Chapter 2
The Kyoto Protocol and European and Italian Regulations in Agriculture

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Abstract Climate change represents the most important challenge for the international scientific community, for the inherent and irreversible modification brought about in natural ecosystems. International institutions increasingly adopt measures to promote preservation of ecosystems and counteract the social and economical consequences of environmental decline. Here we review the actions undertaken by both the Intergovernmental Panel for Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC), aimed to stabilize and reduce concentrations of greenhouse gases (GHG) in atmosphere, including the Kyoto Protocol that obliges developed countries to provide the political and legal framework to meet the Protocol's expectations. Moreover, it is mandatory for national policies to reduce the occurrence of main risky events, such as landslides, floods, and desertification processes, whose frequency have rapidly risen in the Mediterranean regions mostly susceptible to climatic changes. According to the Kyoto Protocol, each signed party should include, in its annual GHG inventory, information on GHG possibly removed by means of carbon sinks activities such as land use, land-use change and forestry (LULUCF). Italian laws encompass the *National System for the Italian Greenhouse Gas Inventory* and the *National Registry for Carbon sinks*. The latter estimates GHG emissions by sources and accounts for their net removal based on sinks of the LULUCF sector that includes forest land, cropland, grassland, wetlands, and settlements. These compartments in 2008 removed 87.3 Mt of CO_2 from atmosphere while, from 1990 to 2008, the total removal as CO_2 equivalent increased by 34.8%, CO_2 accounting for more than 99% of both total emissions and removals of the sector. Within this frame, carbon

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A. Piccolo (ed.), *Carbon Sequestration in Agricultural Soils*,
DOI 10.1007/978-3-642-23385-2_2,

sequestration in cultivated soils has become important to add new carbon sinks other than LULUCF. The relation of soil management practices to the increase in soil organic matter is a basic requirement to develop a solid methodology to assess carbon stock changes in soil pool and provide a useful database over the national territory.

2.1 The Climate Change as a Global Environmental Problem

The Intergovernmental Panel for Climate Change (IPCC) refers to climate change as an alteration in the mean and/or the variability of the climate that is identifiable (e.g., using statistical tests), and persistent for an extended time period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or to a result in human activity. This concept differs from that of the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to an alteration of climate that is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, and it is observed over comparable time periods, in addition to natural climate variability (IPCC 2007a).

The first IPCC report submitted in 1990 confirmed the legacy of the climate change phenomenon with human activities, and essentially identified two main causes: the use of fossil fuels related to greenhouse gas (GHG) emissions and the reduction of principal reservoirs of carbon in the planet, especially forests. The report highlighted the need to develop a comprehensive strategy to tackle climate change and its consequences, drawing up the following key principles on which to base a possible international convention:

- The need to sensitize all countries on the global nature of phenomenon
- The use of an equity criterion in determining response actions
- The existence of responsibilities common to all countries, but differentiated by the degree of economic development of each country
- The precautionary principle, which states that the uncertainty of phenomena from the scientific point of view is not an excuse for not addressing the problem

In the same year, the General Assembly of the United Nations created the UNFCCC, adopted on May 9, 1992. The Convention entered into force on March 21, 1994. Currently, 194 parties (193 states and 1 regional economic integration organization) have signed the convention. The convention is complemented by the Kyoto Protocol which was adopted on December 11, 1997 and entered into force on February 16, 2005. Under this treaty, 37 industrialized countries and the European community have committed to reduce GHG emissions to an average of 5% of the 1990 levels over the 5-year period 2008–2012 (first commitment period). Up to date, 192 parties have ratified the treaty. The difference between the convention and the protocol is that the convention encourages industrialized countries to stabilize GHG emissions, while the protocol has the specific target to reduce GHG emissions.

The ultimate objective of UNFCCC is to stabilize concentrations of GHG in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a sufficient time frame to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and enable economic development to proceed in a sustainable manner.[1]

The Kyoto Protocol is an international treaty on the environmental global warming, signed on December 11, 1997 by more than 160 countries at the UNFCCC conference. The treaty entered into force on February 16, 2005, following ratification by Russia. For the enforcement of the protocol, it was necessary that it be ratified by at least 55 signatory countries and that ratification generated at least 55% of all global emissions. Italy ratified the treaty with the Law 120 of June 1, 2002. The treaty provides the obligation of developed countries during 2008–2012 to reduce polluting emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride) to no less than 5% of the emissions recorded in 1990, considered as the base year.

The Kyoto Protocol dictates that countries must meet their targets primarily through national measures. However, the protocol also offers to signatory countries three market-based mechanisms to meet their targets: Emission Trading, Clean Development Mechanism (CDM), and Joint Implementation (JI). Moreover, the protocol requires that countries' emissions need to be monitored and precise records on the trading process must be kept. A registry system tracks and records transactions among parties under different mechanisms. The UN Climate Change Secretariat keeps an international transaction logbook to verify that transactions are consistent with the rules of the protocol. Furthermore, reporting is periodically done by parties by submitting annual GHG emission inventories and national reports.

Article 3 of the Kyoto Protocol allows each signed party to include in its annual GHG inventory information about anthropogenic GHG emissions that may have been removed by means of sinks represented by land use, land-use change and forestry (LULUCF) activities. In particular, paragraph 3 of Article 3 is related to the activities of afforestation, reforestation, and deforestation, which had begun since 1990 and resulted from a direct human-induced conversion. In the context of the paragraph 3.4, each party may choose to account for anthropogenic GHG emissions removed by means of sinks resulting from any or all of the following human-induced activities: forest management, cropland management, grazing land management, and revegetation. Activities enclosed in Article 3.4 encompass lands that have not undergone conversion since 1990, but are otherwise subjected to a specific land use (UNFCCC 2005a, b).

The convention and the Kyoto Protocol are also designed to assist countries in adapting to the adverse effects of climate change. The convention facilitates the development and deployment of techniques that can help increase resilience to the impacts of climate change. For this purpose, the Adaptation Fund was established to finance adaptation projects and programmes in developing countries which have

[1] http://unfccc.int/resource/docs/convkp/conveng.pdf

become full parties of the protocol. The fund is financed mainly with a share of funds related to CDM project activities. Currently, negotiations for the second commitment period under the Kyoto Protocol are under way, and are oriented to more stringent emission reductions, as indicated by IPCC in their recent reports.

2.2 The Risks of Climate Change

The Fourth Assessment Report (FAR) from the IPCC (2007a) confirms that the consequences of climate change will not only be restricted to an increase in average planet temperature, but it will also entail the change of the entire climate system, including precipitation, wind, frequency and intensity of extreme events, having different impact in the diverse world regions. Studies carried out with global circulation models (GCM) and regional circulation models (RCM) with regard to Europe have both indicated the following:

- Increase in average temperature in Europe
- Decrease in rainfall in Southern Europe
- Increase in rainfall in Northern Europe
- Possible increase in the frequency of heavy rainfall events across Europe

The last point of this list highlights the risk of growing intensity of floods and landslides throughout the Italian territory. In fact, the climatological data indicate that while water scarcity will be a future problem issue for Italy, the possibility for occasional floods with more severe impact than the average of previous events should not be overlooked. Similar considerations apply to landslides, to which the Italian hilly and mountainous territory is particularly vulnerable and they can be triggered by heavy rainfall events (Bigano and Pauli 2007).

Data provided by Emergency Events Database (EM-DAT 2011) indicate that floods were the main type of natural disaster in Europe with 283 disastrous floods in the last 25 years, with an increasing frequency. In regard to Italy, data indicate that, among natural disasters, floods are ranked first, in terms of affected population, and second, in terms of economic damage. Landslides, being localized phenomenon, affect fewer people and cause less damage, but claim more victims than floods. The relevant EM-DAT statistics for Italy from 1900 to 2011 are summarized in Table 2.1. It is important that the impact of climate change is taken into account in policies aimed to protect from the geological risk.

Climate change may affect not only the quantitative status of water resources, but also its quality, due to alteration of the hydrological cycles. The main impacts on freshwater resources are the shifts in rain and snow cycles, changes in the availability and demand for water, variations in water quality, temperature and nutrient content, and fast melting down of glaciers with occurrence of flash floods (IPCC 2007b).

The relationship between landslides and climate change is very complex and less direct than the risk of flooding. It is clear that rain can cause landslides, with

Table 2.1 Major disasters in Italy from 1905 to 2006

Disaster	Type	Events number	Death casualties	Total affected	Damage (thousands US $)
Drought	Drought	2	–	–	800,000
Earthquake (seismic activity)	Earthquake (ground shaking)	30	115,621	1,029,121	33,484,852
	Average per event		3,854	34,304	1,116,161.7
Epidemic	Viral infectious diseases	2	3	10,001	–
	Average per event		1.5	5,000.5	–
Extreme temperature	Cold wave	2	–	–	–
	Extreme winter conditions	1	9	–	–
	Heat wave	3	20,105	–	4,400,000
	Average per event		6,701.7	–	1.466,666.7
Flood	Unspecified	15	492	1,485,020	2,930,000
	Average per event		32,8	99,001.3	195,333.3
	Flash flood	5	373	43,330	8,147,000
	Average per event		74.6	8,666	1,629,400
	General flood	15	182	1,336,962	11,718,600
	Average per event		12.1	89,130.8	781,240
Mass movement wet	Avalanche	1	1	–	5,510
	Landslide	13	2,584	19,596	1,353,700
	Average per event		198.8	1,507.4	104,130.8
Storm	Unspecified	11	188	6,000	2,328,700
	Average per event		17.1	545.5	211,700
	Extratropical cyclone (winter storm)	1	3	–	–
	Local storm	5	44	124	1,048,000
	Average per event		8.8	24.8	209,600
	Tropical cyclone	1	35	200	3,200
Volcano	Volcanic eruption	5	735	21,024	3,100
Wildfire	Forest fire	7	21	320	1,700,000
	Average per event		3	45.7	242,857.1

Source: EM-DAT (2011)

different characteristics depending on types of landslide. Generally, fast landslides are the result of heavy rainfall, while slow ones are caused by rains of medium intensity. For Italy, climate change would represent a general increase of fast landslides and decrease of slow ones (Bigano and Pauli 2007).

2.3 Impacts of Floods and Landslides on Socio-Economic Systems

Although floods are natural events in ecological and agricultural systems, they may cause considerable damages, including mainly loss of people lives. Serious damages are also due to the impact on houses and industrial structures of debris

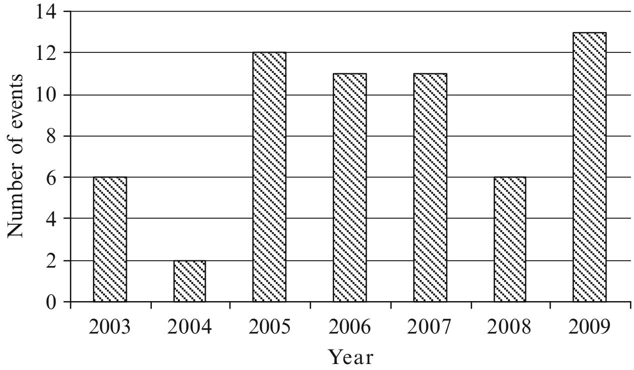

Fig. 2.1 Number of landslides in Europe from 2003 to 2009 (from Spizzichino et al. 2010)

or voluminous material violently transported by water, and to diseases spread by contamination of drinking waters. The latter may become extremely dangerous especially if toxic substances accumulated in sediments are released during floods in concentrations larger than those acceptable for human risk (Munich Re 1997). Violent floods can seriously affect agriculture through crop destruction, loss of livestock, and enhanced surface soil erosion in cultivated areas. Disruptions in transport and damage to civil infrastructure, as well as tourist and recreational areas, may hamper relief helpers and rapid return to normal conditions.

Landslides are more localized phenomena and hit smaller areas, thus causing less monetary damages than floods. For the 2003–2009 period, 61 landslides were recorded in the whole Europe (Fig. 2.1).

In the last 80 years, 5,400 floods and 11,000 landslides occurred in Italy (ISPRA 2011c). Because of the high impact of these events on landscape and human health, the Italian Ministry of Environment decided in 1997 to acquire a complete and homogeneous knowledge on landslides distribution throughout Italy, by funding a 4.1 million € IFFI Project (*Inventario dei Fenomeni Franosi in Italia* – "Italian Landslide Inventory"). In 2004, the Agency for the Protection of the Environment (APAT), now ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale), conferred 650,000 € to complete the databank. Up to December 31, 2007, the inventory had surveyed 482,272 landslides, covering an area of 20,500 km^2 (about 6.8% of Italy). The region where most landslides occurred is Lombardy, with 132,533 landslides (Fig. 2.2).

Landslides are complex dynamic phenomena encompassing different types of mass movements, based on which ISPRA classified the landslides events occurred so far in Italy: (1) 32.5% of total landslides were caused by rotational/translational movements, (2) 15.3% by slow mass flows, (3) 14.6% by rapid debris flow. In the IFFI Project, the relationship between landslides and slope steepness has been also analysed and it was found that slopes instability does not increase with slope angle, while only a specific range of slopes was statistically responsible for most landslides. The instability of a slope is often due to the interaction of several natural

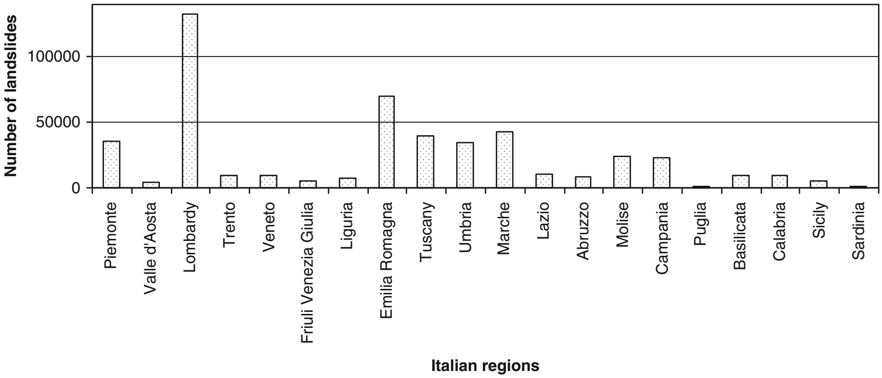

Fig. 2.2 Number of landslides per Italian region (elaboration from ISPRA 2008)

and/or anthropogenic causes. However, intense and short, as well as prolonged rainfall events are the most important factors for triggering slope instability phenomena (ISPRA 2008).

The socio-economic effects of landslides are similar to those of floods on agriculture, in terms of crop and livestock losses, and land subtracted from productivity, although the overall ecosystem disruption results smaller than for floods (Bigano and Pauli 2007).

According to APAT, Italy has funded 447.36 million € until 2006 to fight the flood risk and 667.88 million € to prevent landslides (Bigano and Pauli 2007), while it is documented (ISPRA 2011c) that Italy invested 2.81 billion of € to study and remediate landslides from 1990 to 2010 (Fig. 2.3).

2.4 Desertification and Climate Change

The UNCCD declares the desertification is a process of “degradation of arid, semi-arid and dry sub-humid soil environments resulted from several factors, including climatic variations and human activities” (UNCCD 1994).

The IPCC defines desertification as “the reduction or disappearance of biological or economic productivity and complexity of non-irrigated and irrigated croplands, pastures, forests or woodlands, which result from land uses or other phenomena originated from human activities and modes of settlement, including soil erosion by wind and water, the deterioration of physical, chemical, biological or economic properties of soil, and long-term disappearance of natural vegetation” (IPCC 2007a).

Desertification is thus constantly presented as a phenomenon due to both natural (climate and water cycle) and anthropogenic factors, which have an impact on how soil interacts with water cycle. In the IPCC Third Assessment Report (TAR), the role of unsustainable agricultural practices such as uncontrolled grazing and

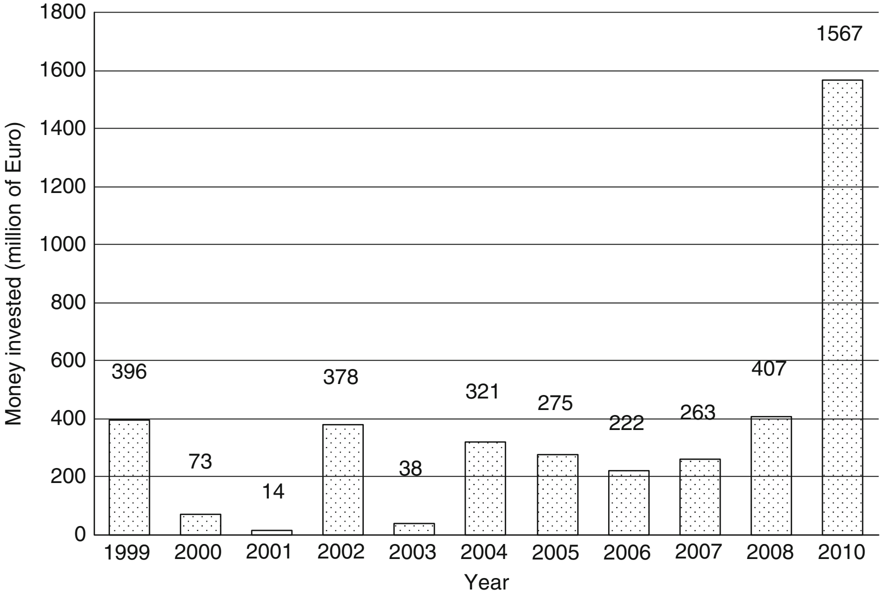

Fig. 2.3 Yearly investments (million euro) in Italy to remediate landslides risk and damage (ISPRA 2011c). The allocated resources allowed a total of 3,642 operations, though only 1,798 are completed and 698 are still ongoing (Fig. 2.4)

deforestation is particularly highlighted (IPCC 2001). TAR also indicates that climate change and human activities are strongly related to land use, involving synergistic impacts on ecosystems and species in desert areas. In fact, desertification is closely linked to characteristic climatic conditions such as drought, dryness, erosion, and rainfall, whose variation inevitably changes the intensity of desertification processes (Gambarelli et al. 2007).

The United Nations Convention to Combat Desertification (UNCCD) identifies physical, chemical, and biological processes of soil degradation. Physical processes lead to loss of resources in terms of reduction of soil volume and surface (erosion, compaction, and consequent limitation in porosity and water infiltration). Chemical processes cause the degradation of soil chemical quality (contamination, salinization, leaching, acidification). Biological processes determine the alteration of biological resources and their features (loss of organic matter, fertility, erosion resistance, buffering, and biodiversity).

According to the Italian National Atlas, risk of desertification in Italy pertains to more than 20% of total surface and rise to more than 40% in southern Italy (Costantini et al. 2007). The Atlas identifies various systems that contribute to desertification such as water erosion, urbanization, salinization, and drought. Sensitive areas would amount to a total of 9.1%, especially in Sardinia, Sicily, Puglia, and Calabria, though important areas with vulnerable soils are also present in Campania, Tuscany, and Lazio (Gambarelli et al. 2007). Desertification in southern Europe has an impact on:

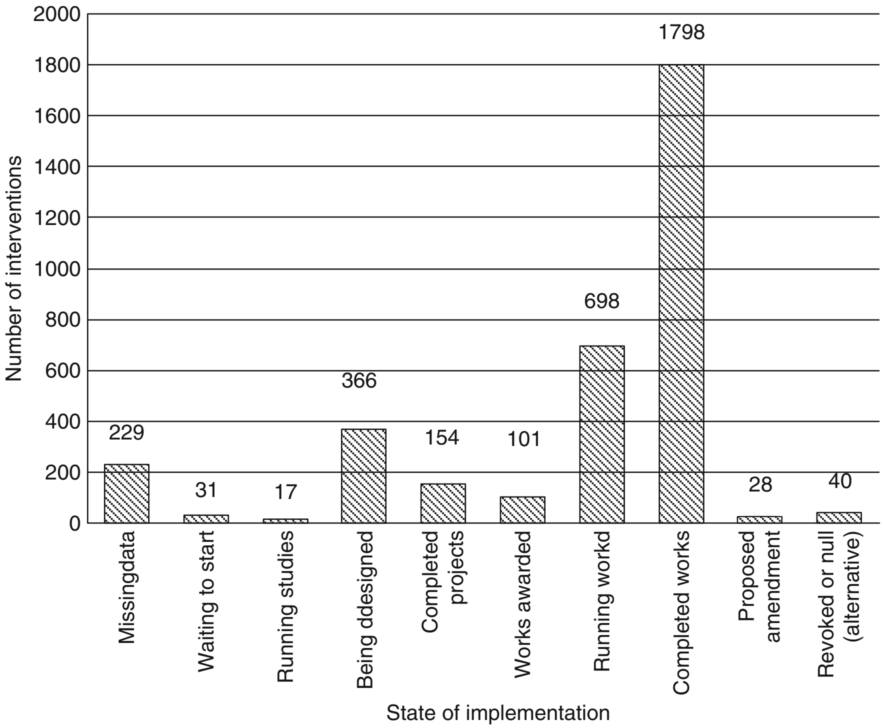

Fig. 2.4 Number of operations for landslides remediation based on their implementation state (ISPRA 2011c)

– Reduction in primary production and growth cycles of plants (Ogaya and Penuelas 2003).
– Reduction in turnover and availability of nutrients in soil (Sardans and Peñuelas 2005).
– Changes in phenology and interactions among species (Maestre and Cortina 2004).
– Risk of fire. A longer dry season increases frequency and severity of fires (Pereira et al. 2005) and a reduced capacity for vegetation recolonization after fires encourages the growth of shrubs over trees.
– Soil erosion due to increased intensity of rainfall events (Giorgi et al. 2004; De Luís et al. 2003).

2.5 Impacts of Desertification on Socio-Economic Systems

Desertification is a cause of direct and indirect social and economic effects. The first approximation to assess the costs related to reduced productivity is the estimate of soil physical damages and loss of fertile soil. A United Nations source in 1992 reported that Turkey, Tunisia, and Morocco lost due to soil erosion 54,237, 18,000, and 2,200 ha of cultivated land each year, respectively (UNEP 1992). A more recent study (Matallo 2006), based on the use of the Universal Soil Loss Equation (USLE), estimated that the loss of fertile soil may reach tens of billions of tons per year.

The only available economic estimate of desertification costs is based on the division of world arid areas in irrigated agricultural areas and non-irrigated grazing land (Dregne and Chou 1992). This classification was based on UNESCO reports for each country and was applied to estimate the economic cost of desertification per hectare, depending on land types or productive activities. Loss of yearly productivity per hectare due to soil degradation was calculated to be about 7 US$ for grazing lands, 38 US$ for non-irrigated land, and 250 US$ for irrigated land. This study shows that the worldwide annual cost of desertification in 1990 amounted to 42 billion US$, whose distribution for irrigated land, non-irrigated land, and pasture accounted to 11, 8, and 23 billion US$, respectively.

Other studies have measured economic losses caused by land degradation in terms of agricultural Gross Domestic Product (GDP). Many of these studies are based on models of general equilibrium mostly related to developing countries (Diao and Sarpong 2007; Young 1999; Bojo 1996; Jebuni et al. 1994; Drechsel and Gliele 1999; ISSER/DFID/World Bank 2005). The estimates generally indicate an annual loss of agricultural GDP ranging from 2 to 10%, with a median around 5%. However, among the various possible effects of land degradation, these figures account only for loss of agricultural productivity and the impact that a productivity decline may have on the rest of national economies.

2.6 European and Italian Legislation Related to Climate Reporting

Under the UNFCCC agreement, all parties must report on the steps undertaken to implement the Climate Convention (Articles 4.1 and 12). This report is provided in a national communication that usually contains information on national approaches, such as vulnerability assessment, financial resources and transfer of technology, education and training. Additionally, information is made available on domestic policies and measures to limit or reduce GHG emissions and enhance their removal by sink mechanisms. The parties of Annex I were requested to submit the Fifth national communication to the secretariat by 1st January, 2010. Italy has already presented this report to the UNFCCC (MATTM 2009). At the end of March 2011, the Italian National Communication was subjected to a review process by experts of the UNFCCC and the review report will be soon available.[2]

[2] The review report for the Fifth National Communication will be available in: http://unfccc.int/national_reports/annex_i_natcom/idr_reports/items/2711.php

Parties have also submitted to secretariat the National GHG inventories of sources and sinks of anthropogenic GHG emissions, which are not controlled by the Montreal Protocol. Annual inventory submissions for Annex I Parties, consisting of *National Inventory Report*[3] (NIR) and *Common Reporting Format*[4] (CRF), are followed by an annual review of GHG inventories finalized with a report.[5] In line with the reporting guidelines for national inventories from the IPCC, every year (x), parties shall report their anthropogenic GHG emissions by sources and sinks for the year $x-2$ (IPCC 1997, 2000, 2003). Detail information on methodologies and emission factors, emission time series, and uncertainties from Italian GHG emission inventory are reported in the NIR report (ISPRA 2011a). Since 2010, reports contain supplementary information as required by Article 7.1 of the Kyoto Protocol, such as those on Articles 3.3 and 3.4, for account of Kyoto units, changes in National Registry, and information on minimization of adverse impacts, in accordance with Article 3.14 of Kyoto Protocol.[6]

At European level, the legal basis for compilation of EC inventory is the 280/2004/ EC (11/02/2004) Decision of the European Parliament and Council, concerning the mechanism for monitoring GHG emissions in EU and implementing the Kyoto Protocol. This decision established a mechanism to monitor, in each Member States, all anthropogenic GHG emissions (including their removal by sink mechanisms). Moreover, it requires the evaluation of progress made to ensure compliance with the EU commitments on emissions and their removal, the implementation of UNFCCC and Kyoto Protocol, and the guarantee that information reported by the European Commission to the UNFCCC Secretariat is complete, accurate, consistent, transparent, and comparable.

The Kyoto Protocol (Article 5.1) requires that each party included in Annex I establishes a *National system* for the estimation of sources and sinks of GHG anthropogenic emissions no later than 1 year prior to the start of the first commitment period. In Italy, the *National System* was set up by the Legislative Decree no. 51 of March 2008, designating ISPRA,[7] formerly APAT,[8] as the entity responsible to design, manage, and archive data of the *National System for the Italian Greenhouse Gas Inventory*, and to collect data and implement a program for monitoring

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[3] A comprehensive description of the methodologies used in compiling the inventory, the data sources, the institutional structures and quality assurance and control procedures.

[4] A series of standardized data tables containing mainly numerical information and submitted electronically.

[5] The last review report from Italy is available at the UNFCCC web site: http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/5687.php

[6] On 1st June 2002, Italy ratified the Kyoto Protocol with the law n.120 of 01/06/2002. The ratification law also prescribed the preparation of a National Action Plan to reduce greenhouse gas emissions, adopted by the Interministerial Committee for Economic Planning (CIPE) on 19th December 2002. The Kyoto Protocol entered into force on 16 February 2005.

[7] ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale.

[8] APAT, Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici.

and quality assurance of data. The Italian *National System*, currently in place, is fully described in the document "*National Greenhouse Gas Inventory System in Italy*" (ISPRA 2011b). The "*National Registry for Carbon sinks*", set up by a Ministerial Decree on April 1, 2008, is part of the Italian *National System* and includes information on lands units subjected to Article 3.3, activities listed under Article 3.4, and related carbon stock changes. The "*National Registry for Carbon sinks*" is the instrument to estimate the GHG emissions by sources and removal sinks for forest land and related land-use changes, and account for their net removal, thereby enabling the Italian Registry to deliver the relevant amount of removal units (RMUs).

2.7 Italian Greenhouse Gas Emissions

Emission estimates comprise ten GHG: carbon dioxide, methane, nitrous oxide, HFCs, PFCs, sulfur hexafluoride, nitrogen oxides, carbon monoxide, non-methane volatile organic compounds, sulfur dioxide. The first six GHGs directly contribute to climate change owing to their positive irradiative forcing effect. The national Kyoto target is a reduction in the period 2008–2012 of 6.5% of GHG, as compared to the 1990 base year level. In spite of it, total GHG emissions, in CO_2 equivalent, decreased by 5.4% between 1990 and 2009 (from 519 to 491 millions of CO_2 equivalent tons), excluding emissions and removals of carbon dioxide (CO_2) involved with LULUCF. Emission estimations include the following sources: energy, industrial processes, solvent and other product use, agriculture, LULUCF, and wastes. The most important GHG, CO_2, which accounted for 85% of total emissions in CO_2 equivalent in 2009, showed a decrease by 4.3% between 1990 and 2009. CH_4 and N_2O emissions were equal to 7.6 and 5.7%, respectively, of the total CO_2 equivalent GHG emissions in 2009. Both gases showed a decrease from 1990 to 2009, equal to 14.3 and 25.3%, respectively. Other GHG, HFCs, PFCs, and sulfur hexafluoride (SF_6) ranged from 0.04 to 1.7% of total emissions (ISPRA 2011a). The major contribution to the national GHG emissions is the energy sector (82.8%), followed by the agriculture (7.0%), and the industrial processes (6.1%) sectors (Table 2.2).

According to guidelines of IPCC national inventory for the agriculture sector, methane (CH_4) and nitrous oxide (N_2O) emissions should be estimated and reported. Enteric fermentation (4A), manure management (4B), rice cultivation (4C), agricultural soils (4D), and field burning of agriculture residues (4F) are included in this sector. In 2009, agricultural activity has been the dominant national source for CH_4 (41%) and N_2O (69%) emissions, and have decreased by 11.4 and 17.9%, respectively, in respect to 1990.

While the agricultural sector is responsible for 34.48 Mt of CO_2 equivalent, the GHG trend from 1990 to 2009 shows a decrease of 15.1% (Fig. 2.5). This was mostly due to a decrease of CH_4 emissions from enteric fermentation (−11.5%), and to a decrease of N_2O from agricultural soils (−20.6%), which account for 31 and 45% of total agricultural emissions, respectively (ISPRA 2011a). In particular,

Table 2.2 Greenhouse gas (Gigagrams, Gg) source and sink categories for Italy in 2009

GHG source and sink categories	2009 CO_2-equivalent (Gg)
Energy	406,743
Industrial processes	29,940
Solvent and other product use	1,862
Agriculture	34,481
Land use, land-use change and forestry[a]	−94,671
Waste	18,094
Total (including LULUCF removal)[a]	396,449
Total (excluding LULUCF)	491,120

Source: ISPRA (2011a)
[a]Includes net CO_2, CH_4, and N_2O

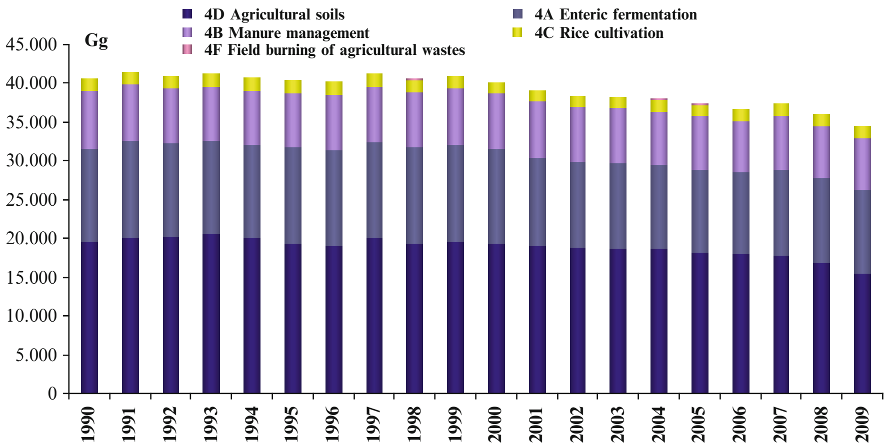

Fig. 2.5 Total GHG emissions from 1990 to 2009 for the agriculture sector (Gg CO_2 eq) (elaboration from ISPRA 2011a)

estimations from agricultural soils as source include (1) direct N_2O emissions from nitrogen fertilizers use, sewage sludge application, soil application of manure, N-fixing crops, incorporation of crop residues, histosols and pasture and (2) indirect N_2O emissions from atmospheric deposition and nitrogen leaching and run-off (ISPRA 2011a). Main drivers are the reduction in the number of animals, use of synthetic N-fertilizers, and agricultural production. Between 1990 and 2009, market interventions (I Pillar) due to Common Agricultural Policy (CAP), such as the milk quota, influenced reduction in number of dairy cattle (29%). Between 1990 and 2009, the use of N-fertilizers has been reduced by 37%, while the reduction was by 17 and 25% in the years 2007/2008 and 2008/2009, respectively. In addition, after the CAP Health Check reform, also Rural Development Plans *2007–2013* (II Pillar) will be likely to contribute to emission reduction by reducing nitrogen surplus (Cóndor et al. 2010).

The LULUCF sector includes estimations of CO_2 removal and emission of CO_2, CH_4, and N_2O for the following categories: *forest land*, *cropland*, *grassland*,

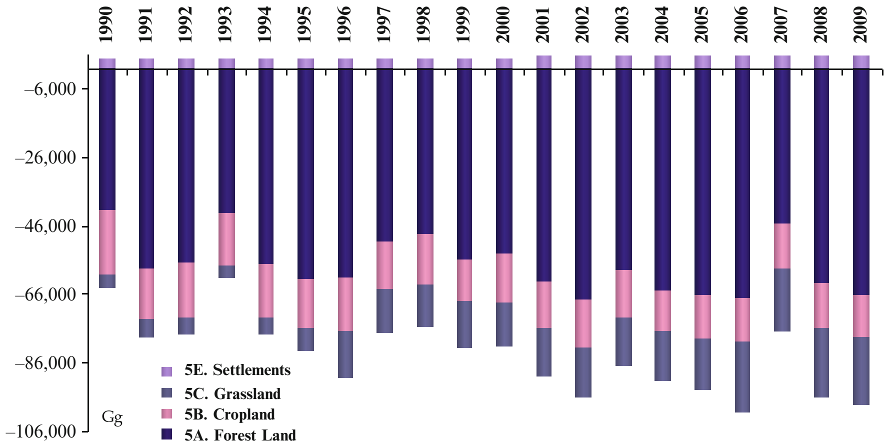

Fig. 2.6 Total emissions and removals from the LULUCF sector from 1990 to 2009 (Gg CO_2 eq) (elaboration from ISPRA 2011a)

wetlands, and *settlements*. Emissions and removals are estimated for each category, and each further subcategories "*land remaining land*" and *"land converting to land*". The sector was responsible in 2009 for removal of 94.7 Mt of CO_2 from atmosphere (Fig. 2.6). From 1990 to 2009, total removal as CO_2 equivalent increased by 53.2%, CO_2 accounting for more than 99% of total emissions and removals of the sector (ISPRA 2011a).

Forest land removals accounted for 65% of total CO_2 LULUCF emissions and removals in 2009. In particular, the living biomass removals represented 50%, while removals from dead organic matter and soils stood for 8 and 42%, respectively, of total forest land CO_2 removed in 2009. The key driver for such rise was the increase in CO_2 removals from forest land remaining *forest land.*

Cropland removals were 12.1% of total CO_2 LULUCF emissions and removals. In particular, the living biomass removals represented 97%, while the emissions and removals from soils were up to 3% of total cropland CO_2 emissions and removals.

Between 1990 and 2009, mean *Grassland* emissions reached 13.6% of absolute CO_2 LULUCF emissions and removals. Living biomass emissions represented 7%, while removals from dead organic matter pool reached 3% and those from soils were up to 91% of absolute total grassland CO_2 emissions and removals (ISPRA 2011a).

2.8 Italian Research Supporting Climate Reporting

Two main lines are significant to improve estimations of GHG emissions from agriculture. A first line is related to collection of information on methods of agricultural production. For instance, agricultural statistics related to housing and storage facilities used by farmers and modality of land spreading are relevant information required by the inventory. Currently, the National Institute of Statistics (ISTAT), with the support of ISPRA, incorporated these specific queries in the 6th Agricultural Census of 2010. Therefore, in the future, information on animal production methods will be obtained. A second line encompasses the collection and incorporation of country specific parameters as a function of national research studies. The GHG inventory already uses different Italian emission factors (i.e., rice cultivation emission factors). However, information on the national emission factor for N_2O emissions for agricultural soils is still needed.

In accordance with the COP/MOP Decisions, the IPCC Good Practice Guidance on LULUCF, and every relevant IPCC guidelines, the *National Registry for Carbon sinks* is the instrument to estimate GHG sources and sinks in forest land and related land-use changes. In 2009, a technical group, formed by experts from different institutions (ISPRA; Ministry of the Environment, Land and Sea; Ministry of Agriculture, Food and Forest Policies), set up the methodological plan for the necessary activities to implement the registry, and defined the relative funds. Some of these activities which should be completed by 2010 are expected to supply useful data to update and improve present estimations. Activities planned in the framework of the *National Registry for Forest Carbon Sinks* should also provide data to improve estimate of carbon sequestration due to Afforestation/Reforestation activities (with a special focus on soil organic matter content), and should allow to refine the estimates for forest land category. For the 2011 report submission, data and methodologies used for the inventory under the Convention were employed to estimate emissions and removals for activities related to Articles 3.3 and 3.4.

In recent years, different national research studies have focused on carbon sequestration in agricultural soils, highlighting the relationship between agricultural management practices and soil organic matter content. In fact, soil organic matter content represents a critical issue for Italy due to the small amount of soil surveys conducted since 1990, and their extreme fragmentation. Concerning forest land, results of the third phase of the National Forest Inventory (INFC) based on measurements of soil organic matter content will enable a more accurate analysis of the relationship between biomass carbon and carbon content in litter and soil, thus providing an improvement of national and regional estimates.

However, the issue is still open for soil organic matter content related to other land uses, particularly for cropland and grassland. Recent studies have reported that soil organic carbon was reduced in many areas, while an increase in atmospheric CO_2 has been concomitantly detected. This apparently shows that past changes in land use history and management practices were the main drivers for carbon emissions from soil rather than high temperatures and rainfall changes resulting from climate change (Fantappiè et al. 2010). Further investigations are needed to develop a solid methodology to assess carbon stock changes in soil pool and provide a robust database over the national territory with precise records of soil organic matter content vis-à-vis of land use and management practices.

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http://www.springer.com/978-3-642-23384-5

Carbon Sequestration in Agricultural Soils
A Multidisciplinary Approach to Innovative Methods
Piccolo, A. (Ed.)
2012, XIV, 310 p., Hardcover
ISBN: 978-3-642-23384-5