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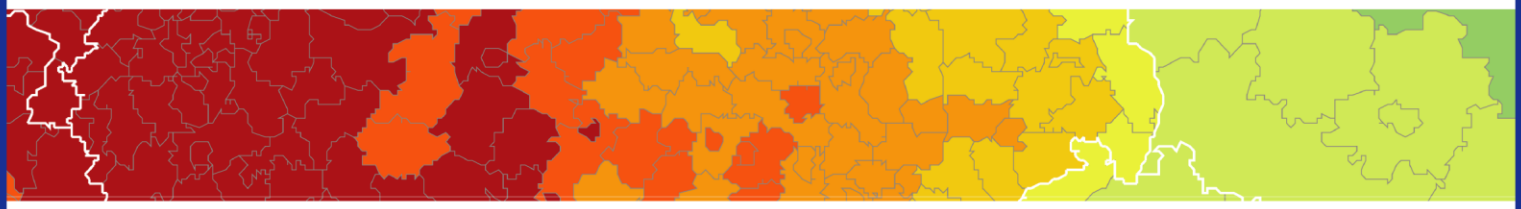

ESPON-TITAN
Territorial Impacts of Natural Disasters

Applied Research

Final Report – Case Studies Report
Andalusia Region (Spain)

June 2021

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Abreviations

ARPSIs	Áreas de Riesgo Potencial Significativo de Inundaciones - Significant Potential Flood Risk Areas
CCA	Climate Change Adaptation
CGMs	Climate Change Models
CPSACMA	Comisión Permanente para situaciones de Adversidad Climática o medioambiental - Permanent Commission for situations of climatic or environmental adversity
DANA	Depresiones Aisladas en Niveles Altos - Isolated Low Atmospheric Pressures in High Levels bringing heavy rainfall
DRM	Disaster Risk Management
EAFRD	European agricultural fund for rural development
ENESA	Entidad Estatal de Seguros Agrarios – State Entity of Agricultural Insurance
EU-27	The 27 member countries of the European Union
GDP	Gross Domestic Product
INFOCA Plan	Plan de lucha contra Incendios Forestales en la Comunidad Autónoma de Andalucía - Forest Fire Fighting Plan in the Autonomous Community of Andalusia
IPCC	Intergovernmental Panel on Climate Change
MITERD	Ministerio para la Transición Ecológica y el Reto Demográfico - Ministry for the Ecological Transition and the Demographic Challenge
PAAC	Plan Andaluz de Acción por el Clima - Andalusian Cimate Action
PGRIS	PlanPlanificación de la gestión del riesgo de inundación en las Cuencas Intracomunitarias de Andalucía - Planning of flood risk management in the Intra-Community Basins of Andalusia
PPAICUA	Plan de Prevención de Inundaciones en Avenidas y Cauces Urbanos de Andalucía - Plan for the Prevention of Floods in Urban Streams of Andalusia
REDIAM	AndalusiaRed de Información Ambiental de Andalucía - Andalusian Environmental Information Network

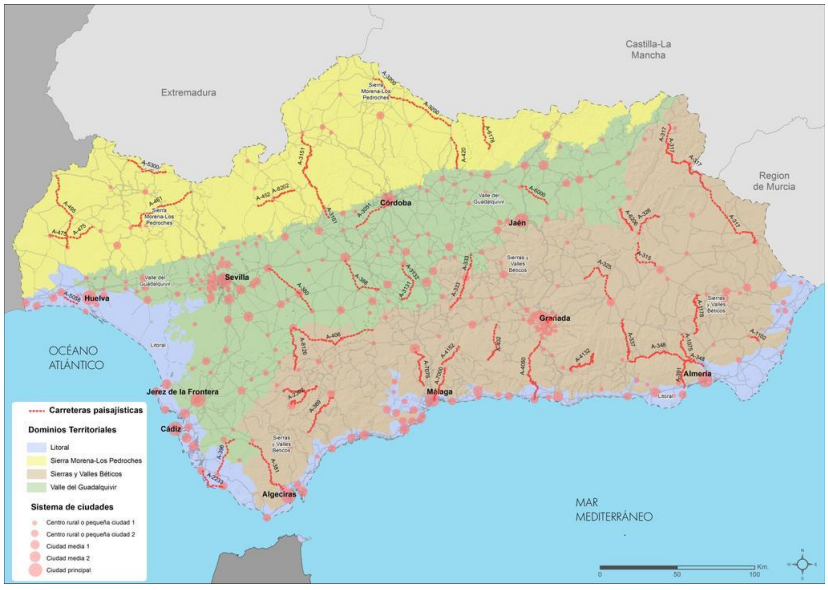
1 Introduction

Andalusia Region is the second largest of the 17 autonomous communities in Spain, located in the south of the country. It is delimited by Portugal (West), Extremadura and Castilla-La Mancha autonomous communities (North), Murcian Region (East), and the Atlantic Ocean and Mediterranean Sea (South). The territory is very diverse in terms of environmental and socio-economic aspects, resulting on a rich cultural and natural heritage.

The region occupies an area of 87.600 km^2 (17,3% of total Spain) being the fourth biggest European Union region. Andalusia is composed by eight provinces and 771 municipalities, grouped in 4 main territorial systems (Figure 1) defined by their geographical characteristics and demographic density:

- Sierra Morena-Los Pedroches: A mountainous area in the north-east part of the region, with a particular landscape conformed by grassland and agricultural activities;
- Valle del Guadalquivir: An area related to the Guadalquivir River valley, traditionally densely occupied and with a large extension, counting on a vast natural and culturally valuable space;
- Sierras y Valles Béticos: Conformed by a diversity of landscapes like mountains, valleys, forests, and deserts;
- Coastal area. A dynamic space both naturally and social-economically, that induces continuous territorial transformation.

Figure 1. Distribution of the main territorial systems in Andalusia



Source: Caballero Sánchez et al., 2016

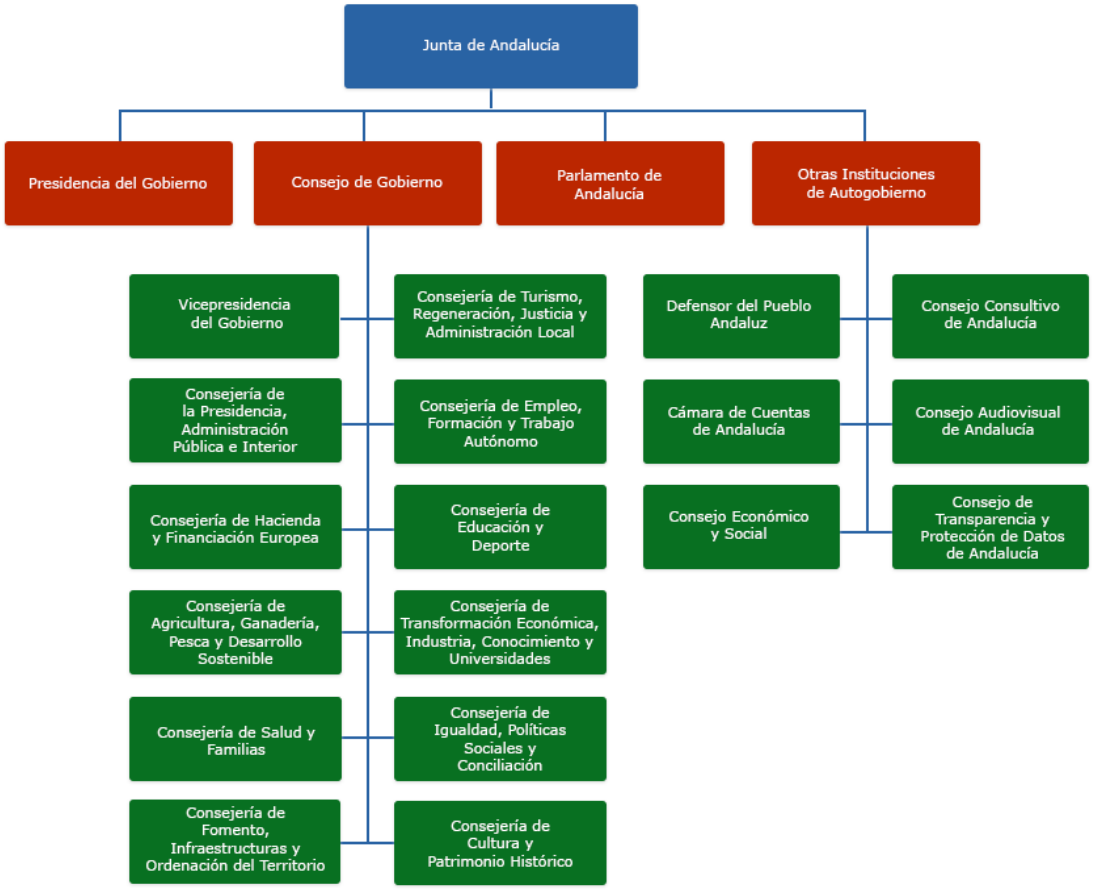
From an economic point of view, primary sector in Andalusia represents 4,9% of the GDP, while in Spain it is around 2,5%, and in the EU-27, 1,8%. Despite the progressive decrease, the primary sector has recently increased again as a consequence of the losses in secondary in the tertiary sector.

2 Main characteristics of the administrative structure and planning system

2.1 Brief introduction to the administrative structure

Spain is a quasi-federal State with a decentralized structure with administrative power at national and regional levels, i.e. on the 17 Autonomous (constitutional) Regions (Comunidades Autónomas). The hierarchy in the administrative structure is the State General Administration, Autonomous Regions, Provinces and Municipalities. The State General Administration (NUTS0) and the Autonomus Regions (NUTS2) both present legislative competencies (as a Composite State as Spain is) either exclusive (at national or regional levels), or shared among both levels (basic legislation at national level to be developed and applied at regional level, as it happens for risk legislation). Provinces (NUTS3) and municipalities (NUTS5 = LAU2) have their own administrative competences. The Andalusian government, similar to the other Spanish regions, is organized in 11 Regional Ministries and General Secretariats (Figure 2).

Figure 2. Regional government structure (2019)



Source: Decree 2/2019 Junta de Andalusia webpage[1]

[1] https://www.juntadeandalucia.es/organismos/sobre-junta/organizacion/organigrama.html

Stakeholders and decision-makers from different departments were consulted in order to get information to develop the present report, covering the matters of climate change, urban planning, environment, agriculture, water resources, civil protection, among others.

2.2 Brief introduction to the planning system

Territorial planning in Andalusia is implemented through different instruments. The Spatial Plan of Andalusia is a reference document that establishes the base for the organization and structure of the territory, acting as a framework for subregional plans. It aims to promote a compact, functional and diverse economically city model, activate development potential and foster competitivity, as well as improve territorial cooperation. This plan derives in others, such as the Coastal Protection Plan, Subregional Spatial Plans (in charge of territorial structure and articulation system, land-use planning and territorial protection), Special Plans (highlighting areas with important heritage, agricultural, environmental or landscape value, as well as risk areas), Land-use Plans, etc.

In Andalusia, according to the Spatial Planning Law (1994)[2], there are two levels and instruments. The Regional Spatial Plan (2006)[3] represents a comprehensive planning instrument that defines the territorial organization model. It acts as framework for public action and for all interventions with territorial impact. The main aim of this plan is to contribute to sustainability, based on cohesion and competitiveness principles. The spatial subregional plans (17 up to now)[4] have all clear integrated/comprehensive nature, to which other sectoral plans, never considered Spatial Plans as such, must be subordinated (a singular case in Spain when making this clear distinction betwees spatial – comprehensive – and other instruments). Among those plans, a special mention may be given to the coastal planning, which faces one of the most conflictive area of the Andalusian territory (in fact, this coastal plan, initially approved an into force, was annulled by the courts by default).

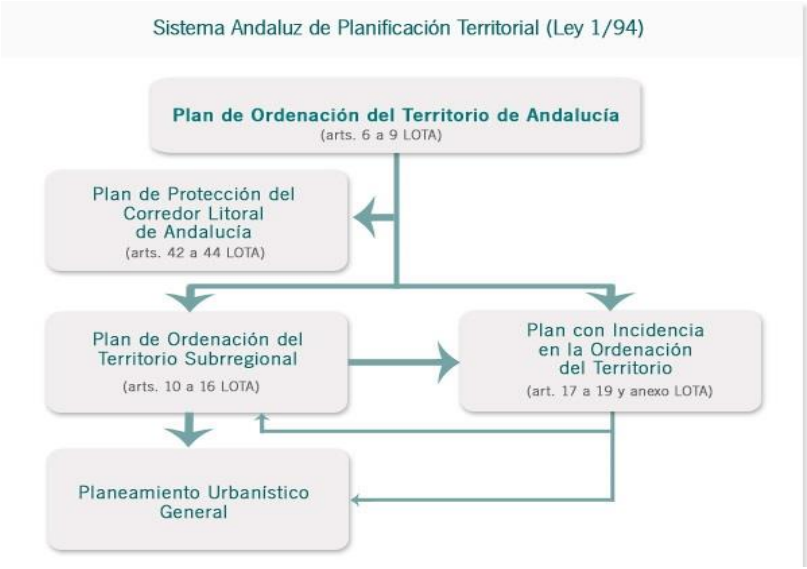
According to the hierachical system of planning that characterize spatial planning in Andalusía (Figure 2), as said, urban and sectoral plans respond to the regional and subregional spatial planning system. However, it should be noticed that environmental law and instruments are above all this system.

[2] https://www.boe.es/buscar/pdf/1994/BOE-A-1994-2989-consolidado.pdf

[3] https://www.juntadeandalucia.es/organismos/fomentoinfraestructurasyordenaciondelterritorio/areas/ordenacion/planes/paginas/plan-pota.html

[4] https://www.juntadeandalucia.es/organismos/fomentoinfraestructurasyordenaciondelterritorio/areas/ordenacion/planes-subregionales.html

Figure 3. Spatial planning system



Source: Law 1/1994 Junta de Andalusia webpage[5]

[5]https://www.juntadeandalucia.es/organismos/fomentoinfraestructurasyordenaciondelterritorio/areas/ordenacion/planes-subregionales.html

3 Hazard profile and economic impacts of natural hazards in Andalusia region

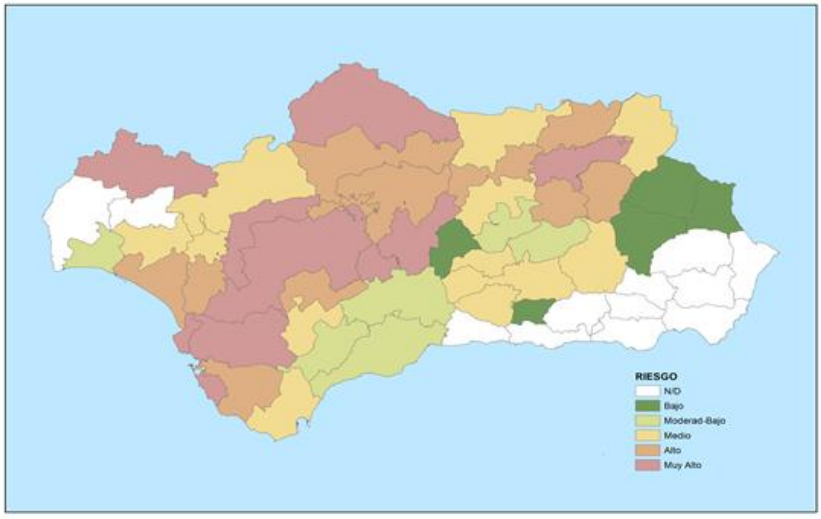
The common natural hazards in Andalusia are presented in the “Atlas of the history and territory of Andalusia” (Instituto Cartográfico de Andalucía, 2009).

The natural hazards related to the water cycle, **floods and droughts,** are considered the most relevant and important ones for Andalusia. Nevertheless, some other hazards as **volcanism**, have been very active in the past, leaving an having left an extensive territorial footprint, while others are still present and extensive today, such as **earthquakes** (as recently in Granada this same year, as new manifestation of the friction between the European and African plates).

Andalusia is affected by a Mediterranean climate, and therefore, constitutes a territory with high exposure to the risk of flooding due to frequent river overflows. Intense and torrential rainfalls take place along with long periods of drought. These phenomena, in turn, can cause important floods and landslides.

Given the alternation of dry and wet cycles, **droughts** (long dry periods) are becoming increasingly frequent and intense (Figure 3). Thus, throughout the 19th and 20th centuries, the most severe droughts were those occurring in the periods of 1941-1945, 1979-1983 and the most severe of all, 1990-1995.

Figure 3. Drought risk level in Andalusian agrarian areas for the period 2014-2020



Source: Agroseguro and Andalusian agricultural sector risk plan in the area of preventive investments of measure 5 of the Rural Development Program 2014-2020[6].

Catastrophic episodes of **flooding** (detailed in section 3.1) have affected a large part of Andalusia in different periods. In the East of the region, torrential rains are more frequent

[6] https://www.juntadeandalucia.es/export/drupaljda/planes/18/07/180625_Plan_gestion_riesgos.pdf

(such as those of cold drops in autumn; e.g. 1871 and 1891 in Almería, 1879 in in Almeria, 1879 in the Bajo Almanzora, 1970 and 1973 in the Adra river). The occupation of the territory (urbanisation, infrastructures, alterations to the vegetation cover vegetation cover...) usually act increasing the territorial effects of this risk.

Andalusia has also significant **seismic** risks, which can be explained by the fact that it is located close to the meeting of three tectonic plates (African, Atlantic and European). The risks are higher in the south-eastern part of the region, more exposed to the pressure of the African plate, where the highest seismicity indices of the Iberian Peninsula are located.

Even so, they are also important in the westernmost part, as demonstrated by the Carmona earthquake (Seville) in 1504, as well as the most serious earthquake on record, the Lisbon earthquake of 1755. This had its epicentre on St. Vincent Cape, an area considered to be one of the most seismically active in the world, and caused tsunamis with waves up to 15m high, that cause death and destruction along the coasts of Portugal, and the Spanish provinces of Huelva and Cadiz.

The 1884 earthquake, which affected a large area of the provinces of Granada and Malaga, had its epicentre in Arenas del Rey, and killed around 800 people and injured other 1.500. It destroyed some 4.400 houses and damaged another 13.000. The economic effects were also very important.

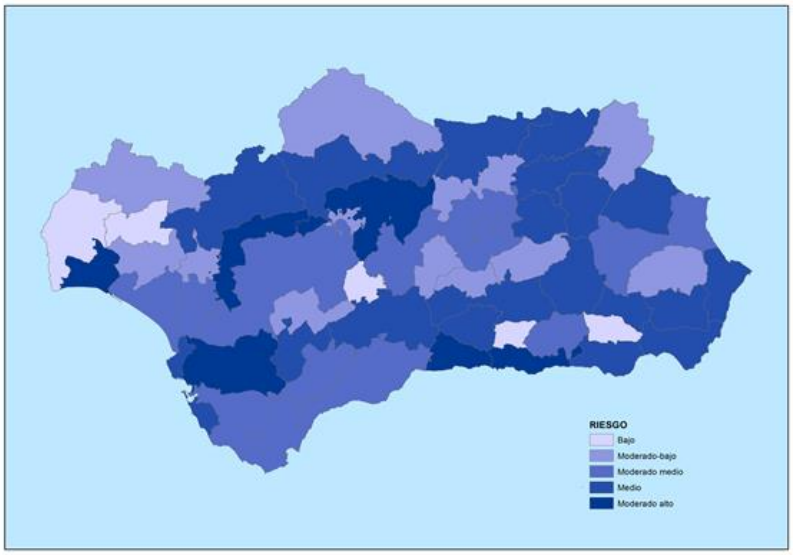
Forest fires also present a serious, and can cause significant, ecological, economic and social losses. Andalusia has the INFOCA Plan[7], which guarantees the protection of the natural environment against these fires, thanks to an extensive network of facilities, land and air resources that are quickly mobilised each time a forest fire begins.

3.1 Flooding in Andalusia

Floods represent one of the main natural risks of the region (Figure 4); a recurring phenomenon coincident with situations of the recurrent DANA, before called “Gota Fría” (or Cold Drop, an isolated high-altitude depression, with a decrease of temperature causing torrential storms and consequent floods). These torrential rains especially affect the rivers of the Andalusian Mediterranean basin and, according to the climate change predictions, show a mid-term tendency to get worse. The implementation of transversal infrastructures that hinder the drainage of the channels and their plains, together with the increasing urbanization and construction in areas exposed to the risk of flooding, are both factors that contribute to its aggravation.

[7] http://www.juntadeandalucia.es/medioambiente/site/portalweb/menuitem.220de8226575045b25f09a105510e1ca/?vgnextoid=2076a5f862fa5310VgnVCM1000001325e50aRCRD&vgnextchannel=321cc98d5b40b410VgnVCM2000000624e50aRCRD

Figure 4. Flood risk level in Andalusia for the period 2014-2020



Source: Agroseguro and Andalusian agricultural sector risk plan in the area of preventive investments of measure 5 of the Rural Development Program 2014-2020[8].

In 2002, the "Plan de Prevención de Avenidas e Inundaciones en Cauces Urbanos de Andalucía" (Plan for the Prevention of Floods in Urban Streams of Andalusia – PPAICUA) identified 1.099 flood risk points, of which 115 were classified as of very high risk. More than 50% of these very-high-risk points were in the provinces of Almería and Granada. Regarding its frequency, 272 flood episodes were registered in the internal demarcations of Andalusia and the Guadalquivir between 1900-2010 (National Catalog of Historic Floods). Some important episodes with serious consequences in the region include the following:

- **October 19, 1973:** a DANA affected the provinces of Granada and Almeria. Several settlements were devastated with serious material damage and fatalities (e.g. about 50 people died in La Rábita).
- **December 1996:** a severe storm especially affected the provinces of Seville, Cadiz and Malaga. More than 2.000 people were affected by the flood. There were 13 fatalities. Likewise, 43 roads and the railway connection between Seville and Huelva and between Jerez and El Puerto de Santa María, in the province of Cadiz, were interrupted.
- **1997:** the Guadalquivir river overflowed, forcing 2.000 people evict their homes. Important economic damage from that year rainfall also occurred in the province of Huelva.
- **2001:** the floods affected all Andalusian provinces, although the most serious damage to agriculture occurred in Seville and Cordoba.
- **Between December 2009 and March 2010:** serious floods occurred in the Guadalquivir basin, affecting particularly Andujar, Alcolea, Cordoba, Palma del Rio, Lora del Rio and Sevilla localities. Jerez de la Frontera, in the Guadalete-Barbate basin, was also severely affected. The problem of flooding in the Guadalete river was aggravated

[8] https://www.juntadeandalucia.es/export/drupaljda/planes/18/07/180625_Plan_gestion_riesgos.pdf

because the water was trapped in the road infrastructures. In this sense, it is worth highlighting the collapse of the A-4 motorway between Seville and Cadiz for several days.

- **December 1 and 6, 2016:** the intensity of the rainfall resulted in floods that caused serious damage in the provinces of Cadiz, Huelva and Malaga. As a result, the regional administration authorized to allocate EUR 18 million to emergency works for actions aimed at restoring channels and repairing road, hydrological and educational infrastructures of autonomous ownership and municipal facilities damaged by torrential rains in these three provinces.
- **September 13, 2019:** another DANA took place. Its effects focused on the provinces of Almería, Granada and Malaga, causing serious damage to greenhouse agriculture, and to the road network and rural roads. To deal with the effects caused by the DANA, the regional administration approved the allocation of EUR 75 million through a set of measures managed by the Tourism, Regeneration, Justice and Local Administration department (Consejería de Turismo, Regeneración, Justicia y Administración Local); the Presidency, Interior and Public Administration department (conserjería de la Presidencia, Administración Pública e Interior); the Agriculture, Livestock, Fishing and Sustainable Development department (conserjería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible); and the Promotion, Infrastructures and Spatial Planning department (conserjería de Fomento, Infraestructuras y Ordenación del Territorio).

3.2 Economic impacts of natural hazards

Regarding the economic impact of these hazards, floods cause property damage, especially related to agricultural activity, and material losses to homes and vehicles when they affect human settlements. In the same way, frequent damage to road infrastructures (road network, rural roads, and railway network) usually occurs, causing accessibility problems among localities. In the most serious episodes, fatalities occur because of the flooding of houses and the dragging of vehicles. In terms of fatalities, the episode occurred in October 1963, in which 300 people died from the floods between the provinces of Almería and Murcia, stands out.

As the agricultural sector is the most affected, in surface terms, by the natural hazards analyzed in ESPON-TITAN, it is interesting to emphasize the economic impact of these hazards on this specific productive sector. Thus, in rural areas, there are job losses and depopulation due to abandonment of agricultural activity in the most extreme cases. Likewise, there is an increase in production costs in both livestock and crops caused by climatic adversities, and a need for economic investment to reconstitute the productive potential or to adapt crops to these adversities (planting other varieties, different cultivation techniques). Finally, the decrease in the value of production due to the depreciation of the product (e.g., damage caused by hail in fruits), reduces the margins of the sector.

Regarding indirect economic impacts, in the event of droughts, fires and floods affecting forest lands, these negatively influence the productive capacity of the forests (wood, fruits, etc.), their ecological and natural value, and favour the disappearance of forests and the

decline of biodiversity. Finally, it should be noted that these hazards also affect the tourism industry and increase the financial risk for companies.

The data on the economic impacts of hazards come from the insurance compensation consortium (consorcio de compensación de seguros) and from Agroseguro S.A. In the case of droughts, it is complemented by data from REDIAM (Environmental Information Network), which offers technical services in environmental matters from the regional administration.

Finally, it should be noted that information on direct and indirect economic impacts is not available for all types of hazards, neither is done in a regular basis, being its analysis usually requested after an important disaster occurs.

4 Disaster Risk Management in the Andalusia region

4.1 General remarks

There is a Spanish Basic Civil Protection legislation that contains the guidelines for the preparation of territorial emergency plans. This regulation is constituted by the following national and regional legal texts:

- Law 17/2015, of July 9, on the National Civil Protection System (Ley 17/2015, de 9 de julio, del Sistema Nacional de Protección Civil) [9];
- Basic Civil Protection Standard - Royal Decree 407/1992, of April 24 (Norma Básica de Protección Civil - Real Decreto 407/1992, de 24 de abril) [10];
- Law 2/2002, of November 11, on Emergency Management in Andalusia (Ley 2/2002, de 11 de noviembre, de Gestión en Emergencias en Andalucía) [11];
- Law 5/2010, of June 11, on Local Autonomy of Andalusia (Ley 5/2010, de 11 de junio, de Autonomía Local de Andalucía) [12].

Law 2/2002, of November 11, on Emergency Management in Andalusia, establishes that special plans are those prepared to deal with emergencies caused by risks for which the regulations issued by the Spanish General State Administration establish their regulation through the corresponding basic guideline regarding floods, transport of dangerous goods, wildfires, earthquakes, and serious accidents involving dangerous substances. It adds those plans established to deal with emergencies generated by risks of special significance in Andalusia, the nature of which requires an adequate technical-scientific methodology; and the internal emergency/self-protection plans are also included as specific plans.

The **Territorial Emergency Plan of Andalusia**[13], together with some other plans of a sectorial or specific nature, is the normative instrument establishing organic and functional framework (as well as the mechanisms of action and coordination between different Administrations and entities under the directive function of the Junta de Andalucía) to deal with general emergencies that may arise in the Andalusian territory (if they are not declared of national interest by Spanish General State Administration and then directly depending on it). In this Territorial Plan, a wide variety of risks are identified and analyzed, including drought, major storms, strong winds, floods and pests.

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[9] https://www.boe.es/buscar/pdf/2015/BOE-A-2015-7730-consolidado.pdf

[10] https://www.boe.es/buscar/doc.php?id=BOE-A-1992-9364

[11] https://www.boe.es/diario_boe/txt.php?id=BOE-A-2002-24156

[12] https://www.boe.es/buscar/pdf/2010/BOE-A-2010-11491-consolidado.pdf

[13]https://www.juntadeandalucia.es/organismos/presidenciaadministracionpublicaeinterior/areas/interior/emergencias-112/planes/paginas/pteand-planes-emergencia.html

More focused on climatic adversities, at the Spanish national level there is a permanent Commission for climatic or environmental adversity (Comisión Permanente para situaciones de Adversidad Climática o medioambiental - COPAC), regulated by Order AAA / 2272/2013, of November 27[14]. The actions of COPAC are the following:

a) Analysing03, evaluating and informing the situations of climatic or environmental adversity;
b) Studying and proposing extraordinary palliative measures corresponding to the events that occurred;
c) Studying and proposing preventive measures;
d) Proposing and delimitating the territorial and sectoral areas affected, after hearing the autonomous communities and, where appropriate, the local administrations, and the representative organizations of the sectors;
e) Channeling of relations with representative organizations of the agricultural, fishing and environmental sectors;
f) Channeling of relations with the competent bodies of the autonomous communities involved;
g) Participation in interministerial commissions created, according to current regulations, due to natural disasters;
h) Monitoring, evaluation and, where appropriate, preparation of proposals for readjustment of the measures adopted to better adapt them to the evolution of the effects of the climatic or environmental risk in question;
i) Others that, for the better fulfilment of its objectives, were entrusted to it by the Undersecretariat of Agriculture, Food and Environment.

It should be noted that strategic planning is already being considered for the management of certain risks. Thus, **drought management** is done through Special Action Plans in alert situations and eventual drought (Planes especiales de actuación en situaciones de alerta y eventual sequía), Special Drought Plans (Planes Especiales de Sequía) or flood management with the PGRIS.

In the specific case of **flood risk prevention**, the main regulatory framework is constituted by the Plan for the Prevention of Floods in Urban Streams of Andalusia (Plan de Prevención de Inundaciones en Avenidas y Cauces Urbanos de Andalucía), approved by Decree 189/2002, until the entry into force of Directive 2007/60/CE of the European Parliament and Council (better known as the *Flood Directive*). The transposition of this Directive into the Spanish legal system occurred through the Royal Decree 903/2010, of July 9[15], of evaluation and management of flood risks. This last is the basic legislation that regulates the content and the procedure of elaboration and processing of the Flood Risk Management Plans (PGRIS) for the entire Spanish territory. Those plans are approved in conjunction with the Hydrological Plans (Planes Hidrológicos) of each River Basin District (Confederacions Hidrográficas), depending from the responsible Spanish Ministry of Environment, in case river basins are

[14] https://www.boe.es/buscar/doc.php?id=BOE-A-2013-12687

[15] https://www.boe.es/buscar/doc.php?id=BOE-A-2010-11184

cross-regional. So, in terms of floods management, it is necessary to differentiate between intracommunity river basins, managed by the regional administration, and intercommunity basins managed by the State (case of the Guadalquivir river, with a hydrographic basin of 57.527 km^2, 90% in Andalusia).

At the local level, each municipal administration is responsible of their own Local Civil Protection Plans (Planes Locales de Protección Civil), where the risk of flooding, among others, is taken into account. Also, these risks are considered normatively when municipalities are elaborating municipal urban plans; in fact, land-use plans, flood zones has to be declared non-developable, according with areas of risk defined by the State, as well as by regional level administration (if differerences appear among their respective cartographies, planners usually take the most restrictive one in order to avoid problems along the process of approval and implementation of municipal plans).

In the agricultural sector, in order to complement and reinforce the abovementioned legal framework, the Department of Agriculture, Livestock, Fisheries and Sustainable Development (Consejería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible) formulated the **Risk Plan for the Andalusian agricultural sector**[16] (Plan de riesgos del sector agrario andaluz). It is based on the framework of preventive investments, included into measure Nº5 of the Rural Development Program 2014-2020 (Programa de Desarrollo Rural 2014-2020); more specifically in sub-measure 5.1 on preventive investments.

In this context, the role of agricultural insurance in risk management and prevention should be highlighted. At the Spanish national level there is Law 87/1978 on Combined Agricultural Insurance[17] (Ley 87/1978 de Seguros Agrarios Combinados), as well as the Royal Decree 2329/1979 that establishes the Development Regulations (Reglamento de Desarrollo) and the Annual Agricultural Insurance Plans (Planes Anuales de Seguros Agrarios). At the Andalucía Autonomous Region level, the legal framework is as follow:

- Decree 63/1995[18], which regulates subsidies for agricultural insurance in Andalusia. This decree develops supplementary aid and other complementary actions of the Autonomous Administration;
- Orders and Resolutions of the Agriculture, Livestock, Fisheries and Sustainable Development department of the Junta de Andalucía;

[16] https://www.juntadeandalucia.es/export/drupaljda/planes/18/07/180625_Plan_gestion_riesgos.pdf

[17] https://www.boe.es/buscar/act.php?id=BOE-A-1979-870

[18] https://www.juntadeandalucia.es/boja/1995/57/3

4.2 Risk assessments

A large part of the risk analysis in Andalusia is implemented using data from the National Agricultural Insurance System (Sistema Nacional de Seguros Agrarios). This system contemplates the participation of private entities (grouped in the Agroseguro S.A. pool), the Ministry of the Environment and Rural and Marine Affairs (Ministerio de Medio Ambiente y Medio Rural y Marino) through the State Entity of Agrarian Insurance (ENESA), the Ministry of Economy and Finance (Ministerio de Economía y Hacienda), and the Autonomous Region of Andalucía, through its Regional Ministry of Agriculture. Adherence to the system is voluntary, both for farmers by signing an insurance policy from one of the established insurance lines, and for insurance companies by joining Agroseguro S.A.

Thus, for **climatic or meteorological risks**, Agroseguro S.A offers risk maps, where agricultural regions are classified according to the risk level of different climatic adversities (drought, frost, floods, etc.). This offers a basis for establishing the first level of prioritization of eventual support in the Risk Plan for the Andalusian agricultural sector (Plan de riesgos del sector agrario andaluz). This prioritization, complemented with other variables, will affect the most vulnerable systems.

In the specific case of **floods**, Flood Risk Management Plans are prepared by River Basin District (Confederaciones Hidrográficas), within the framework done by the European Flood Directive, which establishes two previous phases. The first phase, called Preliminary Flood Risk Assessment, aims to determine within the scope of each hydrographic delimitation, those areas for which it has been concluded that there is a potential risk of significant flooding or in which that risk is considered probable. This delimitation is performed throught the use of the available information, especially that referring to floods that have occurred in the past, and that have had negative impacts and a significant probability of reoccurring. This way, the current circumstances of land occupation is considered, as well as the location of populated areas, areas of economic activity and strategic equipment and infrastructures that may be vulnerable to flood episodes. Likewise, the possible effect of climate change on the frequency and intensity of floods is also taken into consideration. The delimited areas are called Areas of Significant Potential Risk of Floods (ARPSI).

Once the preliminary evaluation is performed, the second phase of Preparation of Flood Hazard and Risk Maps starts. This phase consists of mapping within each ARPSI the areas exposed to flood risk according to three probability scenarios: high probability of flooding (return period of 10 years), medium probability (return period of 100 years) and low probability of flooding (return period of 500 years). Likewise, the risk for each of these scenarios is evaluated based on the types of soils affected, distinguishing urban areas, economic activities, unique facilities, protected areas, etc. In this context, the data corresponding to the current situation (as dictated by the European Directive) are considered. The consequences of climate change are considered, although they are not yet reflected in current risk maps.

Finally, within the scope of the river basin districts and the identified ARPSI, the PGRI are formulated. These Plans aim to achieve coordinated action by all public administration and society, to reduce the risks of flooding and its negative consequences. This action must be based on the programs of measures that each administration must apply within the scope of their competences to achieve the planned objective, following the principles of solidarity, coordination and inter-administrative cooperation and respect for the environment (e.g.: Plan de Gestión del Riesgo de Inundación de la Demarcación Hidrográfica del Guadalquivir, Ciclo 2016–2021). However, as it happens transversally with other kind of plans and instruments, meaning a huge coordination effort, this is nowadays mostly a desired situation than a reality, given the difficulty to be put into practice.

It should be noted that the planning and management of the flood risk associated with a specific river basin district is framed within the **Sectoral Planning for Water** (Hydrological Planning). This planning is closely linked with other spatial planning instruments (especially with the Spatial and Urban Planning Plans) and with other areas of sectoral planning (Civil Protection Plans, Infrastructure Planning, Agriculture, etc.). Thus, flood risk planning and management has interactions with other planning domains at the local level in land-use planning. In fact these reports (sectoral and environmental, some of them depending of Spanish Government) are previous to Spatial Plans, and binding for their approval. Lack of coordination leads to extensive procedures, in some cases hindering spatial planning.

In the case of **seismic risk**, there is a 2009 emergency plan that analyzes the threat and vulnerability of the region. This plan was formulated by the Civil Protection department.

4.3 Risk management

In the case of Civil Protection, there is an institution called exactly like this, in charge to provide a quick and coordinated response to minimize the impacts of catastrophic emergencies on people and, secondly, on properties. Very consolidated and efficient when episodic alerts happen. Thus, the action protocol is conducted by Civil Protection. In this sense, there is a collaboration between Civil Protection agents, agencies, entities and individuals affected by emergencies. Its action is governed by the Regional Territorial Plan and the different specific plans, such as the PGRI.

As detailed above, there is strategic planning for managing the risks of drought or flooding. This is the case of the PGRI, in which the flood risk management objectives and the program of measures are established by each administration, according to their area of competence. PGRI are set to prevent or mitigate the negative consequences of flooding at the level of each river basin district and for each of the ARPSI declared in the preliminary assessment.

In the same way, these PGRI focus on the importance of the dissemination of information and awareness campaigns on the risk of flooding and, above all, on the adoption of preventive measures to reduce the effects of floods.

On the other hand, the Agriculture, Livestock, Fisheries and Sustainable Development department offers an Alert System against Climate Adversities within its website[19]. Furthermore, this department has a **Commission for Catastrophes, Natural Hazards and Adverse Meteorological Phenomena** (Comisión de Catástrofes, Desastres Naturales y Fenómenos Meteorológicos Adversos). Its functions are to become aware of the existence of an event presumably classifiable as a catastrophe, natural hazard or adverse weather phenomenon; to know the reports that are prepared in this regard by the Territorial Delegation and General Directorate of Agricultural and Livestock Production (Dirección General de la Producción Agrícola y Ganadera); and to make the corresponding proposals, if necessary. In this context, this commission designs protocols for action in the event of natural disasters, adverse meteorological phenomena and catastrophes that affect the agricultural sector in Andalusia. If necessary, this commission submits to the Governing Council the corresponding proposed agreement (e.g.: the Agreement of September 17, 2019, of the Governing Council, which declares adverse meteorological phenomena, natural disasters or catastrophes with an impact on the agricultural production potential, in hydraulic infrastructures and the hydraulic public domain, and measures are urged to mitigate their effects[20]). These proposed agreements also establish amount of funds to mitigate the damage or to recover the production potential (e.g., Order of July 2, 2019, which establishes the regulatory basis for aid under non-competitive competition for livestock farms affected by drought and under the minimum regime[21]).

In the same way, concerning the risk management of adverse meteorological phenomena, there is the voluntary subscription by farmers of Agricultural Insurance, as well as the aid within the Rural Development Program of Andalusia 2014-2020 (Programa de Desarrollo Rural de Andalucía 2014-2020) for investments to preventive improvement of farms. Specifically, sub-measure 5.1 of this program indicates that the necessary investments and expenses will be promoted to reduce and prevent the consequences and occurrence of possible natural hazards, adverse weather events and catastrophes identified in the corresponding Risk Plans related to the agriculture sector.

Finally, the financial mechanisms behind risk management are indicated. Thus, the public administration tends to act through the provision of public funds (at Spanish and Andalucía levels) for the execution of emergency measures to restore strategic infrastructures when they are damaged and out of service. Also, subsidies to townhalls and individuals to repair damaged agricultural activities are set by the public administration. In the specific case of agriculture, the Agricultural Insurance System, the minimum aid and the fiscal aid agreed by the Spanish Government are of special relevance. Finally, in certain circumstances, to

[19] https://www.juntadeandalucia.es/agriculturaypesca/sigsafac/adversidades

[20] https://juntadeandalucia.es/boja/2019/521/4

[21] https://www.juntadeandalucia.es/boja/2019/130/1

mitigate the consequences of the risks on agricultural and forestry land, aid lines have been established, financed by European Funds (EAFRD aid) or by self-financing.

Regarding the relation between risk management and citizenship, information on emergencies is made available to the public, including general recommendations on the different existing risks and how to proceed in a general way. This information is available on the Civil Protection website and it is static and universally applicable. However, when a specific incident occurs, this information is transferred to social networks as an immediate communication channel that complements the media, traffic (information panels), and even the local police (in this case, the information provided is ad hoc).

5 Climate Change Adaptation in Andalusia region

5.1 General remarks

The results of the fifth IPCC Report shows the climate change effects in Andalusia until 2099. According to the less unfavorable models, the temperatures will increase by 3,6 ºC. In relation to rainfalls, the reduction expected in most unfavourable situation is around 17%. To face these challenges, Andalusia has developed some specific instruments.

At the Spanish level, there is a **National Climate Change Adaptation Plan** that represents the framework to coordinate all public administration in evaluation, assessments, and adaptation actions in climate change matters. This plan is currently under revision, expecting to be approved in 2021, and to be in force until 2030.

The Adalusian Government's response to climate change began in 2002 with the establishment of an Andalusian Strategy for Climate Change. In 2007, a step forward was taken with the Climate Action Plan **(Plan Andaluz de Acción por el Clima)**[22] with an associated Adaptation Programme (2010) **(Programa Andaluz de Acción por el Clima)**[23], which aims to minimize the negative impacts thanks to the improvement of the adaptation of the territory through spatial planning. It includes an analysis of how climate change is presented in other plans, working in particular areas as protected areas and in municipal plans. It represents a framework at the regional level to facilitate the development of sectoral adaptation.

Recently, the Law 8/2018 (Ley 8/2018, de 8 de octubre, de medidas frente al cambio climático y para la transición hacia un nuevo modelo energético de Andalucía) (article 11) recognises this goal for economical, environmental and social impacts reduction derived from climate change, and highlights the important role of spatial planning. The law (article 8-14) provides the elaboration of the Andalusian Climate Action Plan (Plan Andaluz de Acción por el Clima, PAAC) as the general planning instrument in the Autonomous Community of Andalusia for the fight against climate change, through three programs: mitigation and energy transition, adaptation, and communication and participation. The PAAC is in currently going through the approval process (scheduled for 2021).

Besides, local urban plans have started to consider risk and include the climate change impact in their contents, however, this is still recent and not very common, due conflictiveness on updating municipal land-use plans (Planes Generales de Ordenación Urbana).

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22 http://www.juntadeandalucia.es/medioambiente/site/pacc/menuitem.f0b2b1e23eb863d9490cda105510e1ca/?vgnextoid=5a8be185d4693210VgnVCM10000055011eacRCRD&vgnextchannel=c00c1e9604273210VgnVCM10000055011eacRCRD&lr=lang_es

23 http://www.juntadeandalucia.es/medioambiente/site/portalweb/menuitem.7e1cf46ddf59bb227a9ebe205510e1ca/?vgnextoid=f33e322ecfa85310VgnVCM2000000624e50aRCRD&vgnextchannel=132e693aa8465310VgnVCM1000001325e50aRCRD

5.2 Climate change impact assessment

Local climate change scenarios represent the concretion of worldwide models, mainly based on General Circulation Models to anticipate the meteorological conditions in a long-term. There are social-economic scenarios related to the climate change impacts, based on population growth, technological globalization, resources and information available, environmental protection, and energy resources.

The impact assessment at local level is done by downscaling; by improving general models by using local information and running more detailed simulation models, in which participate not only local universities, but also public and private bodies. These climate change local scenarios aim to predict not only the future climate change, but also to anticipate their effects in primary production, habitats, water regime and climatic comfort.

5.3 Climate change impact adaptation

Adaptation initiatives include all the sectors and resources at risk, from agriculture activities, public health, to industry, tourism and water management. This initiative produces knowledge for futures situation, improving the coordination in the administrative actions, and favoring social education and participation.

Spanish Agriculture, Livestock, Fisheries, and Sustainable Development Regional Ministry, responsible for these initiatives, with respect to other administrative levels with their own competences in this field, developed the climate change report related to the implementation of the adaptation program to be evaluated by the economical-political commission. This report includes all the sectoral reports developed by the different regional departments, including adaptation initiatives based on the evaluation and diagnosis of every sector. The idea is to reduce vulnerability as maximum as possible without affecting the social-economical and environmental interests.

As example, in agriculture policy and planning actions, they are the following:

- Irrigation Design and Irrigation Planning, taking into account the projections of lower water availability, higher frequency of droughts, and water stress;
- Adaptation strategies for crops (monitoring, studies for each cropping system to evaluate them, proposals for changes in rotations, management, pest, and disease control);
- Establishment of a system of indicators to analyze the evolution of the agriculture sector with climate change;
- Preparation of training programs for farmers to put into practice techniques for adaptation to climate change;
- Greater prominence given to incentive systems for more sustainable agricultural practices and those that contemplate the adoption of basic adaptation measures from the agronomic aspect;
- Promotion of energy crops within the framework of coordination between mitigation and adaptation policies;
- Control of soil erosion in the most vulnerable areas.

Another example is related to coastal area management. Besides, it is a good example of coordination and cooperation between administration. The Spanish Ministry in charge of environment (MiTERD) is developing a strategy for coastal adaptation and, through the intervention of province services of coastal areas (Cádiz, Almería, and Málaga), administratively dependent on it, present the ideas to the municipalities related to the coastal zones on how to adapt to the national strategy.

Besides these initiatives at Spanish government level, as development of the previously mentioned Law 8/2018, at regional level, the Adaptation Program of the Andalusian Climate Action Plan (PACC, in approval process) aims to reduce economic, environmental and social risks derived from climate change by incorporating adaptation measures into regional and local planning instruments.

The Law 8/2018 establishes Municipal Plan Against Climate Change, which constitute PAAC complementary planning instruments, under local authorities competences. Experts in environmental assessment have developed a checklist and some guidelines to facilitate the inclusion of climate-related content into local plans.

6 Vertical and horizontal cooperation system in DRM and CCA in Andalusia region

The drafting committees and the development of the sectoral reports represent the horizontal and vertical system in Andalusia. As an illustrative example, the PGRI (Plan of flood management and risk) highlight the coordination between administrations that should implement their programmed initiatives, including participation of external entities and education activities (related with floods). PGRIS development consists of three phases, all of them organized through a public information process in order to involve society and administration.

With the approvement of the climate action plan, coordination and cooperation should improve, as a consequence of the importance given to this instrument in aspects as multi-sectoral and multilevel working groups to face climate change effects. All of them considering an integrated perspective.

Although civil protection is oriented more on preventive action and on ex-post contingency interventions after a disaster, their activities also contributes to cooperation and coordination. Guidelines are distributed for the management of risk, such as floods, to national, regional and local levels. Municipalities should implement these guidelines. Besides the creation of multilevel working groups to develop plans to face these risks, civil protection connects from the national to the local level, with clear deference in this case among levels, specially between Spanish and regional, usually conflictive instead.

Civil protection, through their commission, assists the technical development of local-level plans. Civil protection also homologates these plans and collects information about the local level risk and any conflict that may raise, and that should be managed at regional or national level.

According to the perception of actors from different departments, beyond a one-off effort, in Andalusia Government the lack of a proper vertical coordination is a critical limitation. Although there is a formal flow of invitations to the participation of different departments in the development of territorial and sectoral plans, the effective interchange of data and needs is not fully explored. Besides, a more intense interchange on good practices is desirable, mainly in terms of coordination instruments, shared responsibilities, shared funding, communication channels, etc.

7 Lessons learned

There is an ambivalent relation between spatial planning and the risks addressed in this study. In this way, although regional territorial planning considers risks in the regional level, it does so from a very static perspective based on their spatial location. Regional planning is established as a reference framework standard for its subsequent development through special plans, which remain undeveloped or out-of-date. Risk management is not so preventive (for this a better integration with Spatial Planning is needed, that should be improved by their own) and tends to be oriented to corrective actions (projects, interventions and investments, much more recognized and valued both by population and decision makers) after the appearance of a certain natural event.

The **weaknesses** of this model can be seen as critical points that need attention and as opportunities for future development:

- Intersectoral coordination can be greatly improved in all areas of risk management, as well as in the adaptation to climate change;
- The system is focused more on correcting the consequences of risks than on preventing them. This is related to the greater importance that should be given to monitoring and evaluation against mitigation. In short: give continuity to the risk prevention policy. An example of this weakness is that certain special plans need to be updated (e.g., Emergency Plan for Seismic Risk in Andalusia 2009) [24];
- Concerning certain risks, there is a lack of clear and updated information on their economic impact, either direct or indirect;
- It makes no sense to repeal the subregional spatial plans, as long as they detail the regional plan that contains the risk management framework. Losing them means losing a more specific framework, so reducing the available tools for risk management;
- The methodology used to assess flood risks is based on the return period (historical information); one can explore alternative methods for future projections, as it is done in the case of climate change assessment, where a policy of scenarios is implemented.

The **strengths** of this model are:

- The creation of platforms to share information for the intervention of the different units and organizations;
- Civil Protection favours inter-administrative coordination (from the local level to the general State administration) thanks to its intermediate position, assisting technically at the local level in the development of its local civil protection plans, from which it collects information that is facilitated to the remaining administrations. In turn, it collects information to provides to local entities;
- The identification of zoned flood risk areas, identifying dangerous and risky areas, with continuous inter-administrative collaboration. An exhaustive conformity analysis is done, givin rise to a planimetry that has not been seen so far.

[24] https://www.juntadeandalucia.es/organismos/presidenciaadministracionpublicaeinterior/consejeria/sobre-consejeria/planes/detalle/42582.html

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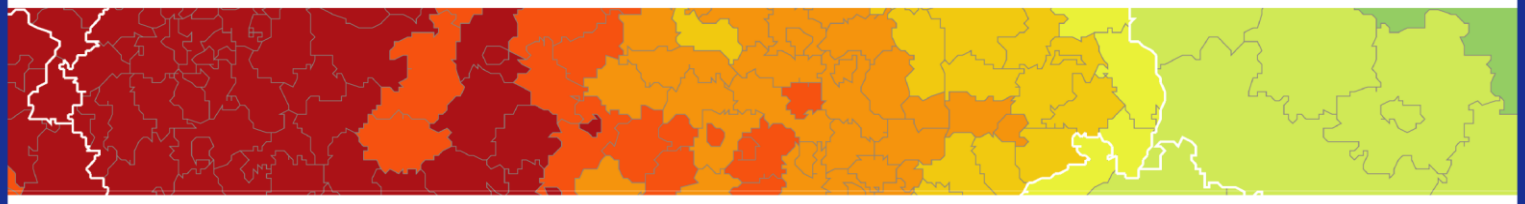

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