THE ECO-RESPONSIBILITY INITIATIVE OF MURCIAN AGRICULTURE AS A CO_2 SINK: THE LESSCO2 BRAND

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1. CLIMATE CHANGE: THE ENVIRONMENTAL PROBLEM THAT MOST CONCERNS EUROPEANS

Climate change is one of the primary environmental challenges that most countries face in the medium- and long-term in order to achieve sustainable development. The causes that gave rise to changes in climate are intimately linked to our production and consumption model based on the use of fossil fuels. Knowledge of the forecasted consequences, which will affect all aspects of society and the economy to differing degrees, has gone beyond the scientific community as the issue receives increasingly extensive coverage in the mainstream media. Concern for the forecasted impact is now a constant topic of public opinion. According to Eurobarometer[1] published in November 2009, climate change is the second most worrying problem to European Union citizens, ranking higher than the economic crisis.

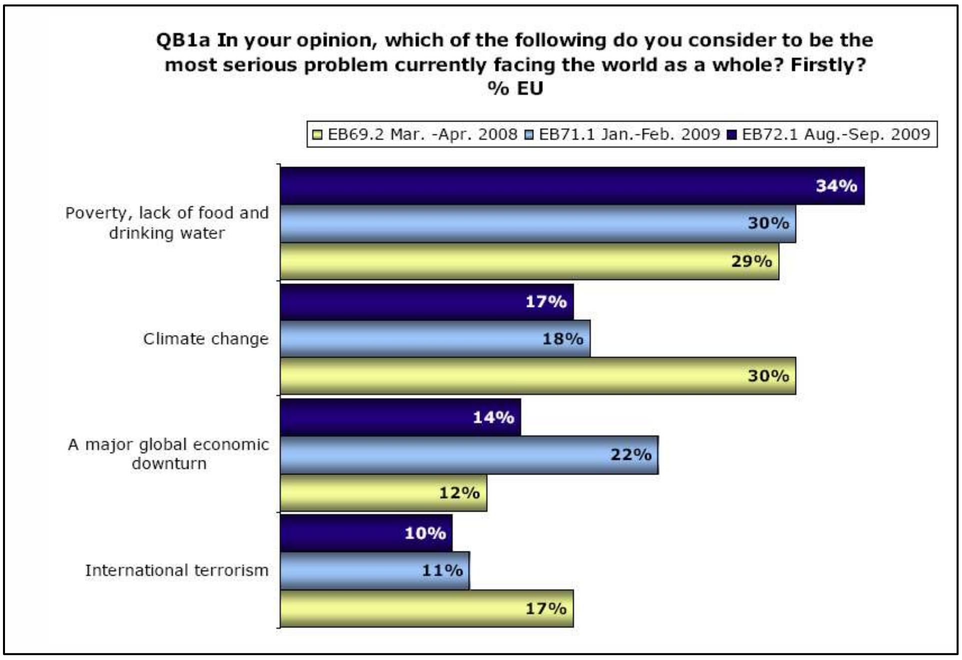

Figure 1. Responses of European citizens to the question "In your opinion what is the most serious problem the world faces today?"

[1] *Europeans' attitudes towards climate change* (Special Eurobarometer 322 / Wave 72.1 – TNS Opinion & Social), Publisher in November 2009 by the European Commission.

2. THE GLOBAL CHARACTER OF CLIMATE CHANGE

Atmospheric gases are practically transparent to short-wave radiation, the type of solar radiation with the highest energy input that heats the Earth's surface after crossing into the atmosphere. At night, the Earth cools, irradiating that energy, but certain gases in the form of longer-wave radiations that are not as transparent (these are the greenhouse gases, GHG, that make up 1% of the gases that comprise the atmosphere, including CO_2 and methane) reflect the energy back towards the Earth's surface. This process, similar to what happens in an agricultural greenhouse, has kept the Earth's temperatures at levels suitable for life for billions of years, and in fact, without this effect it is estimated that the Earth's average temperature would drop by 30 ºC.

This greenhouse effect has escalated considerably in the last few decades due to an increase in these gases in the atmosphere as a result of human activity. This increase is fundamentally owed to the burning of fossil fuels and changes in land use (the elimination of the plant cover that acts to recycle and remove CO_2 from the atmosphere).

Most of the capacity of the atmosphere's greenhouse effect (53%[2]) is caused by carbon dioxide.

The concentration of CO_2 in the atmosphere has gone from 280 ppm in 1750 (pre-industrial era) to 387 ppm in 2009[3], as shown by measurements taken at the Izaña Atmospheric Observatory in the Canary Islands.

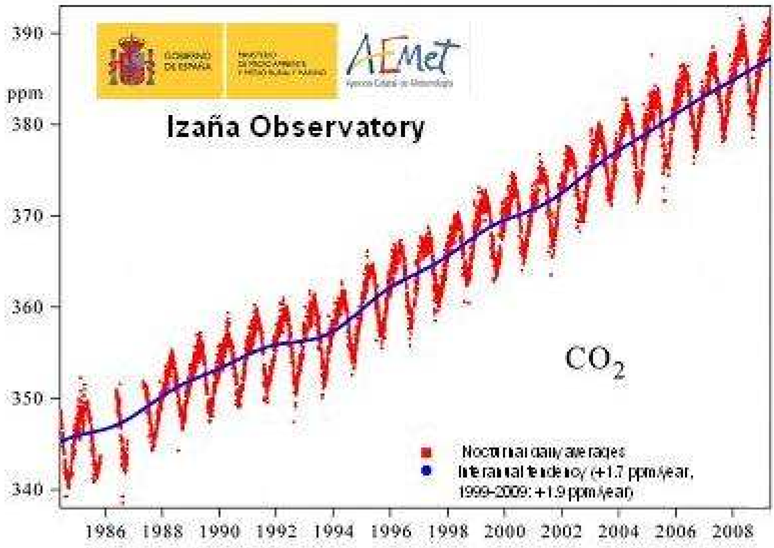

Figure 2. Changes in the concentration of CO_2 in the atmosphere from 1984 to 2010. Izaña Atmospheric Observatory. Spanish Ministry of the Environment and Rural and Marine Affairs.

Greenhouse gases are homogeneously dispersed throughout the atmosphere and alter its composition in the same way everywhere at once, regardless of their point of origin. The impact of that alteration is therefore global in scope, affecting humanity as a whole and all the Earth's ecosystems and biodiversity. This global character means that sinks that collect and store CO_2, no matter where in the world they are located, play an important role in partially removing emissions from the atmosphere, no matter where they are generated.

[2] Kristin Dow and Thomas E Downing. The Atlas of Climate Change. Ed, EARTHSCAN
[3] Spanish Ministry of the Environment and Rural and Marine Affairs. Izaña Atmospheric Observatory in Tenerife.

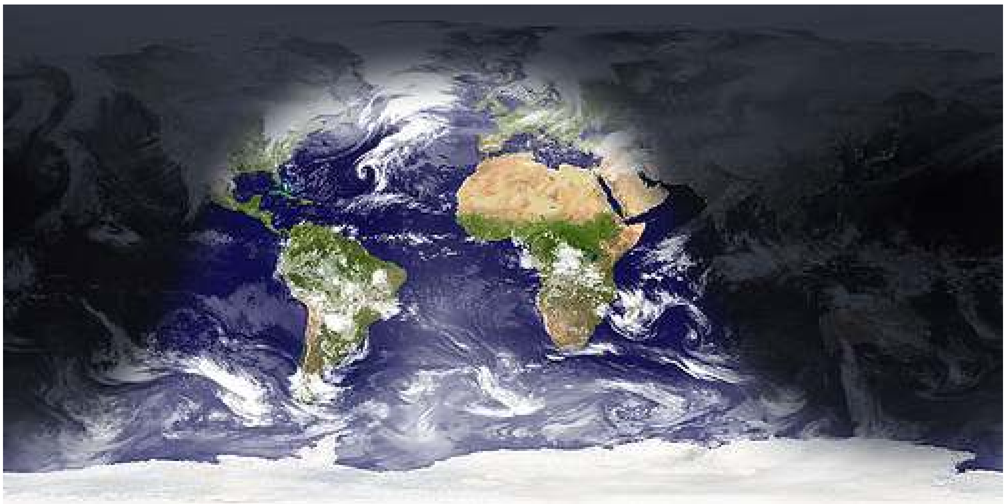

Figure 3. Ever since David Keeling started measuring atmospheric concentrations of CO_2 in the 1950s, we have known that this gas is uniformly distributed, with similar concentrations at all points across the planet.

3. AGRICULTURE: A CO_2 SINK

Agriculture is a basic strategic sector for the production of food, but at the same time it is a multi-functional sector whose assets contribute to the sustainable development of the rural landscape and provide notable environmental benefits.

Crops prevent desertification, emit oxygen into the atmosphere, help to regulate climate and hydrology and, above all, act as CO_2 sinks.

Agricultural trees and crops, and vegetation in general, recycle and remove CO_2 from the atmosphere through photosynthesis, storing it and therefore acting as CO_2 sinks. Agricultural products and by-products grow thanks to carbon fixation.

Many species of agricultural interest are characterised by their ability to grow very quickly, even faster than many natural plant species, which means they have a higher CO_2 fixation rate. In a recent research study conducted by the University of Murcia[4] within the framework of the *Murcian Agriculture as a CO_2 Sink* initiative, the net CO_2 fixation rates of a common agricultural species (lettuce) were measured and compared with two very common species of vegetation in the region – pine (*Pinus halepensis*) and esparto grass (*Stipa tenacissima)* (Table 1). This data made it possible to compare, for example, the annual fixation ability of some natural plant species with that of agricultural plants. The results of the study show that a hectare of land occupied by coniferous species such as pine fixes less CO_2 than a hectare of land with the same watering conditions used for agricultural species.

Table 1. Net CO_2 fixation rate (g CO_2 $year^{-1}$ kg^{-1} individual) of food crops (lettuce), scrub and natural woodland of the Region of Murcia.

SPECIES	Net CO_2 fixation rate (kg CO_2 $year^{-1}$ kg^{-1} individual)
Pinus halepensis (Aleppo pine)	10,63 ± 0,89
Stipa tenacissima (esparto grass)	4,66 ± 1,24
Latuca sativa (L) v. romana (Lettuce)	77,57 ± 17,75

Source: University of Murcia, Department of Plant Physiology

An important aspect of the behaviour of sinks is the time in which the carbon remains stored or is released into the atmosphere, because CO_2 removed by a sink can return to the atmosphere by means of various different mechanisms, for example, through forest fires.

Agriculture is not very different from a forest – part of the CO_2 fixed by the plant is stored in the soil by means of its roots, behaving like a long-term sink, while the CO_2 needed for the carbon contained in the harvest and by-products behaves like a temporary sink. But this temporary sink plays an important role in climate change mitigation policies because the fixation conducted by the plant and the consequent recycling or removal of the CO_2 from the atmosphere is renewed year after year.

The concept of the temporary sink is related to the concept of prevented emissions. For example, agricultural waste and other by-products can be used as biomass to prevent the emission of CO_2 from the fuels that they replace.

Therefore, the proper management of agricultural crops can in many cases increase net CO2 storage, after emissions generated during field work, handling and transport are deducted.

The net storage or sink capacity varies from crop to crop depending on its CO_2 fixation rate and the level of emissions generated which, in turn, depends on the agricultural practices employed. Most agricultural crops in the Mediterranean area, and especially fruit trees as we will see a little later, should be considered authentic temporary CO_2 sinks.

[4] Research conducted by Alfonso Ros Barceló, Chair, Department of Plant Physiology and Pedro Sánchez Gómez, Associate Professor, Botany Department of the University of Murcia, who participated in the "Comparative study of CO2 fixation in the natural vegetation of a phytoclimatic transect compared to crops in the Region of Murcia", being conducted along with Juan Guerra Montes, Chair, Botany Department, within the framework of the *Murcian Agriculture as a CO_2 Sink* initiative.

4. MARKET RESPONSE

A good number of the larger supermarket chains in Europe include climate change information as a fundamental element in their marketing, using it as an instrument for communicating their social corporate responsibility to the consumer.

Figure 4. Images of advertising campaigns related to climate change launched by supermarket chains in various European countries.

As mentioned earlier, climate change is the result of the increase in the concentration of GHG in the atmosphere, regardless of where they come from. This global characteristic is one of its essential features. We all contribute to global emissions because most of our daily activities require the emission of GHG. Citizens are directly responsible for a considerable part of these emissions. Among these (direct) emissions, those derived from the use of fuels to make our homes inhabitable and to power private vehicles have a particularly high impact.

Emissions that can be directly attributed to individuals in different European countries have been calculated at over two tonnes of CO_2 per capita per year.

Country	Kt CO_2	Population	t CO_2/citizen
Germany	217,885	82,431,390	2.65
United Kingdom	153,482	60,441,457	2.54
The Netherlands	38,182	16,407,491	2.33
Spain	67,831	40,491,051	1.68

Table 3. Comparison of CO_2 emissions directly attributed to citizens (mainly heating and use of private vehicles) in different countries of the European Union. Source: authors, using data from the European Environment Agency

However, the emissions needed to maintain our current level of consumption are much less perceptible; we might call this the virtual part of our carbon footprint. If we think about the emissions needed to create and transport consumer products or to allow us to enjoy all our various entertainment and leisure activities, these, according to a British study[5], create a carbon footprint even bigger than that left by the production, transport and storage of food items.

The boom in the use of the concept of the "carbon footprint" has led numerous companies to publicise information about emissions related to their products. Many supermarket chains have decided to ask the producers of the foods they display on their shelves to provide information to consumers about the carbon footprint of each of their products.

Providing carbon footprint information on a product is intended to let the consumers themselves decide which foods to buy based on the emissions generated as a result of the processes they have been subjected to. This decision translates into a certain amount of pressure on producers to be more eco-efficient.

Figure 5. Different labels on the world market related to the carbon footprint of a product.

Citizens today are aware that their small gestures and decisions can have a notable influence on the final balance sheet of European CO_2 emissions.

Studies conducted by the market consulting firm LEK Consulting[6] in 2009 found that nearly 40% of people polled feel responsible for the emissions needed to maintain their lifestyles, placing the responsibility of manufacturers in second place.

[5] The British organisation, the Carbon Trust – Making Business Sense of Climate Change, published a studied entitled "The carbon emissions generated in all that we consume" at the end of 2006 based on a 2005 study conducted by the Centre for Environmental Strategy of the University of Surrey, which defined a new model for carbon emissions attribution for the United Kingdom. The report revealed the amount of CO2 emissions generated by the average UK citizen.

[6] LEK Consulting, an international consulting firm in expert strategies, operations, services and actions on issues of climate change and the environment.

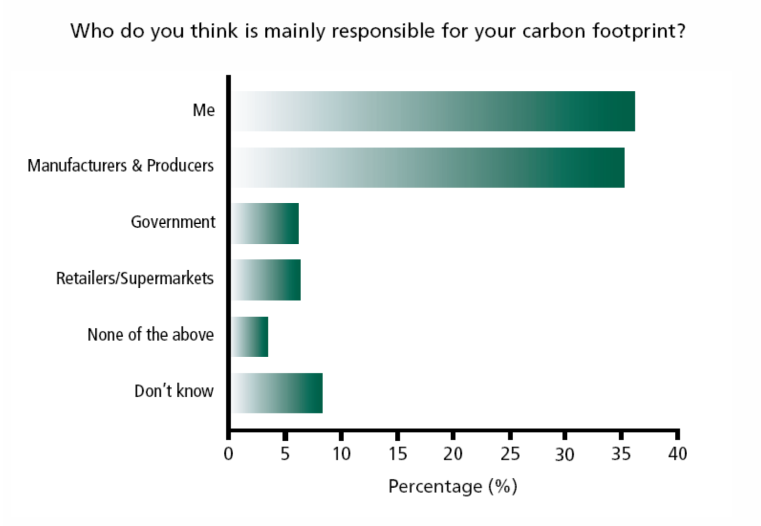

Figure 6. Survey responses to the question "Who do you think is mainly responsible for your carbon footprint?" Source: *LEK Consulting*, *The LEK Consulting carbon footprint Report, 2007*

LEK Consulting also revealed that nearly 60% of people surveyed would be willing to change their intention to buy in favour of products with a smaller carbon footprint.

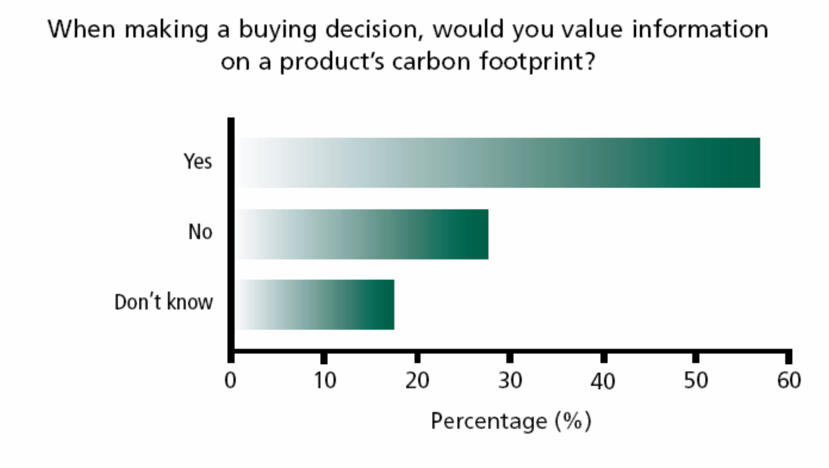

Figure 7. Survey responses to the question "When making a buying decision, would you value information on a product's carbon footprint?" Source: *LEK Consulting, The LEK Consulting carbon footprint Report, 2007*

This opinion is consistent with the results of a July 2009 survey conducted by Eurobarometer which found that 72% of Europeans are in favour of making a carbon footprint label on products obligatory in the future.

The figure of the carbon footprint is beginning to go beyond the voluntary disclosure of companies. For example, on 8th October 2009 the French parliament approved the Grenelle 2 Law, which develops instruments to combat what they call the "environmental, climatic and economic crisis" and which includes the obligation for providers of goods and services, including foods, to examine their carbon footprint as of January 2011.

Meanwhile, citizens are bombarded with messages that we have not been able to reduce emissions and that we must at least try to make up for those we generate. But compensation can only be acceptable if we have already done everything possible to reduce GHG emissions.

Compensation is primarily based on the implementation of CO_2 sinks by means of the maintenance and expansion of plant cover and it is currently being promoted by numerous organisations and institutions of all types, but fundamentally, it is companies that are offering consumers emissions compensation as an added value to their products or services.

Since the Vatican adopted a 17-hectare forest in Hungary in 2006 to compensate for its emissions, numerous emission compensation initiatives have been put into action. For example, a German automotive manufacturing multi-national announced that for every car of a certain model that they sell, they will plant 17 trees in the Sierra de Alcaraz in Albacete (Spain), which will compensate for the CO_2 emitted by the vehicle during its first 50,000 kilometres of operation.

Figure 8. Images expressing different initiatives related to emissions compensation.

5. ECO-EFFICIENT AGRICULTURE: CARBON BALANCE INSTEAD OF CARBON FOOTPRINT

The concept of the carbon footprint applied to the agricultural products displayed in supermarkets would reflect the equivalent[7] CO_2 emissions generated in their manufacture and transport.

It is clear that the carbon footprint of agricultural products will be bigger in cases in which a lot of energy in the form of fossil fuels is needed in their manufacture, handling and transport. This occurs, for example, when the temperature of an agricultural greenhouse in a cold climate has to be kept up using fossil fuels or when products are transported long distances in environmentally harmful modes of transport, such as air shipping.

However, defining the role that an agricultural product plays in relation to climate change by its carbon footprint alone (i.e. only counting its emissions) is not enough. Such a reckoning does not take into account the important environmental service agricultural crops provide in their capacity as CO_2 sinks by means of photosynthesis.

As a result, the extension of the concept of the carbon footprint to agricultural products must take into account that this sector, along with the forest product sector and the marine ecosystem, are the only ones that have the ability to trap or remove CO_2 from the atmosphere. This means we need to talk about a "carbon balance" instead of a "carbon footprint" because many agricultural crops, depending on the techniques employed in their production, actually achieve a positive balance, behaving as sinks of net CO_2, that is, they fix more CO_2 than is emitted in their production and transport.

[7] According to ISO 14064:2006 this is the unit which compares the radiative forcing of a GHG with CO_2.

6. MURCIAN AGRICULTURE AS A CO_2 SINK: AN INSTITUTIONAL INITIATIVE TO DRIVE COLLECTIVE COLLABORATION IN THE MITIGATION OF CLIMATE CHANGE

The agricultural sector of the Region of Murcia is among the most profitable agricultural sectors in Spain and Europe due to its high level of productivity. It is an agricultural sector based on quality, safety and a commitment to the environment.

Murcian agriculture, due to its efficiency and the mild climate in which it is cultivated, depends very little on energy sources, which means that many crops cultivated on more than 150,000 hectares of irrigated land have a positive carbon balance (behaving as a CO_2 sink), even when emissions derived from processing and transport to central Europe are considered.

The region wants to take advantage of this characteristic to contribute to the fight against climate change, using it to demonstrate an environmentally responsible production system that is closely connected to the social demands of European consumers. This has led to the establishment of the *Murcian Agriculture as a CO_2 Sink* initiative[8], created as a voluntary agreement[9]. The initiative seeks to channel as many individual efforts as possible to work together in mitigating climate change, each contributing the capacity to act as a sink and receiving the scientific and technological support of two universities and two research centres.

Through the official website of the initiative (www.lessco2.es) stakeholders, and especially consumers, can receive objective, transparent information about the environmental efforts being made by agricultural companies to maintain and improve the CO_2 sink capacity of their crops. Furthermore, within the framework of this initiative, companies that want to demonstrate the carbon balance of their products and the commitments they have made to improve that balance can do so with officially recognised verification by receiving the “LessCO2” seal of identity.

Figure 9.Graphic image of the LessCO2 brand.

[8] The initiative was published in the Official Gazette of the Region of Murcia (Nº 273) on 25th November 2009, by means of the Order of 20th November 2009 of the Ministry of Agriculture and Water, which describes *the Murcian Agriculture as a CO_2 Sink* initiative and establishes the procedure for obtaining and using the Less CO2 anagram-seal that identifies the commitment adhered to within the framework of the initiative.

[9] One of the advantages of environmental agreements is the degree of freedom that they allow organizations when it comes to taking on environmental obligations. This makes it possible to adapt environmental efforts to the characteristics unique to each sector or business activity, thereby developing a more cooperative attitude and preventing drastic and traumatic changes. And this is why if we are trying to achieve or encourage more sustainable changes in forms of production and consumption in the shortest time possible, participation in a voluntary agreement offers many more advantages than the use of conventional legislative instruments. In the Autonomous Community of Murcia, the regional government has encouraged initiatives that reflect an advanced and innovative perception of the way environment and sustainable development policies are managed. One example of this is the Social Pact for the Environment, which in the three years it has been in effect has achieved voluntary participation in environmental commitments that go beyond the limits required by current legislation with more than 700 companies and institutions involved in the Region.

In short, the *Murcian Agriculture as a CO_2 Sink* initiative is characterised by:

- Demonstrating an equal balance of CO_2 emissions and removal (carbon balance)[10] instead of a carbon footprint, that is, taking the levels of CO_2 fixed by crops, as determined by official research centres[11], and subtracting the equivalent CO_2 emissions required for their production and transport.

  The calculation of these emissions to be subtracted is based on the criteria stipulated in ISO standard 14064[12] and the official conversion factors published by the Intergovernmental Panel on Climate Change (IPCC[13]) and the National Inventory of Spanish Emissions[14].

- Requiring companies to adhere to an annual commitment adapted to the characteristics of every facility and every crop in order to improve their carbon balance by reducing their emissions or increasing the CO_2 fixed by their crops.

- Ensuring the transparency and traceability of results by means of the official website of the initiative (www.lessco2.es) so the consumer or any other stakeholder can check the balances and commitments of the participating companies at any time.

- Providing the possibility of receiving certification so that companies that wish to do so can have their carbon balance and annual commitments verified and validated by accredited verifiers. This certification is expressed through the granting of the LessCO2 brand.

The initiative and its associated LessCO2 brand are not limited to solely certifying a certain balance, rather the consumer can also see the commitments taken on by the company, thereby reflecting its commitment to produce more eco-efficiently and responsibly, in such a way that every unit of product sold means more CO2 absorbed, year after year, and therefore an increased contribution to the fight against climate change.

In conclusion, the *Murcian Agriculture as a CO_2 Sink* initiative has a double objective: on one hand it seeks to increase the sink capacity of agriculture in the region, and on the other, to provide incentive for eco-efficiency, linked to a low-carbon economy in the agricultural sector, taking advantage of the motivation associated with the competitive advantages that environmental responsibility and a reduction in costs afford. This involves the incorporation of good practices in agricultural production in order to achieve a reduction in GHG emissions at the facility level.

Up to now, only one type of label or brand related to CO_2 has been introduced on the market – those describing the carbon footprint of products and services. These labels are expressed in different forms – those that identify products with a small carbon footprint, those that point out a classification of products based on the carbon footprint (bronze, silver, gold) and those that quantify the carbon footprint in terms of grams of CO_2.

The LessCO2 brand associated with the *Murcian Agriculture as a CO_2 Sink* initiative makes way for a second group among the brands related to CO_2. This label makes the public aware of the final result or CO_2 balance of an agricultural product, calculated using the photosynthetic capacity of crops to fix CO_2.

Figure 10 contains different examples of brands that express the carbon footprint of a certain product compared to the Murcian initiative, which expresses carbon balance. Figure 11 shows the official website of the *Murcian Agriculture as a CO2 Sink* initiative and the associated LessCO2 brand, where visitors can consult the carbon balances of the crops of participating companies.

Brands that express a product's carbon footprint	Brand that expresses a products carbon balance

[10] Among other greenhouse gases (GHG), agricultural activities can emit CO_2 into the atmosphere resulting from the use of fossil fuels and nitrous oxide (N_2O) from (mainly inorganic) fertilisers.
[11] The research centres participating in the initiative are the University of Murcia, the Universidad Politécnica de Cartagena, the CEBAS – the Spanish National Research Council and the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (Murcia Institute of Agricultural and Food Research and Development).
[12] UNE-ISO 14064:2006, greenhouse gases.
[13] The Intergovernmental Panel on Climate Change analysed the relevant scientific, technical and socioeconomic data in order to understand the scientific elements related to climate change of anthropogenic origin as well as their possible repercussions and risks, and possible ways to attenuate or change those elements.
[14] National Inventory of Spanish Emissions,
http://www.mma.es/portal/secciones/calidad_contaminacion/atmosfera/emisiones/inventario.htm.

Label for products with a small carbon footprint

Label for products categorised depending on the size of their carbon footprint

Label for products that quantify their carbon footprint in grams of CO_2

Label that shows the carbon balance of agricultural products

Figure10. Different types of carbon labels on the food product market.

Figure 11. Official website of the *Murcian Agriculture as a CO_2 Sink* initiative, www.lessco2.es.

7. COLLECTIVE COMMITMENT TO CONTRIBUTE TO THE MITIGATION OF CLIMATE CHANGE BY REMOVING A MILLION TONNES OF CO_2 PER YEAR

The department of climate change of the environmental administration of the Autonomous Community of the Region of Murcia has tested the application of the criteria established in the initiative on a series of representative fruit and vegetable crops in Murcia to find the resulting carbon balance.

7.1. UNIVERSITIES AND RESEARCH CENTRES STUDYING THE CO_2 FIXATION OF THE PRIMARY CROPS CULTIVATED IN THE REGION OF MURCIA

The total quantity of Co_2 fixed over the course of a year by an agricultural crop depends on numerous factors including the genetic characteristics of the plant, the particular growth conditions the crop is exposed to (edaphoclimatic) and how the crop is handled, which is why all data used in each particular study must originate in the area or region where each crop is cultivated.

In order to calculate the carbon balance of a crop, you have to know the total quantity of CO_2 that it fixes – information that up to now has not been available in the literature. This lack of information led the *Murcian Agriculture as a CO2 Sink* initiative to coordinate a scientific research project[15] in which official research centres and public universities of the region have participated.

In this research, data from biomass analyses of representative samples of primary crops obtained by means of uprooting the plants, sectioning them and determining their carbon content are complemented by the results of applying CO_2 flow measurement techniques and techniques based on teledetection. All of this allows the net primary production of agricultural crops in the region to be estimated and monitored.

The biomass analysis, which involved uprooting and sectioning the trees and determining their carbon content, was conducted by CEBAS – the Spanish National Research Council[16] and yielded the following results.

Table 4. CO_2 fixation per plant or tree of the primary fruit and vegetable crops cultivated in the Region of Murcia.

CROP	**CO_2 FIXATION**
LIGNEOUS	**kg CO_2 tree^{-1}**
APRICOT TREE	84
PLUM TREE	41
LEMON TREE	107
MANDARIN TREE	31
PEACH TREE	50
ORANGE TREE	49
NECTARINE TREE	47
GRAPE VINE	19
HERBACEOUS	**kg CO_2 plant^{-1}**
ARTICHOKE	2
BROCCOLI	0.24
CAULIFLOWER	0.34
LETTUCE	0.13
MELON	0.80
PEPPER	1
WATERMELON	1.5
TOMATO	1.59

Table 5. CO_2 fixation per hectare of the primary fruit and vegetable crops cultivated in the Region of Murcia.

CROP	**CO_2 FIXATION**
LIGNEOUS	**t CO_2 / Ha. / year**
APRICOT TREE	22.81
PLUM TREE	25.89
LEMON TREE	30.51
MANDARIN TREE	13.06

[15] CEBAS - the Spanish National Research Council, the Universidad Politécnica de Cartagena, University of Murcia and the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario.
[16] Micaela Carvajal Alcaraz, research professor of the Spanish National Research Council "Investigation into CO2 absorption of the most representative agricultural crops of the Region of Murcia".

PEACH TREE	30.71
ORANGE TREE	20.72
GRAPE VINE	18.65
HERBACEOUS	**t CO_2 / Ha. / year**
ARTICHOKE	22.70
BROCCOLI	6.85
CAULIFLOWER	11.98
LETTUCE	9.08
MELON	10.41
PEPPER	25.72
WATERMELON	7.44
TOMATO	16.24

To complement the results of the primary analysis and using the same method, the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario[17] (Murcia Institute of Agricultural and Food Research and Development) as part of the Ministry of Agriculture and Water of the Autonomous Community of Murcia calculated levels of captured CO_2 to find the annual biomass of the following crops.

Table 6. CO_2 fixation of three crops cultivated in the Region of Murcia.

CROP	**CO_2 FIXATION**
LIGNEOUS	**kg CO_2 / tree / year**
ORANGE TREE	45.1
PEACH TREE	44.1
GRAPE VINE	21.2

Figure 12 contains images showing the different stages of the research carried out by CEBAS – the Spanish National Research Council and the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario.

[17] Francisco Moisés del Amor Saavedra, agricultural engineer at the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario.

Figure 12. Evaluation of carbon fixation in agriculture of the Region of Murcia.
CEBAS – the Spanish National Research Council and the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario.

Research conducted by the Universidad Politécnica de Cartagena using similar techniques yielded similar estimations, for example, in the case of the apricot tree in which the fixation capacity was found to be 24.84 t CO_2 per hectare and year.[18]

The Universidad Politécnica de Cartagena, estimating net CO_2 absorption of crops using the eddy covariance method, is involved in the continual tracking of net primary production and the CO_2 trapping of agricultural crops.[19]

[18] Alejandro Pérez Pastor, Soil-Water-Plant Research Group. Sustainable Horticulture in Arid Zone Group "Effects of edaphoclimatic factors on the carbon balance of fruit cultivated in different areas of the Region of Murcia".
[19] Alain Baille, Chair, UPCT, head of the subproject "Estimation and tracking of net primary production of Murcian agriculture and its contribution to the removal of CO_2 from the atmosphere."

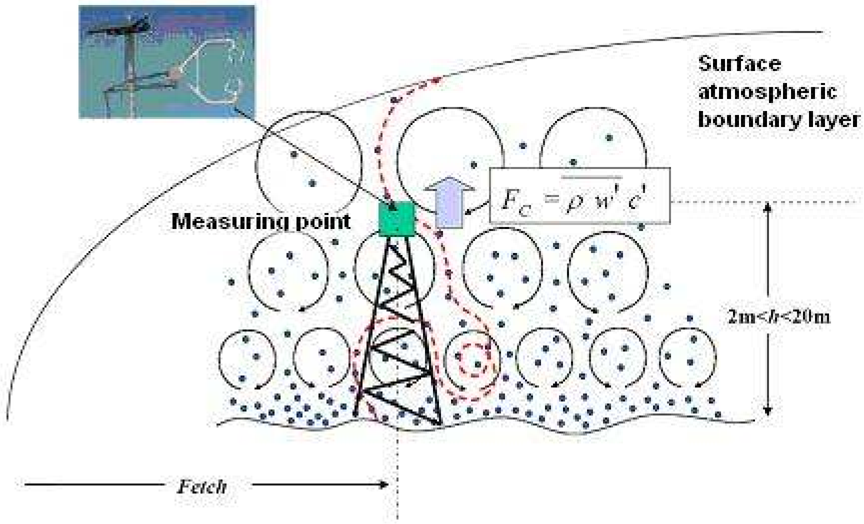

Figure 13. Principle of the eddy covariance method. Measurements are taken of fluctuations in vertical speed (w') and CO_2 (c') concentrations induced by turbulent eddies and the crossed covariance p'c'w is calculated, which is equal to the flow of CO_2, F_C. Measurements must be taken within the surface boundary layer, in an area far enough away from the edge of attack. If H is the height of the measurements, a fetch value must be respected on the order of 50 to 100 times the value of H.

The first research results, from July to 31st December 2009, on the net flows of CO_2 in irrigated orchards of young and adult orange trees, generated monthly and Net Ecosystem Exchange (NEE)[20] values, as shown in the following table.

Month	NEEa (adult trees) KgCO2/ha/month	NEEy (young trees) KgCO2/ha/month	Ratio NEEy/NEEa
July	3039	1659	0.55
August	2156	1429	0.66
September	1849	1218	0.66
October	1152	630	0.55
November	1597	994	0.62
December	1001	562.1	0.56

Table 7. Monthly and Net Ecosystem Exchange (NEE, $kgCO_2$/ha/month) values in two orange orchards.

If we assume a similar development during the first six months of 2010 (to be confirmed with the measurements of the first half of 2010), we can estimate a net potential CO_2 uptake of 20 t CO_2/ha for adult orange trees.

These net values are on the same order of magnitude as the 20.7 t CO_2/ha per year that result from the destructive method of biomass estimation for the orange tree (estimated by CEBAS – the Spanish National Research Council). An estimation of ecosystem respiration is needed for a valid comparison of the two methods. The Universidad Politécnica de Cartagena is measuring soil respiration (Figure 16, top left photo) to estimate this component and develop a soil carbon balance model.

[20] NEE is the net CO_2 absorbed by the ecosystem, that is, the fixation of CO_2 by vegetation minus the emission of CO_2 by the soil (soil respiration and decomposition of plant waste).

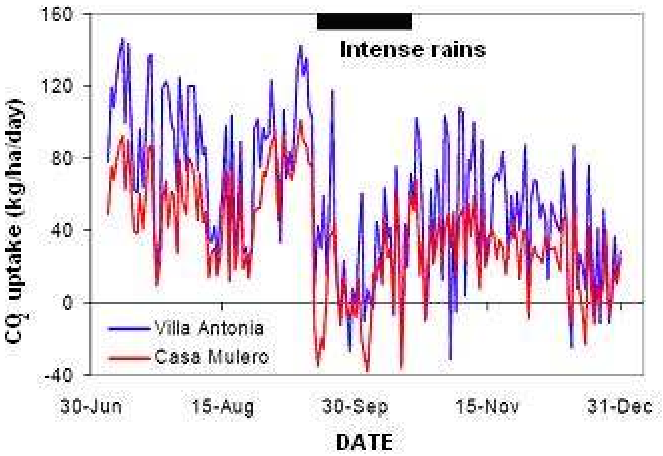

Figure 14. Daily CO_2 uptake rate (in kg. of CO_2 per hectare and day) during the period of July to December 2009 in the two orange orchards. Note the low absorption rates in the rainy periods (especially in September), in which negative NEE values were recorded. These negative values (the agrosystem emits more CO_2 than it absorbs) are due to low levels of radiation and high soil respiration due to excess water. Universidad Politécnica de Cartagena.

Figure 15 shows the installation process of the measuring equipment used by the Universidad Politécnica de Cartagena.

Figure 15. View of the eddy covariance equipment (sonic anemometer, CO_2 and H_2O analyser) to measure the flow of CO_2 and evapo-transpiration installed by the Universidad de Cartagena.

Research conducted on CO_2 flow can validate the use of an operational tool based on simple biomass productivity models using teledetection data. This will allow satellite images to help in updating data on the CO_2 fixation of crops.

An in situ research project is also being undertaken to evaluate the net primary CO_2 balance (fixation minus elimination by respiration) of agricultural crops with different fertigation strategies in order to quantify the effects of fertilisation on the production of biomass and on net CO_2 balance (including the CO_2 balance of the soil)[21]. The resulting data can also later be used to calibrate the eddy covariance equipment.

[21] José Antonio Franco Leemhuis, Vice Rector of the Universidad Politécnica de Cartagena, subproject "In situ characterisation of net primary production of agricultural crops in the Region of Murcia."

Figure 16. Instruments used to evaluate the effects of edaphoclimatic factors in the carbon balance of fruit trees cultivated in different areas of the Region of Murcia[22].

Work is also being done to determine the long-term CO_2 fixation and storage capacity of agricultural soils, data which will presumably improve the initial removal associated with each crop.

Lastly, a line of research is being developed which consists of comparatively analysing the carbon balance in ecological agricultural facilities and precision agricultural facilities for the purpose of drawing conclusions about the notable effects of good practices on the final carbon balance[23].

Figure 17. Ecological agricultural facilities whose carbon balance is also being studied.

7.2. ESTIMATING CO_2 EMISSIONS IN FRUIT AND VEGETABLE FACILITIES IN THE REGION OF MURCIA USING THE METHODOLOGY PROPOSED IN ISO STANDARD 14064:2006

[22] Alejandro Pérez Pastor, Soil-Water-Plant Research Group. Sustainable Horticulture in Arid Zone Group "Effects of edaphoclimatic factors on the carbon balance of fruit cultivated in different areas of the Region of Murcia"
[23] Work carried out by José María Egea Sánchez within the framework of the *Murcian Agriculture as a CO_2 Sink* initiative.

To calculate equivalent CO_2 emissions, 55 audits were perfumed by the staff of the department of climate change of the environmental administration of the Autonomous Community of the Region of Murcia at representative agricultural facilities for each crop distributed throughout the regional territory.

The methodology used is proposed in ISO standard 14064 and, like the GHG Protocol[24], states that when calculating equivalent CO_2 emissions, both direct emissions (fuel consumption for the processing of crops in the field which include ploughing, sowing, pruning-chipping, rinsing, mulching, applying any treatments, bottom fertilising, irrigation installations, fresh processing, collecting and transport to the storage facility as well as nitrogen oxide emitted from the soil due to fertilisation[25]) and indirect emissions due to energy must by considered.

The conversion factors used are published by the IPCC and by the Ministry of the Environment and Rural and Marine Affairs in the 2007 National Inventory of Spanish Emissions.

Because it is impossible to find conversion factors that are sufficiently contrasted for the remaining indirect emissions (different from those generated by the consumption of energy), the lifecycle analysis (LCA)[26] is not recommended. The *Murcian Agriculture as a CO_2 Sink* initiative therefore does not require that a complete LCA including other indirect emissions is conducted, but if the appropriate conversion factors are available, producers can decide to include them in their balance and this information will be reflected on the website.

Although in order to calculate carbon balance in keeping with the methodology established in ISO standard 14064 it is not obligatory to include transport among the emissions considered (only direct and indirect emissions from energy have to be considered), because this is a factor that bears consideration, emissions generated in transporting the products to distribution centres have also been calculated. To do this, southern Germany has been chosen as a representative central European market, considering therefore a transport distance of 2,000 kilometres from the centre of the Region of Murcia.

The results of these emissions calculations are shown in the following table.

[24] Greenhouse Gas Protocol (GHG Protocol). Corporate Accounting and Reporting Standard. World Resources Institute and the World Business Council for Sustainable Development.

[25] Nitrous oxide has a much greater global heating potential than CO_2. According to the latest report from the Intergovernmental Panel on Climate Change (IPCC) it is 310, which means even small emissions of this gas can have a significant impact on the carbon balance of agricultural facilities and, as a result, on the carbon balance associated with each crop.

[26] According to ISO standard 14040:2006, *Environmental management. Lifecycle analysis: principles and reference framework,* a lifecycle analysis is the compilation and evaluation of the input, output and potential environmental impact of a production system throughout its lifecycle. *Lifecycle* is defined as the consecutive, interrelated stages of a production system from the acquisition of the raw material or its generation through natural resources to its final disposal.

Table 8. CO_2 equivalents of certain crops cultivated in representative fruit and vegetable facilities in the Region of Murcia. Source: authors

LIGNEOUS	TOTAL EMISSIONS WITHOUT TRANSPORT	TOTAL EMISSIONS WITH TRANSPORT TO GERMANY
	CO_2 Emissions (t CO_2/year/ha)	
APRICOT	4.91	6.64
PLUM	8.46	11.92
LEMON	4.96	11.40
PEACH	11.08	14.33
ORANGE	4.96	11.40

HERBACEOUS	TOTAL EMISSIONS WITHOUT TRANSPORT	TOTAL EMISSIONS WITH TRANSPORT TO GERMANY
	CO_2 Emissions (t CO_2/year/ha)	
ARTICHOKE	2.87	5.62
BROCCOLI	2.69	4.61
CAULIFLOWER	9.85	11.08
LETTUCE	5.33	22.00
MELON	9.25	10.69
PEPPER	16.08	25.70
WATERMELON	1.53	2.30
TOMATO	8.28	25.60
GRAPE VINE	3.99	8.80

From the set of carbon audits performed to study equivalent CO_2 emissions, the contribution of the different stages of cultivation and the transport can be differentiated, the latter contributing an average of 30% of the total when the 2,000 kilometres that separate Murcia and Southern Germany are taken into account.

Table 9. Contribution to equivalent CO_2 emissions of the different stages needed for cultivation and transport. Source: authors.

DIRECT EMISSIONS	%
Preparation of the land	4,50%
Transport and harvesting	3,50%
Fertilisation I (N_2O from soil´s natural process of denitrification)	13,00%
INDIRECT EMISSIONS	%
Drip irrigation	28,00%
Storage and misc.	15,00%
OTHER INDIRECT EMISSIONS	%
Fertilisation II (NH_3 and NO_x indirect emissions from soil)	4,00%
Transport to Germany	32,00%
TOTAL	100,00%

7.3. CARBON BALANCE OF AGRICULTURE IN THE REGION

Carbon balances are achieved by subtracting emissions calculated by means of the methodology indicated in section 7.2 from the CO_2 fixation conducted by crops (section 7.1). As the table below shows, the results of this calculation are positive in every case. This means that the amount of CO_2 absorbed by the plants is higher than the equivalent CO_2 emissions needed for their production.

Table 10. Carbon balance of representative agriculture in the Region for the following crops. Source: authors

CROP	Carbon balance per ha	Carbon balance per kg of fruit or vegetable	Carbon balance per piece of fruit or vegetable
LIGNEOUS	**Balance t CO_2 / ha**	**Balance g CO_2 / kg**	**Balance g CO_2 / piece**
APRICOT	17.90	994.4	59.66
PLUM	17.43	484.23	48.42
LEMON	25.56	381.42	47.68
PEACH	19.33	572.67	108.81
ORANGE	15.77	235.56	29.42
HERBACEOUS	**Balance t CO_2 / ha**	**Balance g CO_2 / kg**	**Balance g CO_2 / piece**
ARTICHOKE	19.83	991.56	297.47
BROCCOLI	4.16	319.82	111.94
CAULIFLOWER	2.13	106.63	42.69
LETTUCE	4.89	146.43	58.57
MELON	1.17	78.27	78.27
PEPPER	9.64	137.77	27.55
WATERMELON	5.17	646.25	775.50
TOMATO	7.97	63.22	5.06
GRAPE VINE	18.15	453.73	294.93

7.4. CARBON BALANCE IN FRUIT AND VEGETABLE PRODUCTION OF THE REGION OF MURCIA AS A WHOLE

The carbon balance of the fruit and vegetable production on the more than 117,000 hectares of irrigated land studied in the region[27] after taking into account emissions generated by production and transport of the products to Germany[28] is over a million tonnes annually. This capacity as a sink neutralises the equivalent of direct responsibility CO_2 emissions that a half a million people would generate, according to the data used in table 3.

Table 11. Carbon balance in fruit and vegetable production of the Region of Murcia as a whole including transport to Germany. Source: authors

CARBON BALANCE IN FRUIT AND VEGETABLE PRODUCTION OF THE REGION OF MURCIA		
	Total Ha	**Total t CO_2**
TOTAL (herbaceous and ligneous)	117,043	1,022,493.66

Murcian agriculture as a whole does not only behave as climatically neutral for most of the distances in which the products are sold, but is a net CO_2 sink that can work to compensate for emissions generated in other places.

It is important to mention that this balance has been calculated without taking into account the potential reduction in emissions that our agriculture still has. The cost associated with reducing emissions in agriculture is competitive with the cost that such a reduction would represent in other business sectors such as industry, transport, etc. And this is one of the greatest characteristics of the *Murcian Agriculture as a CO_2 Sink* initiative – the requirement that participants make voluntary environmental commitments in which every businessperson describes a strategy for improving their carbon balance, adapted to the reality of their facility, that is, a commitment to continual improvement.

As mentioned earlier, in order to use the LessCO2 brand associated with the *Murcian Agriculture as a CO_2 Sink* initiative, each and every piece of information supplied by participating companies will have to be verified and validated by officially recognised bodies and, in every case, will have to be included on the official website of the initiative www.lessco2.es.

[27] 15 different crops were used for this study, which represent 117,000 Ha of the total 148,000 Ha that make up the irrigated cropland of the Region. The data suggest that with the inclusion of the 31,000 Ha of irrigated cropland that has not been studied, the sink capacity of the region would increase to over 1,022,493.66 tonnes of CO_2.
[28] For the purposes of this study it has been assumed that all the produce obtained from the 117,000 Ha, i.e. 2,800,000 tonnes of agricultural products, are delivered a distance of 2,000 km.

8. CONCLUSIONS

CO_2 is the planet's main greenhouse gas and, due to its current excess in the atmosphere, contributes to climate change regardless of where emissions are generated.

Climate change is one of the primary concerns of European consumers and in response to this social demand, the big supermarket chains are developing advertising campaigns and are beginning to apply the concept of the carbon footprint to food products. For this laudable effort to provide consumers with information about the CO_2 emitted during the manufacture of a product, which is similar to the campaign begun some time ago to include nutritional information on food products, it seems more appropriate to use the concept of carbon balance, which allows consumers to see the environmental benefit that eco-efficient agriculture provides through acting as a net CO_2 sink.

Furthermore, institutions and organisations of all kinds contribute to raising citizen awareness of the need to reduce emissions for which they are responsible or compensate for those which cannot be avoided. This brings the new concept of "compensation" onto the scene, which allows us to neutralise our emissions by means of efforts to absorb CO_2 any place in the world – a service that eco-efficient agriculture offers.

For all these reasons, agriculture, a strategic basic sector that while producing food removes CO_2 from the atmosphere, presents itself as an ideal instrument for working with the consumer, the big supermarket chains and all the other stakeholders in the mitigation of climate change at this time in which unease caused by climate change is modifying the way the market thinks and operates.

This cooperation is only possible with eco-efficient farms – those that achieve a positive carbon balance, fixing more CO_2 than they emit and thereby behaving as a net CO_2 sink.

The agriculture of Murcia does this because it is a farm for Europe, nearby, its products do not need to travel far distances, its products are not transported by air, its climate and good practices mean it does not require much energy to cultivate its crops and its products are sold fresh, with little or no processing.

However, this capacity of eco-efficient agriculture to achieve a positive carbon balance by removing CO_2 from the atmosphere, used in isolation and individually by some production companies would represent a mere gesture to responsibility, with little practical use. What is really important is to have the ability to channel a great number of voluntary efforts to collectively create a quantitatively significant level of CO_2 removal. This effort also has to be supported by intense scientific work that not only identifies the origin and cause of emissions, but more importantly, determines the amount of CO_2 fixed by crops so that through the use of good practices, the sink capacity of agriculture as a whole improves year after year.

This is what the *Murcian Agriculture as a CO_2 Sink* initiative seeks to do – promote a widespread, voluntary agreement which the entire fruit and vegetable producing community of the Region of Murcia is committed to and which reflects the convergence of the interests and concerns of consumers and the supermarkets that sell fruit and vegetables in Europe.

The difference between this initiative and any other brand used to certify that the production of a certain company is climatically neutral is that in this case, the Region of Murcia seeks to affirm a commitment from the entire agricultural sector, which is responsible for no less than 20% of the fruit and vegetables exported by Spain.

The carbon balance or sink capacity, that is the CO_2 removed from the atmosphere by fruit and vegetable producers in the Region of Murcia as a whole, even when transport to the centre of Europe is taken into account, is at more than a million tonnes of CO_2.

The indisputable stars of this effort being made at the benefit of European society are therefore the companies participating in the initiatives and the agricultural organisations that have driven them, as well as the technical and managerial staff of all the associations that have made a commitment to continual improvement possible.

Agriculture like that in the Region of Murcia, which contributes to removing more than a million tonnes of CO_2 a year – the equivalent of the emissions that hypothetically would be the direct responsibility of more than a half of a million of consumers – should be considered as excellent news in the fight against climate change in that, as the Assistant Director-General of the FAO, Alexander Müller, points out: *"The world will have to use all options to contain average global warming within two degrees Celsius. Agriculture and land use have the potential to help minimise net greenhouse gas emissions through specific practices, especially building soil and biomass carbon. These practices can at the same time increase the productivity and resilience of agriculture, thus contributing to food security and poverty reduction."*

The agriculture of the future must include as a fundamental objective, as that in the Region of Murcia has, the mitigation of climate change. The accomplishment of this objective must include continual improvement so the carbon balance is more and more positive, that is, crops must fix increasingly more CO_2 and emit increasingly less CO_2 in their production and transport to consumer centres.

Figure 18. Advertising campaign for the *Murcian Agriculture as a CO_2 Sink* initiative.

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