Chapter 8

Agriculture

8

Chapter 8 Summary

Agriculture

The impact from climate change on agriculture is expected to be significant because of the vulnerability of agriculture to climate conditions in general. Precipitation, temperature, weather extremes and evaporation rates all impact production. Agriculture is important to the economy of Croatia due to its overall value and its impact on food security, vulnerable populations, and the employment it generates. In 2001, 92% of Croatia was classified as rural and 48% of the Croatian population lived in rural areas. Generally, rural households are more vulnerable due to poorer access to basic infrastructure and poorer housing conditions than households in urban areas.

Existing climate variability already has a significant impact on agriculture. Extreme weather events have resulted in average losses of EUR 176 million per year during 2000-2007. This represents 0.6% of national GDP, or 9.3% of the GVA generated by the agricultural, forestry and fisheries sector. Looking at the future effect on maize alone, the lost revenue due to climate change would be EUR 6-16 million in 2050 and EUR 31-43 million in 2100. This corresponds to 0.8-5.7% of all revenue from arable crop sales in Croatia in 2005. Most of this damage is due to water shortage during critical times, as well as flooding and hail-storms which also cause damage. Particular years, such as 2003 and 2007, suffered huge economic damage that is difficult to recover. While some Government-supported insurance programmes and a new irrigation programme exist, current vulnerability to climate variability remains – particularly related to drought.

However, little information is available to assess the consequences of farm practices and climate variables. There are few crop models or agricultural sector economic models that would help the sector understand current levels of vulnerability or future levels due to climate change. Furthermore, basic economic information about the sector and about the gross margins of crops is not available. Thus, while climate change may be a risk in the future, there are a number of actions that could be taken now to address current vulnerability to the climate.

Models to simulate the effects of climate (including climate change) on crops need to be calibrated for Croatian conditions to understand how the country should adapt. Furthermore, the Government should conduct a comprehensive overhaul of its existing systems for collecting data on agricultural production, prices and accounting for farm revenues/costs in order to produce information. This should reflect the reality of the situation on the ground.

A multi-crop, multi-region agricultural sector model should be developed to assist the public sector in developing strategies and measures for coping with existing economic development, pressures to preserve the quality of the environment, climate variability and finally climate change. This would also assist farmers in implementing best management practices, as well as support national agricultural development and marketing strategies. More work also needs to be done to assess economic impacts from the agricultural sector on the larger economy.

Adaptation options can only be evaluated once a basic understanding of the interaction between climate, agricultural production and the economy is developed. This should include a comprehensive cost-benefit analysis of the Government's current large irrigation programme, as well as the other programmes discussed in this chapter as possibilities for dealing with water shortages. Adaptive actions may require a change of practice and may include management changes, technical adaptation/ equipment changes and infrastructure measures (e.g. the choice of crop variety and pesticides, sowing dates, the adoption of new husbandry practices, on-farm water harvesting and storage facilities, irrigations systems, etc.).

8.1. Introduction

Agriculture is expected to suffer severely from the impacts of climate change.[1] Precipitation, temperature, weather extremes, and evaporation rates all have significant impacts on production and agricultural production impacts economic development, food security, and Croatia's development. Impacts in this sector particularly affect vulnerable groups who use agriculture as a means of subsistence and for income generation. Agricultural production also affects food prices, which impacts the entire economy. This chapter discusses the importance of agriculture for human development and the current and potential future impacts from climate variability and climate change. It then evaluates the potential for adaptation, including "no regrets" and "low regrets" measures and makes recommendations for the further analysis of potential adaptation measures within the agricultural sector.

8.2. The role of agriculture in Croatia

Agriculture has been Croatia's backbone for millennia.[2] In the 20th century Croatian agriculture endured three wars, which destroyed farms and rural communities.[3] During the war from 1991 to 1995, a third of the livestock was destroyed and a quarter of the agricultural machinery.[4] More than 200,000 farmers were displaced and became consumers rather than agricultural producers.[5] Nearly a third of agricultural land remained inaccessible for cultivation due to minefields.[6] About 1.7% of the utilised agricultural area (UAA) still contains mines.[7] The farming sector has not fully recovered and the volume of agricultural production over the period 2000-2004 was about 15% lower than 1986-1990.[8]

The structure of the Croatian population has changed drastically in recent decades. Rapidly developing industry has required a large labour force. Most people were recruited from rural areas. Independent farmers became industrial workers. Over time, many rural areas became depopulated. Land remained abandoned and returned to shrubs and forest.[9] As policy measures in recent decades have not favoured the development of private farming,[10] mostly less educated, poorer, and older farmers have remained. Over time, society has developed a negative attitude towards farmers and farming that is still prevalent today.[11]

Figure 8-1: Dried out corn field in the middle of a drought in Požega.

Source: Borislav Trninić.

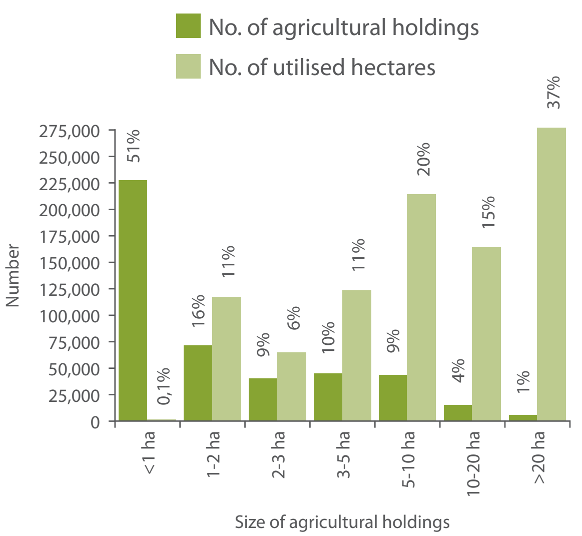
8.2.1. Family farms and agricultural companies

Croatia has two parallel production systems: family farms and private agricultural companies. While family farms form the core of Croatian agriculture, private companies, which have mostly evolved from former state-owned enterprises, are much larger in terms of land-use (Figure 8-2). This farm-size structure is the result of past communist agrarian reforms and continuing inheritance laws that allow for the division of farms between heirs, even if the farms become unviable.[12] While family farms are very important to Croatian agriculture, there is a vast discrepancy in the distribution of land, which favours larger agricultural companies. This is not a particularly new or unique phenomenon, as large farms are generally more efficient. However, small farms are, relatively speaking, much greater generators of employment and economic value.

"While family farms form the core of Croatian agriculture, private companies, which have mostly evolved from former state-owned enterprises, are much larger in terms of land-use"

Many people still live on agricultural land. In 2003 every third Croatian lived in an agricultural household.[13] Thus, the majority of agricultural households are not viable commercial enterprises. They are outside of the administrative, bookkeeping, fiscal, and inspection systems. They are subsistence, non-market-oriented farms, producing for self-consumption. Their owners usually earn their living working in other sectors but use the homesteads as places to live. In a number of cases, people without sufficient pensions or other income use small-scale farms to survive.[14] Contrary to most family farms, the industrial agricultural actors have access to capital and are geared towards industrial, high external-input farming aimed at maximising yields.[15] Agricultural subsidies are very unequally distributed among farmers and benefits go primarily to the big producers.

Figure 8-2: Distribution of utilised agricultural land and the number of agricultural households and companies according to size.



Source: Znaor 2008.

8.2.2. Economic importance of agriculture

Agriculture is very important to the economy of Croatia due to its basic value, as well as its impact on food security, vulnerable populations, and the number of people it employs (which is far more than its economic output would suggest). Some recent calculations question the validity of the official figures of annual GVA from agriculture, suggesting that it is significantly lower – see Table 8-2 for more.

Table 8-1: Characteristics regarding family farms and industrial farms in Croatia

There is a large difference in farm sizes	- The average size of family farms is 1.9 hectares, while the average size of the land used by the agricultural companies is 152 hectares.[16] 51% of agricultural holdings are less than one hectare in size. - 52% of the UAA is made up of 5% of holdings larger than 10 hectares
Small family farms are very important	- Small-scale, family farms account for 82% of annual working units (AWU) [I] and create 54% of all gross value added (GVA)[II] generated by farming and related upstream sectors (energy supply and distribution, trade, transport, agri-chemical industry, veterinary, advisory, research, education and administrative services). - Agricultural households account for 99.7% of the total number of agricultural holdings, occupy 80% of UAA, own 85% of all livestock and 98% of all tractors. [17]
Subsidies, like land are distributed unequally	- For example, the top 5% of milk producers receive 41% of all subsidies paid for milk production. [18]

[I] The AWU is defined as full-time equivalent employment (corresponding to the number of full-time equivalent jobs), i.e. as total hours worked divided by the average annual number of hours worked in full-time jobs. In the European context a working week is considered to be the equivalent of 40 hours (EC 2007).

[II] GVA is slightly different than Gross Domestic Product (GDP). National GDP takes into account some taxes and subsidies, which are impossible to obtain at the sectoral level in Croatia. GVA is therefore a close approximation of GDP.

The GVA produced by people not included in the mainstream economic and administrative systems still adds value to the economy but is not counted in national statistics. Their products are mainly for their own and (extended) family consumption, are bartered or sold directly on farms or at farmers' markets for cash, without receipts or VAT charges. These farmers are not obliged to practise bookkeeping or pay income tax. More than 90% of agricultural holdings inscribed in the Farm Register do not practise any bookkeeping and their economic size is unknown.[19] This means that a fairly large amount of agricultural production is not being accounted for. Additionally, the agriculture sector is important for the balance of trade and food self-sufficiency. Since independence in 1991, Croatia has been facing an increasing agricultural negative trade balance.

8.2.3. Role of agriculture related to employment and vulnerable people

A significant amount of the Croatian population lives in rural areas. Generally, rural households are more vulnerable in a variety of ways, which tend to be characterised by poorer access to basic infrastructure, such as roads, connections to the public water supply, public sewage systems, telephones and central heating systems. They also have poorer housing conditions (electricity, water supply, sewage systems, central heating, kitchens, toilets and bathing facilities in the house) than households in urban areas.[29]

The agricultural labour force is decreasing and many people engaged in the sector are not employed full-time. However it is unclear what percentage of the part-time workers' income comes from agricultural

"The agricultural labour force is decreasing and many people engaged in the sector are not employed full-time"

Table 8-2: Economic importance of agriculture in Croatia

While GVA and GDP from agriculture are important, it is not clear how much they contribute to the Croatian economy	- The GVA of the agricultural sector in the period 2000-2005 increased from EUR 1.50 to 1.76 billion per year, yet its share in total GDP decreased from 7.4% to 5.8%. [20] - Some recent calculations question the validity of the official figures of annual GVA from agriculture, suggesting instead an annual GVA of EUR 395 million during 2000-2003,[21] EUR 623 million in 2005[22] and EUR 626 million during 2001-2005.[23] - If these estimates are correct, farming makes up just 2.5% of GDP instead of the 5-7% reported by the Central Bureau of Statistics (CBS). [III]
Much of the value of farms is not captured by official statistics	- In 2007, 176,027 agricultural households were registered. [24] However, the number of commercially viable farms was about 50% lower and in the same year only about 86,000 farms received production subsidies. [25] - There are estimates that nearly 60% of holdings that are commercially oriented have gross margins below EUR 7200 per year.[IV]
Direct payments/ subsidies are quite large and comparable to EU levels	- The share of direct payments (subsidies) from the Government in the total gross output is very similar in Croatia (37%) and in the EU-27 (38%). - In 2005 Croatian farmers received just 6% less in direct payments per hectare than their colleagues in the EU-15 (EUR 238 vs. EUR 253).[26]
Croatia's food self-sufficiency has been decreasing over time.	- In the period 2000-2005, Croatia was self-sufficient in only five products: wheat, maize, eggs, poultry, meat and wine. [27] - In the period 2001-2005, imports of agricultural goods increased from EUR 287 million to EUR 377 million (an equivalent of EUR 85 per capita). For the same period, agricultural exports decreased from EUR 70 million to EUR 57 million.[28] - In the period 2001-2005 the deficit increased dramatically from EUR -217 million to EUR -320 million.

[III] Although this may appear very unlikely, these figures are probably more reliable than those of the CBS, which calculates farming GVA using 3.13 million hectares (instead of the 1.2 million hectares actually in use). The CBS suggests that on the per hectare basis Croatia generates some 20% higher GVA than the EU-15 or 40% higher than the EU-25. Taking into account the overall structure and development of the Croatian agriculture sector this is very unlikely. The CBS also applies a flat rate for the costs of production – extrapolated from a survey of 25 years ago. This means that each year they assume a fixed percentage of the cost of the crops to be the production cost, of regardless the actual cost of production for farmers.

[IV] One ESU is equal to EUR 1,200 of standard gross margin.

> "While agriculture in Croatia constitutes a significant part of GDP, its importance to the economy and to food security is more than just that of a component of GDP, especially in rural areas and among vulnerable populations"

activities. This is due to the structure of employment within the agricultural sector – with many workers actually being unpaid family labour. A vast majority of small-scale farmers, engaged in farming, are not registered with the Labour Office or the Revenue Office. Agricultural jobs do not pay well and, therefore, these farmers are exempt from paying pension insurance or income taxes.

The Croatian farming community is generally older than the general population. Since younger rural inhabitants regard farming as a labour-intensive and unprofitable business and tend to work elsewhere, the ageing process of the agricultural population is accelerating.[30]

As noted earlier, two-thirds of agricultural households have less than 2 hectares. It is very likely that most of these households practise subsistence farming and that agriculture forms the backbone of their survival strategy.[31] However, the exact number of smallholdings personally consuming more than half of their final production is unknown.

Agriculture is also a survival strategy for many urban people who go to the countryside over the weekends to help or farm on their own and return to the city with free or cheap food.[32]

This analysis shows that, while agriculture in Croatia constitutes a significant part of GDP, its importance to the economy and to food security is more than just that of a component of GDP, especially in rural areas and among vulnerable populations. Industrial farming is also important to Croatia, though perhaps more because of the impact on national food security and the balance of trade than for employment. However, population migration away from rural areas and shifts in the employment structure will probably mean that fewer people are dependent on agriculture in the future.

Table 8-3: Characteristics of the agricultural labour force

Significant amounts of Croatia are rural – including a large portion of the population	- In 2001, 92% of Croatian territory was classified as rural, and was populated by 48% of Croatians.
The agricultural labour force is decreasing, and many people engaged in the sector are not employed full-time.	- In the period 1991-2001, the agricultural labour force decreased by 37%.[33] - The CBS estimates that about 84,000 people (44% of which are women) are employed full-time in agriculture, accounting for about 6% of all the employed labour force.[34] - The labour survey also suggests that in 2005, 272,000 people were employed on a full-time or part-time basis in the agriculture, forestry, hunting and fishing sectors.[35] This total is approximately 6.2% of the entire population.
The percentage of people that earn their livelihoods in agriculture is more than the proportion of GDP	- The proportion of people working in agriculture is more than double the proportion of GVA from agriculture and much more important for livelihoods than the 84,000 figure suggests - There are estimates that the average AWU of those engaged in the Croatian farming sector in the period 2001-2005 was 180,824.[36] This means that many people worked part-time in the sector.
A vast majority of small-scale farmers who are engaged in farming are not registered and the jobs are not well paid	- The World Bank[37] suggests that three-quarters of those employed in Croatian agriculture are self-employed farmers. Most of this is unpaid family labour. - The average number of private farmers contributing to the pension insurance scheme in the period 2004-2006 was only 49,450 and their number has been declining every year, by 11% on average.[38] - The average monthly income (net), in all sectors in 2005 was EUR 591, while in the agricultural sector this was only EUR 502 per employee (15% lower).[39]
The Croatian farming community is generally older than the general population.	- In 2001 the ageing index (ratio between the population older than 60 and younger than 19 years) was twice as high in the rural population as in general (1.8 vs. 0.8). - 47% of the population living in agricultural households are older than 45 years of age.[40]

8.3. The impact of existing climate variability and extreme weather on the Croatian agricultural sector

Climate variability impacts and weather-related disasters appear to be occurring more frequently throughout the world and in Croatia. This variability has already had significant impacts on agriculture and the well-being of the rural population. A 2006 European study[41] analysing changes in natural annual events, such as the flowering of plants, suggests that changes in climate are affecting the seasons. In the future, agricultural yields could drop sharply as temperatures rise and water becomes scarcer, resulting in yield losses of 10-30%, notably in Southern Europe.[42]

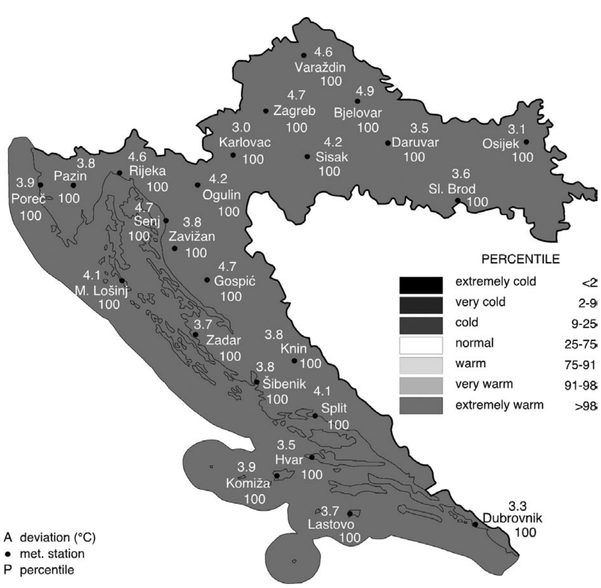
8.3.1. Droughts and heat waves

The period 1991-2000 was the warmest decade of the 20th century in Croatia.[43] The annual minimum daily temperature is rising. This process is more advanced along the coast than inland.[44] Summers have become steadily warmer in the last ten years.[45] The number of cold days and nights is diminishing, while there are more warm days and nights. In the 20th century,

Table 8-4: Problems related to water availability and heat in agriculture

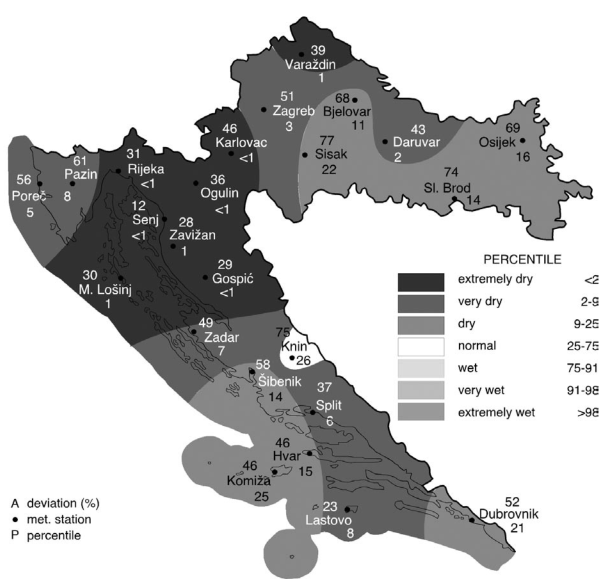
The shortage of water in agriculture is growing	- In the period 1994-2003, Croatian agricultural soils exhibited a much higher shortage of water than in the larger period 1961-2003. - In 1994-2003 the average annual water deficit was 57 litres per square metre, 19% higher than in 1961-2003. This has been attributed to changes in climate.[46]
The frequency of drought appears to be increasing	- During the period 1970-1992, droughts occurred 40% more frequently after 1981.[47] - The frequency of drought occurrence has increased over the last 20 years throughout Croatia. From 1982 to 1992, there were 55 drought periods, 29 of which affected all five geographic regions.[48]
Heat stress on crops is a problem	- Frequent air temperatures above the 25°C threshold (above which crops suffer from heat stress) have become a problem in some parts of Croatia over the last 20-30 years.

Figure 8-3: Summer 2003 - the mean seasonal air temperature deviation (°C) from the corresponding average values for the period 1961-1990.



Source: DHMZ 2004.

Figure 8-4: Seasonal precipitation quantities for summer 2003, expressed as a percentage of the average values for the period 1961-1990.



Source: DHMZ 2004.

annual precipitation dropped throughout the country, with the reduction being more pronounced in the northern Adriatic, on the Dalmatian islands and in eastern Slavonia.[49] A decreasing trend of average annual cloudiness has also been identified throughout Croatia. Average annual precipitation is decreasing, especially along the coast. The northern Adriatic, Northwest Croatia, and the bread-basket region of Eastern Croatia are becoming increasingly dry.[50] As a result, the need for water is growing in Croatian agriculture. Similarly, due to high temperatures and the risk of summer drought, agriculture in the mid-Adriatic coast and islands indicates the highest vulnerability to climate variability.[51]

Severe droughts inflicted severe damage on Croatian agriculture in 2000, 2003 and 2007 (See Table 8-5).

8.3.2. Additional damage from weather events

In addition to droughts, during 2000-2008, agriculture suffered from hail-storms, exceptionally strong winds, frosts, heavy rains and flooding.[60] The hail-storms that hit some parts of Croatia (particularly on the Adriatic coastline) in 2001 destroyed large areas of grapevines and other crops.[61] In the same year, summer frosts damaged/destroyed crops in several parts of Northern Croatia and Istria.[62] However, 2002 did not suffer many extreme weather conditions, although some parts of Croatia were affected by frost, causing damage to some crops, notably fruit.[63]

In 2004, a severe bora wind (north wind) blew along the entire Adriatic coast on November 14 and 15, killing 2 people, injuring over 50 and causing substantial

Table 8-5: Effects of the droughts of 2000, 2003 and 2007 on agriculture

2000	- Extremely hot and dry, with some regions going without rain for around 40 days. The last time the same intensity of drought occurred was in 1893. - The mean annual temperature in 2000 in Zagreb was the highest since the beginning of systematic recording in Croatia in 1861.[52] - Fifteen out of 20 counties declared a state of natural disaster due to the combined effects of drought and wildfires. - Some of the most important agricultural areas, such as Vukovar, received only 3-10 litres of precipitation per square metre in the period April-August, which was far below the requirements for the normal growth of crops.[53] - Agricultural production was reduced by up to 30%. In some cases, crops were almost completely destroyed.
2003	- Croatia and several other areas in Europe were gripped by a heat wave and the worst drought in 50 years.[54] - The heat wave began in March and lasted over three months, causing severe damage to agriculture. - Due to high temperatures and low precipitation, the entire country was classified as 'extremely warm' (Figure 8 3). - With the exception of the Knin region, dry weather prevailed throughout Croatia (Figure 8 4). - By the beginning of June, the main agro-meteorological station in Križevci found that the field moisture capacity of the soil was already 27 litres per square metre short at a depth of 10 cm, 77 litres at 30 cm and 170 litres at 60 cm.[55] - The soil was not only dry but it was also extremely warm – up to 45°C in Osijek, resulting in all plant crops experiencing a temperature shock. This situation affected the fertile region of eastern Croatia the hardest, where precipitation amounts reached barely 30% of the 30-year average. - Crop yields were diminished by 30% on average, with some crops, such as sugar beet, suffering a 50% reduction.[56] - In May 2003, a state of natural disaster was declared in 10 counties in eastern and northern Croatia and the Government formed a crisis group headed by the Prime Minister.[57] By the end of the growing season, 19 out of 21 counties had proclaimed a state of natural disaster.[58]
2007	- Croatian agriculture was again struck by a severe summer drought, causing shortages of both grain and corn.[59]

damage to infrastructure, buildings, and agriculture. Many olive trees were uprooted, while the sea salt left on vegetation caused damage to sheep farming on the northern Adriatic islands.[64] Again in 2007, hail damaged or destroyed crops in several regions.[65] The following year, in June, July and August, exceptionally strong hail hit northern Croatia, causing severe damage to maize and vineyards.[66] A state of natural disaster was declared in several municipalities.

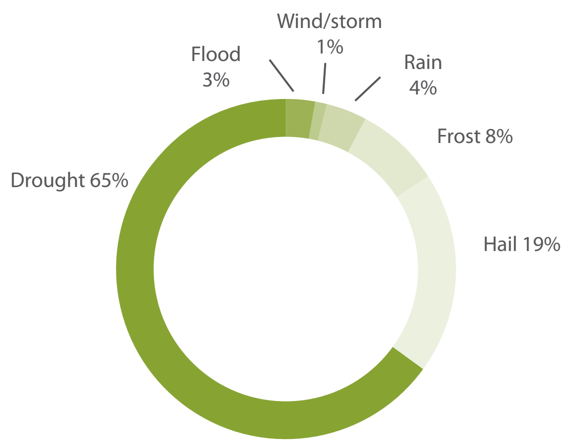
Figure 8-5: "The Harvest of 2008" - exceptionally large hailstones size of an egg on August 8, 2008 in Zagreb.

Source: Ana Pisak.

8.3.3. Existing economic damage from current climate variability

All of these natural disasters and climate variability events have resulted in economic damage. During 2000-2007, Croatian counties claimed EUR 1.4 billion in crop damage caused by extreme weather conditions.[67] This figure is equivalent to an average of EUR 176 million per year, representing approximately 0.6% of GDP or almost *one tenth* of the GVA generated by the agriculture, forestry and fisheries sector. This damage surpasses, by 25%, the value of the average annual direct payments (subsidies) for the same period, paid to farmers by the Ministry of Agriculture, Fishery and Rural Development by (see Figure 8-7). Therefore,

Figure 8-6: Share of extreme weather conditions in damage claims.



Source: Znaor, after MF 2008

the damage caused by existing climate conditions and climate variability already has a substantial impact on agriculture in Croatia. This may or may not be due to climate change, but it certainly points towards current vulnerability.

In the period from 1980-2002, natural disasters caused approximately EUR 5 billion in damage in Croatia (average EUR 217 million per year). Some 73% of this damage was due to weather. The damage from drought, frost and hail – extreme weather conditions causing damages predominantly in agriculture – is estimated at EUR 3.5 billion for the period 1980-2002, which is the equivalent of EUR 152 million per year.[68] Drought has caused the most damage, followed by hail, frost, rain, floods and wind/ storms (Figure 8-6).

[V] Assuming that the GVA figure of about 626 MEUR as estimated by the Economic Institute (2007) and Znaor (2008) is more accurate, this damage would be equal to some 28% of the GVA created by agriculture.

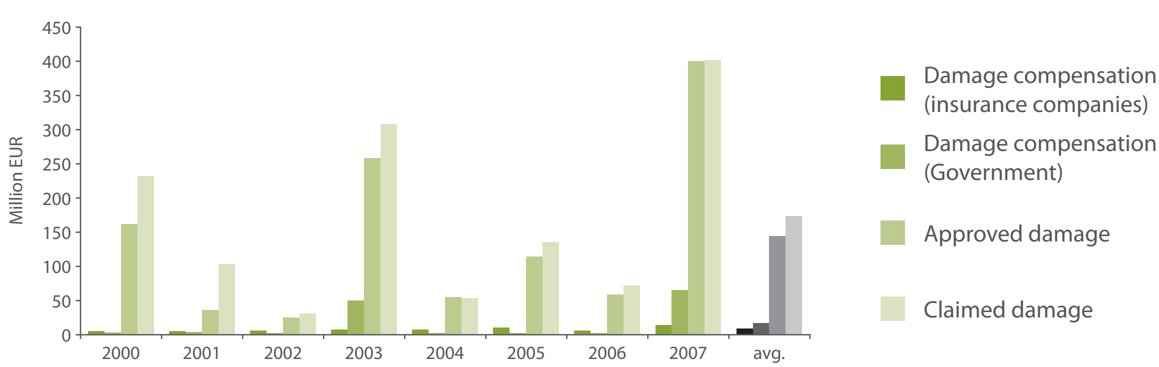
Table 8-6: Claimed, approved and compensated damage to the agricultural sector in the period 2000-2007.

Year	2000	2001	2002	2003	2004	2005	2006	2007	Avg.	
Claimed damage (Million EURO)										% of damage
Hail	16	35	15	13	33	41	64	52	34	19
Drought	238	17	0.4	313	0.2	-	2	346	115	65
Erosion	-	-	-	-	-	18				0
Flood	2	9	1	-	20	5	5	0.2	5	3
Wind/storm	-	-	0.4	-	4	5	-	8	2	1.2
Rain	-	-	-	-	-	52	2	-	7	3.8
Frost	-	51	29	5	-	22	-	-	13	7.6
Total	256	112	32	332	57	143	73	406	176	100
Approved damage	175	36	26	270	57	117	59	401	143	
Compensation										
Government	3	3	2	51	1	1	1	62	15	
Insurance companies	4	5	6	7	7	10	5	12	7	
Total	7	8	8	58	8	11	5	75	23	

Source: after MF 2008 and Hanfa 2008.

The Government has attempted to relieve some of the risks and damages associated with climate variability. Subsequent to the Act on the Protection from Natural Disasters, the Government approved damage payments of EUR 1.1 billion (78% of all claimed damages). However, due to a shortfall in funds, only EUR 124 million (11% of approved damage) was actually paid out. The most significant payment was in 2007, when EUR 62 million was paid to compensate grain farmers and cattle breeders adversely affected by the drought. In 2003, the Ministry of Agriculture and Fisheries (MAF - the name of the ministry at that time) also granted a one-year grace period on MAF loans to 1,030 farmers who suffered damage from the 2003 drought.[69] During 2000-2007 farmers with insurance policies received EUR 57 million (on average EUR 7 million per year) from insurance companies (See Figure 8-7 and Table 8-6). However, generally speaking, insurance companies will not insure farmers against drought.

Figure 8-7: Claimed, approved and compensated damage to the agricultural sector in the period 2000-2007.



Source: after MF 2008 and Hanfa 2008.

The 2007 drought also caused economic damages reaching beyond the agriculture sector. Shortages of both grain and corn resulted in increased food prices. Retail prices of milk, bread, eggs, and meat all rose following the Government's announcement that there was just enough wheat to meet domestic demand and there was a corn deficit of up to 300,000 metric tonnes.[70] To try to stabilise the local market, the Government imposed a tariff of EUR 108 per tonne on corn exports.[71]

8.3.4. Potential impacts of future climate change on agriculture in Croatia

While current damages due to climate variability are estimated at 0.6% of GDP, or 9.3% of the GVA generated by the agriculture, forestry and fisheries sector, the scale of damages could get worse in the future. Climate models predict a further decrease in precipitation, and the Government expects that climate change will cause crops in Croatia to suffer from water shortages, notably in the fertile region of Slavonia. [72] Most climate change models predict an increase of drier summers and extreme heat waves and droughts. For this reason, an increase in the frequency of extreme weather events may be the most serious potential impact on agriculture from climate change. However, in addition to the frequency of extreme weather events, there may also be an impact from the change in the average temperatures, the average precipitation rates, and overall changes in climate.

The potential impact of changes in the averages of climate variables (long-term climate change) on the Croatian agricultural sector is largely unknown. The forecast for climate change in Croatia is not optimistic, and negative climate trends are predicted to worsen.[73] As discussed in Chapter 3, the various climate change scenarios for Croatia envisage significant temperature increases, regardless of the season, as well as decreases in precipitation.

The First, and then the Second, Third and Fourth (combined) National Communications of the Republic of Croatia to the UNFCCC detailed significant expected climate change impacts on agriculture (See Box 8-1) – some beneficial, others not. However, much more information and analysis will be necessary in order to actually transform these generalized statements into predictions about specific crops, the economic impacts of climate change, and to identify actions that will lead to adaptation.

Except for a series of closely-related studies,[74] the impacts of climate change on crop yields have not been quantified in Croatia. This work focused on the effects of climate change on maize development and yield in the central part of Croatia. The results of these studies correspond quite closely with those obtained for western Hungary.[75] This sort of research is necessary to better understand the relationship between climate and agriculture (See Box 8-2 for more information). The results showed:

A shorter growing season (30-36 days in 2050 and 34-44 days in 2100);

A reduction in grain production (3-8% in 2050 and 8-15% in 2100); and

No significant difference in the yield of biomass (range between -2% and +2%).

> "Climate models predict a further decrease in precipitation, and the Government expects that climate change will cause crops in Croatia to suffer from water shortages, notably in the fertile region of Slavonia"

Box 8-1: Expected impacts from climate change according to the National Communications to the UNFCCC

Regarding the potential impact of climate change on the Croatian agricultural sector, the First National Communication of the Republic of Croatia to the UNFCCC concludes the following:[76]

1. Soil moisture during summer months in lowland Croatia (the most fertile and most important agricultural region) is expected to decrease by 30-60%.
2. The annual number of days with temperatures exceeding 10ºC is expected to increase to 25-40 or 55-90 days.
3. The mountainous areas, which at present do not face water shortages, are expected to experience shortages during August.
3. The vegetation period is expected to extend by 25 to 45 days.
5. The coastal region of Croatia is expected to have a decrease in soil moisture by 25-56%.
6. It will probably be possible to plant/seed spring crops earlier, and, depending on the water quantities available for irrigation, the growing season will be prolonged.

In the more recent document, the Second, Third and Fourth National Communication of the Republic of Croatia to the UNFCCC[77], climate change is expected to:

1. Have a positive impact on yields and crop quality (notably winter crops) due to the extended vegetation period. The overall number of active vegetation days (temperature above 5°C) will increase by 35-84 days in the lowlands of Croatia and the period with temperatures above 20°C will be prolonged by 45-73 days.[VI]
2. Endanger spring crops because of high temperatures and water shortages during summer months.
3. Expand the area suitable for fruit and vine growing due to the disappearance of very cold winters and late spring frosts. This will particularly benefit southern Croatia, where it will probably be possible to grow more types of Mediterranean fruit.
4. Result in unfavourable conditions for pests, resulting in a significant reduction in pesticide use. A warmer and drier climate is expected to reduce the outbreaks of natural infections by mycoses that depend on frequent precipitation and high air humidity.
5. Result in more cost-effective production due to temperature rise, assuming that irrigation will be practised.
6. Lower yields and quality of pasture, forage crops and cereals.
7. Cause salinisation in coastal areas and impoverish pastures due to high-intensity rainfall and stronger winds in the coastal area. This is expected to have an adverse effect on milk production and the growth of small ruminants. Also strong winds (bora), lasting for several days, in the Dinarides may kill weaker and undernourished sheep, goats and their young (already frequently happening during gale-force winds blowing at 80 km/h).
8. Accelerate the multiplication of various pathogenic micro-organisms and parasites hazardous to livestock.

[VI] This may be an important threshold for some crops, though it is unclear.

Box 8-2: Modelling the potential impact of climate change on crop production – how to start.

"I began my research into crop models 15 years ago on my own initiative for my PhD dissertation. Analysing agricultural systems and modelling the potential impact of climate change on crop production is a very important topic, particularly now as food supplies are becoming scarcer in many parts of the world. My crop-modelling research activity was very slow and I had to take great efforts in learning everything myself in my free time. To my knowledge I am the only one in Croatia who has applied climate change to any crop-model. Corresponding with eminent experts from the USA, Slovenia and Hungary I was sent papers, books and the Decision Support System for Agrotechnology Transfer (DSSAT) software which helps analyse the effects of weather on agricultural systems.

In 1999 I carried out field maize experiments at the Faculty of Agriculture of the Zagreb University and simulated the yields using the Zagreb historical data (1949-2004). Then I stopped because I did not have the weather generator and climate change scenarios and could not analyse projections for the end of 21st century. Having waited for five years, in August 2005, I participated in the AGRIDEMA workshop *Introducing tools for agricultural decision-making under climate change conditions by connecting users and tool-providers* which was held in Vienna. With the help of the project, I carried out the Pilot Assessment *Modelling of maize production and the impact of climate change on maize yields in Croatia.*

The AGRIDEMA project was very useful because it connected providers and users. After publishing the results of the Pilot Assessment, the State Hydro-Meteorological Service improved its resources available by procuring an updated version of the DSSAT software. Presently I am participating in the Croatian Ministry of Science project *Climate variations and change and response in affected systems* and I am a delegate in the Commission for Agricultural Meteorology of World Meteorological Service and in the Management Committee of the European Cooperation in the field of Scientific and Technical research (COST) Action 734 *Impact of Climate Change and Variability on European Agriculture.* I am also participating in the COST Action 725, which aims to establish a European phenological database – a database describing the relationship between climate and biological phenomena.

There are not many agrometeorologists in the world and only 1.5 in Croatia – my husband Marko Vučetić who deals with protection from forest fires and "half of me" because agrometeorology is my "hobby". I really would like for agrometeorology to become a main topic of my research in my Service. I am eager to learn the new version of DSSAT model in the upcoming year. While the research is difficult and complicated, it will be necessary for ensuring that we understand the risks that climate change poses to the food supply in Croatia."

MSc Višnja Vučetić is the head of the Numerical Modeling Unit in the Meteorological Research and development Division of the Meteorological and Hydrological Service of Croatia and has been with the Service since 1982. She is the author or co-author of approximately 80 scientific and professional papers regarding agrometeorology, wind and wind energy.

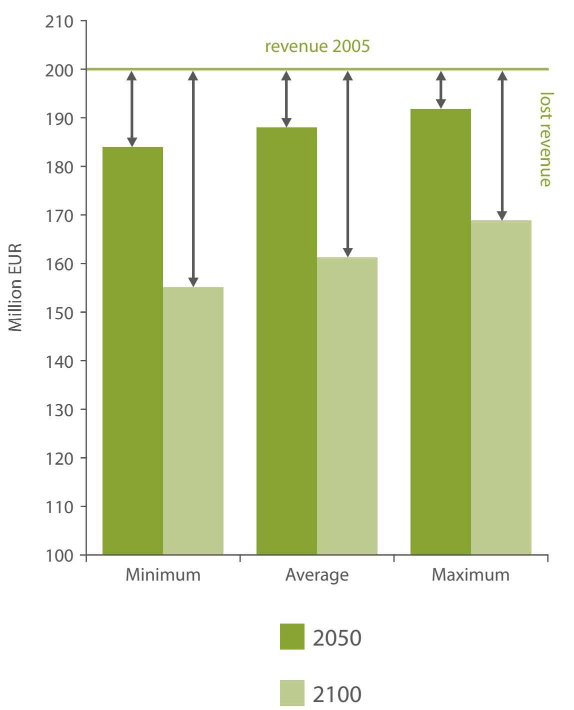
While these studies are important, they need to be supplemented by a much larger effort. The focus of these studies was on a single crop in a single region. This work needs to be extended to include more commercially-important crops and to cover more regions in Croatia.[VII]

[VII] There are technical limitations to these studies. For example, they did not take into account direct effects of atmospheric CO_2 on crop yields. Also, instead of using composite climate scenarios, taken directly from global climate models, the data need to be downscaled to a smaller geographic grid. Finally, instead of using composite climate scenarios, the effects of climate change and higher CO_2 concentrations on crop yields need to be investigated for various IPCC scenarios.

"If the reductions in maize production are similar for other crops, the possibility of lost revenue and lost food sources is significant"

Predicting crop yields in the future is only one step. Crop yield results[78] were used for an economic analysis which estimated the potential loss of revenue from the production and sale of maize due to climate change, taking the year 2005 as the baseline for maize yields, area harvested and prices. In 2005 grain maize was by far the most economically important single crop with 59% of arable land (318,973 hectares) and 39% of the total harvested area growing maize. Croatia produced 2,207 kilo tonnes of maize grains in 2005.[79] When multiplied by the average annual producer price[80] the realised revenue from maize sales was EUR 199 million, representing 20% of the total crop production output.

Figure 8-8: Revenue from maize sales obtained in 2005 and projected for 2050 and 2100



If climate change reduces maize yields, as described in the crop models above,[VIII] the lost revenue would be EUR 6-16 million in 2050 and EUR 31 – 43 million in 2100 (2005 EUR value) (Figure 8-8). This corresponds to 0.8-5.7% of the entire revenue from the sale of arable crops in Croatia in 2005.[81] This estimate does not take into account any change in production costs due to climate change, nor does it take into account adjustments that farmers might make to their crop mixes, or changes in the market price of maize due to the effects of climate change on the production, exports and imports of maize and other crops in the rest of the world and Croatia.

If the reductions in maize production are similar for other crops, the possibility of lost revenue and lost food sources is significant – perhaps 4-20% of all agricultural economic production. While this is a large conjecture, it indicates that there is risk associated with a change in mean temperatures and precipitation levels associated with climate change that should be examined further.

8.3.5. Combined impact of climate on agriculture

As shown above, existing climate variability has already had a significant impact on agriculture. Extreme weather events have resulted in average losses of EUR 176 million per year from 2000-2007, representing 0.6% of national GDP, or 9.3% of GVA generated by the agricultural forestry and fisheries sectors. More research would be necessary to determine whether this amount is greater than damage from extreme weather prior to 2000.

[VIII] As stipulated by Vučetić 2006a, Vučetić 2006b, Vučetić 2008

Table 8-7: Revenue from maize sale obtained in 2005 and projected for 2050 and 2100.

Crop	Year	Area (ha)	Yield (tonnes per hectare)			Yield (kt)			Price per kg (2005 EUR)	Revenue from sale (MEUR)			Difference from 2005 (MEUR)		
			min	max	avg.	min	max	avg.		min	max	avg.	min	max	avg.
Grain maize	2005	318,973	6.9	6.9	6.9	2,207	2,207	2,207	0.09	199	199	199	0	0	0
Grain maize	2050	318,973	6.4	6.7	6.5	2,031	2,141	2,086	0.09	183	193	188	16	6	11
Grain maize	2100	318,973	5.4	5.9	5.6	1,726	1,868	1,797	0.09	155	168	162	43	31	37

Furthermore, looking at the future effects on maize alone, lost revenue would be EUR 6-16 million in 2050 and EUR 31-43 million in 2100 (using a 2005 EUR value – see Figure 8-8). This corresponds to 0.8-5.7% of revenue from arable crop sales in Croatia in 2005. In human development terms, this translates to increasing vulnerability among rural populations, which are already among the most vulnerable. In order to address the risks posed by climate in rural areas, action must be taken to reduce vulnerability to current climate shocks and future climate change.

8.4. Addressing climate variability / climate change in the agricultural sector

The previous section highlighted the current impacts of climate variability/ climate change and some of the potential physical and economic impacts of future climate change on agriculture in Croatia. In general, Croatia lacks the information to quantify the full extent of these physical impacts and to value them. However, it is apparent from looking at current climate impacts and likely future impacts to maize that agriculture is vulnerable to climate change.

However, there are a variety of measures that can help agriculture adapt. These measures can be applied to both climate variability and climate change and can be divided into three basic groups (see Table 8-8):

1. Actions that build adaptive capacities;
2. Field adaptive (technical) actions; and
3. Autonomous or unassisted adaptation.

The rest of this chapter analyses some of the adaptive capacity of the Croatian agricultural sector, such as: the information currently available to stakeholders which can help them incorporate climate into decision-making; the current resources available for adaptation – including institutions involved; and some of the potential adaptation options that are available, including "no regrets" measures.

8.4.1. Information availability for decision-makers to assess vulnerability and adapt to climate conditions and climate change

In order to adapt to climate change and variability, both the private and public sectors need information that will help them to adjust better. This includes information about the impacts of climate on agriculture,

"Extreme weather events have resulted in average losses of EUR 176 million per year from 2000-2007, representing 0.6% of national GDP, or 9.3% of GVA generated by the agricultural, forestry and fisheries sectors"

Table 8-8: Approaches to adaptation in the agricultural sector.

Type of Adaptation	Characteristics	Examples
Building adaptive capacity	Creating the information and conditions (regulatory, institutional, and managerial) that enable adaptation actions to be taken.	- Climate change impacts research funded by agriculture advisory services. - Awareness-raising among farmers. - Genetic resources for breeding programmes. - Policy support tools.
Taking adaptive action	Taking actions that will help reduce vulnerability to climate risks or exploit opportunities.	- Creating water collection and storage facilities on farms for use in irrigation. - Introducing new crop varieties. - Diversification. - Resource management tools and infrastructure.
Autonomous or unassisted adaptation	Adaptation that occurs naturally or arises not as a conscious response to changing climate.	- Natural responses of agricultural crops to seasonal changes (e.g. earlier springs). - Autonomous farming practices evolution (e.g. treatments and sowing dates).

Source: AEA 2007

adaptation options that can be used to avoid damages from these impacts and information about which adaptation options work "best" for avoiding damages, including the benefits and costs.[82] For example, one study[83] used physically-based and statistical crop yield models to estimate the impacts of climate change in the original 15 EU countries for five different IPCC climate change scenario-GCM model scenario combinations. The results generally showed that, in both the short- and long-term, crop yields would reduce in Southern Europe, but increase in most of the rest of the Europe.

The study also used an economic model[IX] to simulate the effects of these yield changes on GDP. This analysis showed decreases in GDP in all countries, for all five scenarios, ranging from -0.16% to -0.60% by 2080. It is important to note that this higher amount is equal to the average amount of damage that Croatia has already faced due to climate variability and extreme weather events since 2000.

Croatia was not included in the analysis of EU countries, nor could it have been, as Croatia currently lacks the information necessary to undertake these exercises (See Table 8-9).

Improving the capacity to simulate the impacts of climate change and higher CO_2 concentrations on crop yields would involve the following steps (See Box 8-3 for more details):

- Improving the capability to downscale global climate model results to the regional and local-scales, compatible with existing models to transform climate into daily weather data,
- Selecting and calibrating appropriate crop yield simulation models for different crops, environmental and climatic conditions and management in Croatia, and
- Applying models to simulate the impacts of climate change and elevated CO_2 on the yields of commercially-important crops and introducing management options for avoiding these impacts.

Currently, the only institution involved in monitoring, collecting data, and conducting research about the impacts of climate change in the Croatian agricultural sector is the DHMZ. This organisation runs its own climate change models, but these are general and not agriculture-specific. Only one person[87] conducts research dealing with climate change and crop (maize) models, but this does not appear to be a programmatic decision of the DHMZ. The DHMZ also participates in the EU-funded research project COST 734 – involving 27 European countries and the World Meteorological Organisation – which evaluates the possible impacts

[IX] The GTAP general equilibrium model

Table 8-9: Information needed to carry out adaptation assessments in agriculture

Information Needed	Notes
Crop models required to assess the impacts of current climate variability, climate change and increased atmospheric concentrations of CO_2 on various crops, pastureland and livestock, and methods to simulate the physical damages avoidable by adaptation options.	- A certain amount of information exists from the previously cited work on maize yields.[84] - Theoretical predictions are available on the potential impact of the climatic change on Croatian crops, livestock and soils.[85] However, these provide few Croatia-specific calculations and information that goes beyond theoretical predictions and general warnings that climate change might soon affect Croatian agriculture. - Several authors also report on the water retention capacity of Croatian soils and on the water requirements of different crops.[86] However, these calculations (often based on long-term monitoring or experiments) are mostly used to justify the need for the expansion of the irrigation practice. - Crop yield simulation models were originally developed to help farmers cope with climate variability. - Developing the capability to calibrate and apply these models to Croatian climatic and environmental conditions represents a "no regrets" capacity-building approach that is useful for coping with the existing climate.

on agriculture, arising from climate change and variability.[88] The DHMZ Agro-meteorological Division also monitors and forecasts agriculture-relevant meteorological data. It publishes a weekly bulletin, providing weather-related information for agricultural producers. These include the meteorological data for the last 7 days, minimum and maximum temperatures, soil temperatures and a map with precipitation, sun intensity, forecasts, etc.[89] The crop (maize) model described previously seems to be the only such model available for Croatia. No plans or concerted actions seem to exist to incorporate the findings of this model or to initiate similar research for the purpose of strategic planning and policy making.

Economic and management information

Simulating the effects of climate change on crops – even many crops at many locations – is far from the end of the story. Croatia also lacks the ability to simulate how physical impacts will influence the management decisions of farmers. It lacks the ability to model the impact of these decisions on production costs, on income from the sale of agricultural products, on the prices of these markets, and on the imports and exports of agricultural commodities. Once a farmer recognises that the climate is changing, he/she also understands that it will affect the profitability of the many different crops he/she can grow. He/she also realises that he/she will have to sell the crop to a national and/or international market where the effects of climate will influence the crop selection, management and production of many other farmers, not to mention the equilibrium market price for each crop and, ultimately, the farmer's net income. This knowledge will motivate the farmer to think about which crops to plant and when/ how to manage them. Agricultural sector models (see Box 8-3 for more information) take these farmer-market interactions into consideration in both the climate variability and climate change context.[90] However, Croatia lacks much of the information necessary to create such sector models, as well as the sector models themselves (See Table 8-10).

As with crop yield simulation models, developing agricultural sector models also represents a "no regrets" approach to improving the agricultural modelling expertise of a national government. These types of models are already used in developed countries to assist policy makers in exploring a variety of policies related to the impact of climate variability, as well as supporting national agricultural development and marketing strategies in the context of modern market economies. In other words, developing this analytical capacity is a good idea, regardless of climate change, so that policies can be geared towards helping farmers improve their economic situation.

Improving the capacity to simulate the impacts of climate change and higher CO_2 concentrations on crop yields would involve the following steps:

- Developing a Croatian agricultural sector model with sufficient spatial detail to capture the effects of different environmental conditions on production decisions,
- Linking the model to a system of crop yield simulation models, to allow a large number of simulations without an undue amount of external data handling,
- Using this tool to assess the economic impacts of climate change, estimating the value of damages and the benefits and costs of avoiding these damages by various, selected adaptation measures.

It is important to note that Croatian farmers are generally poorly educated. Ninety-eight percent of those living in agricultural households rely on practical experience and have no agricultural education. Only 0.3% attended an agricultural course, while 1.3% finished secondary agricultural school and 0.4% finished agricultural college or university.[91] This indicates that there is a fairly low level of academic knowledge among farmers that could present difficulties in terms of spreading knowledge on adaptation.

"Developing this analytical capacity is a good idea, regardless of climate change, so that policies can be geared towards helping farmers improve their economic situation"

Table 8-10: Information needed on economics in the agriculture sector

Information Needed	Notes
Information on input use, management, and crop yields – basically "farm budgets"	- The standard gross margins (SGM) for different commodities and regions have not been established. [92] - The Faculty of Agriculture of the University of Zagreb does have some gross-margin (GM) calculations but these are for selected, commercial holdings over 10 hectares, ten years old and thus of limited relevance for today.[93] - The GM for different crop and livestock production has also been calculated by the Croatian Agricultural Extension Institute (CAEI).[94] However, these are based on theoretical assumptions of the potential results that could be achieved if farmers implemented good management practices, optimally applied agricultural inputs and if the yields obtained were as envisaged as the norm in agricultural textbooks. - Croatian farmers tend not to implement best practices – generally obtaining lower yields than the standard during 2001-2005.[95] - In early 2008, the World Bank-financed project "Establishment of the Farm Accountancy Data Network (FADN)", began to establish a better farm accounting system - first undertaking a survey of the farms throughout Croatia. - Within the framework of this project a trial survey will be carried out on a selected sample of farms and a typology of farms will be developed. - A full survey is expected in line with EU methodology in 2010.
Reliable macro-economic data on the gross and net income from agriculture production. (i.e. GVA)	- The GVA for the agricultural sector alone is not available – it is combined with forestry and hunting under official statistics. - Agricultural output seems to be derived from the non-existent agricultural land area of 3.15 million hectares and not calculated in accordance with the EC methodology.[96] - The GVA created by Croatian agriculture seems to be 50-65% lower than reported in official figures.[97] - If the CBS figures on the GVA were correct, this would mean that Croatian GVA per hectare basis is 20% higher than the EU-15 or 40% higher than the EU-25,[98] which is very unlikely. - The GVA is very difficult to determine since more than 90% of agricultural holdings in the MAFWM Farm Register do not practice any bookkeeping.
Agricultural sector models	- These simulate the impacts of climate change and elevated CO_2 using yield results from crop simulation models as inputs. - They can also be further modified to include simulating the effects of climate change on the livestock sector and on the supply and demand for irrigation water. - In addition, the sector models can be developed to include a wide range of farm policy options. - They can simulate adaptation to climate change in two ways: 1. Adaptation that involves changes in management at the farm level; and 2. Adaptation that occurs normally because of farmer reactions to changes in product prices in the market.

Box 8-3: Description of models needed for addressing climate variability and climate change

To address the risks to agriculture from climate variability and climate change, the effects of the physical systems must be understood, as well as the sector as a whole.

Models of the physical environment's effects on crops:

Crop models are representations of how crops respond to certain characteristics of the physical system. Phenological-based simulation models are considered state-of-the-art in crop yield modelling related to climate change. These models, which relate to the timing of plant maturation, include CERES, EPIC and DSSAT, and they all help to analyse a number of row crops and are expanding to include additional crops. These models are readily available "off the shelf," but they must be calibrated to local geo-physical and climatic conditions. In most cases, this applied work is supported by crop-specific, plot-level agronomic research and by larger field studies, which look more closely at issues such as disease and pest management.

These types of models are generally calibrated from plot data at a few locations. The calibrated model is used in a representative fashion to simulate yields over a number of other locations with the same characteristics as the plot locations. The models simulate the effects of daily weather on the growth and yield of individual row crops. As such, they require daily observation of a number of meteorological variables, as well as information about the physical environment in which the crop is grown, related to soils, drainage, water uptake, other physical factors, and "management." This feature of the models requires the output of Global Climate Models (GCMs) to be downscaled spatially to local and regional scales. Then the data have to be transformed to the hourly level, using a weather generator. These types of models can also be used to simulate a number of different types of management practices related to the type, timing and quantity of inputs applied (water, fertilizer, harrowing, ploughing, etc.). The relevant output of these models is the physical yield of the crop that can be harvested in weight units.

Agricultural sector models:

In addition to modelling the physical systems upon which agriculture is based, it is necessary to understand how these physical changes will affect the sector as a whole. To predict how climate change will affect crop mixes, production levels and crop prices at the national level a "price-endogenous" spatial equilibrium (SE) sector model for the agricultural sector is necessary. Price-endogenous simply means that crop and food product prices are a result of the model. They are not a variable put in to the model to yield results. Spatial equilibrium means that the model represents the different production possibilities in various locations and the various methods of transporting products to different market locations. Both features are very important for modelling the impacts of climate change from the bottom up, because changes in climate will vary in different places and, because many producers and consumers in many places will be affected differently by climate change at the same time, market prices will also be affected.

"While the Government has supported the agricultural sector following climate-related damage, the subject of adaptation to climate change within agriculture does not seem to be high on the agenda of policy-makers, researchers and other stakeholders"

8.4.2. Resource availability for adaptation and adaptation studies and the role of institutions and decision-making authorities

Following Croatian independence, the agricultural sector was almost completely "privatized" overnight. All the important monitoring, data collection and management activities conducted under the previous government were scrapped. The adoption of a new agricultural system of "governance", in terms of information management, was further postponed by war in the early 1990s. The Government in general considers the agricultural sector and rural development to be a priority for funding and for political action. Some of the programmes that support agriculture are outlined below. There are significant budgetary resources available to address human development risks within agriculture.

The estimated total budget of the Ministry of Agriculture, Fisheries and Rural Development for 2008 was EUR 630 million, of which EUR 530 million (EUR 440 per hectare) was allocated to various forms of agricultural support, such as subsidies. This is a significant amount of resources considering the entire sector's contribution to GDP is approximately EUR 1.76 billion. There are already some schemes in place to protect farmers from climate risk.

Aid scheme for insurance against possible damage to agricultural production[99]

A major current policy measure that relates to climate change adaptation is the Insurance Programme from Possible Damages in Agricultural Production.[100] The programme was introduced in 2003 to motivate farmers to insure production. Under the scheme, agricultural producers can receive aid from the Ministry of Agriculture, Forestry and Water Management towards the payment of insurance premiums. This aid is 25% of the cost of the total insurance premium (or a premium under collective insurance), regardless of the risk covered by the insurance policy.[101] However, no private insurance company in Croatia will provide insurance against drought.

The compensation for damage caused by natural disasters, as ensured by the Natural Disaster Protection Act[102], can also be regarded as a policy measure which reduces the risk to farmers. It makes it possible for farmers to receive compensation for damages caused by drought, floods, frost and hail.[103] Local and regional authorities assess the cost of the damage caused by adverse weather conditions and then report the damage to the national authorities. The requests for damage compensation payments are forwarded to the Ministry of Finance, which then makes the payments. However, this policy only addresses actual (past) damage and does not address climate change through adaptation or with forecasting damage. Furthermore, as evidenced by the lack of funds available in previous years during drought, the resources available for reimbursing farmers are often not nearly enough. Finally, such schemes need to be looked at with caution. If they act as subsidies for certain practices, they can impede autonomous adaptation and could be unsustainable.

While the Government has supported the agricultural sector following climate-related damage, the subject of adaptation to climate change within agriculture does not seem to be high on the agenda of policy-makers, researchers and other stakeholders. Consequently, there is hardly any on-going dialogue or cooperation

Table 8-11: Number of beneficiaries and total amount of aid to the agricultural sector due to damages.

Aid for insurance against damage					
2004		2005		2006	
Number of beneficiaries	Amount (EUR)	Number of beneficiaries	Amount (EUR)	Number of beneficiaries	Amount (EUR)
5739	Apprx. 2 million	4141	Apprx. 2.78 million	4583	Apprx. 2.95 million

between different ministries, Government agencies, research organisation and the business sector on the topic of climate change and agriculture. However, the national irrigation programme (which will be discussed in more detail below) has significant high-level Government support – though it does not explicitly address the threat of climate change. The programme is being supervised by a National Project Commission headed by the Prime Minister, with the Minister of Agriculture, Forestry and Water Management as its deputy. The Minister appointed an Expert Team that prepared a Project Strategy, which was adopted in November 2005.

Limited cooperation regarding climate change explicitly has been in the form of the expert committees preparing inputs on climate change and agriculture for the agriculture chapter of the National Communication of the Republic of Croatia under the UNFCCC. Ten experts from the Faculty of Agriculture of the University of Zagreb and an expert from the Ministry of Agriculture contributed to the last report.[104]

Some initiatives do exist to address climate-related issues in agriculture. Croatia is a signatory of the UN Convention to Combat Desertification in Countries Experiencing Serious Drought and in 2002 the Government established the National Committee to Combat Desertification. This Committee has 14 members, representatives from the ministries, scientific institutions, NGOs and the business sector. There is also an Expert Working Group dealing with agriculture.

There are an increasing number of climate change-oriented projects financed by the Ministry of Science,[105] but it is difficult to find evidence suggesting that these specifically cover the agriculture-related aspects of climate change. Neither the MEPPPC, MAFRD, nor Environmental Protection and Energy Efficiency Fund finance research or education by demonstration projects dealing specifically with agriculture and climate change. The Environmental Protection and Energy Efficiency Fund may be in a good position to provide resources for adaptation studies. It is an extra-budgetary institution owned by the Republic of Croatia whose objective is to finance environmental protection programmes and projects. In 2008 the Fund had EUR 182 million available for programmes. While climate change adaptation in agriculture is not specifically mentioned in its current activities, it would be an interesting avenue for new programmes.

8.4.3. Analysis of available technological options for adaptation

In this section we discuss how farmers in Croatia might adapt to present climate variability and future climate change. Farmers adapt by taking measures to avoid damages and thus reduce their losses in net income. We expect that farmers will adapt to climate change because they already adapt to climate variability. Regardless of the cause of climate variability, the principles of adjustment at the farm level are the same, although the actions taken to adjust to climate change and their outcomes may be different.

Commercial farmers, for example, will adjust their use of fertilizer, pesticides or water to reduce crop yield damages, as long as their increase in revenue is greater than the increase in cost. Household farmers will carry out a similar calculation, but it will be related more to the way in which they re-allocate household resources to provide for their families and may include nutrition for themselves as a factor. If climate change causes significant damage, it will probably be either impossible or too costly to completely eliminate the damages. However, in many cases, it will be possible for farmers to make adjustments that will actually make their households better-off financially and nutritionally. This type of adaptation is sometimes referred to as “autonomous adaptation,” because farmers and households will adapt in order to lessen the possible damages, irrespective of Government action.

"A great deal of the adaptation that will take place in Croatia will not involve new technologies"

Box 8-4: Differences in adapting to climate variability and climate change

There are two differences in adapting to climate variability and climate change. The first is that climate change implies that the mean values for meteorological variables, such as daily precipitation and temperature, are changing over time. The second is that climate change may involve fluctuations in meteorological variables that are outside their usual range in the existing climate record. In either (or both) case, the actions used to adapt to existing climate variability may not be enough for optimal adaptation to climate change.

In particular, entirely new adaptation actions may be required in the agricultural and other sectors. Some may have to be more forward-looking (long-term planning and investment to prevent damages). For example, having occasional droughts may be within the range of current climate variability, and, if so, farmers can do a better job of adapting to these droughts. But if droughts become more frequent or more intense, there may be no mechanisms in place that would facilitate adaptation to such changes. Thus, proper adjustment to climate change will require better information on long-term climate changes, and projections will need to be downscaled both spatially and temporally to meet the needs of farmers.

Autonomous adaptation constitutes just one part of adaptation to climate change. The public sector can also help farmers and households adapt, just as governments take action to help farmers and households adjust to the adverse impacts of climate variability. The involvement of the public sector as an agent of adaptation can take place in at least five different ways:

1. Disaster risk planning and disaster risk management.
2. Longer-term Government programmes focused on maintaining or improving the nutritional or economic well-being of farmers and households. This includes schemes to make crop insurance available more cheaply and a variety of crop and land subsidies. This is already underway in Croatia as outlined above.
3. Helping to finance large-scale investments in climate-sensitive infrastructure, such as irrigation water supplies, and non-climate sensitive infrastructure, such as transportation to improve market access.
4. Increase incentives which encourage farmers and households to adapt, by reducing the costs and/or increasing the benefits of adapting. This can include encouraging the utilisation of better farming techniques that can reduce vulnerability to climate-related risks.
5. Providing information about climate change that will help both the private and public sectors to adjust more smoothly, with less risk at lower costs.

A great deal of the adaptation that will take place in Croatia will not involve new technologies. It will involve changing the way in which crop and pastureland is managed, through changes in land use and crop mixes, substitution of inputs, changing the timing of management activities, etc. Some of these adaptations will simply be extensions of existing practices to cope with existing variability, but will also work well for adaptation to climate change. Many of these will be short-term measures. Some management changes may also involve changes in capital equipment or inputs; e.g. new types of machinery/ equipment or new pesticides and herbicides. As such, these measures will have to be supported by investment planning and, farmers will have to be sure that the expected benefits of making these investments will be greater than their costs.

Finally, some adaptation measures in agriculture may involve substantial investments in infrastructure, for example: irrigation equipment, dykes, tiles and drainage canals, which may have to be financed collectively or by the Government. In these cases, climate risk increases the costs of either over- or under-estimating these investments. This fact highlights the importance of having good information about climate in order to reduce the economic risks of making bad planning decisions about the state of the future climate.

It is not possible to predict which adaptation options will be best for the Croatian agricultural sector without better information. However, there are "no regrets" options, which can be adopted as Croatia's first line of defence against climate change.

There are several "no regrets" options that would help to reduce the vulnerability of the agricultural sector. These include a variety of options to increase water availability and address the problem of the lack of water content in soils.

Option 1: Increasing the carbon content in the soil

In his June 2008 address, the EU Commissioner for Environment, Mr. Stavros Dimas stated that increasing the carbon stock in the soil is essential in "mitigating the impacts of … more frequent and severe droughts."[106] Wider crop rotation could increase the carbon content in the soil. The current crop rotation is very narrow and largely determined on the basis of contracts between farmers and the companies to which farmers sell their products (often the food processing industry). Stable forms of organic carbon, such as humus, can absorb up to seven times their own weight in water, although some authors use a more conservative figure.[X]

In this respect, it may be helpful to stimulate the adoption of measures aimed at increasing the water absorption capacity of the soil. An increase in the amount of organic matter (carbon) in the soil would increase its water absorption capacity and thus help to fight drought. It would also contribute to climate change mitigation. A detailed explanation of the multifunctional benefits expected from the increase of carbon stock in Croatian soils and the calculation of the expected cost-benefit ratio is presented in Chapter 12, on mitigation.

Introducing fast-growing crops, such as various annual legumes, mustard, Sudan grass, other grasses and fodder crops, can help develop biomass in a short period of time. Once sufficiently developed, they can be incorporated into the soil to contribute to the soil's organic matter. Alternatively, a forgotten, once common practice of under-sowing can be applied. Assuming that the Government had to pay farmers an incentive (subsidy) of EUR 200 per hectare for soil moisture conservation measures over the next 10 years, to initiate this practice as a standard measure in agriculture, the cost of this policy would still be a fraction of the cost of the irrigation project outlined later.

[X] Morris 2004 for instance uses a factor of four for Australia, while the EU Commissioner for Environment claims a factor of twenty (Dimas 2008). Vukadinović (2008) claims a factor of three.

[XI] It is estimated that one part of the soil's organic matter in Croatia retains (on average) three parts of soil water (Vukadinović 2008). Since about 58% of the soil's organic matter is pure carbon and with the average dry bulk density of Croatian soils of 1.45 g per cubic cm (Vukadinović 2008), it appears that in the top 30 cm layer, Croatian soils contain 5.0 kg C per square metre on average. Assuming that 1 kg of organic matter holds three times that in water, it follows that 1 kg C can retain 5.2 litres of water. Šimunić, Senta, et al. (2006) estimated the average annual water deficit of agricultural soils at 55 litres per square metre. In order to provide at least 25% of this water shortage (14 litres per square metre), which would probably be sufficient to keep crops alive during dry periods, an increase in soil carbon content of 55% (2.8 kg C per square metre) would be required In terms of organic matter, this would mean that the present average organic matter level in Croatian soils of 2.2% (Znaor, 2008) would have to be increased to the level of 3.5%.

Table 8-12: Basic information about increasing carbon content in soils as an adaptation option

Description of the measure	Characteristics	Examples
Increase the carbon content in the soil: Wider crop rotation - more perennial legumes and grass-clover mixtures Under-sowing - sowing crops into the existing main crop during the growing season. The under-sown crop continues to grow after the main crop is harvested.	- By increasing the carbon content of the soil by 55%, it could be possible to provide about 25% of the water (14 litres per square metre) required, but currently missing for optimal crop development. [XI] - The amount of organic matter gained per year depends on crop rotation, manuring, geographic location, temperature, rainfall, and soil type. It would probably take 30-50 years to achieve this increase, so this is a long-term approach, but could help with long-term climate change.	- An incentive (subsidy) of EUR 200 per hectare would be required to stimulate Croatian farmers to introduce cover crops and under-sowing.[107] - The pilot agri-environment measures under the SAPARD/IPARD programme envisage a subsidy of EUR 106 per hectare for introducing green cover and EUR 156 per hectare for widening crop rotation.[108]

Option 2: Conservation tillage and liming

Conservation tillage is a technique for crop production in fields where the residue of a previous crop is purposely left on the soil. Some Croatian scientists[109] argue that current conventional tillage methods accelerate the deterioration of soil quality making it more prone to the adverse effects of climate change. The principal benefits of conservation tillage are improved water conservation and the reduction of soil erosion. Shallow ploughing of cereal residues after harvesting is another soil moisture conservation technique. It is recommended in nearly all agronomic literature in Croatia, but very rarely practiced and should be promoted. The application of lime prior to drought years was found to increase maize yields up to 50%[110] but why this method works is still unknown,[111] especially since there are no long-term trials underway on this topic. In this respect, it is highly recommended that a few long-term liming trials be undertaken. These are relatively cheap (a few hundred EUR per hectare per year) but could cast more light on the question of whether liming could potentially be a useful climate change adaptation measure.

Option 3: Promoting the adoption of organic farming.

Organic farming avoids, or largely excludes, the use of synthetically produced fertilisers, pesticides, growth regulators and livestock feed additives. Organic farming systems rely on crop rotations, crop residues, animal manure and mechanical cultivation to maintain soil productivity, supply plant nutrients and to control weeds, insects and other pests. Water use appears to be much more efficient on organic farms. The FAO states that "properly managed organic farming helps to conserve water and soil on the farm"[112] and that "due to the change in soil structure and organic matter content under organic management, water efficiency is likely to be high."[113]

Option 4: Irrigation Investments

Investments to substantially increase the area of irrigated land in Croatia may or may not be a "no regrets" measure. The reason we include a discussion on this option is to illustrate how difficult it is to decide which adaptation measures should be undertaken in Croatia, given the insufficient information about future trends in the local climate, the potential impacts of climate change, the value of the economic damages associated with these impacts, and the economic benefits and costs of avoiding these damages. The irrigation project described below is currently the most tangible adaptation measure that has already been initiated by the Croatian Government.

Irrigation programmes transport water from lakes, aquifers, and other sources directly to the crops. In 2004, the Government initiated a massive irrigation project entitled the National Project of Irrigation and Management of Agricultural Land and Waters.[114] The project objective is to ensure more efficient agricultural land management and provide more water to crops by constructing irrigation facilities on 65,000 hectares, by 2020, thus raising the percentage of irrigated land from 0.86%[XIII] to 6%.[115]

The estimated investment is about EUR 592 million, of which the Government is expected to contribute EUR 213 million by 2010. The remainder will be financed by counties, cities and end-users.[116] While most projects are still awaiting the completion of technical documentation and location and construction permits, irrigation systems have already been completed and put in operation on 5,000 hectares. The project is supported by all key stakeholders and has received good media coverage. However, a detailed cost-analysis of this project was not available to the authors of this Report.

The economic feasibility of the national irrigation programme is questionable. Theoretically, the production of some of these crops, which cover more than 65,000 hectares, might repay the irrigation investment costs (See Table 8-15). However, a more detailed analysis reveals that the economic benefits of the project are unlikely to outweigh the costs (See Box 8-5).

The strategy paper of the national irrigation project[117] relies heavily on farmers' genuine interest in irrigation and foresees that farmers will apply for the irrigation projects under various EU funds, notably the SAPARD programme. However, this has yet to happen. Out of the 37 projects awarded under the SAPARD, only one irrigation project was financed, with a total budget of just EUR 0.23 million.[118]

XIII The percentage of the irrigated agricultural land in Croatia believed to be among the lowest in Europe (GRC 2007)

Table 8-13: Cost-benefit analysis of the national irrigation project

		Period	Hectares	EUR per year (millions)	EUR per hectare per year
A	Gross-margin (GM)				
A	GM from crop production	2001-2005	1,052,178	503	478
A	Lost GM due to damage from drought	2000-2007	1,052,178	115	109
	Total A			**618**	**587**
B	Annualised capital cost of the irrigation project*	20 years	65,000	51	779
	Difference A-B				**-192**

* Assuming an adjusted discount rate of 4.48% (annual discount rate of 5% and depreciation rate of 0.25%) and amortisation period of 20 years.

Box 8-5: Economic analysis of the irrigation project

Although the average annual damage from drought in the Croatian agricultural sector during 2000-2007 was EUR 115 million, the required investment in the national irrigation project of EUR 9,100 per hectare (2005 EUR value)[119] seems to be difficult to justify economically. Assuming an adjusted discount rate of 4.48% (annual discount rate of 5% and depreciation rate of 0.25%) and an amortisation period of 20 years, the annualised capital cost of the irrigation project would be EUR 779 per hectare (Table 8-13).

On the other hand, the average annual gross-margin (GM) of Croatian crop production is EUR 478 per hectare (for 2001-2005).[120] The GM is the difference between gross output and variable costs (these are volume sensitive and always change according to the size of production, e.g. use of fuel, seeds, etc.). With this level of economic return on production, the investment repayment cannot be realised. However, some crops, such as vegetables, tobacco, fruit, olives, and grapes have a GM higher than EUR 779 per hectare (See Figure 8-9 and Table 8-14).[121] These crops cover an area of 86,936 hectares, of which 9,265 hectares are already under irrigation.[122] This leaves an area of 77,671 hectares producing crops whose GM is higher than the annualised cost of the capital investment for the irrigation project.

As the Government plans to establish irrigation for 65,000 hectares (12,671 hectares less than the area under these crops (Table 8-15), the project would seem to make sense. At least theoretically, it seems that producing these crops might repay the irrigation investment costs.

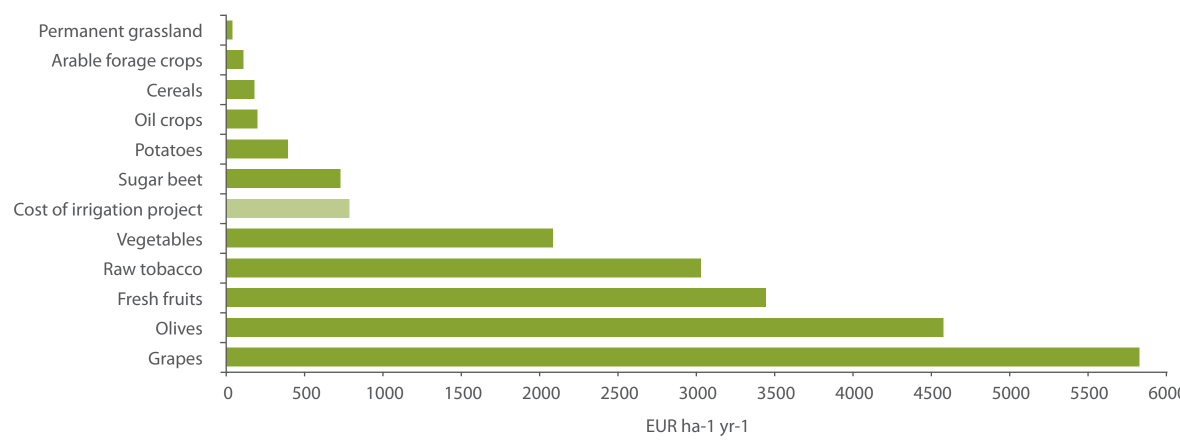
From the GM, farmers still have to pay their own labour costs (salary), depreciation and fixed costs. Fixed costs (overheads) are not commodity-specific and remain constant regardless of the volume of production. They include energy and transport, maintenance and repair of farm buildings and machinery, utilities and communication, insurance and loan repayments. In the case of fruit production for instance, the average annual GM is EUR 4,767 per hectare.[123] However, the Agriculture Extension Service sets apple orchard establishment costs at EUR 37,260 per hectare.[124] Assuming an adjusted discount rate of 4.48% (annual discount rate of 5% and depreciation rate of 0.25%) and an amortisation period of 20 years, the annualised capital cost of establishing an apple orchard would be EUR 3,192 per hectare. This leaves just EUR 1,584 per hectare for all other costs, as well as for the repayment of EUR 779 per hectare for the annualised capital cost of the irrigation project. It should also be noted that the costs of the energy and water required for the irrigation is not included in this calculation.

One might argue that the above-presented calculation is incorrect, since the producers are expected to pay only 33% of the total investment cost, while the Government provides the rest.[125] This is only partly true, since the above calculation takes into account the entire public investment. Public money has to be obtained from somewhere – either by taxing businesses or individuals.

Table 8-14: Gross margin (GM) of croatian crop production, annual average for the period 2001-2005 (Znaor 2008)

Crop	Area (hectares)	EUR per hectare
Permanent grassland	265,000	44
Cereals	542,883	167
Oil crops	119,661	196
Arable forage crops	89,358	103
Potatoes	18,903	389
Sugar beet	29,370	725
Vegetables	21,161	2.079
Raw tobacco	5,131	3.021
Fresh fruits	30,644	3.441
Olives	12,357	4.575
Grapes	30,000	5.819
Total	**1,164,467**	**478**

Figure 8-9: Cost of irrigation project investments and GM in crop production.



Source: Znaor 2008.

Table 8-15: Area with GM higher than the annualised capital cost for the irrigation project

Crop	Area (hectares)
Crops with GM > 779 EUR per hectare *	86,936
Present area under irrigation	9,265
Area requiring irrigation	77,671
Planned by the project	65,000
Difference (required - planned)	12,671

* without olives

Considering that the national irrigation project is currently one of the biggest Government investments and a key endeavour in the response to climate change, it is highly advisable that before pursuing further investments, the Government makes a thorough cost-benefit analysis of its strategy. These calculations currently do not seem to exist. The project is driven primarily by the fact that Croatian agriculture suffers from frequent droughts, even though Croatia has ample amounts of water. Before investing further into irrigation, the Government should compare the cost-benefit analysis of this project with potential alternative solutions, notably the introduction of the soil moisture conservation measures described in the options above.

Most of the above-mentioned adaptation measures (with the notable exception of irrigation) can be implemented as "no regrets" measures, as they address the lack of water risk, which is helpful regardless of future climate change. These measures should be demonstrated beforehand in a capacity-building programme, as they are capacity-building oriented, practical and will have an effect after just a few years of application. Their adoption does not require special skills, tools or machinery beyond those already available and they are unlikely to involve high costs and can easily be replicated by other farmers.

The adoption of measures promoting the conservation of soil moisture (Options 1-3) will undoubtedly be higher if the Government introduces subsidies for their adoption. These measures are likely to be able to solve the water shortage problem, at least partly, and are probably cheaper than irrigation. Additionally, measures to increase carbon content in soils could have a number of other beneficial effects (see Chapter 12 on mitigation) and are in line with the latest recommendations of the EC. While investing in the irrigation project could provide a solution for 5.4% of agricultural land, investing the same amount of money into other soil moisture conservation measures could benefit 42% of agricultural land (See Table 8-16).

The required annual subsidy to accomplish this much coverage would be equal to some 19% of the total Ministry of Agriculture's 2008 budget for agricultural subsidies. Therefore it is highly recommended that the Ministry of Agriculture re-analyse the costs and benefits of the irrigation scheme versus the potential of other methods that would encourage soil moisture conservation. Because of climate change, it is also important to evaluate various options regarding the long-term sustainability of planned irrigation schemes, taking into account changing climatic conditions. Costly investments that would provide services for decades need to be evaluated against their ability to continue to provide the same services in the future. If the irrigation project goes ahead, projected changes in the water sector in Croatia must also be taken into consideration, so that it does not rely on water resources that may become scarce in the coming decades. When designing these adaptation measures and related payments, the Government should also take into account the proposed agri-environment pilot measures due to be implemented under the EU IPARD programme[126] and those foreseen by the World Bank/ Global Environment Fund projects on agricultural pollution of waters.[127]

Table 8-16: Cost comparison: irrigation project vs. soil moisture conservation measures

				Irrigation project investment sufficent for	
		EUR per hectare per year	Total cost EUR per hectare	Hectares	% of agric. land
A	Annualised capital cost of the irrigation project	779	15.580	65.000	5,4
B	Subsidy for soil moisture conservation measures	200	2.000	506.360	42,0
C	Difference A-B	579	13.580		

Addressing water-logged fields and hail damage

Another climate related problem that may need adaptation is the problem of excessive water in Croatian fields due to heavy rains and inadequate drainage (See Box 8-6). Due to the changing precipitation patterns expected from climate change (including wetter winters), this could become more of a problem in the future. Increasing the carbon stock in Croatian soils can also help in addressing this issue, as the increase of organic matter in the soil would serve not only as an anti-drought measure, but also as a measure to prevent damage from floods. This is very important since Croatian soils are relatively poor in organic matter, leading to a constant or temporary water surplus or shortage.[128]

Box 8-6: Facts about water-logging in Croatia

- About 50% of the Croatian agricultural area requires drainage during certain times of the year.
- Full or partially built drainage systems exist on 2/3 of those areas with excessively moist soil, while the remaining 1/3 has no drainage at all.
- Subsoil pipe drainage has been installed on only 19% of the area required.[129]
- Since most of the drainage system was built before 1990 and has been inadequately maintained, it is in rather poor condition.[130]
- Some 57% of agricultural land (mostly arable) suffers from seasonal water-logging.[131]
- Water-logging enhances soil acidity which seriously hinders the fertility and the effective utilisation of applied nutrients, particularly phosphorus.[132] It is estimated that about 35% of all agricultural land is acidic.[133]

Another negative impact of the climate is hail damage. Unfortunately, very little can be done to prevent damage from hail. It damages all crops mechanically. Hail-storms are too infrequent and too hard to predict in the short-run, so it is hard to do anything in advance to avoid damages. However, even if the number of hail-storms increases, they will probably still remain so unpredictable that people won't abandon their land.

Adjusting to changing seasons

One longer-term adaptation issue may involve adjusting to changing seasons. Adjustment may entail a number of changes in farm practices. These could include changing the type, timing, date of, and duration between management activities, planting different crops/ different crop rotations/ different crop phenotypes, etc. If, for example, the crop seasons simply changed to different months, farmers wouldn't need to change anything but the dates of management. However, if other stress factors become prevalent – long-term drying out of the land, increased numbers of "hot" days that damage crops, etc. – other management decisions may be necessary. Almost all of these adaptations are measures that farmers already take to adjust, but it will take time for farmers to become more certain about how the climate is changing. An effective flow of information between farmers, the offices of the Agriculture Extension Service, and climate data services will be important in this process.

8.5. Conclusions and recommendations

Current climate-related impacts have already cost Croatia EUR 176 million per year since 2000, in terms of drought and other damages. Future climate change may mean an additional decrease in agricultural production. Taking into account the negative effects of extreme weather conditions and climate variability in Croatia, it is highly recommended that policy-makers and farmers begin dealing with climate in the following ways.

Recommendation 1: Build adaptive capacity – knowledge and information

- To build adaptive capacity, key Croatian stakeholders should be made aware of current and potential future climate-related impacts on the agricultural sector, the level of vulnerability, and adaptation measures that can be taken. This has not been happening. A programme should be designed and implemented which strengthens the adaptive capacities of the key stakeholders: farmers, farmers' unions, farm advisors, scientists, policy-makers and consumers. The MAFRD, in close co-operation with the MEPPPC, should take the lead in initiating such a programme.
- This programme would develop the knowledge and increase the information about the agricultural sector and the economic aspects of agriculture in its current state. Models to simulate the effects of climate change and elevated CO_2 concentrations on crop yields need to be calibrated for Croatian conditions, to understand how to adapt to these impacts. This can be done within Croatia or in conjunction with partner institutions outside the country.
- In addition, the Government should conduct a comprehensive overhaul of its existing systems for collecting data on agricultural production, prices and accounting for farm revenues and costs, in order to produce information that reflects the reality of the situation on the ground.
- A multi-crop, multi-region agricultural sector model should be developed to assist the public sector in developing comprehensive strategies and measures for coping with economic development, environmental quality pressures, climate variability and climate change. This should be designed to assist farmers in implementing these measures and to support national agricultural development and marketing strategies.
- Finally, a methodology needs to be developed to project the economic impacts of climate change in the agricultural sector on the larger economy, by coupling the agricultural sector model to a model of the Croatian economy.
- A committee responsible for the supervision of programme implementation should be established, consisting of representatives from different stakeholder groups. The Ministry of Agriculture, Fisheries and Rural Development could set-aside some (perhaps 1% - EUR 6.3 million) of its annual budget to support the design and implementation of this capacity-building programme, which could enable the actions outlined above in terms of information gathering. Money for this programme could also be provided by the following sources:
    1. Bilateral projects (e.g. such as government to government aid programmes already being developed between the Netherlands and Croatia);
    2. EU or GEF-funded projects (such as the on-going GEF project on agricultural pollution of waters); and
    3. The Environmental Protection and Energy Efficiency Fund, in the form of a new programme oriented towards adaptation to climate change.

Recommendation 2: Develop a cost-benefit analysis of potential adaptation options

After developing a basic understanding of the interaction between climate, agricultural production, and the economy, alternative options for adapting to current vulnerabilities from climate variability should be evaluated using crop yield and agricultural sector models. This should include a more comprehensive Cost-Benefit Analysis (CBA) of the irrigation programme, as well as the other programmes put forward as possibilities for dealing with water shortages. These options and whatever is identified as the most cost-effective for agriculture would represent “no regrets” options for adaptation if they help address current climate variability/ climate change. In particular, the irrigation programme should be re-assessed in terms of a cost-benefit analysis in comparison to some of the other programmes outlined above.

Along with examining “no regrets” options for adaptation to current climate variability, future climate change and its effects on agriculture should also be analysed. This will involve developing and incorporating downscaled regional climate models into crop yield studies and then into sector models. This will provide some level of understanding of the future risks of climate change to the Croatian economy and particularly the agricultural sector. It will also yield information about what areas may be helpful for adaptation and what the costs and benefits may be.

Recommendation 3: Take adaptive action – especially no regrets and low regrets options

Once future climate change is better understood, along with its likely impacts on Croatian agriculture, adaptive action addressing present climate variability and future climate change can be developed into projects that will reduce future risks. The implementation of adaptive actions requires a deliberate change of practice. Adaptation options in the agricultural sector can be divided into three groups: management, technical/equipment, and infrastructure measures. The management measures can include the choice of crop variety and pesticides, sowing dates, etc. The technical/equipment measures refer to the technical understanding required to implement management decisions - the distinction between the two being somewhat arbitrary. These include the adoption of new husbandry practices, introduction of new equipment, etc., and the adoption of these measures often largely depends on the advice provided by government agencies. Infrastructural measures require capital investment and include the establishment of on-farm water harvesting and storage facilities, irrigations systems, etc.

Existing climate variability is already having a dramatic effect on the agricultural sector due to the lack of water and severe droughts. This has amounted to approximately 0.6% of total GDP during 2000-2007 or EUR 176 million per year for the period. Future changes in precipitation rates and increased heat effects are likely to have increased impacts in the future. The effects of climate are having and will have a large impact on vulnerable populations in Croatia, both in rural communities and potentially because of the effect on food prices. There are “no regrets” options that should be further investigated and implemented to deal with some existing impacts. Further study is necessary into understanding the sector, its interactions with the economy, and the interaction between climate and agricultural production.