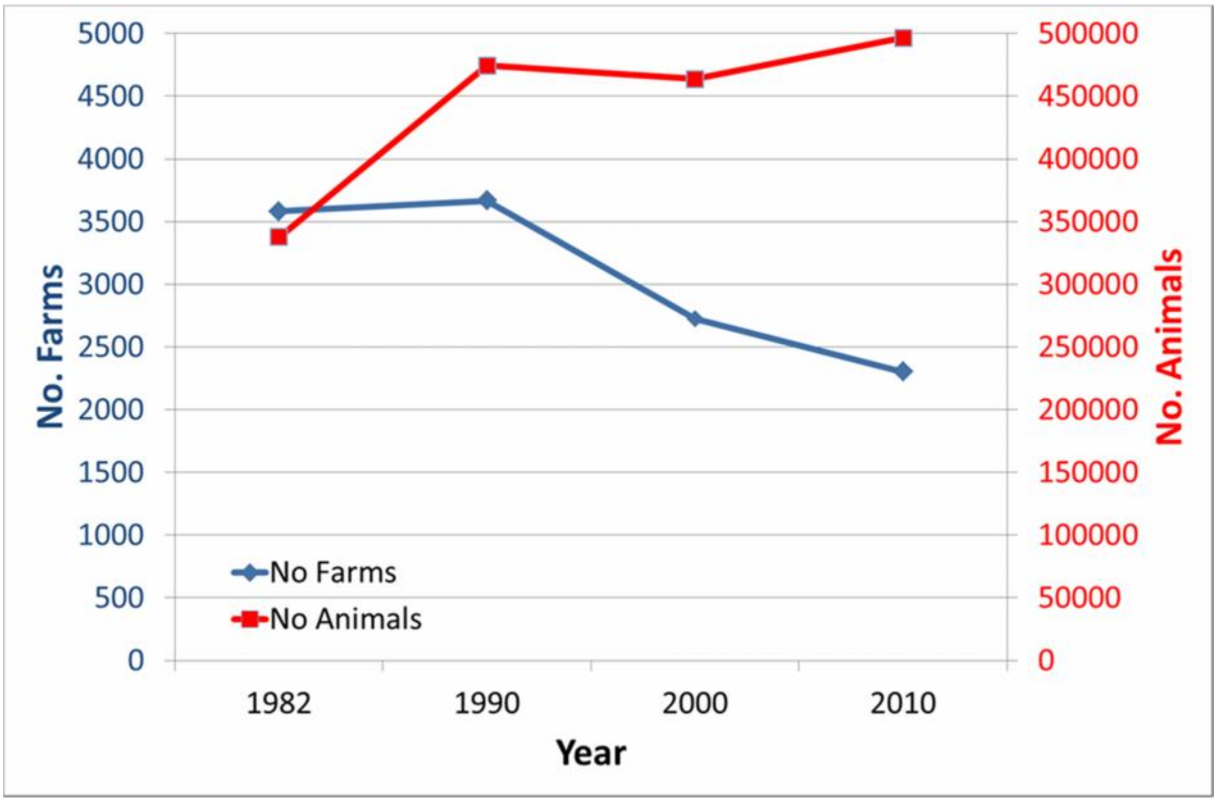


Figure 24. Temporal evolution of dairy sheep farming systems (1982-2010). Data source: Censimento Agrocoltura 2010, own elaboration.

In general, dairy sheep farms and farming activities were operated in the whole province of Oristano with a different density. A majority of farms is concentrated in the northern hilly mountainous areas (mainly in Paulilatino, Sedilo, Samugheo, Busachi and Santulussurgiu) from 1982 to today. However, the farming activity was largely operated in the northern hilly mountainous communes including Montresta and Bosa until 1990, but from 2000 until today the it has densely spread over the central and southern plain areas (e.g. Palmas Arborea, Santa Giusta, Marrubiu, Uras and Mogoro) (Figure 25).

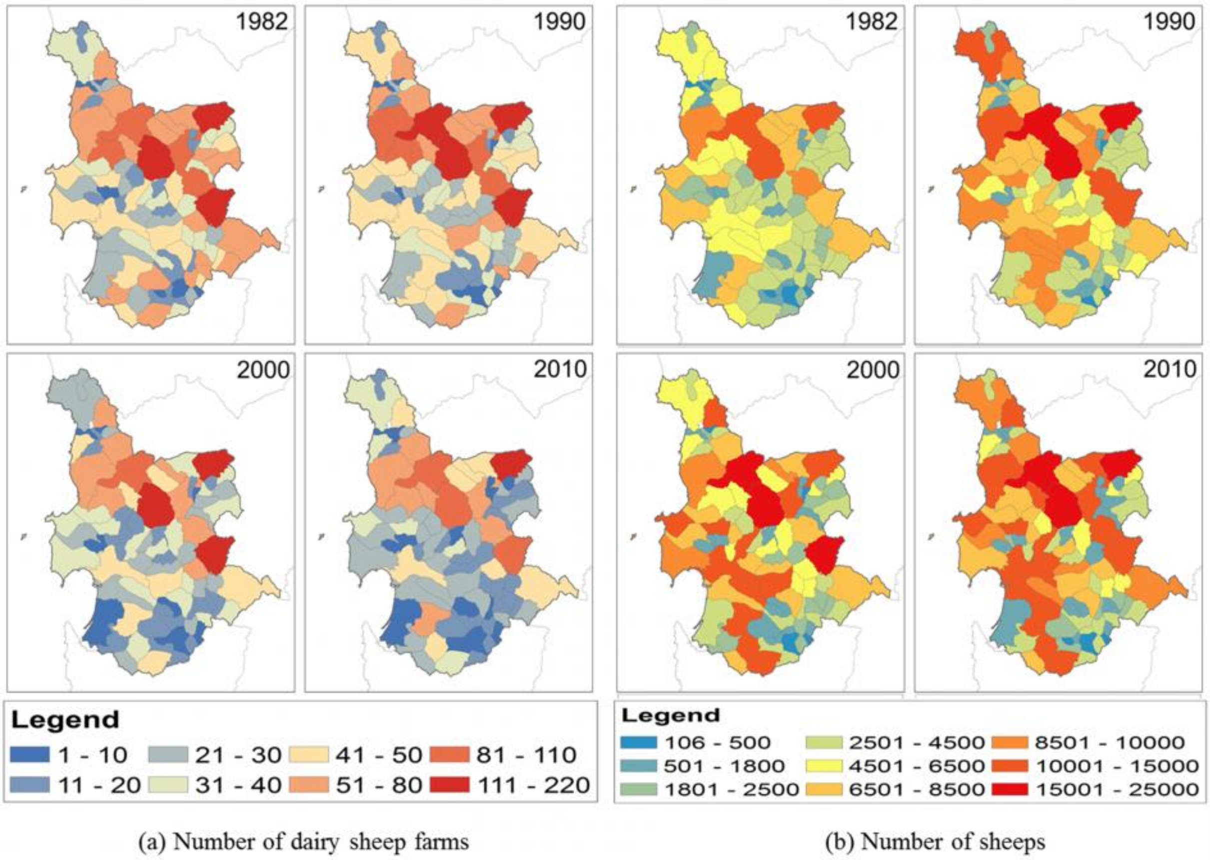


Figure 25. Spatial evolution of dairy sheep farming (1982-2010). Data source: Censimento Agricoltura 2010, own elaboration.

8.4.1.3. Rice farming

Figure 26 shows that the number of rice farms has decreased considerably, approximately 100 farms (between 200 farms and 102 farms respectively), while the rice cultivated areas has increased around 560 hectares in 30 years.

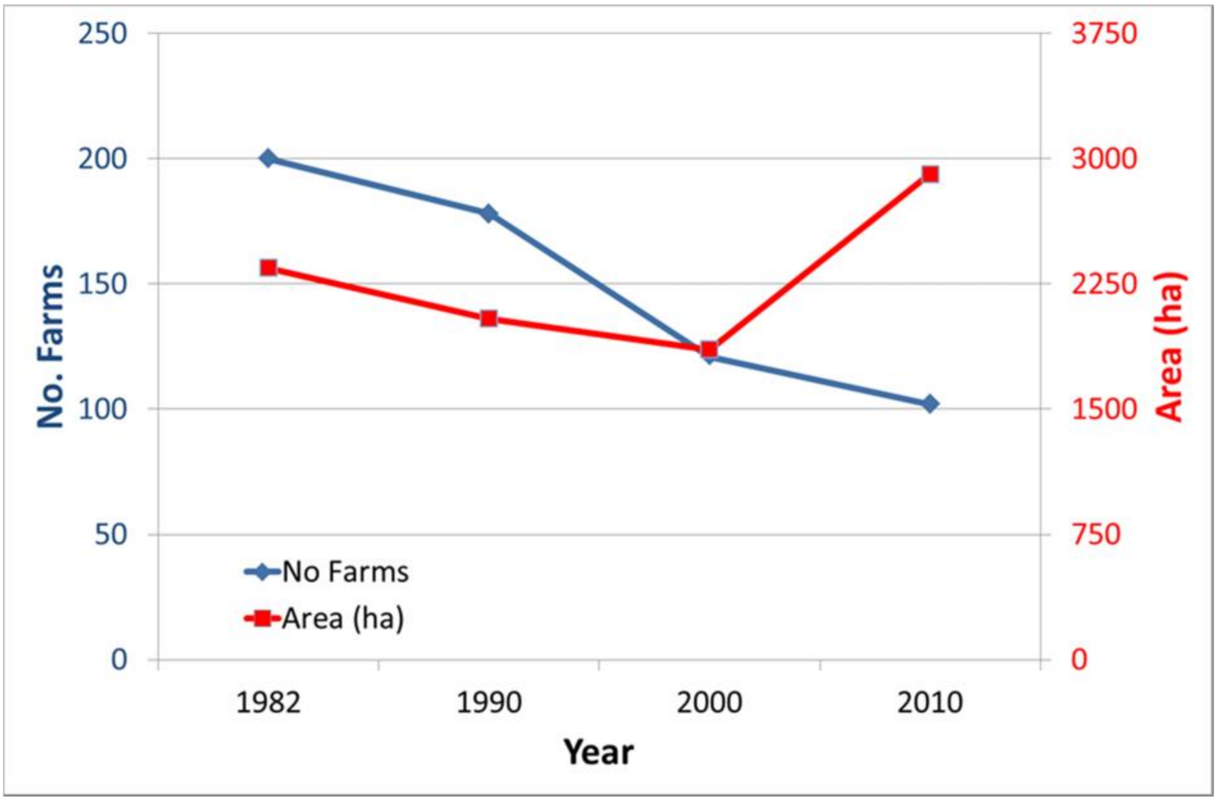


Figure 26. Temporal evolution of rice farming systems (1982-2010). Data source: Censimento Agrocoltura 2010, own elaboration.

The rice farming activity is highly concentrated along coastal communes, mainly in Oristano, Cabras, lesser in Simaxis, Zeddiani, and slightly in Santa Giusta, Siamaggiore, Baratili, S. Vero Milis, etc. This farming activity has not spatially evolved in 30 years both location of farms and rice farming zones (see Figure 27). In 1982, there was 3 farms operating in in the three communes of Tresnuraghes, Assolo, Gonnosnò with about 1,5-2 ha/farm, but they have vanished since 1990. There is one farm born in 2010 in Riola Sardo commune with a cultivated area of around 14 hectares (see Figure 27).

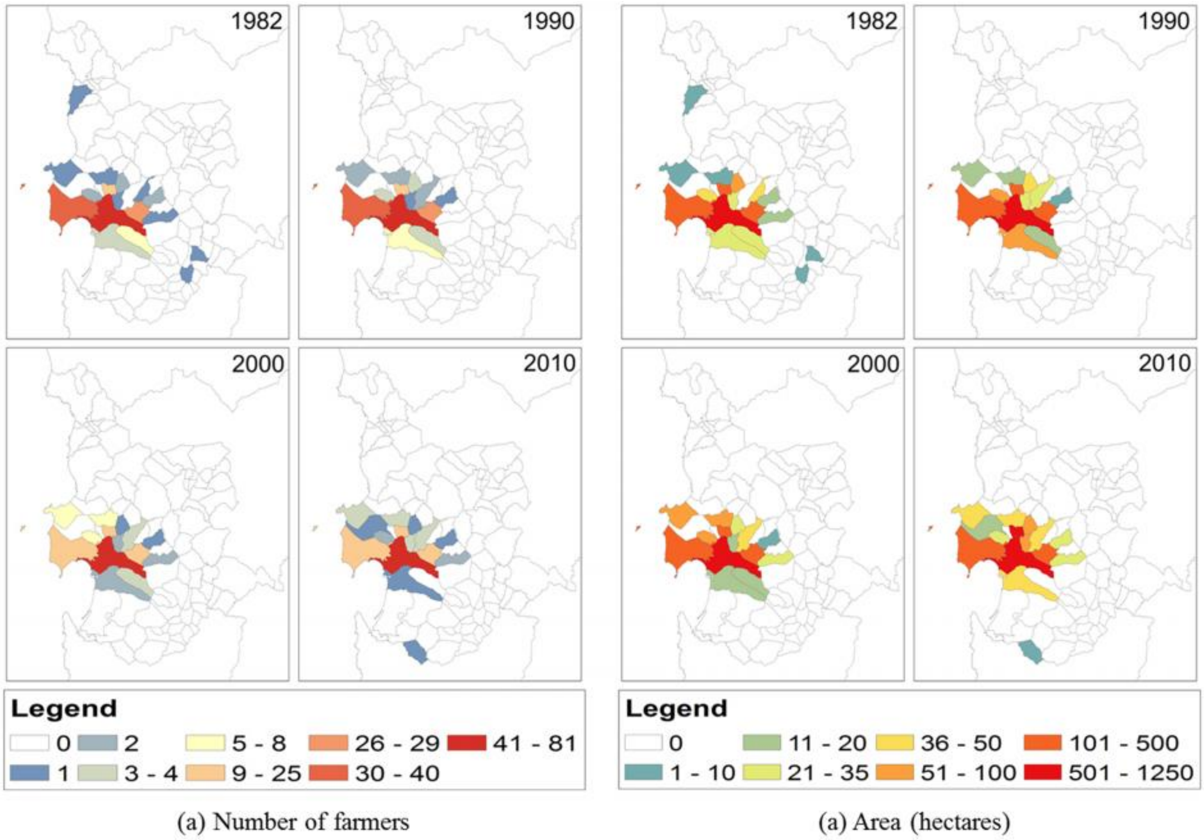


Figure 27. Spatial evolution of rice farming system (1982-2010). Data source: Censimento Agricoltura 2010, own elaboration.

8.4.1.4. Horticulture

The horticultural farms has continuously decreased in 30 years (approximately 2220 farms), while the cultivated area increased between 1982 and 1990 (around 950 hectares) and has gradually decreased again since 1990 (see Figure 28).

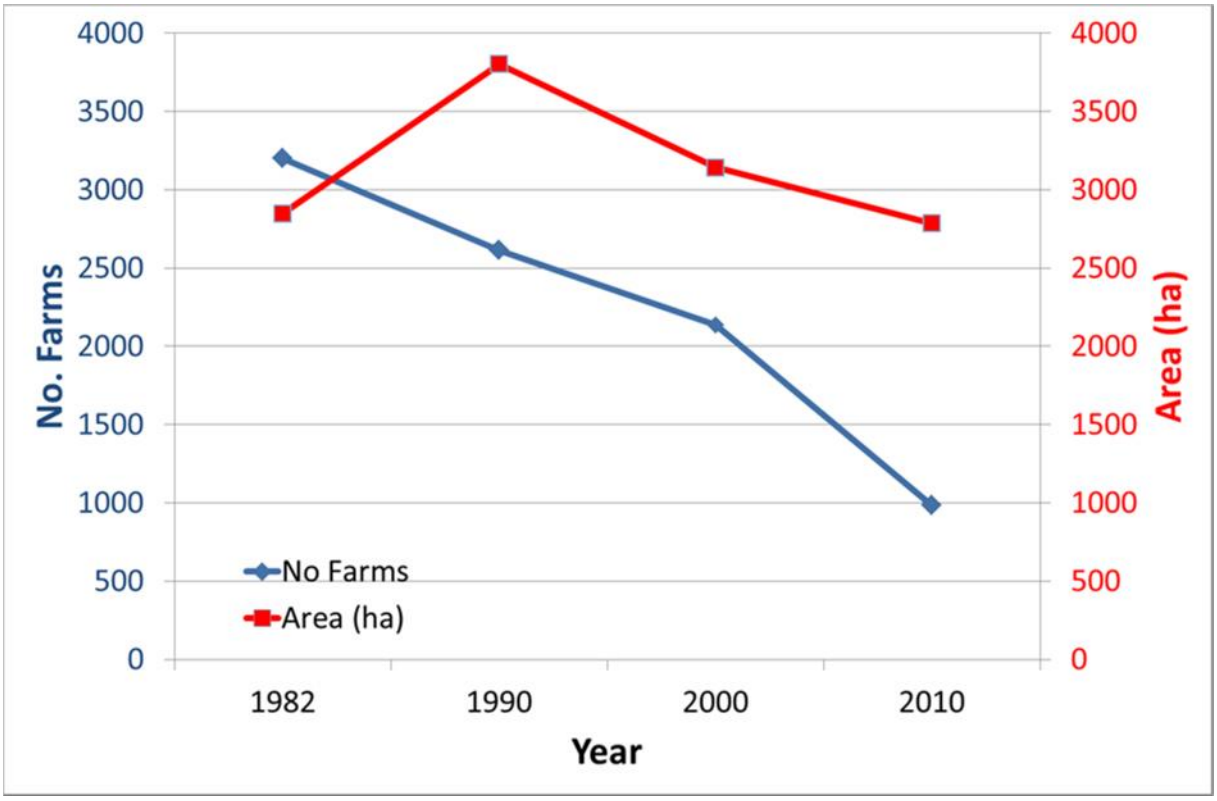
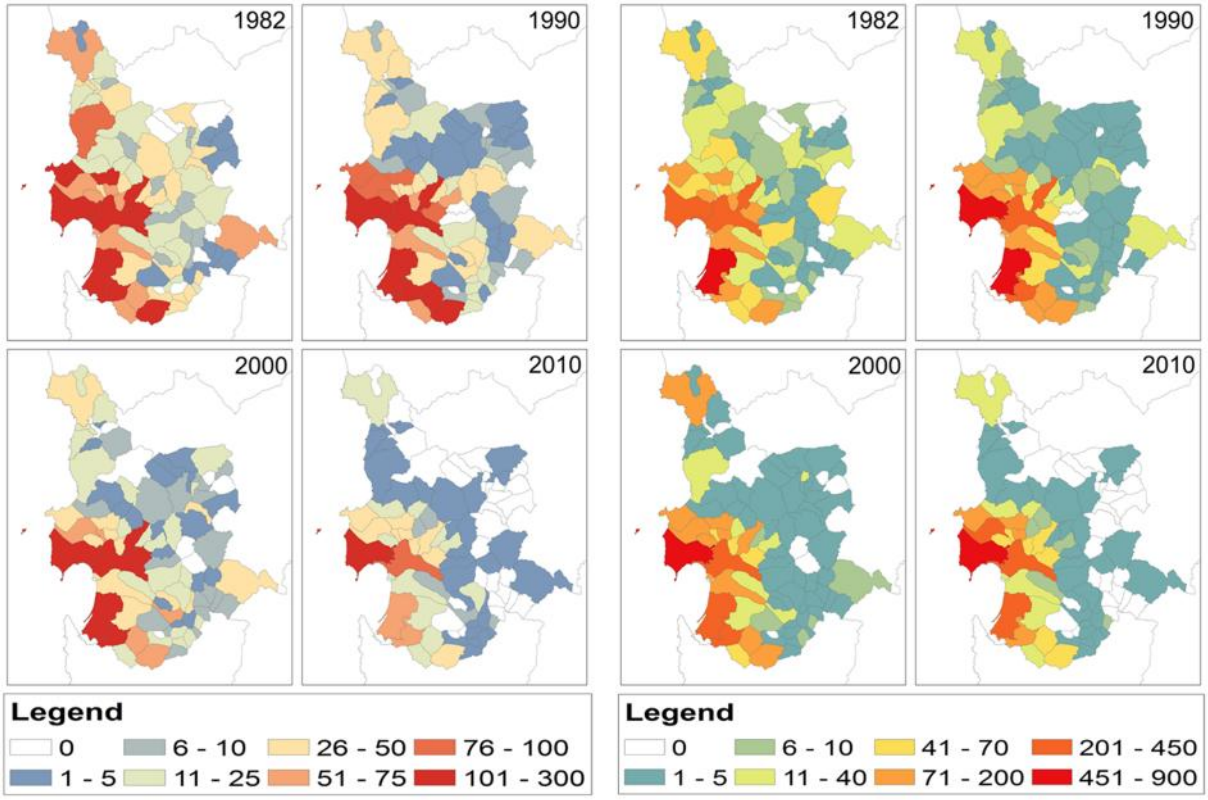


Figure 28. Temporal evolution of horticultural systems (1982-2010). Data source: Censimento Agrocoltura 2010, own elaboration.

In 1980s, the horticultural activity spread over the province of Oristano and has continuously dropped down to vanishing or remaining of around 10-20 farms in most communes. Today the activity is mainly concentrated in around 10 central coastal communes (e.g. Cabras, Oristano, Arborea, Tarralba, Riola Sardo, S. Vero Millis, Simaxis, Zeddiani , Baratili San Pietro, Mogoro), although the number of farms has also gradually been decreased in these communes (see Figure 29).

The highest concentrated area of horticultural activity since 1982 until today is in Cabras commune with 873 ha. Among only 4 communes having increased cultivated areas in 30 years (including Oristano and Riola Sardo, Cabras, and Baratili San Pietro). Cabras is the top commune having an increased cultivated area of 620 hectares (254 ha in 1982 and 873 in 2010 respectively), although the number of farm decreased from 179 to 141 farms in 30 years. In other communes, the cultivated area has continuously descended in 30 years. Arborea is an example of communes where both number of farms and cultivated area has dropped significantly.



(a) Number of farms (a) Area (hectares)

Figure 29. Spatial evolution of horticultural system (1982-2010). Data source: Censimento Agricoltura 2010, own elaboration.

8.4.2. Socio-economic, climatic and environmental changes

Farmers pointed out a number of changes in their land and their area during the semi-structured interviews. These indicators were recorded and tested again the level of farmer's agreement during the questionnaire survey. According to them, CC has provided several impacts including climatic, environmental and socio-economic changes in their area Table 23 and Table 24.

	Mean	S.E.	Mode	Range
A. Climatic impacts				
Increased temperature	3,97	0,9	4	5
Irregular rain	3,99	0,9	4	5
Increased cold days	2,91	0,9	3	5
Increased hot days	3,74	0,9	4	5
Increase droughts	3,90	1,0	4	5
B. Environmental impacts				
Increase plant disease	4,02	0,9	4	5
Increased animal disease	3,73	0,9	4	5
Increased soil temperature	3,72	0,9	4	5
Decreased plant growth	3,38	1,0	3	5
Loss of biodiversity	3,35	0,9	3	5
Decreased quantity of groundwater	3,57	1,0	4	5
Decreased quantity of surface water (lakes, rivers, ponds)	3,26	1,0	3	5
Decreased water quantity in reservoirs	3,08	1,0	2	5
C. Socio-economic impacts				
Loss of/decreased production	3,68	1,0	4	5
Increased economic crisis	3,81	1,1	4	5
Increased emigration	3,31	1,2	3	5
Lack/decreased income/benefit	3,85	1,1	4	5
Increased dis-occupation	3,51	1,1	4	5

Note: 5 scales (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)

Table 23. Farmers' perceptions about changes in their land and their territory (n=25 interviews and 138 questionnaires)

Farmers tended to agree that CC has caused increasing number of hot days, drought, temperature and irregular rain. CC also brought several environmental impacts such as decreased groundwater, increased soil temperature, increased plant and animal diseases. Due to such hard conditions of farming, according to these farmers CC impacts also lead to the situation of increased dis-occupation, loss of production, lack of income and economic crisis in the area. They are all drivers of changes and evolution in their farming systems.

Subsequently, the CC threats and impacts were discussed again during the group discussions in the interactive workshop among different categories of stakeholders, participants identified the impacts of CC on farming systems as well as the weaknesses and vulnerabilities of each agricultural systems in the context of CC as reported in the Table 24.

	CC impacts on the system	Weaknesses of the system
Extensive farming systems	- Reduced productivity of natural pastures (due to reduced rainfall during spring) - More irrigated water consumption due to increased droughts and temperature - Increased risk of soil degradation leads to loss of soil organic matter - Decreased milk quality leads to decreased market value of the product - Less water harvesting and conservation for drinking, especially in hilly mountainous pastures - Invasion of new pests and weeds and loss of native species - Risk of abandoning extensive farming activities → increasing the public costs for maintain biodiversity of pastures - Loss of other businesses associated with pastoral systems (tourism and environmental services - Increased risks of fire during summer	- Variety of forage species is often unsuitable - Difficulties of farms in planning farming activities - Traditional pasture burning habits for grazing animals are no longer sustainable - Rigidity of the current production system, the farmers are rigid to change.
Intensive farming systems	- Reduced productivity (e.g. reduced hay yield in spring, decreased milk quality, increased mortality of animals, infertility) - Increased production costs (increased irrigated water, drugs and veterinary requirements) - Existing crops are no longer sustainable with the new climatic and environmental conditions - Soil degradation(decreased organic matters) and environmental pollution - Increased plant and animal diseases - Low competiveness of farms and products	- Farms have to purchase mineral fertilizer to maintain yields - System produces GHG - Difficulty in animal effluent management (legal constraints) - High concentration of intensive dairy cattle farming - Lack of trainings to farmers on CC/technical assistance - Farms' organization is not ready to adapt to CC (e.g. irrigation systems) - Rigidity of legal instruments - Lack of public and private resources - No funding for innovation projects - Difficulties of private sector in co-financing the RDP
Rice and horticulture	- Increased irrigated water demand - Loss of biodiversity services → land abandonment - Loss of production - Increased pests and diseases - Decrease soil fertility - Increased production costs	- Lack of institutional communication, information dissemination , accessibility of data , and trainings on CC. - lack probabilistic seasonal forecasts on climate services,(not only Agrometeo but also other services like water demand, pest management) - Lack of awareness on GHG emissions associated with the supply chain - Off-seasonal cropping to comply the market pressures. - Farming choices are under uncertainty

Table 24. CC impacts on farming systems and weakness of each system in the context of CC (group discussions, WS Cagliari 19 July 2013).

8.4.3. Farmers' prospective about future farming activities

The survey was also focused on the farmers' prospective about their future in ten years through the issues: (i) if they would abandon their farming activities, (ii) they would change job or retired, (iii) they would go ahead with their activities by keeping the same current practices/techniques, and (iv) they would invest new technologies. The survey results are presented in Figure 30. Majority of dairy cattle farmers, rice farmers and horticulturists showed their positive attitudes about their future farming activity as more than 50% of these farmers declared to continue their farming activities and would not change job or retired. While major part of extensive dairy shepherds were not sure what they would do in the future (30%) or would abandon their farming activities (40%). These farmer group are really in uncertainty to decide about their future: in one hand they thought about abandoning their farming activities, on the other hand they don't know what they would do in the future but they would not want to change jobs or retired (approximately 50%).

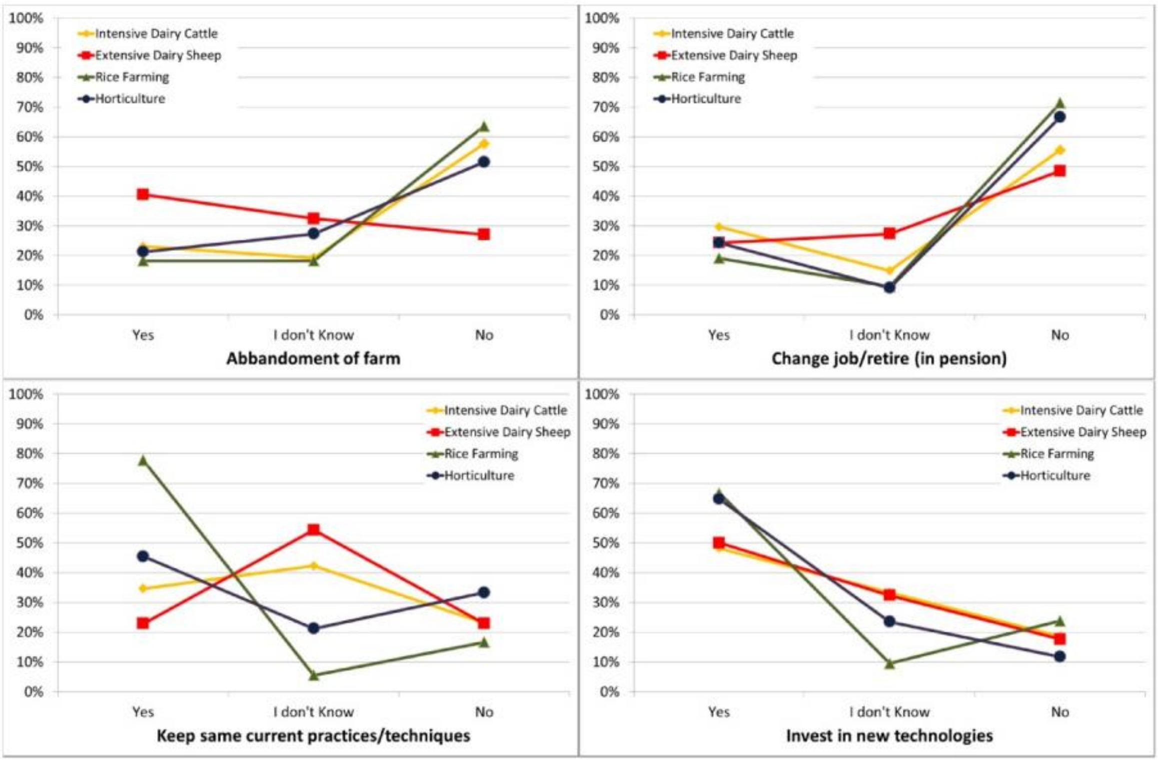


Figure 30. Farmers' prospective about their future farming activities (n=138).

The survey also showed high percentage of rice farmers (closely 80%) declared to keep their current practices/techniques to continue their future rice farming. This might be understood that rice farming practices were adequate with the current environmental and climate conditions and market demand. Similarly, more than 45% of horticulturists also declared to keep the same farming practices, but there is a part of these farmer group (35%) demonstrated their willingness to change their farming practices/techniques and around 20% don't know what they would do. Differently, majority of shepherds and dairy cattle farmers are uncertain about whether they would change their farming practices or they would continue with the same techniques. The difficulties in making decision on farming practices might be due to their current farming practices were not proficient to cope with the present conditions, but the future is uncertain to plan.

Major part of farmers of the four farming systems (over 60% rice and horticulturists, and around 50% shepherds and dairy cattle farmers) would invest in new technologies to bring ahead their farming activities. However, as shepherds and dairy cattle farmers are uncertain about the future, there is also about more than 30% of these farmers are not sure about what they would be going to do.

8.4.4. Farm level possible adaption strategies and adaptation agenda for RDP

Taking into account the CC impacts on each farming systems, the strengths and weaknesses of each systems in coping with climate uncertainties, the participants in the interactive workshop organized by the Agroscenari Project on 19 July 2013 also discussed about possible strategies that each farming system could adopt to maintain and develop their activity in the context of climate change. The workshop also focused on exploring the stakeholder's view points on possible adaptation agenda of farming systems that can be proposed in the Regional Rural development program. Table 25 reports the participants' perspectives on adaptation strategies and proposals of adaptation agenda in the RDP of each farming system.

	Farm level possible adaptation strategies	Adaptation agenda for RDP 2014-2020
Extensive farming systems	- Reduce water consumption through better choices of appropriate and arid resistant variety, irrigation emergency, improve small-scale irrigation infrastructure (e.g. small reservoirs) - Increased use of conservative tillage - Improve new grazing modes to adapt to new scenarios - Improve capacity of self-supply of forage through limit wasting hay in good years and enhance methods of conservation and storage of fodders . - Make radical changes in forage-livestock systems: more use of pasture or grassland, - Strengthen agro-forestry-pastoral system (wood, pastures and bushes, windbreaks, buffer strips, etc..) that provides a range of environmental services and added value at farm scale (e.g. shadow for animals) and may be less sensitive to CC - Recognize the role of pastoralists as “guardian" of the territory	- Help to maintain pastures by pastoral farms through strengthening farms’ economic - Support to improve farms’ structure (e.g. better access to water resources) - Favor the non-implementation of past agri-environmental measures in order to respond to the new challenges associated with the CC - Increase services to transfer technical knowledge - Development of territorial pacts for the exploitation of forage resources (lesson learnt from other regions such as Marche) through encouraging direct and active involvement of farmers, using participatory approach, highlighting the need for revision of the legal framework.
Intensive farming systems	- Increased meteorological forecasts (e. g weather alert) - Enhance farmers’ capacity in better irrigation management, diet of animals and diversification of crops, better preparation of soil - Genetic improvement of crops and animals - Farm adjustment (size, technological reorganizations, farm reorganization) - Promotion of crop and animal insurance - Collective management of services (e.g. bureaucratic practices) - Energy renewable - Test the products before introducing them into the market	- Involvement of stakeholder and bottom-up voice listening - Promote researches of alternative fertilization techniques - Strengthen monitoring systems and dissemination of data (if from public funding) - Help farmers to purchase more land to reduce animal effluent discharge pressures - Support the development of production chain among different areas to take use of feed - Provide fund for alternative energy - Improve irrigation systems both management and infrastructure - Develop efficient business strategies for farmers. - Provide access to credit for young people - Support farm aggregation and cooperatives - Donors should participate in preparation of project calls for proposal - Financing insurance measures - Improving the analysis of context
Rice and horticulture	- Better use of existing services (monitoring, weather and climate forecasting) - Enhance farmers’ role in monitoring through creation of two-way platforms of services also for the technical assistance. - Crop diversification - Conservation and valuing germplasm.	- Enhance synergies between districts, encourage the development of specialized and synergic districts - Promote collective measures - Encourage the stakeholder involvement, flexible design of adaptation measures. - Promote scientific researches in CC adaptation - Incentives for farms’ infrastructure in order to allow them to invest in modern machines and equipment - Improve more flexible irrigation infrastructure - Restore reclamation networks - Funds for projects of irrigation converting - Funds for the development and use of climate systems, monitoring and information systems - Open access to data and information - Promote access to land and agricultural of young people

Table 25. Stakeholder’s outlooks on possible adaptation strategies of farming systems and RDP adaptation agenda (group discussions, WS Cagliari 19 July 2013).

8.5. Discussion

8.5.1.Adaptation scenarios of farming systems

Based on the above research results, it is possible to draw the future scenarios of Oristano farming systems within next ten years into two categories of scenarios: (1) individual adaptation scenarios and (2) collective adaptation scenarios as summarized in Table 26. Adaptation of the farming systems can proceed in a fragmentary way with both individual interests and collective senses involved in using scenarios or experience in implementing change (Adger et al., 2005). Decision making of adaptation are made in different scales, by different interest groups and different levels of responses. The individual adaptation scenarios refer to farm level adaptation to CC which depends much on their response levels to climate change, their attitudes about their future and their adaptive resources. Individual adaptation scenarios can be split into 2 types of scenarios, which can be called: (i) Type 1.1 "Realist" refers to an adaptation scenarios of practical farmers who are proactive and positive in reacting to climate change, and (ii) Type 1.2 "Pessimistic" refers to the one of passive farmers who have negative attitudes about their future, do nothing or react at the last minute to deal with climate change. CC is not an issue of only farmers, there are also interests of other actors in societies such as policy makers, researchers and private sectors. In this case, the adaptation scenarios of farming systems will be the collective actions. However, they can be split and into two types and can be called with the metaphors as: (i) Type 2.1 "Optimistic" refers to the collective adaptation action of multi-forces at multi-levels, where science-policy-practice interface (Urwin and Jordan, 2008; Weichselgartner and Kasperson, 2010) is built and a space of social learning among farmers and other stakeholders is generated; and (ii) Type 2.2. "Mixed" refers to a policy oriented-scenario. It is a short term vision scenario and the typical top-down formulation of adaptation strategies and/or last minute involvement of stakeholder. Sometimes, policy-driven top-down targeted adaptation approach can generate anticipatory action at low cost in some areas (Tompkins et al., 2010), however, they are not long-time sustainable as there is lack of social learning process in order to develop the long-term capacity of local farmers in adapting to climate change.

Individual adaptation	Collective adaptation
Scenario Type 1: Realist • Long term vision • Presence of local knowledge • Investment in technologies • Continue to enlarge the farm size/improve practices and structures • Diversify crops • Lack of communication among farmers • Self- establishment of adaptation practices and strategies	**Scenario Type 3: Optimistic** • Long term vision • Presence of both S &L knowledge • Investment in technologies • Continue to enlarge the farm size • Diversify crops • Intensive communication and social learning • Collective establishment of adaptation practices and strategies • Investment in research • Adaptation is inserted into RDP agenda with strong stakeholder participation
Scenario Type 2: Pessimistic • Short term vision • Abandon farming activities • No investment in technologies • Lack of communication among farmers • Remain the same farming practices/structure • No establishment of adaptation practices and strategies • Dealing with CC at the last minute	**Scenario Type 4: Mixed** • Short term vision • Presence of SK but not LK • Inefficient investment of technologies • There is communication but lack of social learning • Top-down establishment of adaptation practices and strategies • Last minute policies with stakeholder participation • No investment in research

Table 26. Adaptation scenario types of the farming systems.

The adaptation scenarios of farming systems in this case study can be described into 2 main storylines called "Every farmer for himself" and "All for all farmer". Both scenarios are developed from the present situation and explore trends into the future based on different perspectives of different groups of farmers and stakeholders.

Scenario 1: "Every farmer for himself"

In dealing with CC impacts on farming systems, farmers are the first and direct actors who have to react to climate stimuli with short-term or long-term vision and in both ways of well-preparation or at the last minute. Due to different characteristics of farmers' groups with different attitudes, knowledge, local settings, internal and external factors that drive their adaptive capacities, this scenario will lead to two sub-scenarios:

Sub- scenario 1.1. High concentration of farming activities in the central plain and coastal area

The spatial and temporal evolution of Oristano farming systems in 30 years demonstrated that all farming systems have gradually moved from the hilly mountainous area to the plain and coastal areas in 30 years as self-adaptation. This is due to the impacts of CC presented in the areas including increased temperature, hot days, droughts and decreased ground water. The traditional farming activities in the hilly mountainous areas often depended on the climatic conditions such as the availability of rainfall and ground water. Whenever farming activities move to the plain areas, they are transformed into intensive farming activities that need to invest in technologies, improve farming practices and reach the irrigated water. Therefore, only intensive farming will be developed, the farm dimensions will be larger, the number of farms will be significantly reduced. This may lead to the situations:

- Advanced farms may be progressively developed in both dimension and technologies, while the all backward farms will be vanished.
- Farms may be in difficulties to deal with the problem of environmental pollution, costs of water and energy. This may push them to invest in energy renewable, water waste treatment and so on.
- A large pasture in the hilly mountainous areas will be abandoned which will be subject for fire and desertification.

Sub-scenario 1.2: Abandoning farming systems

Since CC causes increased temperature and drought and decreased rainfall in the area, the local production tends to be dropped down or lost. A sub-scenario for future farming systems may be that farmers, who have been severely impacted from climate change, will abandon away from their activities due to low soil fertility and scarcity of water caused by environmental and climate change. This scenario is more realistic for the extensive farming systems rather than irrigated intensive farming systems as farmers showed their prospective during the survey . In this case, the situation may be led to:

- A large grazing lands in the province will be abandoned. Whenever a pasture is not in used, it becomes a wasteland. The area is more susceptible to fires and desertification. Abandoned pastoral activities will determine the low coverage of the territory with that is easy to make the area more susceptible to fires.
- A large of farms may fall into the situation of uncertainties in which they really do not know what they would do for their future. The young generation will not continue their farming activities, but emigrate to cities or fall into the situation of dis-occupation.

2. Scenario 2: “All for all farmers”

CC is not only the issue of farmers, but of the whole society. There is room for a collective adaptation, not just individual adaptation at farm level. Short and long term investments may be taken in Rural development programs at different levels (Europe/National and Region), both in the field of scientific research as in the development of adaptation measures as discussed in the interactive workshop. According to the workshop outcome, besides the vulnerabilities of each farming systems, farmers could adapt to CC by both endogenous and exogenous forces. However, depending on the choices of policy makers in formulation and implementation of polices. If the bottom-up approach is chosen, then local actors will be invited to participate in decision-making about the strategy of adaptation and in the selection of the priorities to be pursued in their local area. In case the top-down approach is selected, policy formation and policy execution will be as distinct activities. Policies are set at higher levels in a political process and are then communicated to subordinate levels which are then charged with the technical, managerial, and administrative tasks of putting policy into practice. This approach provides a common gap' between what was planned and what actually occurred as a result of a policy. Therefore, this scenario also has two sub-scenarios:

Sub-scenario 2.1: "Collective bottom-up adaptation":

Adaptation agenda will be developed for RDP 2014-2020 through participation of multi-stakeholders. Long term investment for CC adaptation will be taken into the RDP. The RDP may foster scientific research to not only focus on the impacts of CC but also on innovative ways of adaptation. There may be also funds to be allocated in agricultural development and adaptation to CC in an efficient and sustainable way. This may lead to several mini- outlets:

- Through the incentives of the RDP, extensive farming activities will be encouraged to maintain in order to reduce the fire risks in the pastures, enrich organic matter in the soil, promote the absorption of carbon and combat desertification. Shepherds may be paid to improve their farm condition and enhance their adaptation capacity.
- Intensive farming systems such as dairy cattle farming may be developed in a sustainable way. With RDP incentives and science-based policies, the environmental pollution will be improved and managed systematically. There will be efficient investments in bio-energies, water waste retreatment to improve the pollution, create local available resource and ensure irrigated water security.
- Science-policy and practice interface (Weichselgartner and Kasperson, 2010) may be enhanced through the RDP. The adaptation policies will be aligned, each level pays its

role in the light of their competences, with a shared views of farmers. Based on the available scientific data, adaptation policies and practices will be developed consistently. This leads to the collective adaptation actions with the strong participation of stakeholders and farmers in the process of designing adaptation measures. It may provide opportunities for social learning occurrence that will increase CC awareness and enhance adaptation capacity of farmers.

Sub-scenario 2.2. "Top-down adaptation"

Since CC is addressed on the spot, only a reactive, short term policy approach towards CC is possible. Therefore, short-term investment will be considered in designing RDP, mostly in the development of responsive adaptation measures. There will be no long-term adaptation will be developed through the multi-stakeholder participation or their voice are not taken into account. No investment in scientific research are made, or they are inefficient and insufficient investments. The scientific research will not made used of policy makers in formulation policies and regulations. Farmers may receive incentives for adaptation, but their long term adaptive capacity will be not improved as there is no a space for social learning occurrence among multi-stakeholders at multi-scales.

8.5.2. Different attitudes looking into the future

The study results showed different ways and attitudes of farmers and stakeholders looking into the future. There are several different scenarios that could be drawn from the past and present conditions and prospective about the future taking into account the internal and external uncertainties of the complex systems (Kowalski et al., 2009; Zhu et al., 2011). The positive or negative attitudes of farmers looking into the future depend on how much their farming activity have been impacted by climate and environmental change. Farmers' adaptation can mediate the direct and indirect impacts of CC on their farming systems (Adger et al., 2005; Evans et al., 2013). In this study, although all farming systems seemed to have self-adapted to changes as they gradually moved from the hilly mountainous areas to the plain and coastal areas in 30 years to search for more resources (e.g. water) and to mediate the impacts of climate change, each group of farmers has their own prospective about the future, for an example, the extensive dairy sheep farmers looking into the future more negatively and uncertainly. This may be because of their hard experiences in managing their past farming activities in the condition of long-term climate and environmental changes. Other groups of farmers seem to be less uncertain about their future as they showed their proactive adaptation attitudes about CC as their farming activities are intensive and less depend on climate conditions (e.g. rainfalls). Even though they have been impacted by CC in the last decades, they could get out of the situation with their endogenous adaptive capacity and are confident to go ahead with their farming activities.

There are not only differences among the insiders' attitudes, but also between the insiders' and the outsiders'. Farmers are the first direct actors who have to directly deal with climate impacts on their farming activity, but how farmers' adaptation to CC can be facilitated and enhanced (Adger et al., 2009)? What are the roles of outsiders in the process of CC adaptation of farming systems? The interactive workshop outcomes showed that the outsiders (policy makers, researchers and intermediate organizations) were seeking for how policy and research could enhance the adaptation capacity of farming systems. For farmers' autonomous adaptation to be effective, and to avoid maladaptation, certain preconditions therefore have to be met. Individuals have to have the right incentives, resources, knowledge and skills to adapt efficiently (Fankhauser et al., 1999). The proposed adaptation agenda for the regional RDP aimed to search for right incentives, resources, and enhance knowledge and skills of farmers in adaptation. These outsider actors seem to be optimistic about the future of farming systems if there is investment in research in order to improve CC reliable information and adaptation modalities, and policies provide the right legal, regulatory and socio-economic environment to support farmers' autonomous adaptation.

8.5.3. Driving forces of changes in adaptation scenarios

The four adaptation scenarios of the Oristanese farming systems has been drawn to demonstrate "limit" and "ideal" adaptation scenarios (Table 26). Although these scenarios are speculative, they partially reflect the current state of adaptation of the farming systems in this study as they are built based on the past and present evolution of the farming systems, environmental and socio-economic changes and prospective of stakeholders. The integration of these driving factors aimed to produce coherent and consistent images of the future farming systems (March et al., 2012). However, the adaptation scenarios of the farming systems may be changed due to the internal and external driving forces, such as knowledge, skills, research, policies and level of stakeholder participation (Rounsevell and Metzger, 2010). Limited adaptation of individual proactive scenario (Type 1.1) is that adaptation stopovers at only the single farm level, there is no knowledge spillover among farmers, and sometimes lack of scientific knowledge on climate impacts (Hofmann et al., 2011) which can lead to maladaptation. The use of metaphor "realist" scenario refers to the self-adaptation capacity to survive and develop in the context of CC thanks to farmers local knowledge (knowing), their skills in technology investment and their anticipatory self-establishment of adaptation strategies. By contrary, the failure in adopting adaptation practices in coping with CC is demonstrated in the scenarios Type 1.2, 2.2 where CC problem is solved just like reacting at the last minute or on the spot without anticipatory adaptation strategies.

Where adaptation is effective the scenarios (Type 2.1) suggest that stakeholders anticipate CC and pursue planned, strategic adaptation (Evans et al., 2013). The metaphor "optimistic" is used to indicate the "ideal" adaptation scenario in which all forces are mobilized for collective actions. Adaption of farming systems includes: improving agricultural practices, strengthening farm management skills, improving research-based knowledge on CC impacts and adaptation and improving policy environment. However, neither stakeholder, scientific knowledge nor governmental and regional incentives can improve adaptation strategies for farming systems but farmers' long-term adaptive capacity will be the main engine for the adaptation of agricultural systems. Inserting CC adaptation agenda into the regional RDP should aim to open a new space for social interaction and social learning in order to build long-term adaptive capacity of farmers. This would also enable a better understanding of divergences in opinion about the efficacy of adaptation options (Bommel et al., 2009), the farmers' adaptive capacity and any real and perceived barriers to the uptake of options (Ford et al., 2010). Recognizing and addressing changing priorities and preferences for adaptation will assist planning and policy development to facilitate pro-active responses of farmers.

8.6. Conclusion

This study aimed to build the images of future farming systems in Oristano province (Italy) through a process of interaction with stakeholders. The four storylines of possible future of the farming systems are summarized taking into account the stakeholders' ideas, experiences and perspectives. In the context of scenarios it is easier for stakeholders to deal with stories than with purely quantitative information (Kowalski et al., 2009), the exploratory storyline scenario approach was chosen to follow in this study. As scenario storyline assumptions are limited by knowledge uncertainties – there are environmental change process that we know little or nothing about (Rounsevell and Metzger, 2010), the analysis of spatial and temporal evolution of the four farming systems in this study helped to provide a trend from the past and present to the future. Although the scenarios made through this study were not constructed and narrated with stakeholder, they were constructed based on farmers' prospective of their future farming activities, their knowledge and experiences about CC impacts, and other stakeholders' perspectives, ideas and knowledge about the strengths and weaknesses of farming systems and prospective about future CC adaptation policies. Although the limits of the scenarios in this study are the short-term timescale of scenarios due to the short-term nature of policy cycle (e.g. rural development programme), the lack of clarity about the purpose of a scenario construction and limited relevance to specify policy details. These scenarios in this study can be seen as "learning processes" having value in support of research and policy. These scenarios may be useful for policy makers to visualize future worlds of farming systems and to help guide and develop sustainable adaptive strategies.

Chapter 9: CONCLUSION: IMPLICATIONS AND LIMITATIONS

Chapter structure

- Introduction
- Summary of the research findings
- Implications of the study
- Suggestion for future researchers
- Concluding summary

"Because we cannot change the world around us, so we have to transform ourselves, facing all with compassion and wisdom mind". Buddha

9.1. Introduction

This chapter concludes this thesis with a discussion of the implications of the research findings, the limitations of this study, and suggestions for future research. To recap, this study retrospectively examined the local farmers' adaptation capacity and adaptation processes in the world of changing climate with the case study of Italian agricultural systems at Oristano province, Italy. More specifically, the research sought to explore:

- relationships between agro-ecological practices, conflicts of interests and social context in a situation of complexity and uncertainty of climate change,
- farmers' perceptions of CC and whether they are adapting to CC
- farmers' knowledge and attitude towards adaptation practices, and
- adaptation scenarios of Italian agriculture systems and roles of different stakeholders in the process of identifying adaptation scenarios,

within the context of both adaptive governance theory drawn mainly from social learning discourse and social sociological perspectives, and a discursive framework. The aim was to contribute towards building a theoretical and cumulative understanding of farmers' perceptions about climate change, their knowledge, attitudes and practices on adaptation, the role of social learning processes in forming local adaptive governance and the roles played by different factors and actors in emerging an "optimistic adaptation" scenario.

9.2. Summary of the research findings

The central findings that may be drawn from this study are the following:

Firstly, farmers in this study have perceived changes in climate overtime. There are differences in perceptions of climate variability and self efficacy in adopted practices found amongst shepherds, cattle farmers, rice producers and horticulturists. For most of them, temperature nowadays has been increased and this is very in line with temperature statistical trend observed by the local meteorological station. Farmers have also perceived unpredictable seasons and extreme weather events in the last 30 years. Most shepherds and horticulturists agreed that there has been an increased intensive droughts in the last 3 decades, while majority of dairy cattle farmers and rice producers were uncertain or disagreed with that. Farmers also expressed their experiences associated with changing in rainfall, rainy frequency which affected their production activities. Although meteorological statistics showed that rainfall has decreased and there are an increasing of number of rainy days in the last decades, the farmers had perceptions that rainfall has been increased. This revealed that farmers' perceptions are constructed based on their own attitudes, motives, interests, experiences and expectations in each social cultural background and situation setting. Results also indicate that most farmers are capable of autonomously adjusting to farm risks caused by climate uncertainties; however, they were more likely to respond to short-term risks and build contingency plans/practices to future changes which have a direct impact on their farm operation rather than longer-term risks related to climate change.

Secondly, although most farmers in this study knew about climate change, but each group has its own way of interpretation of CC causes/ effects and adaptation. This interpretation was not made based on their knowledge obtained from media communication and other sources, but from their daily experiences and perceptions. Farmers' defended their stakes by avoiding talking about the causes of CC concerning their farming activities, or willing to share about climate effects that directly affect their farming activities. Although most farmers strongly agreed that human activities is the cause of global climate change, most farmers having negative attitudes about the potential contribution of farming activities on environment and climate change. But they have quite homogenous attitudes towards CC local impacts as well as homogenous behavior towards to adaptation to CC at farm level. However each group of farmers had their own choice of actions and responses to CC as well adaptation levels based on their own adaptive capacity which driven by both external (e.g. socio-cultural, economic) and internal forces (e.g. motivations, interests) of each farmer group. The research results showed that i) most farmers hold declarative knowledge about CC rather than procedural knowledge, ii) farmers' attitude- relevant - knowledge of CC is a social construct, and iii) their adaptive capacity is influenced, positive or negative, by social capitals such as external (e.g. institutional, organizations) and internal (e.g. socio-economic resources, knowledge, technologies). Farmers' declarative knowledge of CC did not directly influence their adaptation practices, but drove their attitudes towards CC causes and impacts

Thirdly, the spatial and temporal evolution of Oristano farming systems in 30 years demonstrated that all farming systems have gradually moved from the hilly mountainous area to the plain and coastal areas in 30 years (except the rice farming system hasn't been evolved both in farm location and farming zone) as self-adaptation with a significant reduction of farm numbers and great increasing of farm dimensions. This is due to the impacts of CC presented in the areas including climatic, environmental and socio-economic impacts (e.g. increased temperature, hot days, droughts and decreased ground water, increased plant and animal diseases, loss of production, economic crisis, etc.) as perceived by farmers. Farmers of the four farming systems have different prospective about their future farming. Majority of dairy cattle farmers, rice farmers and horticulturists declared to not abandon their farming activities while large number of shepherds were not sure about their future or would abandon their farming activities. A high number of rice farmers and lesser number of horticulturists would keep the same current farming practices and would invest in technologies to go ahead with their farming activities, while majority of shepherds and dairy cattle farmers were in difficulties to make decisions in changing or continuing the farming practices and invest in technologies.

The past and present evolution of the farming systems, environmental and socio-economic changes and prospective of stakeholders on the own adaptive capacities of farming systems and policy sphere would allow to draw the future adaptation of farming systems in Oristano province into 2 main scenarios:

1) “every farmer for himself” which may lead to two main pictures: 1.1) “High concentration of intensive farming activities in the central plain and coastal area” in which advanced farms may be progressively developed in both dimension and technologies, while the all backward farms will be vanished; and farmers will deal with problem of environmental pollution, costs of water and energy. 1.2) “Abandoning farming systems” (mainly extensive farming systems) in which a large grazing lands will be abandoned that is susceptible to fires and desertification and a high number of farm may into the situation of uncertainties, young generation will not continue the farming activities, but emigrate to cities or fall into the situation of dis-occupation.
2) “All for all farmers” which may lead to the two sub-scenarios: 2.1) “Collective bottom-up adaptation” in which adaptation agenda of agricultural systems for RDP 2014-2020 through participation of multi-stakeholders. Long term investment for CC adaptation will be taken into the RDP. Scientific research will be fostered to not only focus on the impacts of CC but also on innovative ways of adaptation. There may be also funds to be allocated in agricultural development and adaptation to CC in an efficient and sustainable way (e.g. extensive farming activities will be encouraged to maintain in order to reduce the fire risks, enrich organic matter, promote the absorption of carbon and combat desertification,

RDP incentives and science-based policies, the environmental pollution will be improved and managed systematically). 2.2) "Top-down adaptation" in which there will be no long-term adaptation will be developed through the multi-stakeholder participation or their voice are not taken into account. No/ insufficient investments in research will be made. Farmers may receive incentives for adaptation, but their long term adaptive capacity will be not improved as there is no a space for social learning occurrence among multi-stakeholders at multi-scales.

9.3. Implications of the study

As defined in the Chapter 2, agricultural systems can be defined as complex human-environmental systems. According to Meadows (2008) a system can be understood a set of interconnected components that produce their own pattern of behavior over time. A human-environmental system consists of natural systems and social systems. While natural systems are inherently evolving and changing through adaptive repetitive cycles, social systems are learning systems, persisting through time mainly as a result of learning processes (Karadzic et al., 2013). Some fundamental features of social farming systems in adaptation to CC are cultural norms, farmers' attitudes and behaviors (Adger, 2000) which influence their capacities of learning from change and changing throughout the learning process. Farmers' behaviors act as drivers for change to adapt within farming systems and they are framed by wider contextual factors (Karadzic et al., 2013). However, behavioral responses are mentally represented and associated with perceptual representations, behavioral responses might be among the forms of knowledge that are automatically activated in response to perceiving climate stimuli (Ferguson and Bargh, 2004). Therefore, perception of CC is one of the most important aspects of farmers' behaviors. Depending on how they perceive climate change, they may react positively or negatively to adapt it. This is demonstrated by the differences in perceptions of climate variability and self efficacy leading to different levels of adopting adaptation practices found amongst shepherds, cattle farmers, rice producers and horticulturists in this study. Therefore, the process of perceiving CC to adaptation to CC is a cognitive process that involves learning, understanding, practicing and transforming (as described in Figure 11). Knowledge of the farming systems produced through such cognitive learning process that drive farmers' attitudes and behaviors in learning CC and adapting to climate change. Knowledge systems of farming systems include two main forms: declarative knowledge (know what) and procedural knowledge (know how) allow farmers to understand appropriately the situation and to act properly in situations and can be automated through practice. In agricultural adaptive systems, declarative knowledge is vital to engage farmers' belief in CC and procedural knowledge grounded on practical experiences is necessary to alter current knowledge regimes in ways that can adapt or avoid the worst effects of CC (Tàbara and Chabay, 2013). Increasing farmers' declarative and procedural knowledge is made through social learning processes. The findings showed that most farmers of this study hold declarative knowledge about CC rather than procedural knowledge as well as farmers' adaptive capacity didn't not link with farmers' declarative knowledge of climate change. As farming systems are as learning systems themselves, there were learning processes occurring within farming systems through direct or indirect interaction of farmers and/or non-farmers for sharing information rather than sharing practices, but the interaction was made within each own groups locality and context that formed the own structure of reaction. This implies that successful social learning must be designed and built in order to ensure new collective capacities to deal with common problems and are able to implement conscious and long term adaptive changes in cognitive frameworks of action, and in institutional arrangements, so as to achieve common goals that would otherwise not be achieved individually (Tàbara et al., 2010). This designed social learning will allow farmers to pursue new pathways of action based on collective experiences and integrated knowledge of declarative and procedural knowledge as well as local and scientific knowledge. In another word, decision making process in the definition of adaptation actions requires a shift to an adaptive governance approach, in which multiple perspectives and different knowledge can be integrated to capture the complexity of agricultural systems. Social learning is considered as a critical element in creating more adaptive governance (Berkes, 2009; Folke et al., 2005) to CC in which social and institutional arrangements (Huntjens et al., 2012) are made to shape actors' decisions and behavior in adaptation within groups or organizations (Hatfield-Dodds et al., 2007). A group or organization can learn and change behavior is embedded in the realistic assumption that groups/organizations do not simply change from one state to another, but that the social and ecological conditions in which their development is based can be improved according to the specific structure of knowledge and human values (Cheng et al., 2011). CC adaptive governance is a continuous problem learning process in order reduce the impacts of CC on environment that implies novel forms of interaction at the science –policy - society interface. Uncertainty is reduced by collectively defining and re-defining problems and solutions in the policy making process as new knowledge is generated. The "optimistic" collective adaptation scenario of the agricultural systems drawn from this study findings presents as an ideal model of adaptive governance in which all forces are systematically mobilized for collective actions.

9.4. Suggestions for future researches

In the pathway of conducting this study, the need of understanding how social learning can be detected in practice and what impacts different kinds of participatory approaches yield on learning outcomes and decision-making has been prominent.

Firstly, this study has examined the role of social learning processes in local adaptation to CC by interpreting that social learning as a change in understanding and practices that becomes situated in groups of farmers of practices through social interactions. However, future applied researches on examining social learning networks as boundary object for direct interaction between farmers and non-farmers (developers, researchers and policy makers) around development of agricultural farming practices for adaptation are suggested.

Secondly, the study farmers proved to have a strong attitude to adapting their practices to variable climatic factors but this baseline capacity was not sufficient to distinguish the concept of climate vs. weather, which is a basic step to design an effective CC adaptation strategy, specific models. Further applied research on integration of scientific and lay knowledge as chapter 5 in development of specific adaptation practices at farm level is suggested.

Thirdly, during the research the question “what kinds of knowledge are required for adaptation to CC at farm-level” is emerged. Thus, it is necessary to understand the different perspectives of farmers of both social and technical, and what kinds of knowledge farmers hold and need in order to enhance adaptation capacity at local levels. It is suggested for the considerations in further research that the integration of environmental psychological discipline into empirical researches in order to examine consistency or inconsistency of knowledge (incl. knowledge and knowing), attitude and behavior of farmers on CC adaptation is necessary.

Finally, the integration of social learning spaces within each group of local actors in any future social or scientific research in order to enhance the sharing and co-production of both declarative knowledge (e.g. on CC causes and impacts), procedural knowledge (e.g. on alternative adaptation practices) in order to develop shared sustainable CC adaptation strategies at both policy and farm levels is highly recommended.

9.5. Concluding summary

To conclude, this study explored farmers' perceptions, knowledge, attitudes and practices of adaptation to CC in the 4 Italian agricultural systems. Using perception theory, knowledge, attitude and practice model and exploratory scenario analysis, the study look at dimensions of farmers' behavior in climate change, adaptive capacity to climate change, and the social contexts that surround farmer behavior and practice change. The research showed that farmers' perceptions are constructed based on their own attitudes, motives, interests, experiences and expectations in each social cultural background and situation settings. Perceived CC risks and socio-cognitive processes will have a direct impact on motivating farmer's responses to CC and adaptive capacity of farmers is influenced by their experiences, knowing, knowledge and technologies. Furthermore, farmers' knowledge about climate is a social construction. In this study farmers interpreted CC causes and effects not only from existing information from media communications, but typically from their daily experiences and perceptions. Most farmers hold declarative knowledge about CC rather than procedural knowledge. Their declarative knowledge of CC do not directly influence their adaptation practices, but drive their attitudes towards CC causes and impacts.

The analysis of exploratory scenario is an useful exercise to foster "learning process" that has value in support of research and policy. It is a process to visualize future worlds of farming systems and to help guide and develop sustainable adaptive strategies which are based on farmers' prospective, knowledge and experiences about CC impacts, and other stakeholders' perspectives, ideas and knowledge about the strengths and weaknesses of farming systems and prospective about future CC adaptation policies.

Finally, this study showed that farmers' adaptation levels are mediated through many factors such as their existing institutional and organizational capacity. Using social learning discourse as a framework of reference, the study highlighted complex system approach to adaptive governance. The pathway to adaptive governance includes the process of understanding socio-economic and culture factors, adaptive capacities including attitude, knowledge and practices of stakeholders and institutional arrangements. Since adaptive governance requires continuous learning among farmers and other actors for co-production of both practice relevant knowledge and policy relevant knowledge for the purposes of adaptation at farm level and decision making at multi-levels, the discussion of adaptive governance in this study aimed to imply the necessity of development of a new form of interaction of science-policy-society interface in order knowledge generated by scientific research can prepare/benefit farmers to develop agriculture and reduce unavoidable detrimental CC impacts and policy decision making for adaptation at local level.

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