statistiche focus

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STATISTICAL MEASURES FOR CLIMATE CHANGE ADAPTATION: REALITIES IN URBAN SETTINGS AND NEW GEOGRAPHIES FOR AGRICULTURE

The consequences of Climate Change are increasingly tangible: all countries are exposed to it, and the severity of impacts varies across territories depending on meteo-climatic, geographic, and socio-economic conditions and related risk parameters (hazards, exposure, vulnerability). Mitigation strategies aimed at reducing the causes of climate-altering gas emissions must be complemented by adaptation measures of different matrix, aimed at reducing direct and associated impacts through the protection and strengthening of natural, economic and social systems, in accordance with the principle of Just Transition, i.e., processes aimed at the development of a system that respects the principle of environmental and economic sustainability, but is also just and inclusive.

Adaptation measures are needed at all levels, consistent with disaster risk reduction strategies-directly or indirectly induced by Climate Change or otherwise-and within the broader framework of Sustainable Development (UN Agenda 2030), with general action plans outlining the framework and specific action plans to consider local and spatial diversity. These include Nature-Based Solutions (NbS) based on strengthening natural systems, of which co-benefit the reduction of biodiversity loss and pollution.

The availability of statistical information is the knowledge base for defining actions and priorities to reduce the vulnerability of human and natural systems, to minimize damage and loss, and to prioritize prevention. Multiple areas of economic, social and environmental statistics can be considered in a connected ecosystem of data and statistical sources. Istat produces statistical measures relevant in the context of climate change adaptation and disaster risk reduction, to be analyzed by considering synergies and cascading effects among phenomena.

International frameworks related to climate change and disaster hazards developed under UNECE and UNSD converge in the need to measure and monitor risk factors, direct and associated causes and impacts related to different hazards, the exposure of the elements present (human, natural, economic systems, infrastructure, etc.), their vulnerability, and the extent of potential loss and damage.

The area related to climate change adaptation represents a challenge but also an opportunity for official statistics. A number of indicators have been identified for this area in the frameworks mentioned above. More specific geographic and spatial analyses taking into account direct and associated risks from climate change are encouraged based on the risk conditions in each country, in a multi-risk perspective. The broad scope and linkage to climate change adaptation is not always straightforward, as it is the result of a concatenation of factors. The contribution of environmental and spatial data is relevant, in combination with social and economic data, to assess the vulnerabilities and resilience of territories and related systems.

Referring to the aforementioned international frameworks, this paper aims to provide some specific elements of analyses related also indirectly to Climate Change, in the area of impact and adaptation and related to two specific and distinct sectoral and territorial contexts:

- the urban context, which is severely affected by increases in air temperature, with critical heat conditions amplified by the microclimatic phenomenon called "Urban Heat Island" (UHI), which is dangerous for human health, especially for the weaker segments of the population;
- the agricultural sector, which faces the great challenge of the negative effects of Climate Change: climate zones that have shifted towards the Pole in recent decades in both hemispheres, changing temperature and precipitation patterns, increases in extreme events that threaten food security in many areas of the Planet, in an extremely dynamic and vulnerable context, given the concatenation of the climate, environmental, economic and geopolitical crisis. Some indicators from the 7th General Census of Agriculture are presented based on the spatial classification by Ecoregions.

United Nations Goal: Limit Global Average Temperature Increase to +1.5°C

Climate change (CC) observed over extremely long time scales can be linked to natural physical phenomena such as ocean current circulation, volcanic activity, solar radiation, and Earth's orbital changes. However, there is scientific consensus that human activities are the primary driver of global warming and the rapid climate shifts recorded since the mid-20th century. At the latest United Nations Annual Conference on Climate Change held in Dubai (December 2023), the target threshold to limit the increase in global average temperature to +1.5°C above pre-industrial levels - as defined in the 2015 Paris Agreement - was reaffirmed.

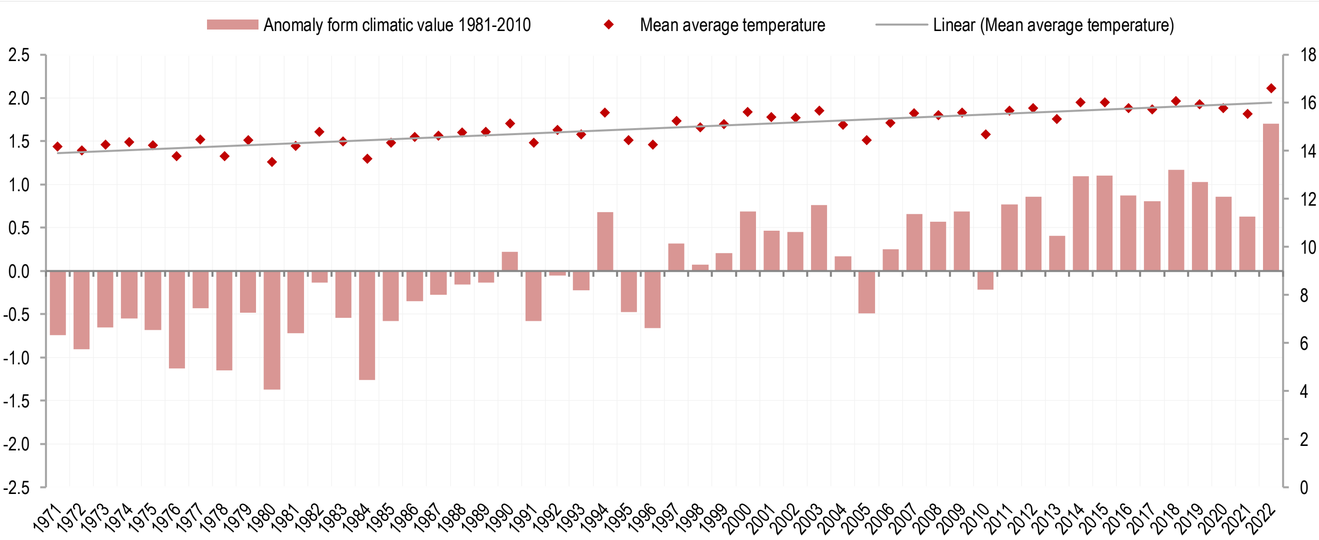
Geophysical studies highlight that the effects of CC are amplified and more pronounced in *climatic hotspots* such as polar ice caps, mountainous regions, the Mediterranean area, and urban areas. Cities, highly vulnerable due to population density, infrastructure, economic activities, and cultural heritage, are at the forefront of climate challenges and play a critical role in governance for the transition toward climate neutrality. In Italy, a territory particularly fragile and exposed to adverse effects of CC, rising air temperatures and extreme weather events (heatwaves, tropical nights, droughts, cloudbursts, and floods) are increasingly affecting many cities. These phenomena have caused irreversible damage to the environment, socio-economic systems, and urban infrastructure, with significant loss of life. In some cities, the +1.5°C threshold for average temperature has been exceeded in several years of the last decade.

The availability of localized, long-term, high-resolution data is crucial to analyzing weather and climate phenomena in urban systems, assessing impacts and at-risk elements, and defining effective adaptation strategies based on the exposure level of specific areas. These meteorological and climate statistics support the monitoring of key national plans and strategies, including the National Climate Change Adaptation Strategy (SNAC 2015), the Integrated National Energy and Climate Plan (PNIEC 2020), the National Recovery and Resilience Plan (PNRR 2021), the National Sustainable Development Strategy (SNSvS 2022), and the National Plan for Climate Change Adaptation (PNACC 2023).

1971- 2022 Years: Average Temperature in Capital Municipalities of Region Rises

Examining Italy's Capital municipalities of Regions from 1971 to 2022, the annual average temperature shows a rising trend, with the highest values recorded in the last decade (data from ground-based thermo-pluviometric stations) (Figure 1A). When annual values are compared to the 1981–2010 Climatological Normal (CLINO), climate anomalies provide insight into long-term CC. After a turning point in the late 1980s, anomalies have remained consistently positive since 1997 (with exceptions in 2005 and 2010), peaking after 2014. That year marked the first time the average temperature reached 16°C, approximately +1.1°C above the 1981–2010 climatic reference value.

FIGURE 1A. ANNUAL AVERAGE TEMPERATURE ANOMALIES[(a)] FROM CLIMATIC VALUES 1981-2010 (left axis) AND ANNUAL AVERAGE TEMPERATURE OF REGIONAL CAPITAL MUNICIPALITIES (right axis). Years 1971-2022, values in degrees Celsius

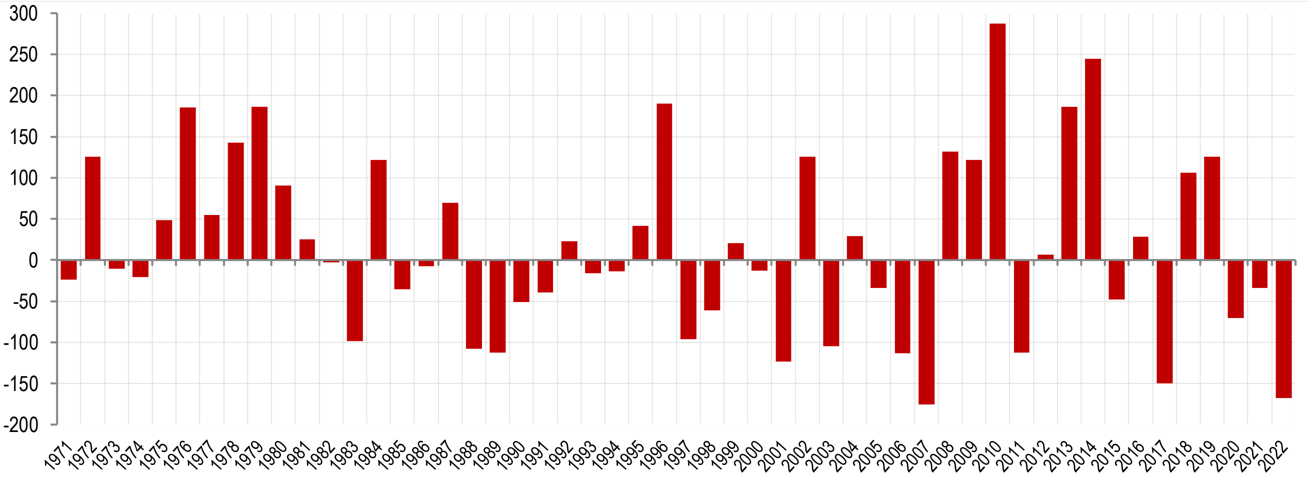


a) The annual average temperature of Capital Municipalities of Region is calculated as the mean of the values recorded by the observed meteorological stations.
Source: Istat, Survey on Meteorological and Hydrological Data.

The year 2022 recorded the highest average temperature since 1971 (approximately 16.6°C), confirming the upward trend and marking an unprecedented thermal anomaly of +1.7°C compared to the considered CLINO. An analysis of decadal averages highlights that the mean temperature of the Capital municipalities of Region increased from 14.9°C in 1991–2000 to 15.2°C in 2001–2010, and further to 15.8°C in 2011–2020 (with an average anomaly of approximately +1°C compared to the 1981–2010 CLINO average value).

Alongside the rise in average temperature from 1971 to 2022, the total annual precipitation of the Italy's Capital Municipalities of Region shows inter-annual variability, as reflected in the annual anomalies compared to the 1981–2010 climatic normal (average value of approximately 743 mm) (Figure 1B). Since the mid-1990s, the amplitude of anomalies relative to the CLINO appears to have increased. The last three recorded years show negative anomalies, with the most significant in 2022 (approximately -167 mm), which also marked the lowest annual precipitation since 1971 (after 2007).

FIGURE 1B. ANNUAL ANOMALIES OF TOTAL PRECIPITATION[a] FROM CLIMATIC VALUES 1981-2010 OF CAPITAL MUNICAPALITIES OF REGION. Years 1971-2022, values in millimeters.



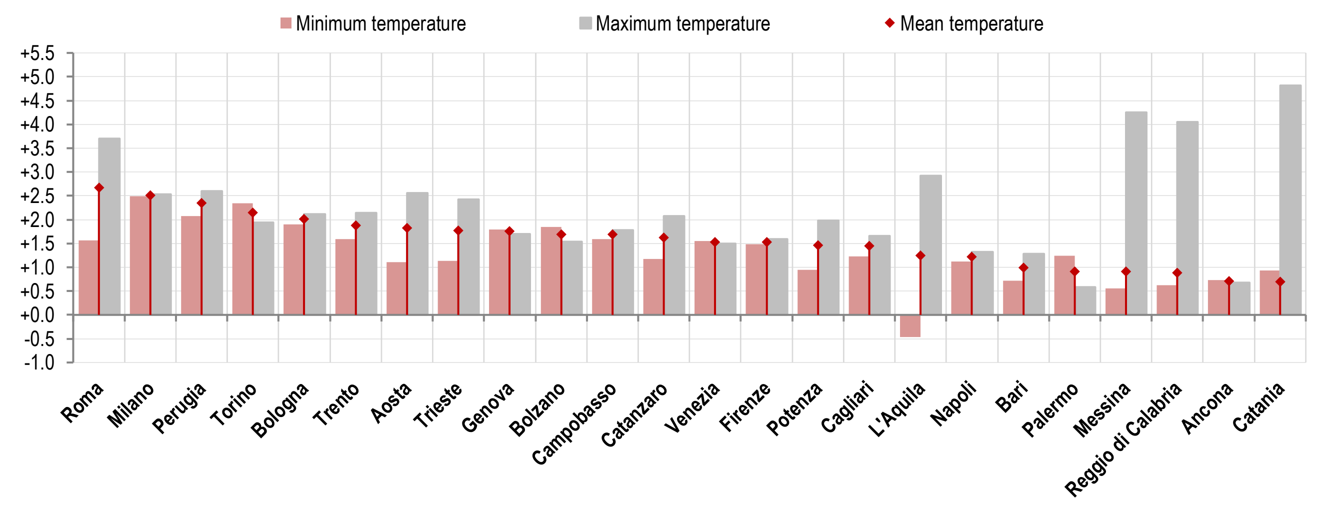
a) The total annual precipitation of the Capital Municipalities of Regions is calculated as the average of the values recorded by the observed meteorological stations.
Source: Istat, Survey on Meteorological and Hydrological Data.

2022 the Hottest and one of the Least Rainy Years in the Last Fifty

With an average temperature of approximately 16.6°C, 2022 was the hottest year since 1971 for Italy's Capital Municipalities of Region, recording a thermal anomaly of +1.7°C compared to the 1981–2010 reference period. This phenomenon affected a resident population of just over 9.5 million people, equivalent to about 16.1% of the national population. In 2022, all Capital municipalities of regions experienced positive average temperature anomalies relative to the 1981–2010 period, with 14 cities exceeding +1.5°C (Figure 2).

The highest anomalies were recorded in Roma (+2.7°C) and Milano (+2.5°C), followed by Perugia (+2.3°C) and Torino (+2.1°C). The smallest anomalies were observed in Ancona (+0.7°C), Palermo (+0.9°C), and Bari (+1°C). The rise in average temperature is attributable to increases in both maximum and minimum temperatures across all cities examined (except L'Aquila). In absolute terms, Palermo had the highest average temperature in 2022 among the Capital Municipalities of Region (approximately 19.8°C), followed by Cagliari (19.5°C) and Roma (18.7°C). Regarding maximum temperatures, the top cities were Roma (24.8°C), Cagliari (24°C) and Palermo (23.1°C).

FIGURE 2. MINIMUM, MAXIMUM, AND ANNUAL AVERAGE TEMPERATURE ANOMALIES FROM THE 1981-2010 CLIMATIC VALUE, DIFFERENCES FROM THE 2006-2015 AVERAGE VALUE FOR CAPITAL MUNICIPALITIES OF REGION AND METROPOLITAN CITIES(a). Year 2022, values in degrees Celsius

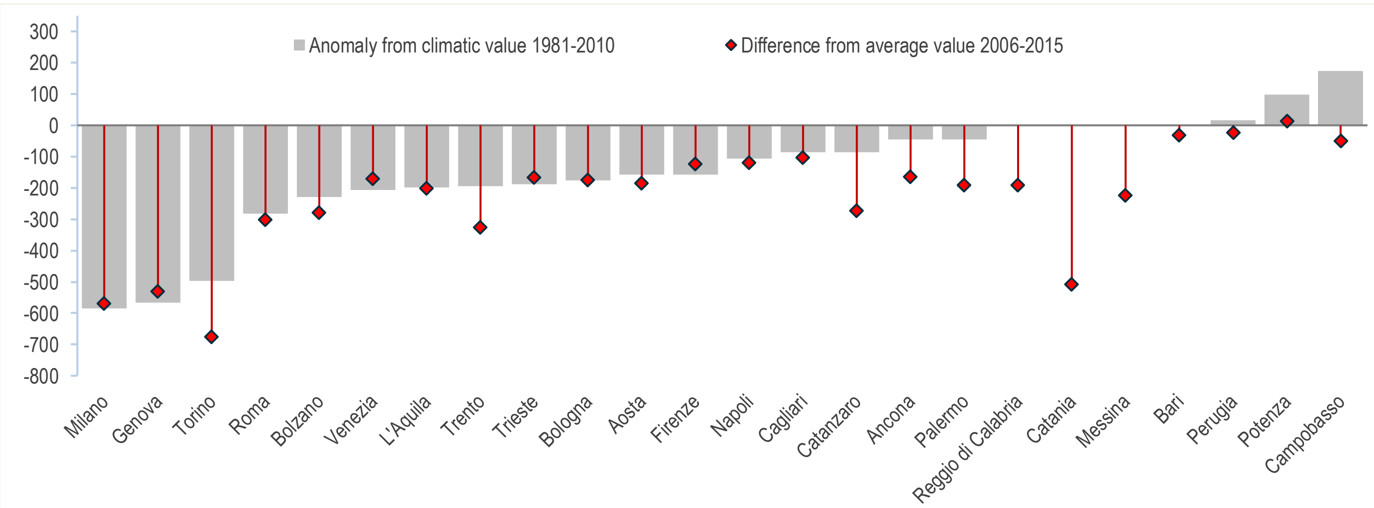


(a) For Reggio di Calabria, Catania, and Messina, the 1981-2010 climatic value is unavailable due to incomplete historical series. The 2022 values are compared with the 2006-2015 average value. Source: Istat, Survey on Meteorological and Hydrological

For the Capital Municipalities of Region, 2022 is the second driest year since 1971 (after 2007), with an average total precipitation of 576 mm (-167 mm compared to the 1981-2010 CLINO). The decrease affects 17 of these cities, particularly Milano (-585.5 mm), Genova (-567.3 mm) and Torino (-496.4 mm). Extending the analysis to the 24 Capital Municipalities of Region and Metropolitan Cities, the 2022 precipitation is on average 561 mm (Figure 3). Compared to the average volumes of the 2006-2015 decade, approximately 232 mm less rain fell. All the cities examined (except Potenza) experienced reductions, particularly Torino (-676.6 mm), Milano (-569.2 mm), and Genova (-531.2 mm).

Analyzing the data for the 109 Provincial Capitals, where nearly 30% of the Italian population resides (equivalent to 17.5 million people), the average temperature in 2022 reached approximately 16.6°C, exceeding the 2006-2015 average by about 1°C (complete daily data available for all cities examined). Compared to the reference period's average, 99 cities experienced increases (with about 60% of them showing increases greater than +1°C). The highest increases were recorded in Modena (+3.4°C), Sondrio (+2.6°C), Cremona (+2.4°C), and Massa Carrara (+2.1°C). Geographically, cities located in the South and Islands and show the highest temperatures (averaging 18.7°C and 16.9°C respectively), while those in the North-West and North-East experienced the most significant increases compared to 2006-2015 decade (+1.4°C and +1.2°C).

FIGURE 3. ANNUAL TOTAL PRECIPITATION ANOMALIES FROM THE 1981-2010 CLIMATIC VALUE AND DIFFERENCE FROM THE 2006-2015 AVERAGE VALUE FOR CAPITAL MUNICIPALITIES OF REGION AND METROPOLITAN CITIES(a). Year 2022, values in millimeters.



a) For Reggio di Calabria, Catania, and Messina the 1981-2010 climatic value is unavailable due to incomplete historical series. The 2022 values are compared with the 2006-2015 average value. Source: Istat, Survey on Meteorological and Hydrological

The Provincial Capitals of the Islands, with 1.9 million people (about 11% of the population residing in the 109 Capitals), are exposed to the highest average temperatures among those recorded in the cities examined by macro-area. They are followed by the Southern Capitals, with nearly 3.2 million residents. Data collected from meteorological stations indicate that, for 2023, the average temperature recorded in the cities remains at very high levels, confirming the positive trend observed since 1971.

The total precipitation across the 109 Provincial Capitals decreases on average by about 279 mm compared to the 2006-2015 value. Reductions are recorded for 95 of the Capitals, with the most significant declines in Verbania (-922.6 mm), followed by Varese (-869.1 mm), Monza (-824.8 mm), Udine (-681.2 mm), and Torino (-676.6 mm).

Based on the geographical location of the 109 Provincial Capitals, in 2022, the annual precipitation was lowest in absolute terms for the Islands and North-western Capitals (approximately 420 mm and 540 mm, respectively, both lower than the 2006-2015 average). These areas are home to 35.5% of the population of the cities examined. All macro-areas experienced reductions in precipitation compared to the 2006-2015 average, with the largest decreases observed in the cities of the North-West and North-East (approximately -492 mm and -271 mm, respectively), where about 43% of the population of Italy's Provincial Capitals resides.

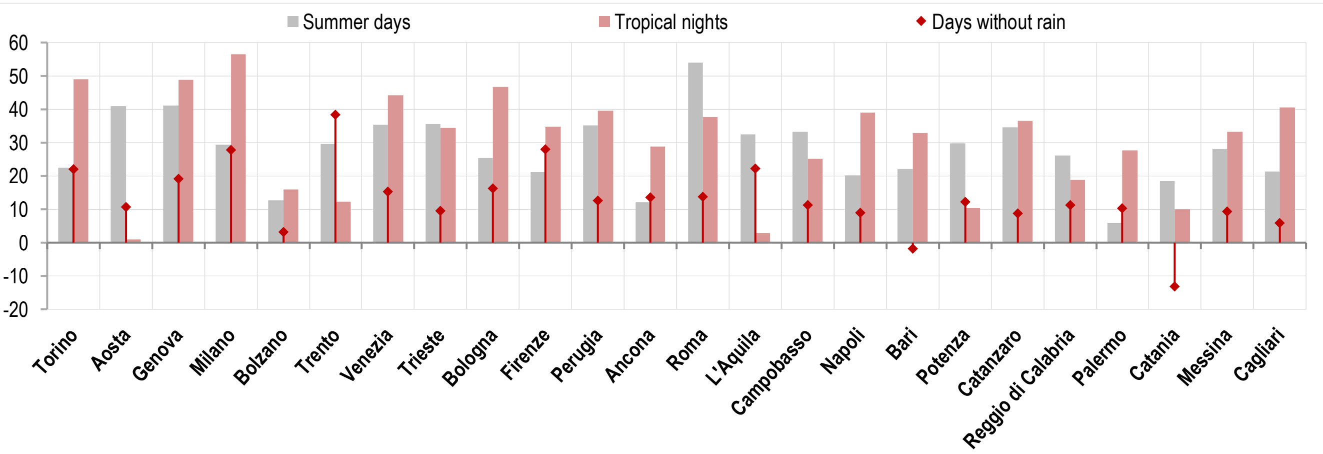
Indices of Meteoclimatic Extremes on the Rise for Major Italian Cities

From 2006 to 2022, for the set of Capital Municipalities of Region, temperature extremes indices show increases compared to the corresponding average values of the 1981-2010 climatic reference period. In particular, *summer days index* (maximum temperature >25°C) and *tropical nights index* (average temperature not falling below 20°C) exhibit positive anomalies for all years examined (except for summer days in 2010 and tropical nights in 2014). For these 21 major cities, during the period studied, there are on average 113 summer days and 49 tropical nights per year (with an average climatic anomaly for the period equal to +12 days and +11 nights above the 1981-2010 CLINO).

The *heatwave index* shows positive anomalies for nearly all years (the highest in 2022), with an average 2006-2022 value of about +10 days above the climatic value 1981-2010. The deviations of such indices are more pronounced in the last years observed, particularly in 2022. The *dry days index* (on average 283 per year from 2006 to 2022), reflecting inter-annual variability of precipitation, shows anomaly fluctuations ranging from a minimum of -23 days in 2010 to a maximum of +15 in 2022 compared to the 1981-2010 CLINO. In 2022, regarding the Capital Municipalities of Region, summer days and tropical nights showed significant positive anomalies compared to 1981-2010 climatic value, affecting all cities (on average +28 days and +32 nights) (Figure 4).

Summer days increased most significantly in Roma (+54 days), Genova and Aosta (+41), while tropical nights increased most notably in Milano (about +57 nights), Torino and Genova (+49), and Bologna (+47). The *dry days* in the Capital Municipalities of Region in 2022 exceeded the 1981-2010 climatic value by an average of 15 days. The increase in dry days affected all cities examined (except Bari), with Trento leading (+38 days), followed by Firenze and Milano (+28), and L'Aquila (+22).

FIGURE 4. ANOMALIES OF SUMMER DAYS, TROPICAL NIGHTS, AND DRY DAYS INDICES FOR CAPITAL MUNICIPALITIES OF REGION AND METROPOLITAN CITIES[a] COMPARED TO 1981-2010 CLIMATIC VALUE. Year 2022, values in number of days.



a) For Reggio di Calabria, Catania, and Messina, the 1981-2010 climatic value is unavailable due to incomplete historical series. The 2022 values are compared with the 2006-2015 average value. Source: Istat, Survey on Meteorological and Hydrological

In 2022, the indices representing temperature extremes recorded increases for most of the 109 Provincial Capitals. Specifically, summer days and tropical nights increased by 19 and 20, respectively, compared to the 2006-2015 decade (on average, 136 summer days and 58 tropical nights were recorded in the observed year). Dry days also increased (+18 compared to the reference decade), reaching 299 days in the year, which is the average value for the set of cities examined.

Temperature Differential between Urban and Vegetated Areas in three Major Cities: Roma, Milano and Napoli

To complement the above analyses, for three large cities selected for their geographic representativeness, spatial extent, population density and spatial comparability of the data, such as Milano (182 Km^2), Roma (1,281 Km^2) and Napoli (119 Km^2), the temperature difference between each point in the city and the average measured in the surrounding vegetated areas was calculated.

The information was processed using the tool provided by the *European Space Agency (ESA), SNAP Toolbox Sentinel Application Platform*, specially designed for processing environmental images from numerous remote sensing missions. The SNAP software application called *Pin Manager* was used to extract the temperature of the urban areas and that falling in the vegetated areas, obtaining for each point the difference in temperature measured between the urban areas, where temperatures are generally higher, and the average in the surrounding vegetated areas.

The temperature difference between urban areas and the average of the surrounding vegetated areas was calculated at the geographical scale of the Municipality. The city most affected by this phenomenon is Roma, where the temperature difference between urban areas and surrounding vegetated areas is +6.5°C, mainly in the central areas of the city (Municipalities I and II) and in the eastern quadrant (Municipality V). Roma is also the city with the lowest temperature difference, which occurs in the municipalities IX, X and XIV. In these municipalities, the greater presence of vegetated areas manages to cool the air to the point of lowering the temperature by almost three degrees (-2.9°C). In Milano, this difference is slightly lower and varies between -1.7 and +4.5°C, very close to that found in Napoli, where it varies between -1.6 and +4.1°C (Annex 3).

In Milano, the average temperatures recorded in urban and vegetated areas show temperature ranges between -0.5°C (highly vegetated areas) and +3.7°C (more urbanized areas). For less affected areas, with similar average temperatures between urban and vegetated areas, excursions between -0.5 and +1.1°C were found on average in Municipalities V and IV, areas south of Milano. The phenomenon is more pronounced in the central districts (Municipality I) and the adjacent area to the north (Municipality IX), between +2.8 and +3.7°C.

In the case of Napoli, the lowest temperature ranges are found in Municipalities IX and VIII, average variations between (+0.7°C and +0.8°C). In contrast, the highest averages are found in Municipalities IV and II, between +2.8°C and +3.7°C. Significant average variations are also recorded in Roma, with temperatures in the fifteen municipalities ranging from a minimum between +0.1°C and +0.6°C, recorded in Municipalities X and IX, located south of Roma, and in Municipality XIV (+0.3°C), to a maximum between +4.3°C and 5.5°C, in the eastern quadrant (Municipality V) and in the historic center (Municipality I), respectively.

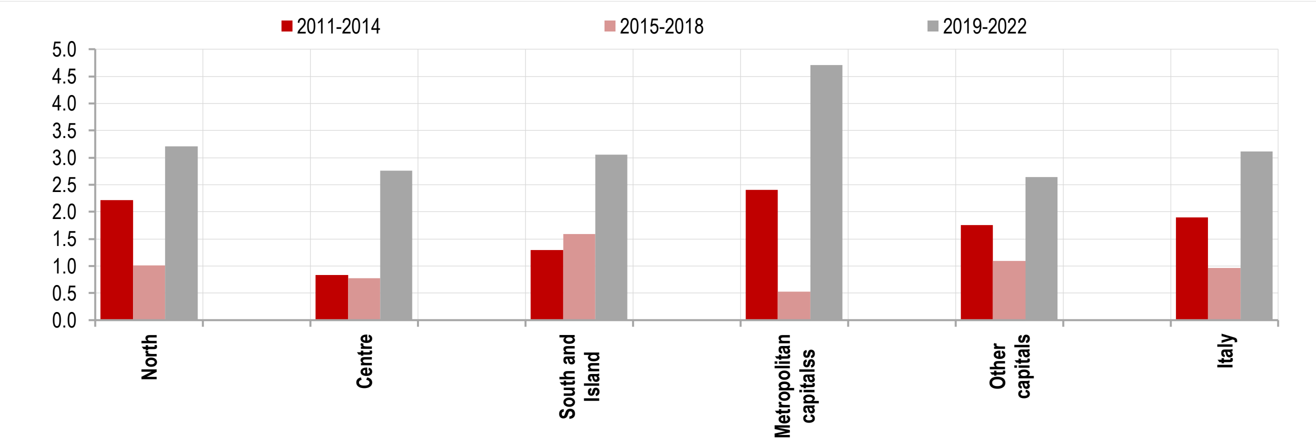
Urban Forestation for Urban Heat Island Adaptation

The expansion of green areas in cities can be one of the natural solutions to high temperatures, with the planting of new trees in large areas dedicated to the growth of new, naturally developing forests (urban forestation areas); forests and green areas that, in addition to the function of absorbing CO_2, are extremely effective in mitigating the phenomenon of Urban Heat Islands in cities, where, as mentioned above, temperatures are on average higher than in the surrounding vegetated areas.

In the entire capital municipalities (provincial and metropolitan), the extent of the total green areas (urban and protected), net of their overlaps, is 3,826 km^2, corresponding to 19.7 percent of the total territorial incidence. Part of this is made up of purely urban green areas (573 km^2, 2.9 percent of the territory), which corresponds to an average availability of 32.8 m^2 per inhabitant. Urban and peri-urban afforestation covers more than half of the capital municipalities (56). They cover a total of 13.2 km^2, corresponding to an average of 34.1 km^2 per hectare. A quarter of the capital municipalities have carried out above-average interventions, particularly the Northern (77 m^2 per hectare in the North-East; 40 m^2 in the North-West), while they fall to 20 m^2 in the center, 10 m^2 in the South and 5 m^2 in the Islands.

In 2011, there were only 30 capitals municipalities with urban and peri-urban forestation interventions: in fact, over the last 11 years, the area dedicated to urban reforestation has progressively increased (+26.1%). The largest increases were recorded near the years in which the legislature intervened to support the development of green areas: with the introduction of Law 10/2013, "Norms for the Development of Urban Green Areas", between 2011 and 2014 the annual increases were 1.9%; in particular, between 2019 and 2022 there was an average annual increase of +3.1% on a national basis, while in the metropolitan capitals the growth was significantly higher (+4.7%). In this regard, it is recalled that Measure 2 - Component 4 - Investment 3.1 "Protection and enhancement of urban and suburban green spaces" of the NRP aims to strengthen precisely these positive trends.

FIGURE 5. AVERAGE ANNUAL CHANGE IN URBAN FORESTATION IN CAPITAL MUNICIPALITIES (PROVINCIAL AND METROPOLITAN) Years 2011-2022, percentages values



Source: Istat, Urban Environmental Data.

Interaction between Climate and Environmental Pressures in Cities

Urbanisation causes pressures on the natural environment. The effects of climate change can intensify these pressures and increase the vulnerability of cities, thus posing a challenge for cities to consider adaptation and mitigation actions in order to increase resilience (Table 1).

An indicator of the pressure on the environment generated by vehicle traffic is the motorisation rate, which in Italy has the highest value in the European Union (682 passenger cars per thousand inhabitants, face to an EU average of 564 in 2022), up 1.2% on the previous year and growing uninterruptedly since 2013 (+12.3%). Moreover, the mitigation contribution of low-emission vehicles is still limited, as the share of cars with traditional fuels, petrol or diesel, has decreased only marginally in recent years (from 91.1% in 2017 to 86.1% in 2022).

In cities, the motorisation rate is lower on average, but still growing: 637 cars per thousand inhabitants in the whole of capital municipalities (provincial and metropolitan), and 600 in the metropolitan capitals - both up 1.4% on the previous year, with significant differences between the geographical areas (602 in the Northern cities, 652 in the Central and 673 in those of the South and Islands).

These differences can be related to the offer of Local public transport, as where this is more abundant, motorisation rates tend to be lower. In general, this is the case in the cities compared to the rest of the territory, in the large cities compared to the small and medium ones (6,812 seat-km per capita in metropolitan capitals face to 2,343 in provincial capitals), and in the capital municipalities of the North (6,085 seat-km/inhabitant) compared to those of the Centre (5,407) and the South and Islands (1,972).

In 2022, pollution by ozone, substance produced in the atmosphere through photochemical reactions of other pollutants, is on the increase after four years of steady decrease, with an average number of exceedances of the long-term objective (120 µg/m3 of the daily 8-hour moving average) of 39 days. The high number of exceedance days characterises only the Northern provincial and metropolitan city capitals (62 days). In the Centre and the South, on the other hand, the trend is stable, with a much lower number of exceedance days.

TABLE 1. MAIN URBAN ENVIRONMENTAL INDICATORS FOR CAPITAL MUNICIPALITIES (PROVINCIAL AND METROPOLITAN) BY GEOGRAPHICAL AREA. Year 2022

YEAR	Average Temperature (absolute value and annual anomaly* in °C)		Toal Precipitarion (absolute value and annual anomaly*in mm)		Tropical nights (absolute value and annual anomaly* in number of nights)		Motorisation rate (passenger cars per 1,000 inhabitants)	Ozone pollution (average number of days exceeding target)	Total energy consumption (toe per 100 inh.)	Urban forestation (m^2 per haofi urban surface)	Total water losses in public water supply network (% on the volume input into the network)
Provincial capitals	16,6	(+1)	598,4	(-279)	58	(+20)	637	39	75,0	34,1	35.2
Metropolitan capitals	17,0	(+1)	561,3	(-232)	75	(+24)	600	37	65,1	21,3	31.0
Capital municipalities of:											
- North	15,8	(+1,3)	566,2	(-425)	54	(+23)	602	62	98,2	60,0	26.1
- Centre	16,9	(+1)	697,9	(-195)	52	(+21)	652	20	69,0	20,0	33.7
- South and Islands	17,5	(+0,7)	581,5	(-158)	67	(+17)	673	13	46,5	8,2	48.5

* Indicators of annual climatic anomaly are calculated wirh respect to avarage value of 2006-2015 decade.

Source: Istat, Survey on Meteoclimatic and Hidrological Datai; Istat, Urban Environmental Data; Istat, Urban Water Census.

Water Losses and Energy Consumption in Cities

Adaptation actions are also grounded in the efficient use of water and energy resources. In 2022, total water losses in public water supply networks across the 109 capital municipalities (provincial and metropolitan) amounted to 35.2% of the volume input into the distribution network, approximately seven percentage points below the national average of 42.4% e 10 points lower than the losses recorded in other municipalities (45.3%). This figure marks the lowest level recorded since 2012, following a peak of 39.0% in 2016. Despite a slight overall reduction in 2022 compared to 2020 (-1 percentage point), distribution losses increased in four out of ten capitals. Critical issues were more pronounced in the southern capital municipalities (48.5%), with losses ranging from 22.4% in the Northwest to 50.3% in the Islands. Furthermore, metropolitan capitals exhibited better water infrastructure conditions, with losses of 31.0% compared to 40.2% in other capitals.

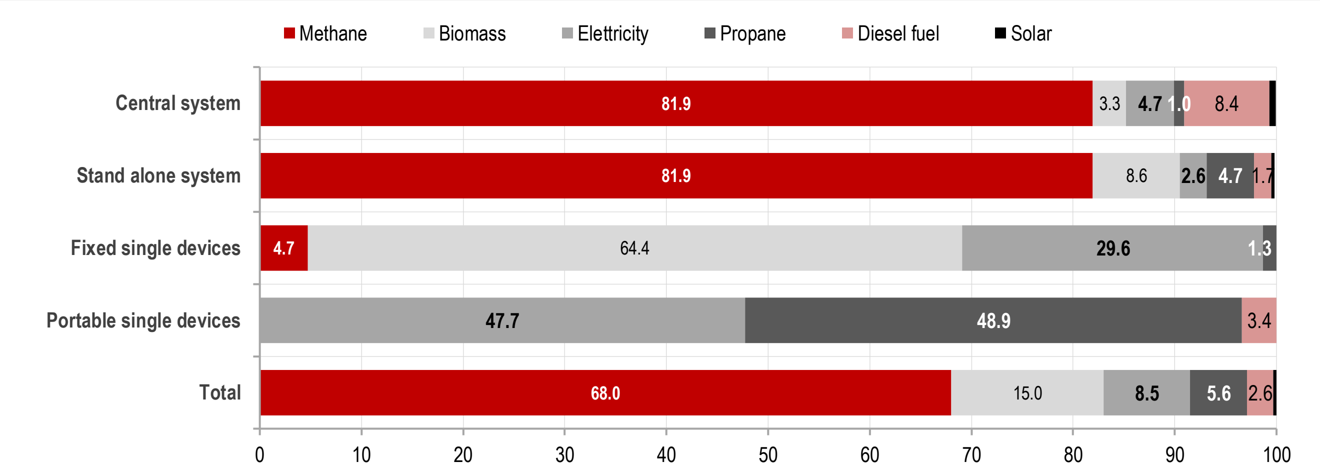
In 2022, for all the 109 capital municipalities, total energy consumption (electricity plus natural gas) decreased by 6.3% compared to the previous year and the level stood at 75 tonnes of oil equivalent (toe) per 100 inhabitants, a value lower than that of the period of the pandemic crisis in 2020 (75.2). The decrease in overall consumption is mainly due to the contraction in demand for natural gas, caused by the rise in raw material prices, by the consumption containment measures launched in the last quarter of 2022 as well as by particularly mild average temperatures in the last months of the year.

In geographical areas, despite the same downward trend, consumption levels are highly diversified because of different climatic, production and infrastructural conditions. In the Northern capitals, a total of 98.2 toe per 100 inhabitants are used (-8% compared to 2021); in the Centre, where the reduction is smaller (-3.6%), the average consumption is 69 toe per 100 inhabitants; finally in the South, consumption drops to 46.5 toe per 100 inhabitants (-4.5%).

Energy Consumption of Resident Households in Italy

Across the country, home heating systems, together with the increasing prevalence of air conditioning systems, devices and household appliances, have increased overall household demand for energy. In 2021, 98.6 percent of households have heating systems in their main residence (FIGURE 6), 99.6% have systems for producing hot water, and 48.8% have an air conditioning system. Refrigerators and washing machines are present in almost all households (99.5 and 97.3%, respectively), while half of them (50.2%) have a dishwasher, 15.2% a dryer separate from the washing machine, and 27.3% a freezer outside the refrigerator. Natural gas (methane) and electricity are the sources that have the greatest impact on household energy expenditure (83.8%). Furthermore, 17.0% of households use firewood and 7.3% use pellets with reference to 2020. 75.4% of households declare having made investments in energy savings in the five years preceding 2021.

FIGURE 6. POWER SOURCE OF THE MAIN HEATING SYSTEM OF THE MAIN RESIDENCES OF FAMILIES RESIDENT IN ITALY[a]. Year 2021, per 100 household equipped with heating.



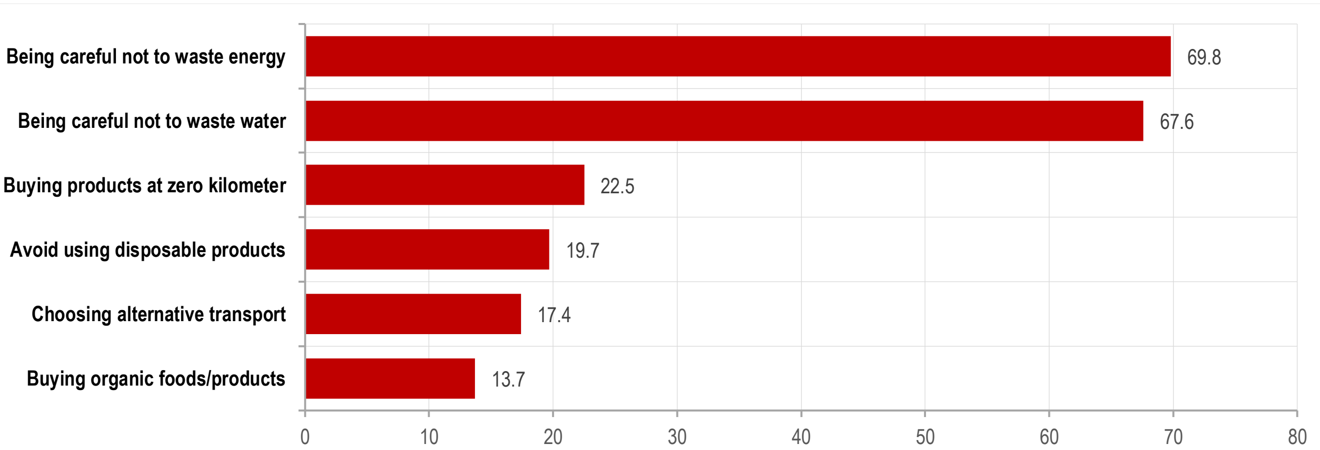
Source: Istat, Household Energy Consumption Survey.
a) Excluded 2.9% of households who could not indicate the source.

Concerns and Eco-friendly Behaviours of the Population

Concern about climate change and the greenhouse effect is among the top five environmental concerns of people (14 years and older): it is for about 71% of people (2022 and 2023). Over time, the share of people concerned about this has gradually increased (after the decline due to the pandemic), albeit to a lesser extent among men and in older age groups.

Many people adopt environmentally friendly behaviours; among the most popular are taking care not to waste energy and water (habitually adopted by 69.8% and 67.6% of people respectively); followed by buying zero-mileage products (adopted by 22.5%), avoiding disposable products (19.7%); choosing alternative means of transportation to the car and/or other private motor vehicles (17.4%), and buying organic products (13.7%) (Figure 7).

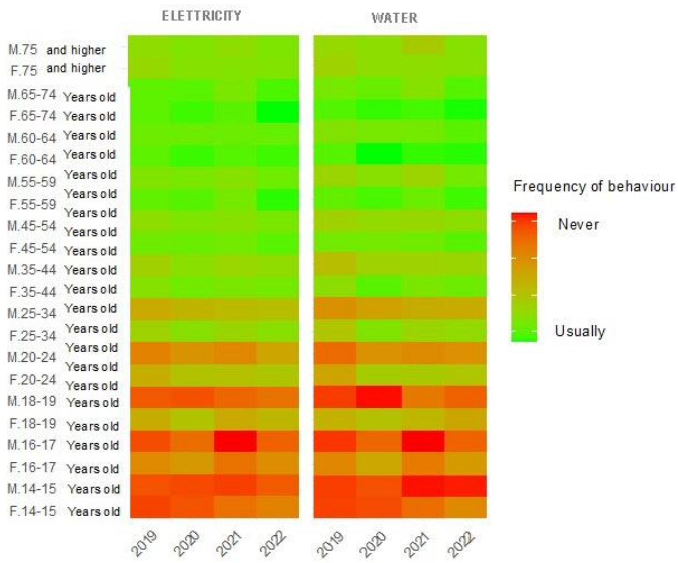
FIGURE 7. ECO-FRIENDLY BEHAVIOURS OF PEOPLE AGED 14 AND OLDER BY GEOGRAPHIC BREAKDOWN. Year 2022, per 100 persons 14 age and more



Source: Istat, Survey on Aspects of Daily Life.

Eco-friendly behaviors are found to be less frequent in younger age groups and among men. About half of 14- to 24-year-olds habitually take care not to waste water (49.5%) and energy (48.6%), compared with about three-quarters of people aged 55 and older (73.9% for water; 76.6% for energy) (Figure 8).

FIGURE 8. ECO-FRIENDLY BEHAVIORS: FOCUS ON NOT WASTING ELECTRICITY AND WATER BY GENDER AND AGE GROUPS. Year 2022, people aged 14 and over.



Source: Istat, Survey on Aspects of daily life.

The Subsections of the Italian Ecoregions

The classification of Italian Municipalities into Ecoregions represents a scientific approach to the ecological classification of the territory which provides for a division into units with an increasing degree of homogeneity. Using this classification, the peculiarities that this geographical typology is able to provide are considered, being the result of specific combinations of climatic, biogeographical, physiographic and hydrographic factors. These elements allow a more integrated and homogeneous view of the consequences of climate change in the territories involved. Through this classification, some data is presented on hydrogeological risk (landslides and floods) - to which Italy is naturally predisposed due to its geological, morphological and hydrographic characteristics, to which are added the increases in temperatures and precipitation extremes resulting from climate changes - and some indicators from the 7th General Agricultural Census.

The Ecoregions of Italy are organised in four nested hierarchical levels: 2 Divisions, 7 Provinces, 12 Sections and 33 Subsections, the latter being the subject of analysis (plus the 2 portions of the Provincie Illirica and Ligure Provenzale) (Table 2).

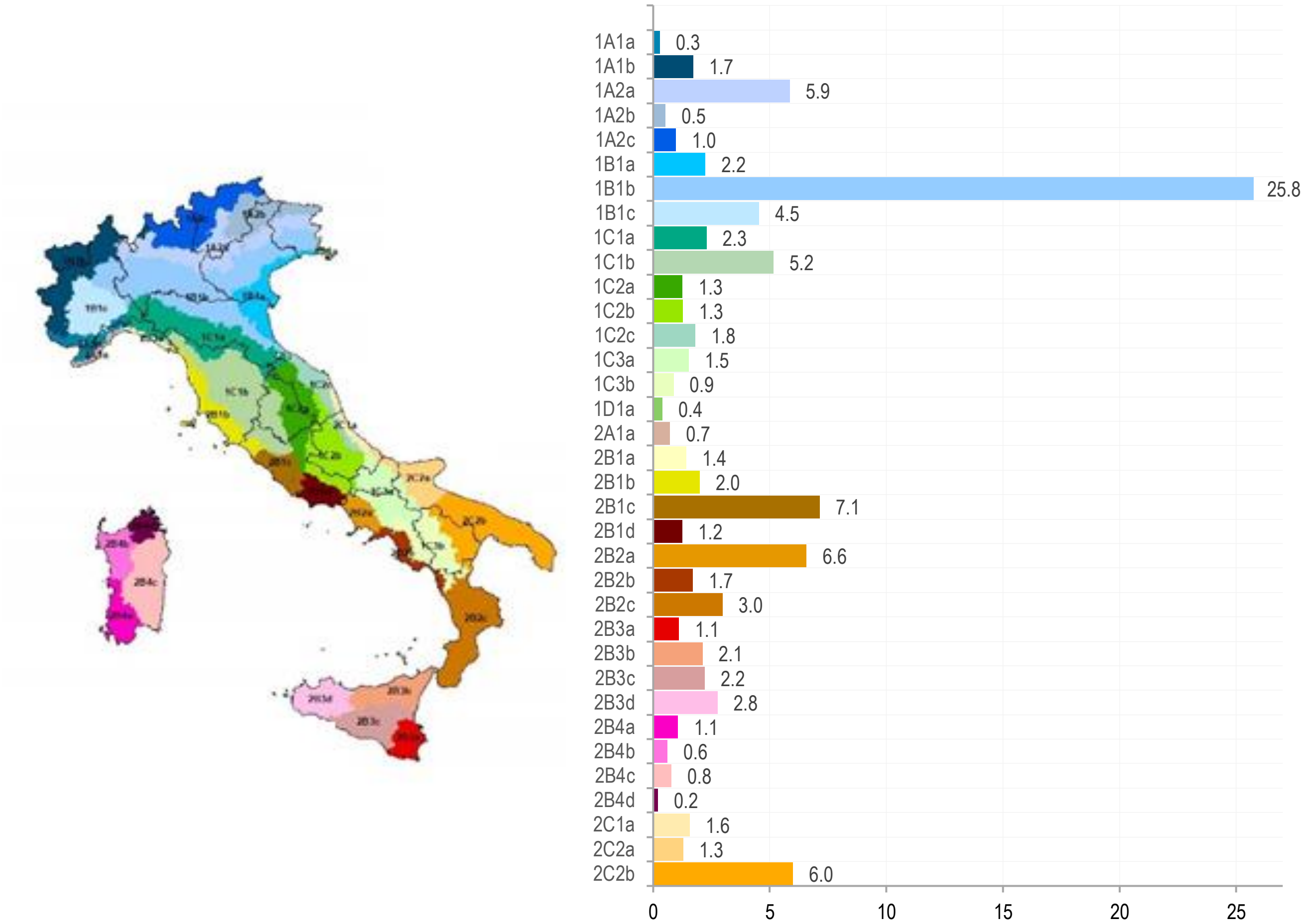
TABLE 2. CODES AND NAMES OF THE 33 SUB-SECTIONS OF THE ECOREGIONS (a)

1A1a	Alpi Marittime	1C2c	Sub-Appennino di Marche e Abruzzo	2B3a	Iblea
1A1b	Alpi Nord-Occidentali	1C3a	Appennino Campano	2B3b	Montana Siciliana
1A2a	Prealpina	1C3b	Appennino Lucano	2B3c	Siciliana Centrale
1A2b	Dolomitico-Carnica	*1D1a*	*Porzione della Provincia Illirica*	2B3d	Siciliana Occidentale
1A2c	Alpi Nord-Orientali	*2A1a*	*Porzione della Provincia Ligure Provenzale*	2B4a	Sarda Sud-Occidentale
1B1a	Lagunare	2B1a	Liguria di Levante	2B4b	Sarda Nord-Occidentale
1B1b	Pianura Centrale	2B1b	Maremmana	2B4c	Sarda Sud-Orientale
1B1c	Bacino Occidentale del Po	2B1c	Romana	2B4d	Sarda Nord-Orientale
1C1a	Appennino Tosco-Emiliano	2B1d	Laziale Meridionale	2C1a	Costiera di Marche e Abruzzo
1C1b	Bacino Toscano	2B2a	Campana Tirrenica Occidentale	2C2a	Garganica
1C2a	Appennino Umbro-Marchigiano	2B2b	Cilentana	2C2b	Delle Murge e Salento
1C2b	Appennino Laziale-Abruzzese	2B2c	Calabrese		

(a) Plus 2 portions of Provincie Illirica and Ligure Provenzale.

More than half of the population lives in the five most populous subsections (51.5%): 25.8% in the Pianura Centrale subsection (1B1b, 15,312,558 inhabitants), 7.1% in the Romana subsection (2B1c, 4,232,149 inhabitants) 6.6% in the Campana Tirrenica Occidentale (2B2a, 3,865,869 inhabitants), 6.0% in the Delle Murge e Salento subsection (2C2b) and 5.9% in the Prealpina (1A2a). The subsections of Sardegna appear to have very low population shares: 2.7% overall, with 1,569,832 people. The lowest share is related to North-Eastern Sardegna (2B4d, 0.2%, with 140,845 inhabitants).

FIGURE 9. PERCENTAGE DISTRIBUTION OF THE POPULATION IN THE SUB-SECTIONS OF THE ECOREGIONS Year 2023, percentage values (Itay=100)



Source: Istat, Population at 31/12/2023.

Hydrogeological Risk in the Subsections of the Italian Ecoregions

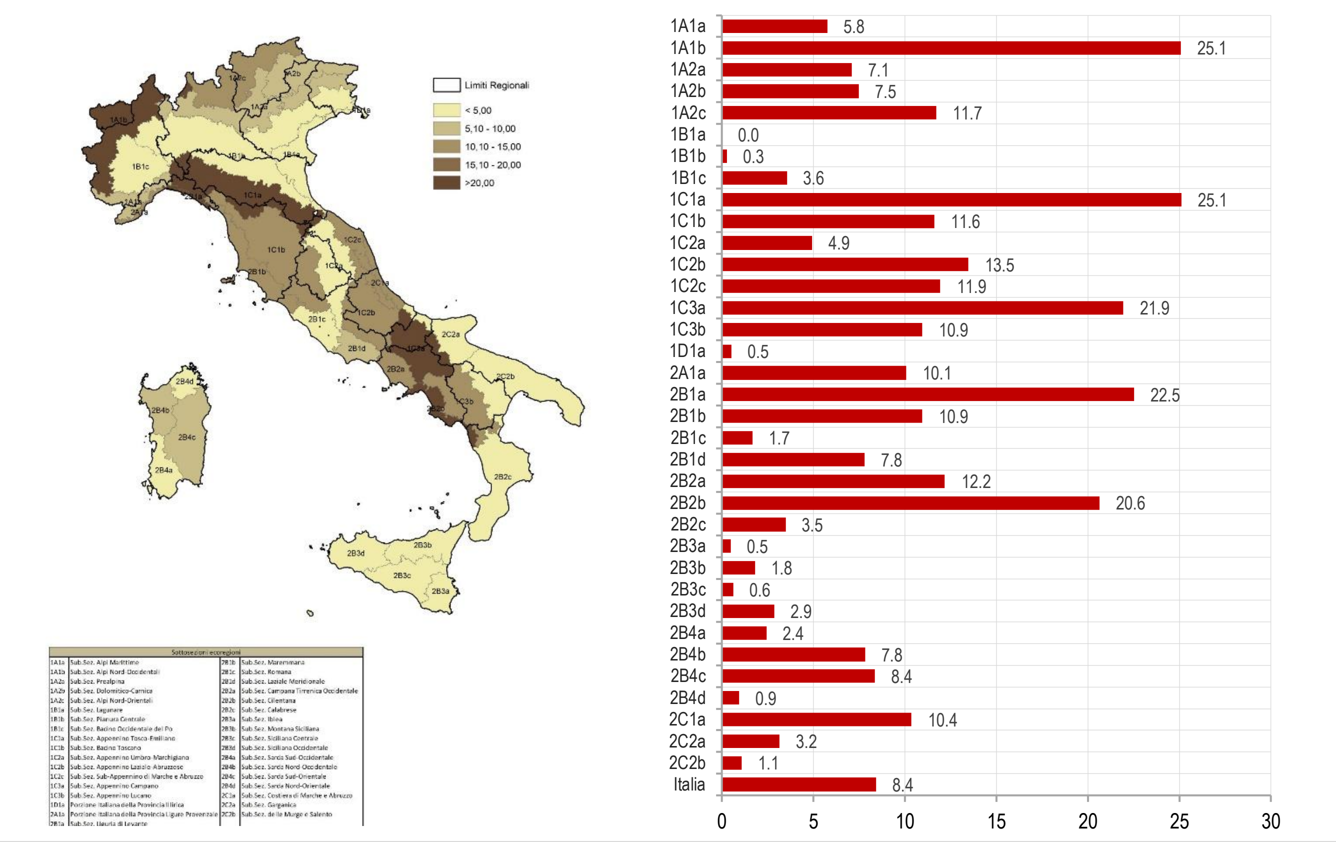
The hydrogeological risk, resulting from landslides in the area and from alluvial climate events in areas where rivers flood, is closely connected to the territorial morphology and the geology and lithology of the land. The interpretation provided by the classification of Italian Municipalities according to the Ecoregions contributes to enriching knowledge for the estimation and evaluation of risks. In the 33 ecoregional subsections, the share of surface exposed to landslide risk and flood risk[1] highlights a picture where some subsections are affected more by one phenomenon than the other, while some are affected by both (Figure 9).

The Lagunare (1B1a) and Pianura Centrale (1B1b) subsections, which cover a large part of the Valle del Po territory, involve portions of the Emilia-Romagna, Veneto, Friuli-Venezia Giulia, Lombardia and Piemonte regions and, given the flat morphology of the territory, have a natural predisposition to flood events, while the risk of landslides appears to have lower values and less than 5%. The particular exposure to the risk of flooding compared to the risk of landslides is linked to the predominantly flat and rather complex territorial morphology from the point of view of the river network which, in the presence of major flood events, can lead to disruption for the entire territory involved.

[1] Data on hydrogeological risk of areas exposed to landslides and flooding were compiled by ISPRA for the year 2020.

Even for the Maremma subsection (2B1b), which involves a part of the territory of the Toscana region and a small part of the territory of north-western Lazio, a rather large part of the territory is subject to flooding. In this case the territorial morphology which is partly flat and partly hilly also leads to an increase linked to the risk of landslides, so that the territory exposed to high and very high risk of landslides reaches 10.9%.

FIGURE 10. SURFACE EXPOSED TO HIGH AND VERY HIGH LANDSLIDE RISK BY SUB-SECTIONS OF THE ECOREGIONS (a). Year 2020, percentage values



Source: Istat, processing of data from ISPRA.
(a) Very high or high PAI landslide hazard areas - P3 and P4.

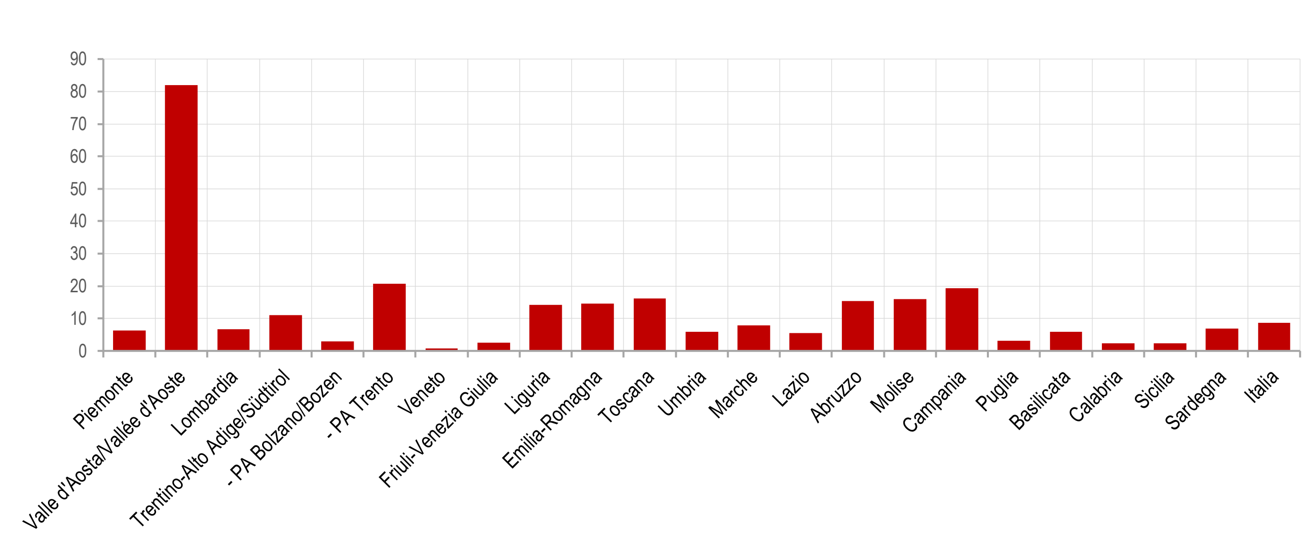
As regards Emilia-Romagna, Liguria and Toscana, part of their territory is included in the Appennino Tosco-Emiliano subsection (1C1a). Since it is a predominantly mountainous territory, the exposure to flood risk decreases, as it is crossed by the hydrographic network of rivers that head towards the valley floor, while the high and very high landslide risk reaches 25.1%, given the presence of the Appennino Tosco-Emiliano mountain range. For the subsections of Sicilia and Sardegna, there is a more homogeneous exposure to landslides and floods, as the risks present involve lower percentages of exposed surface, in the case of landslides between 5.1 and 10%.

The Dolomitico-Carnica subsections (1A2b) and the Alpi Nord-Orientali subsection (1A2c), which involve part of the Alpine arc, have a smaller surface exposed to flood risk. For the Dolomitico-Carnica subsection, the surface exposed to landslide risk is less than 10%, while that of the Alpi Nord-Orientali, which includes the entire Valle d'Aosta/Vallée d'Aoste, is greater than 20%.

This information is integrated with the regional analyses (Figure 11), so that the Valle d'Aosta/Vallée d'Aoste presents a high surface exposed to the risk of landslides (80%). Just under 15% of the surface of Emilia-Romagna is exposed to "high and very high" risk of landslides. For some regions such as Campania, Molise, Abruzzo, Tuscana, Liguria and Trentino-Alto Adige/Südtirol the surface exposed to "high and very high" risk of landslides is much more marked than that exposed to the risk of floods.

The presence of economic, social, environmental elements on the territory is decisive for risk assessment, based on the parameters of hazards, exposure and vulnerability.

FIGURE 11. SURFACE EXPOSED TO HIGH AND VERY HIGH LANDSLIDE RISK BY SUB-SECTIONS BY REGIONS (a). Year 2020, percentage values



(a) Very high or high PAI landslide hazard areas - P3 and P4.

Source: Istat, processing of data from ISPRA.

Italian Agriculture in the Context of Climate Change

In the context of climate change, Italian agriculture must deal with effects on crops and water availability, mainly due to the adverse impacts caused by extreme temperature and rainy events. This requires a strong capacity for resilience also in identifying diversified solutions that allow the preservation of economic activities. Below some indicators from the 7th General Census of Agriculture are shown.

They are presented according to the classification by Ecoregions, i.e. based on homogeneity with respect to climatic, biogeographical, physiographic and hydrographic factors, extremely relevant for territorial analyzes and management strategies of the territory at different scales.

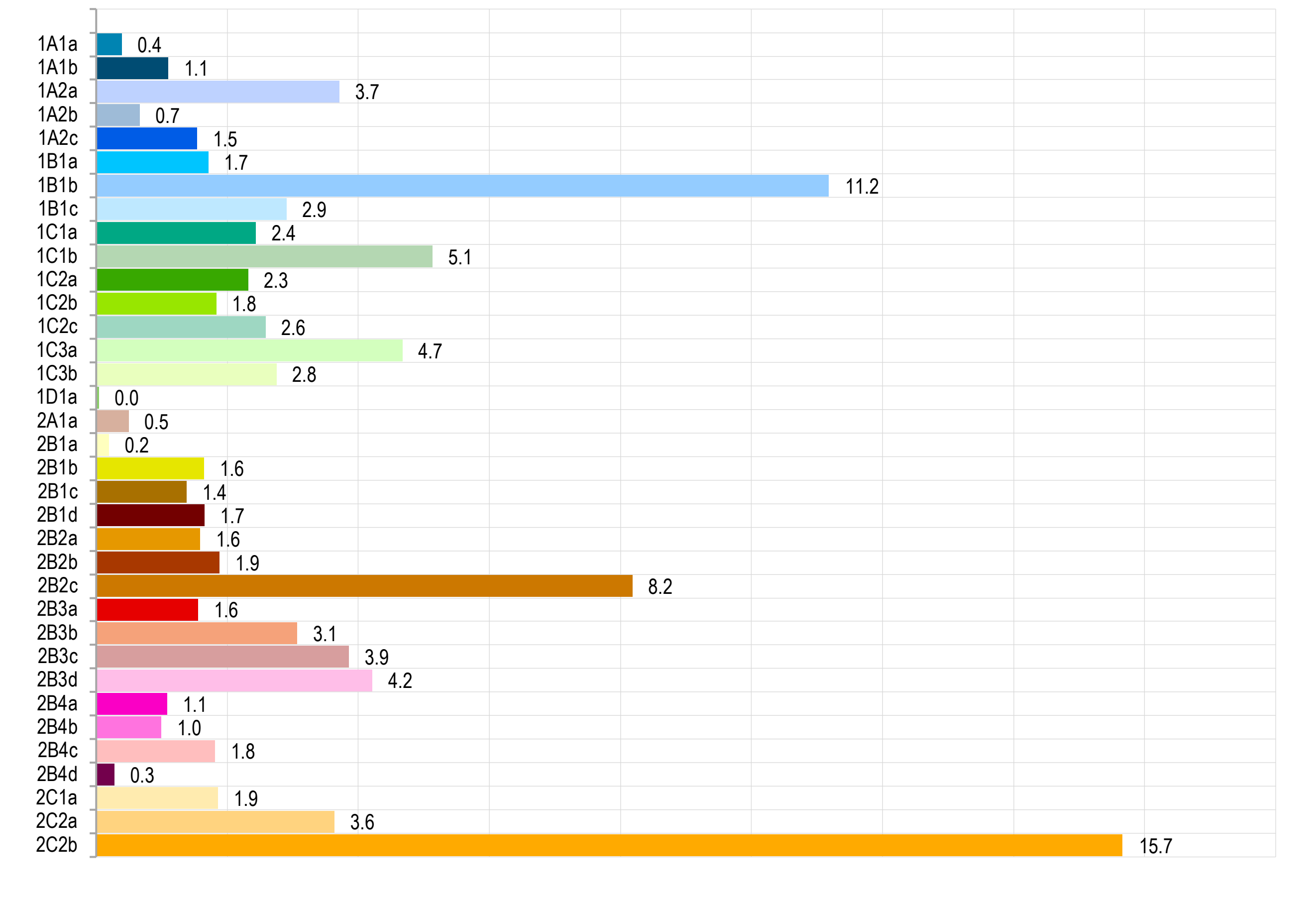
The Presence of Agricultural Holdings in the Italian Ecoregions

The evidences concerning the agricultural sector are particularly interesting. Agricultural holdings are configured as particular production units closely connected with the territory in which they are located, structured as individual businesses or partnerships, which practice the production of primary goods as their main activity. Just because of these characteristics there is high business risks for Italian agricultural holdings, as a consequence of climate change, geopolitical factors that influence supplies - including energy - and significant exogenous events such as the Covid-19 pandemic.

Although highly concentrated compared to 2010, in 2020 Italian agricultural holdings were still very numerous. The 2020 Census counted 1,133,006, for a used agricultural area (UAA) of 12,431,808 hectares.

35 farms out of 100 are located in just three subsections of the Ecoregions, the Pianura Centrale (1B1b, 11.2%), the Calabrese (2B2c, 8.2%) and that of the Murge and Salento (2C2b, 15.7%). These also correspond to approximately 30% of the national UAA (Figure 12).

FIGURE 12. - PERCENTAGE DISTRIBUTION OF AGRICULTURAL FARMING BY SUB-SECTIONS OF THE ECOREGIONS. Year 2020, percentage values (Italy=100).



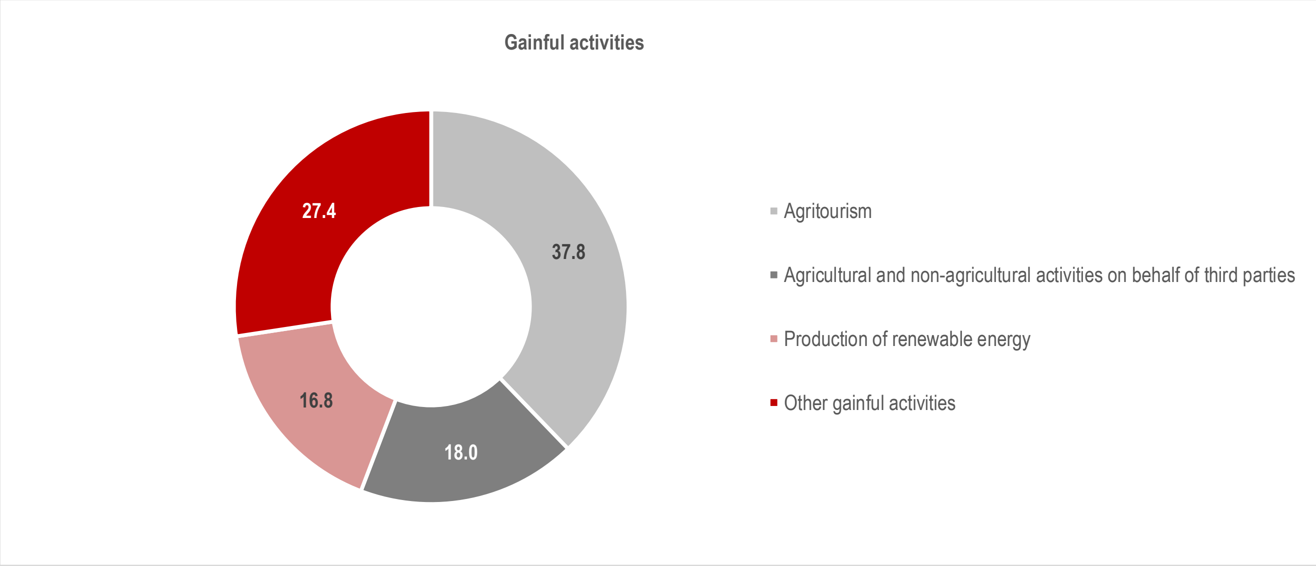
Source: Istat, 7th Agriculture Census.

Agricultural Holdings that Practice other Gainful Activities beyond the Primary one

The practice of other gainful activities beyond to the primary one is associated with the ability of the agricultural holding to diversify sources of revenue and business risk, to enhance the products and traditions of the territory and to enter into communication with various types of users, offering specific services, such as tourist, gastronomic or educational ones. These aspects can be considered factors of strength and resilience of the farms, with respect to the changes and market risks induced by climate change and other exogenous factors.

The photograph taken by the 7th General Census of Agriculture, referring to the 2019-20 agricultural year, i.e. in the period between 1 November 2019 and 31 October 2020, presents an evolving scenario compared to 2010: in ten years the percentage of agricultural holdings with at least one gainful activity increased from 4.7% to 5.7%. This data takes on particular relevance if we consider that, during the reference period, the Covid-19 epidemic spread which, in the primary sector, had important negative consequences on some of the main non-strictly agricultural activities, in particular on those that are open to the public. Among the other gainful activities, in 2020 the most widespread were: agritourism (carried out by 37.8% of holdings with connected activities), agricultural and non-agricultural activities on behalf of third parties (which involved 18.0%) and the production of renewable energy (16.8%) (Figure 13).

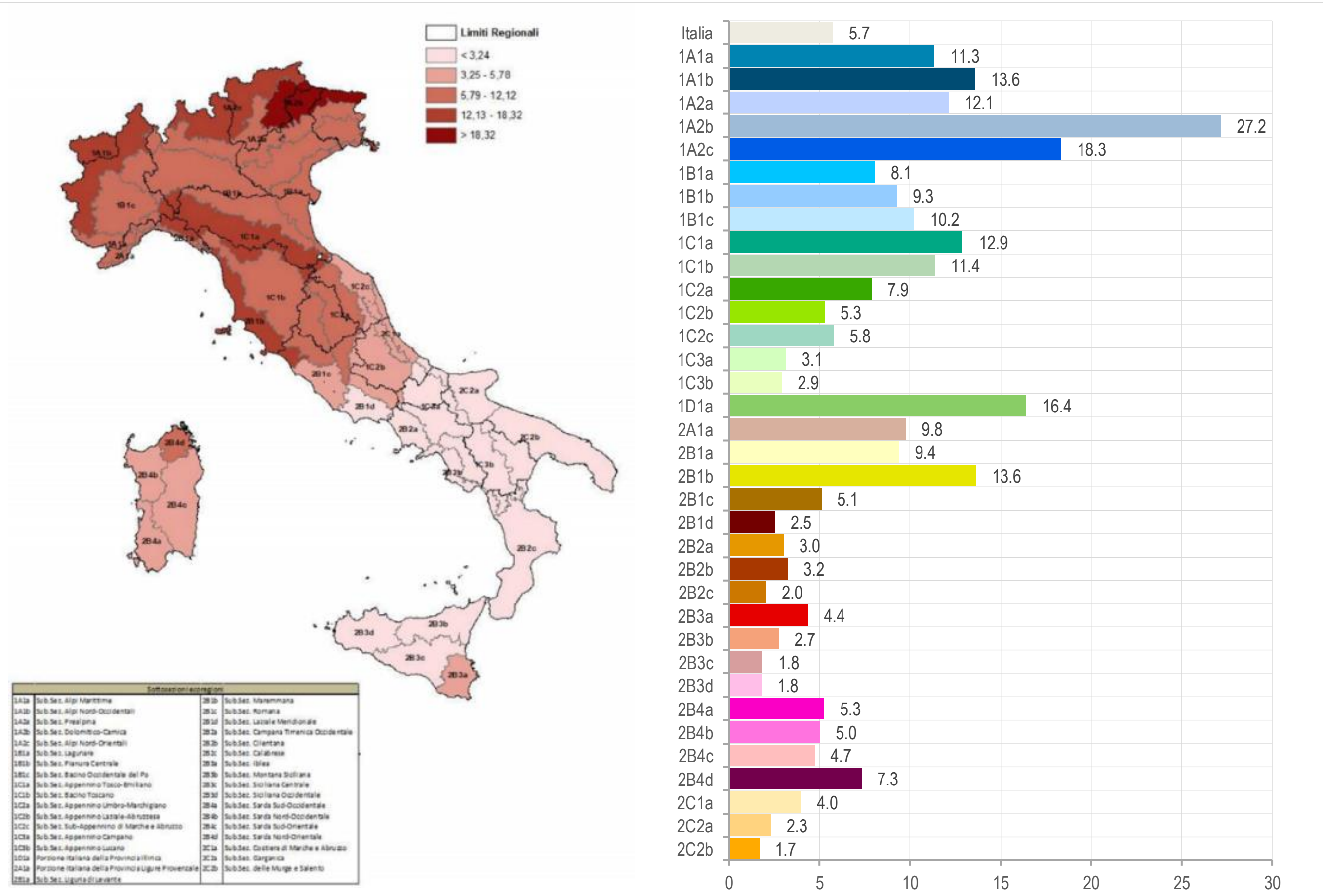
FIGURE 13. GAINFUL ACTIVITIES BEYOND THE PRIMARY ONE. Year 2020, percentage values.



Source: Istat, 7th Agriculture Census.

Clear territorial gaps persist. If, on the one hand, the share of holdings with at least one gainful activity exceeds 10% (in 10 subsections of the Ecoregions, with the peak of 27.2% in the Dolomite-Carnic subsection, 1A2b), on the other hand this share is lower than the national average in 18 of them (Figure 14). Furthermore, the persistent gap between the Centre-North and the South is evident, with the exception of Sardinia, with a strong concentration of holdings adopting diversification strategies located especially in the Alpine and pre-Alpine areas.

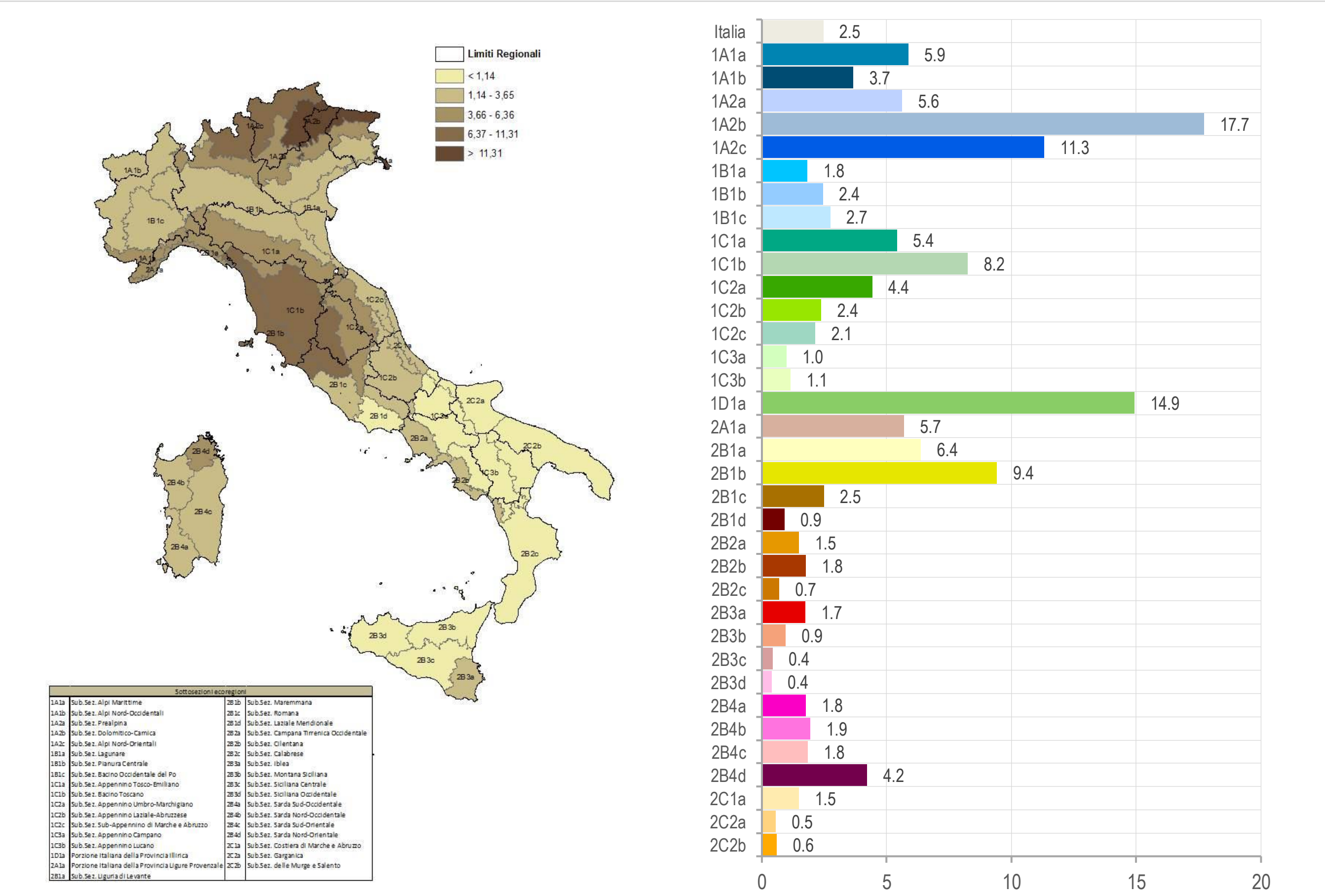
FIGURE 14. AGRICULTURAL HOLDINGS WITH AT LEAST ONE GAINFUL ACTIVITY, BY SUB-SECTIONS OF THE ECO REGIONS. Year 2020, percentage values.



Source: Istat, 7th Agriculture Census.

Among the numerous gainful activities practiced by agricultural holdings, those aimed at offering specific services to particular categories of customers play a central role. These are personal services offered not only by the aforementioned agritourisms, but also by educational farms and care farming. Educational farms were created to promote the connection between city and countryside, to raise awareness of the rural environment, the origin of food products and the life of animals. Care farming aims at the therapeutic use of the activities present on a farm, proposing often manual activities, such as breeding and care of animals and horticulture, which can be beneficial both in the educational field and to people in particular disadvantaged and difficult situations. Overall (Figure 15), in 2020 in Italy 2.5% of agricultural holdings offered one or more of the aforementioned personal services. Also in this case, a strong territorial gap persists, with percentages - with a few exceptions - on average much higher in the Central-Northern Ecoregions: the peaks characterize the Dolomite-Carnic Ecoregions (17.7%), Portion of the Illyrian Province (14, 9%), North-Eastern Alps (11.3%), Maremmana (9.4%) and Tuscan Basin (8.2%).

FIGURE 15. AGRICULTURAL HOLDINGS WITH AT LEAST ONE GAINFUL ACTIVITY THAT OFFERS SPECIAL SERVICES TO THE PERSON, BY SUB-SECTIONS OF THE ECOREGIONS. Year 2020, percentage values.

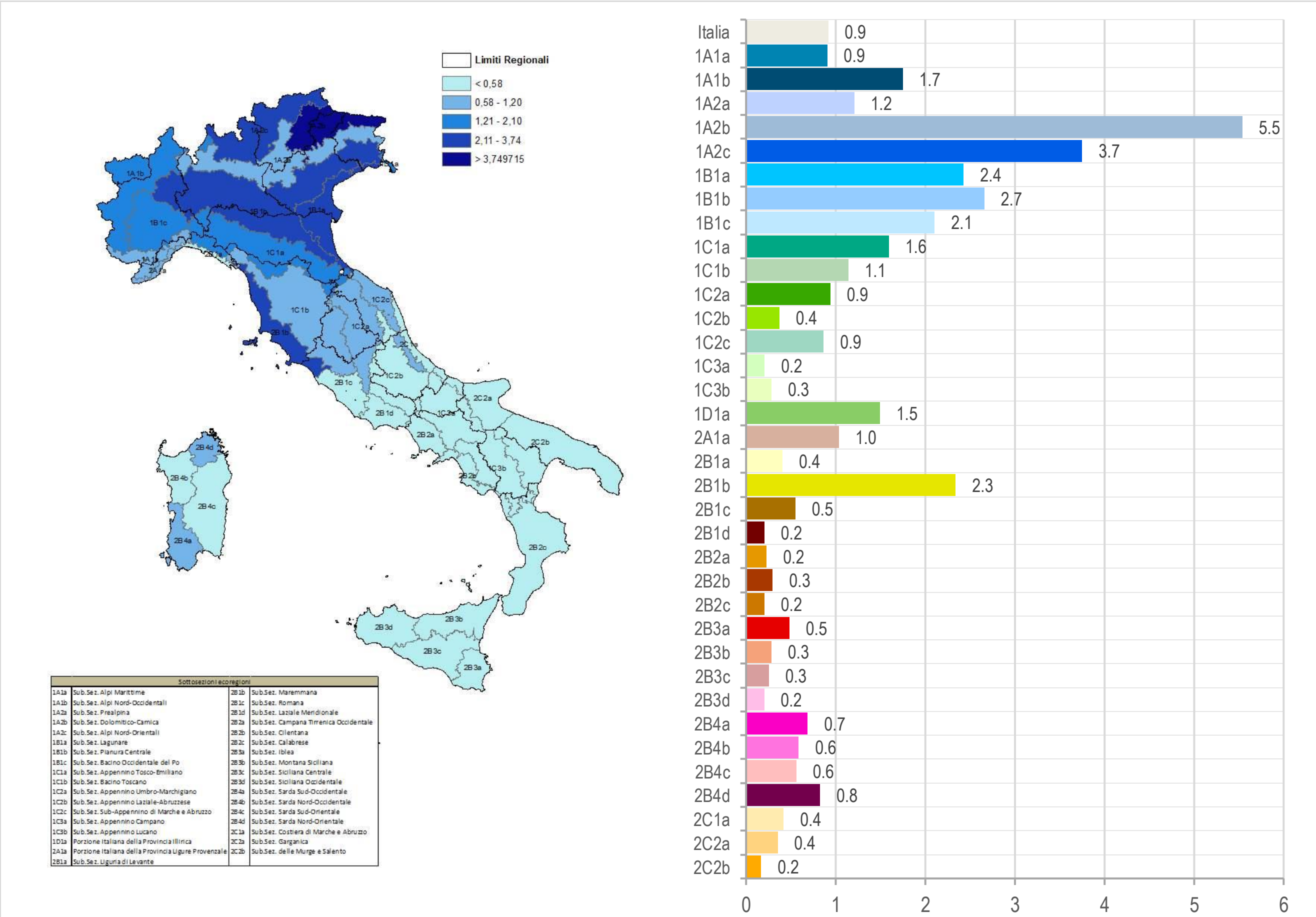


Source: Istat, 7th Agriculture Census. The services considered are agritourism, educational farm and social agriculture

Farms that Produce Sustainable Energy are still Few but Growing

As regards the production of energy from renewable sources, there are still few agricultural holdings capable of producing sustainable energy for commercial purposes, as these are recently developed activities: 0.9% of the total. However, it is a rapidly growing phenomenon, also thanks to the financial incentives of the Common Agricultural Policy and the PNRR, which must be framed in the broader path of growth of sustainability in the agricultural world. There are only six Ecoregions with relative shares higher than 2%, compared to 27 Ecoregions with relative shares lower than the national average. Also in this case the gap that penalizes the South compared to the Center-North is evident. The Dolomite-Carnic subsection is the one with the highest relative incidence of companies with energy from renewable sources (12b, 5.54%), followed by the North-Eastern Alps (1A2c, 3.75%; Figure 16).

FIGURE 16. AGRICULTURAL HOLDINSS WITH AT LEAST ONE GAINFUL RELATED TO THE PRODUCTION OF ENERGY FROM RENEWABLE SOURCES, BY SUB-SECTIONS OF THE ECOREGIONS. Year 2020, percentage values.



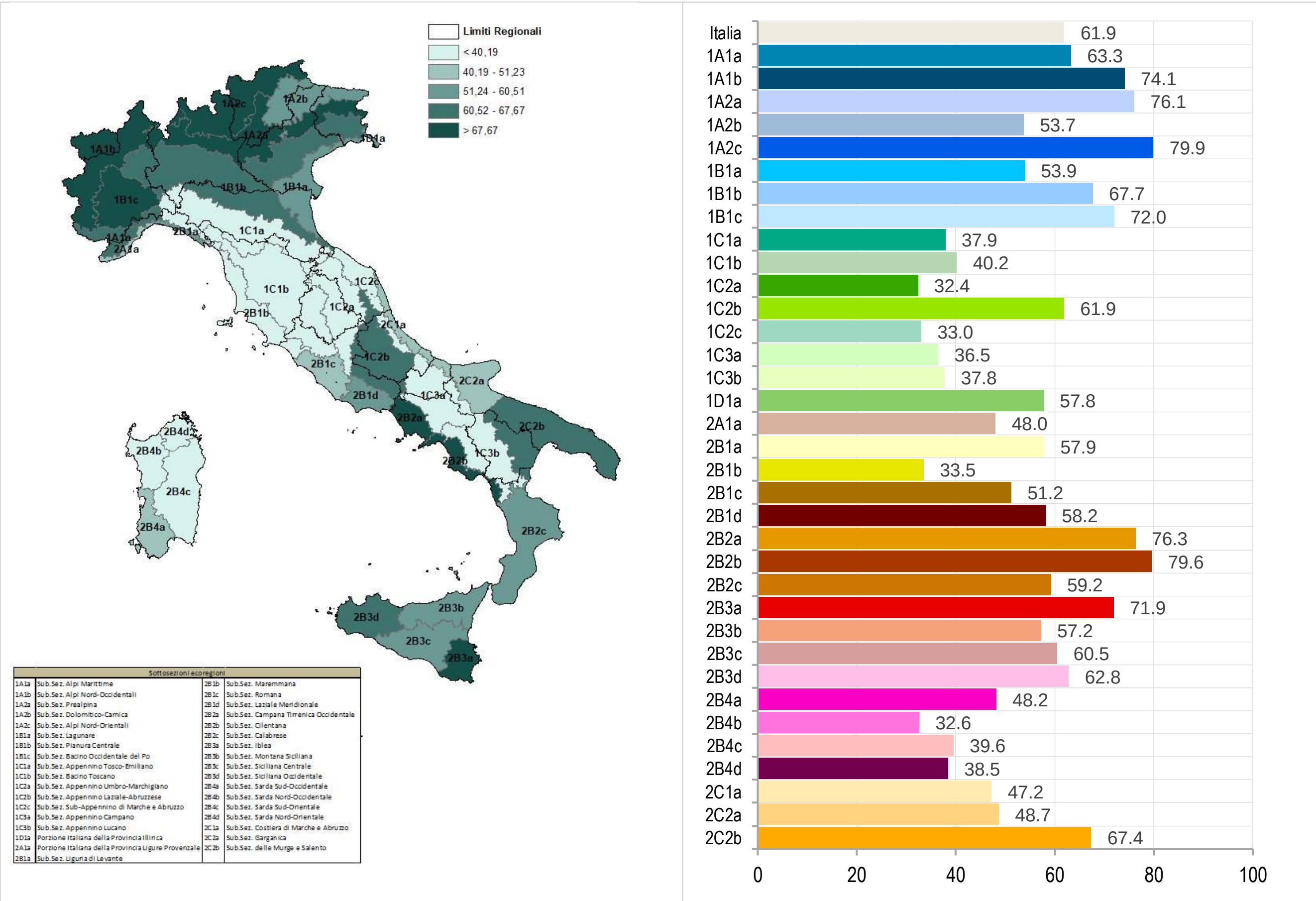
Source: Istat, 7th Agriculture Census.

Heterogeneity of Ecoregions in the Distribution of Irrigated Agricultural Surface Area

One of the undoubtedly important elements with reference to climate change is that relating to the availability of water, measurable through the Agricultural Census, which considers irrigable and irrigated agricultural surfaces. The irrigable surface represents the surface managed by farms that, during the agricultural year, may or may not be the subject of effective distribution of irrigation water. This last type of surface represents the actually irrigated surface. There is an extreme territorial heterogeneity in the percentage ratios between irrigated and irrigable agricultural areas.

Compared to the national average, equal to 61.9% (decreasing compared to 64.5% in 2010), the ratio is placed below or just above 40% in 11 Ecoregions, located mainly along the Apennine and in Sardinia, while it clearly exceeds the national average in the Alpine Ecoregions, along the Campania coast and in the provinces of Ragusa and Syracuse (Figure 17). The trend towards a decrease in the irrigated agricultural areas compared to potentially irrigable ones is an alarm indicator regarding the ability of the national agricultural system to have enough irrigation sources to guarantee both the expected production yields and the related quality standards.

FIGURE 17. IRRIGATED SURFACE, BY SUB-SECTIONS OF THE ECOREGIONS. Year 2020, percentage values.



Source: Istat, 7th Agriculture Census.

Methodological note

Climate is a key element within the major international agreements signed by countries in 2015: the Paris Agreement, the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction[2]. Consequently, the Green Deal and the European Adaptation Strategy, national plans and strategies for Recovery and Resilience, for Sustainable Development, for Ecological Transition, and for Climate and Energy (PNRR, SNSVS, PTE, PNIEC) and all related regional and local acts.

The Paris Agreement adopted at the 21st Conference of the Parties to the Convention (COP21), requires countries to accelerate and intensify efforts to combat Climate Change through nationally determined contributions (NDCs), including national adaptation plans (NAPs).

The 2030 Agenda for Sustainable Development brings together in a holistic view all economic, social, environmental and institutional phenomena through 17 integrated and indivisible goals.

The Sendai Framework clear shift in focus from disaster management to integrated and anticipatory disaster risk management through the prominent role accorded to prevention activities, with 7 global goals to be achieved by 2030:
(a) Substantially reduce global disaster mortality
(b) Substantially reduce the number of affected people globally
(c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP)
(d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services
(e) Substantially increase the number of Countries with national and local disaster risk reduction strategies
(f) Substantially enhance international cooperation to Developing Countries
(g) Substantially increase the availability of and access to multi-hazard early warning systems.

Within UNECE and UNSD, guidelines have been developed and sets of key indicators selected according to criteria of relevance, data availability, and cross-country comparability have been defined for both climate change and disaster risk-related statistics, organized by areas and topics.

- UNECE defined a set of 44 indicators for climate change-related statistics (CCRS), for the 5 areas: determinants, emissions, impacts, mitigation, adaptation;
- UNSD a set of 158 indicators for climate change related statistics (CCRS) for the 5 areas determinants, impacts, vulnerability, mitigation, adaptation
- UNECE also developed a set of 54 indicators for disaster risk (DRS).

The convergence between the different frameworks and sets of indicators is to be seen in the different forms of pressures and determinants, and on the response side in the integration and coherence also with the principles of Sustainable Development. For example, of the 44 UNECE indicators related to climate change, 8 are SDG indicators and 4 are SENDAI indicators; of the 54 UNECE indicators related to disaster risks, 12 are SDG indicators and 12 are SENDAI indicators. The latter are organized according to the identification of different elements at risk, such as: People, Housing, Basic Services, Critical Infrastructure, Economic Activities, Ecosystems, Food Security and Agriculture, Water Security, Energy Security, Health Care, Cultural Heritage.

With particular reference to the Agriculture sector, the UNECE CCRS set identifies a number of indicators relevant to mitigation, impacts and adaptation; the UNSD CCRS set considers both indicators of impacts on agricultural production and vulnerability for food security, the latter identified as an element at risk in the UNECE DRS framework.

Given the interconnectedness of the phenomena, this work involves several goals of the 2030 Agenda, such as Climate Action (Goal 13), Zero Hunger (Goal 2), Sustainable Cities and Communities (Goal 11), Affordable and Clean Energy (Goal 7), Clean Water and Sanitation (Goal 6), and Life on Land (Goal 15).

MAIN SUSTAINABLE DEVELOPMENT GOALS RELATED TO THE WORK PRESENTED

[2] https://unfccc.int/process-and-meetings/the-paris-agreement
www.un.org/sustainabledevelopment/sustainable-development-goals/

OUTLINE OF THE 44 CORE UNECE INDICATORS RELATED TO CLIMATE CHANGE, BY AREA AND SUB-AREA (UNECE, CCRS)

Sub Areas AREA	Drivers	Emissions	Impacts	Mitigation	Adaptation
National total	6	5	1		
Production	2	2			
ConsumptioExpendituresn	1	2			
Physical conditions			3		
Water resources			1		1
Land, land cover, ecosystems and biodiversity			3		
Human settlements and human health			4		1
Agriculture, forestry and fishery			1	1	2
Energy resources				2	
Environmental governance and regulation				4	
Expenditures				1	1
Total	**9**	**9**	**13**	**8**	**5**

The set of core indicators intentionally does not break down drivers and emissions according to economic sectors.
Source: Istat, processing of data from UNECE

OUTLINE OF THE 158 INDICATORS OF THE UNSD GLOBAL SET FOR CLIMATE CHANGE, BY AREA AND TOPIC (UNSD, CCRS)

DRIVERS 26	Total greenhouse gas emission	8
	Atmospheric concentration of greenhouse gases	1
	Energy production, supply and consumption	5
	Fossil fuels	2
	Population	2
	Transports	2
	Land and agriculture	6
IMPACTS 54	Agricultural production affected by climate change	4
	Areas affected by climate change	5
	Freshwater resources	3
	Hazardous events and disasters	5
	Climate change and human health	3
	Climate change evidence	14
	Soil condition	1
	Distribution and status of specie	4
	Distribution and status of ecosystems	8
	Production and consumption of materials	1
	Climate change impacts on transport and critical infrastructure	3
	Climate change impacts on tourism	3

VULNERABILITY 28	Water security, food security and agriculture	6
	Vulnerable species, ecosystems and their service	4
	Buildings and infrastructure vulnerable to climate change	2
	Vulnerable population	13
	Area of country vulnerable to climate change	3
MITIGATION 18	Renewable energy	5
	Climate change mitigation policies, strategies and plans	6
	Climate change mitigation technology and practice	7
ADAPTATION 32	Climate change adaptation policies, strategies and plans	6
	Risk management, disaster forecasting and early warning system	5
	Public awareness of and education on climate change	4
	Area-based adaptation to climate change	8
	Climate change monitorin	5
	Water management	1
	Waste managemen	3

Source: Istat, processing of data from UNSD

OUTLINE OF THE 54 BASIC UNECE DISASTER RISK INDICATORS BY AREA AND RELATED RISK ELEMENTS (UNECE, DRS)

	Elements at risk:	People	Housing	Basic services	Critical infrastructure	Economic activity	Eco-systems	Food security and agriculture	Water security	Energy security	Health care	Cultural heritage
Dimensions of hazards	3	x	x	x	x	x	x	x	x	x	x	x
Disaster Risk Reduction Activity	6	x	x	x	x	x	x	x	x	x	x	x
Exposure	7	x	x	x	x			x			x	
Vulnerability	6	x		x		x	x	x	x	x	x	x
Coping capacity	12	x	x	x	x	x	x	x	x	x	x	x
Direct impacts	20	x	x	x	x	x	x	x	x	x	x	x

Source: Istat, processing of data from UNECE.

APPENDIX 1. 44 UNECE BASIC INDICATORS RELATED TO CLIMATE CHANGE.

DRIVERS
Total energy use by the national economy
Total primary energy supply (TPES)
Share of fossil fuels in total energy use by the national economy
Share of fossil fuels in total primary energy supply (TPES)
Losses of land covered by (semi-) natural vegetation
Total support for fossil fuels in relation to GDP
Total energy intensity of production activities of the national economy
Total CO_2 intensity of energy used in production activities of the national economy
Energy use by resident households per capita
EMISSIONS
Total CO_2 intensity of energy used in production activities of the national economy
Total greenhouse gas emissions from the national territory
CO_2 emissions from fuel combustion attributable to the national economy
CO_2 emissions from fuel combustion within the national territory
Greenhouse gas emissions from land use change (LULUCF)
Total greenhouse gas emissions from production activities
Greenhouse gas emission intensity of production activities
Direct greenhouse gas emissions from households
Carbon footprint
MITIGATION
Renewable energy share in total energy use by the national economy
Renewable energy share in the total final energy consumption within the national territory (SDG 7.2.1)
Share of climate change mitigation expenditure in relation to GDP
Share of energy and transport related taxes in total taxes and social contributions
Total climate change-related subsidies and similar transfers in relation to GDP
Average trading carbon price
Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025 (SDG 13a.1)
Net emissions/removals of carbon dioxide by forest land
IMPACTS
Direct economic loss attributed to hydro-meteorological disasters in relation to GDP (SDG 11.5.2; Sendai Framework C-1)
Mean temperature anomaly (compared to climate normal 1961 - 1990)
Percentage of land area suffering from unusually wet or dry conditions (Standard Precipitation Index)
Occurrence of extremes of temperatures and precipitation
Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (SDG 6.4.2)
Carbon stock in soil
Proportion of land that is degraded over total land area (SDG 15.3.1)
Placeholder for an indicator on CC impact on biodiversity
Number of deaths and missing persons attributed to hydro-meteorological disasters per 100,000 population (SDG 1.5.1, 11.5.1,13.1.1; Sendai Framework A-1)
Number of people whose destroyed dwellings were attributed to hydro-meteorological disasters (Sendai Framework B-4)
Incidence of climate-related vector-borne diseases
Excess mortality related to heat
Direct agricultural loss attributed to hydro-meteorological disasters (Sendai Framework C-2)
ADAPTATION
Share of government adaptation expenditure in relation to GDP
Change in water use efficiency over time (SDG 6.4.1)
Share of green urban areas in the total area of cities
Placeholder for indicator on CC adaptation by forests
Proportion of agricultural area under productive and sustainable agriculture (SDG 2.4.1)

Legend of colors:

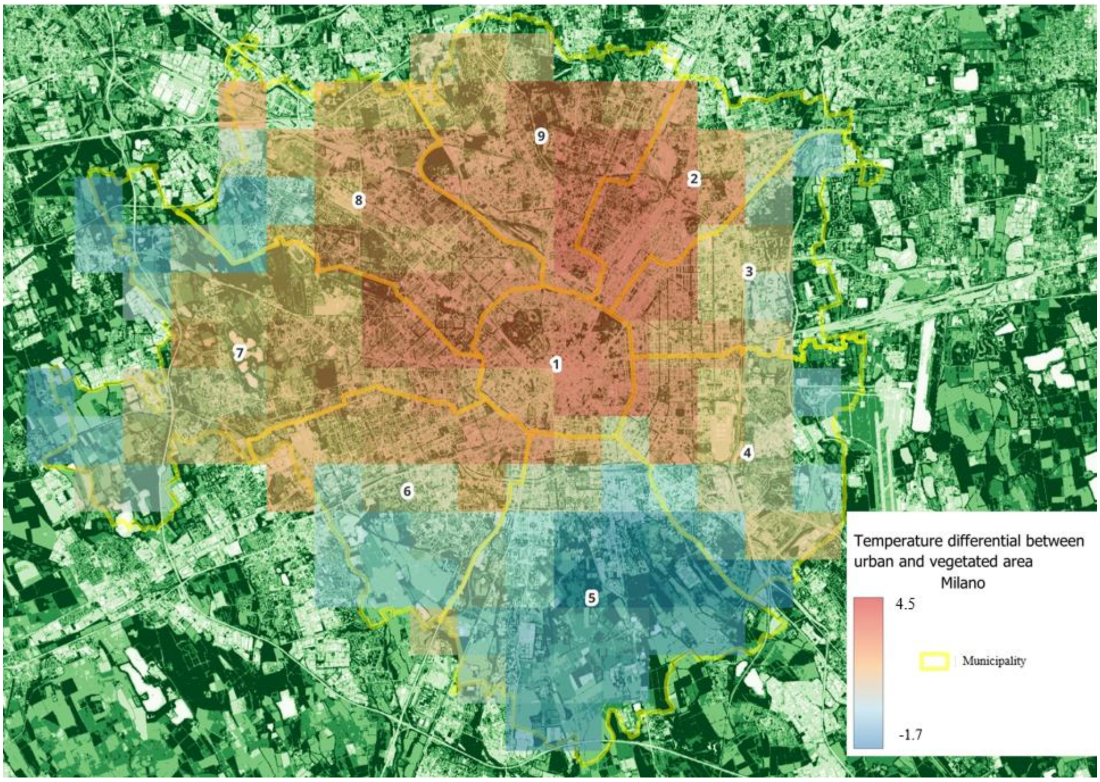
- Calculable indicator for Italy with data from environmental accounts
- Calculable indicator for Italy with data from statistical sources other than environmental accounts
- Calculable indicator at the European level
- Indicator not calculable for Italy

APPENDIX 2. 54 UNECE DISASTER-RELATED CORE INDICATORS.

Area	Indicator (SDG = Sustainable Development Goals Indicator; SF = Sendai Framework Indicator; ISIC=- International Standard Industrial Classification of All Economic Activities, rev. 4.0)
Dimensions of hazards	Number of hazardous events per year (per type of hazard)
	Proportion of hazardous events with deaths per year (per type of hazard)
	Proportion of coastal areas vulnerable to sea level rise
Disaster Risk Reduction Activity	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies (SDG 1.5.4, SF E-2)
	Proportion of government expenditure on DRR in relation to GDP
	Proportion of curriculum (hours) in schools dealing with disaster risk in relation to total hours
	Proportion of government expenditure in early warning or Early Warning Systems (EWS) in relation to GDP
	Proportion of government expenditure on risk awareness programs in relation to GDP
	Proportion of municipalities with land use plans with consideration of disaster risk in relation to total land use plans
Exposure	Proportion of population living in hazard-prone areas in relation to total population
	Proportion of population living in areas affected by projected 1 m sea-level rise
	Proportion of dwellings located in hazard-prone areas in relation to total dwellings
	Proportion of road infrastructure (km) located in hazard-prone areas in relation to total road infrastructure (km)
	Proportion of farmland in hazard-prone areas in relation to total farmland
	Proportion of hospital beds in hazard-prone areas in relation to total beds
	Proportion of population supplied by water supply industry (ISIC 36) in relation to total population in hazard prone areas
Vulnerability	Proportion of population living below the national poverty line, by sex and age (SDG 1.1.1)
	Old-age dependency ratio
	Proportion of energy from thermal, nuclear and hydroelectric power plants in relation to total energy generation
	Proportion of population without quality access to electricity
	Proportion of world heritage sites without an emergency preparedness plan
	Proportion of land that is degraded over total land area (SDG 15.3.1)
Coping capacity	Proportion of agricultural area under productive and sustainable agriculture (SDG 2.4.1)
	International Health Regulations (IHR) capacity and health emergency preparedness (SDG 3.d.1)
	Number of people per 100,000 that are covered by early warning information through local governments or through national dissemination mechanisms (SF G-3)
	Percentage of population exposed to or at risk from disasters protected through pre-emptive evacuation following early warning (SF G-6)
	Proportion of the target population covered by all vaccines included in their national programme (SDG 3.b.1)
	Health worker density (SDG 3.c.1)
	Proportion of population served by municipal waste collection
	Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type (SDG 15.1.2)
	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water (SDG 6.2.1)
	Proportion of population with access to electricity (SDG 7.1.1)
	Percentage of local governments having a plan to act on early warnings (SF G-4)
	Proportion of government expenditure in strategic reserves
Direct impact	Number of disasters (per hazard type) declared by government per year
	Direct economic loss attributed to disasters in relation to global gross domestic product (GDP) (SDG 1.5.2, SF C-1))
	Proportion of government expenditure in disaster assistance in relation to GDP
	Number of deaths attributed to disasters, per 100,000 population (SF A-2)
	Number of missing persons attributed to disasters, per 100,000 population (SF A-3)
	Number of injured or ill people attributed to disasters, per 100,000 population (SF B-2)
	Number of refugees, migrants and persons displaced by disasters, per 100,000 population
	Proportion of destroyed dwellings in relation to total number of dwellings
	Number of people whose destroyed dwellings were attributed to disasters (SF B-4)
	Economic value of lost or damaged housing stock in relation to total value of housing stock
	Number of disruptions to basic services attributed to disasters (SF D-5)
	Number of person days without electricity due to hazardous events
	Number of person days without gas supply due to hazardous events
	Number of person days without water supply due to hazardous events
	Damage to critical infrastructure attributed to disasters (SF D-1) (Economic value of damage to critical infrastructure attributed to disasters)
	Proportion of land that is degraded over total land area (SDG 15.3.1)
	Direct economic loss to cultural heritage damaged or destroyed attributed to disasters (SF C-6)
	Proportion of flooded land over total land area
	Proportion of forest area affected by forest fires
	Direct agricultural loss attributed to disasters (SF C-2)

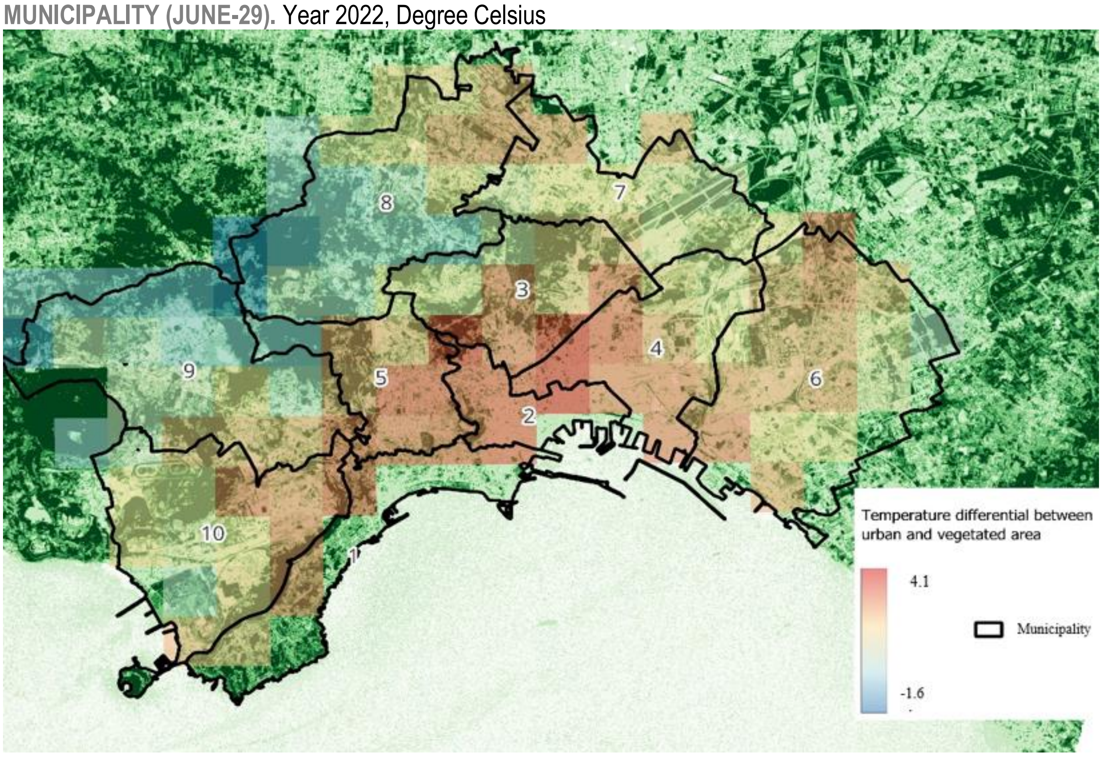
APPENDIX 3. TEMPERATURE DIFFERENTIAL BETWEEN URBAN AND VEGETATED AREAS IN THE MUNICIPALITY OF MILANO, NAPOLI, ROMA.

FIGURE 1. TEMPERATURE DIFFERENTIAL BETWEEN URBAN AND VEGETATED AREAS IN THE MUNICIPALITY OF MILANO BY MUNICIPALITY (JULY-31). Year 2022, Degree Celsius



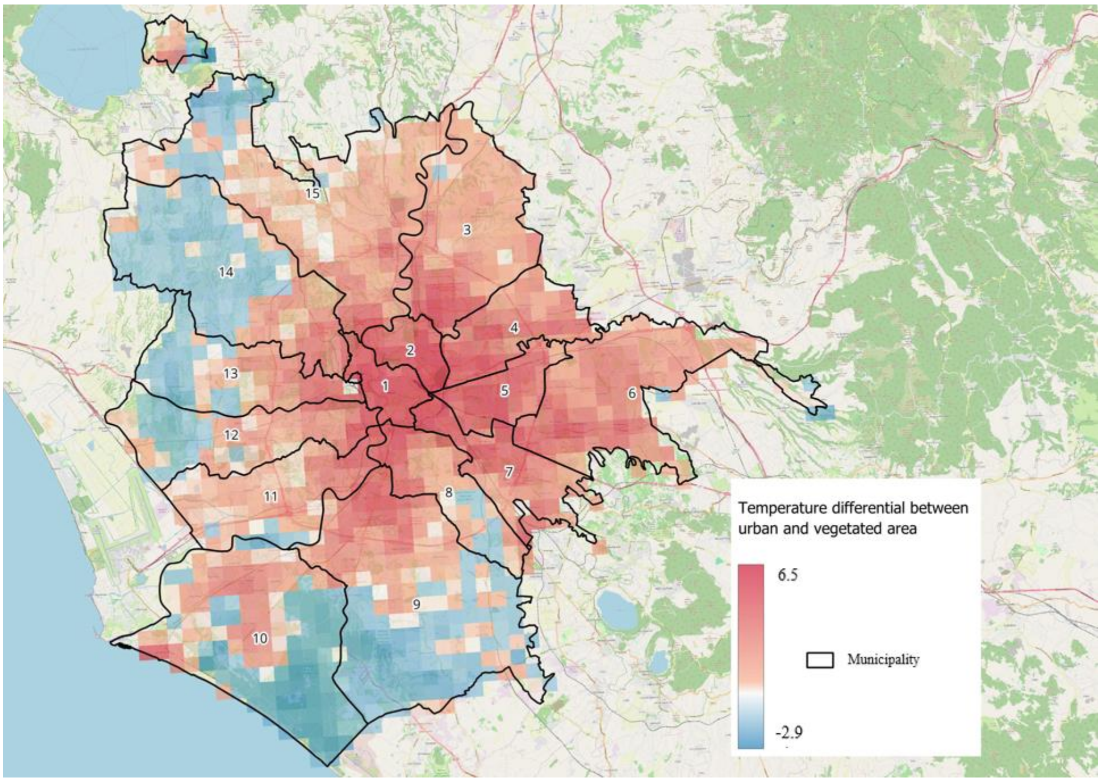
Source: ESA, processing of data from European Space Agency (ESA); Basi Territoriali 2021 (Istat).

FIGURE 2. TEMPERATURE DIFFERENTIAL BETWEEN URBAN AND VEGETATED AREAS IN THE MUNICIPALITY OF NAPOLI BY MUNICIPALITY (JUNE-29). Year 2022, Degree Celsius



Source: ESA, processing data from European Space Agency (ESA); Basi Territoriali 2021 (Istat).

FIGURE 3. TEMPERATURE DIFFERENTIAL BETWEEN URBAN AND VEGETATED AREAS IN THE MUNICIPALITY OF ROMA BY MUNICIPALITY (JUNE-14). Year 2022, Degree Celsius.



Source: ESA, processing of data from European Space Agency (ESA); Basi Territoriali 2021 (Istat) and OpenStreetMap.

Meteoclimatic Statistics, Indices of Extrems and Climate Change Indicators

Statistical measures on meteoclimate are produced through data collected by the current Istat Survey on Meteoclimatic and Hydrological data (included in the National Statistical Program code IST-02190) from Management Bodies of national networks of thermo-pluviometric stations located on the ground, within the municipal territory of the 109 Provincial Capital municipalities. The reference period of the daily data collected is the year. Variables detected: minimum temperature, mean temperature, maximum temperature, total precipitation, relative umidity. The measurements of the stations detected, statistics and calculated indicators provide measurements relating to climatic characteristics of the individual monitored areas. Through this Survey, the Istat georeferenced Meteo Database 1971-2022 was updated. In addition to the indicators of average annual temperature and total annual precipitation, by applying methodologies defined by the World Meteorological Organization (WMO) of the United Nations (UN), a set of 21 Indices of Meteoclimatic Extremes (12 of temperature and 9 of precipitation) are calculated for each city, expressed in physical units (number of days in which a certain event occurs, degrees Celsius, millimeters). The annual values of temperature and precipitation indicators and of Indices pf Extreme are compared (a) with the corresponding average values of the decade 2006-2015 to calculate the *climatic differences* in the short term for each city; (b) with the climatic values of the thirty years 1981-2010 and 1971-2000 (Climatological Normals) to measure the *climatic anomalies* describing long-term climate changes by city.

For further information:

Istat Survey on Meteoclimatic and Hydrological Data – Information

Istat – Statistical Report Climatic Profiles of Provincial Capitals

Istat – Tables of Data Temperature and Precipitation in Provincial Capital Municipalities, Year 2022 and time Series 2006-2022

The seventh census of agriculture

The 7th census of agriculture finds its regulatory basis in Regulation (EU) 2018/1091 of the European Parliament and of the Council of July 18th 2018 relating to integrated statistics on agricultural holdings. Therefore, the 2020 census was mandatory in each European Union country and coherent with recommendations by FAO (2017). The census had the purpose of updating the structural data collected with the 2010 census and enriching the available information assets. The most critical feature was the actual state of activity of the farms, in a historical context characterized by the concentration of farms and the consequent decrease of very small agricultural units. The census referred to October 1st 2020 and included questions concerned with the degree of modernization and sustainability of farms. It counted 1,133,006 farms, including common lands, outlining the sharp decrease in the number of agricultural holdings between 2010 and 2020 (-30.1%). The 2020 census questions derived from the information needs that emerged at the EU level, connected to multiple aspects of business management that are not always strictly connected with sustainability. However, the main value added is the capability of collecting several indicators at the level of each active farm (microdata), without a relevant size threshold. On the other hand, the main limitation is periodicity (10 years in the EU, 5 in the USA).The final data can be downloaded from the website: https://esploradati.istat.it/databrowser/#/it/censimentoagricoltura.

The Classification of Municipalities according to the Ecoregions of Italy

Ecoregions, or ecological regions, are more or less large portions of ecologically homogeneous territory in which species and natural communities interact in a discrete way with the physical characteristics of the environment. The approach adopted in Italy involves a hierarchical and divisive classification of the territory into units with an increasing degree of homogeneity, consistently with specific combinations of climatic, biogeographic, physiographic and hydrographic factors that determine the presence and distribution of different species, communities and ecosystem. https://www.istat.it/it/archivio/224780

Measurement of temperature differential between urban and vegetated areas

In the present work, three large municipalities, Milano for the North, Roma for the Center, and Napoli for the South, were analyzed for their geographical representativeness and comparability at the spatial level, examining both urban and non-urban areas at a geographical scale of the municipality to which they belong. The satellite data were pre-processed with SNAP software from the European Space Agency's (ESA) Sentinel toolboxes suite, specially developed for processing environmental images from numerous remote sensing missions to obtain two different measurements: the average ground temperature of urban areas and that of the surrounding vegetated areas. From the difference between the two measurements, the differential of the average temperature at each point (pixel) of the municipal area was obtained, which made it possible to map the difference in microclimate between the purely urban areas and the average of the surrounding vegetated areas.Cities were analyzed during nighttime hours, a period when cities are on average warmer than surrounding vegetated areas, on the hottest days of the year with cloud cover less than 20 percent, during the meteorological summer period (June 1-August 31) of 2022.

Meaning of Ecoregions and their potential application; the Ecoregional Classification in Italy

Ecoregions, or ecological regions, are more or less large portions of ecologically homogeneous territory (up to vast areas of the earth's surface) within which species and natural communities interact discretely with the physical characteristics of the environment. They therefore represent areas with similar ecosystem potential and constitute an optimal territorial and geographical reference framework for the interpretation of ecological processes, disturbance regimes, the spatial distribution of vegetation and the different types of landscape. In the international panorama, the ecological classification processes that lead to the definition of Ecoregions are therefore promoted as a tool for addressing strategies for the management and sustainable development of the territory at different scales. Among the many examples we can mention:

- the analysis of the ecosystem representativeness of protected areas, plans and strategies for the conservation of biodiversity and the evaluation of forest resources at a global level;
- studies on the impacts of climate change and the assessment of ecosystem services, the planning of protected areas and assessments of the state of conservation at national level;
- the analysis of trends and effects of changes in land use and cover, monitoring of water quality, prioritization of areas for conservation, assessment of environmental risks. In Italy, the process that led to the mapping and characterization of Ecoregions derives from a scientific approach to the ecological classification of the territory defined since the early 2000s.

The approach provides for a hierarchical and divisive classification of the territory into units with increasing degrees of homogeneity, consistently with specific combinations of climatic, biogeographic, physiographic and hydrographic factors that determine the presence and distribution of different species, communities and ecosystems. Since this determinism also influences the types and intensity of human activities, these units can be considered representative of the most general landscape characteristics.

Glossary

Climatic anomaly. Difference between the annual value of a meteorological parameter and the corresponding average value of a reference period (Climatological Normal 1971-2000 or 1981-2010, decade 2006-2015)

Other gainful activities. Activities carried out by the agricultural holding beyond the primary agriculture activity, that can represent additional sources of incomes for the farmer. The census observed these activities: social agriculture (care farming), educational farm, agritourism, craftsmanship, initial processing of agricultural products, transformation of vegetable products, transformation of animal products, production of energy from renewable sources (wind, biomass, solar, water, other sources), woodworking, wood cutting, or third parties activities, livestock services, arrangement of parks and gardens, forestry, production of complete and complementary feed.

Agricultural holding. The agricultural holding (farm) is defined by Regulation (EU) 2018/1091 (art. 2 paragraph a): single technical-economic unit subject to unitary management which carries out, as a primary or secondary activity, agricultural activities pursuant to the regulation (CE) n. 1893/2006, belonging to groups A.01.1, A.01.2, A.01.3, A.01.4, A.01.5, or «activities for maintaining agricultural land in good agricultural and environmental conditions» belonging to group A.01.6, in economic territory of the Union; as regards the activities of class A.01.49, only the activities of 'breeding of semi-domestic animals or other live animals' (with the exception of insect farming) and 'beekeeping and production of honey and beeswax' are included.

Metropolitan city. Reference to "large area" Territorial Bodies of the Italian Republic (article 114 of the Constitution, governed by Law N. 56 of 7 April 2014, which replaced the former Provinces of the same name). Since 2020, Italian Metropolitan cities are 14: Roma Capital, Torino, Milano, Venezia, Genova, Bologna, Firenze, Bari, Napoli, Reggio Calabria, Cagliari, Catania, Messina, Palermo.

CLINO. Acronym for Climatological Normal.

Ecoregion. More or less large portions of ecologically homogeneous territory.

Ecosystem. Natural whole formed by a community of living organisms and the physical environment in which they live. It is made up of two closely related components: the first represented by living organisms (biological community or biocenosis) and the other by the physical environment (abiotic component or biotope) in which they live.

Urban forestation. Vacant and uncultivated areas that by size and location are suitable for the creation of true natural development forests in urban areas.

Indices of meteoclimatic exstremes. Indices defined by the World Meteorological Organization (WMO) of the United Nations (UN) expressed in physical terms (°C, mm, number of days). They are classified according on the phenomenon observed (precipitation or temperature), reported below.

Indices of extremes of precipitation

- dry days (index R0): number of days in the year without precipitation
- rainy days (index R1): number of days in the year with daily precipitation >= 1 mm
- very rainy days (index R10): number of days in the year with daily precipitation >= 10 mm
- days with very intense rainfall (index R20): number of days in the year with daily precipitation >= 20 mm
- days with extremely intense precipitation (index R50): number of days in the year with daily precipitation >= 50 mm
- consecutive dry days (index CDD): maximum number of days with daily precipitation < 1 mm
- consecutive wet days (index CWD): maximum number of days with daily precipitation > = 1 mm
- daily rainfall intensity (index SDII): total annual precipitation divided by number of rainy days in the year (with daily precipitation >=1 mm)
- precipitation in the very rainy days (index R95P): sum in mm in the year of daily precipitation above the 95^{th} percentile.

Indices of extremes of temperature

- days with frost (index FD0): number of days in the year with minimum temperature < 0°C
- summer days (index SU25): number of days in the year with minimum temperature > 25°C
- tropical nights (index TR20): number of days in the year with minimum temperature > 20° C
- minimum of the minimum temperatures (index TNn): monthly minimum value of daily minimum

temperatures

- maximum of the minimum temperatures (index TNx): monthly maximum value of daily minimum temperatures
- minimum of the maximum temperatures (index TXn): minimum value of minimum temperatures
- maximum of the maximum temperatures (index TXx): maximum value of maximum temperatures
- warm spell duration index (index WSDI): number of days in the year with maximum temperature above the 90th percentile, for at least 6 consecutive days
- warm nights (index TN90p): number of days in the year with daily minimum temperature above the 90th percentile
- warm days (index TX90P): number of days in the year with daily maximum temperature above the 90th percentile
- cold nights (index TN10p): number of days in the year with daily minimum temperature below the 10th percentile
- cold days (index TX10P): number of days in the year with daily maximum temperature below the 10th percentile

Morphology. It is the study of forms in various fields, such as biology, geography, and linguistics.

Climatological Normal. According to World Meteorological Organization (WMO) of the United Nations (UN) methodologies and recommendations, the reference climatological averages are calculated worldwide over a 30-year interval, called Climatological Normal (CLINO). Such period is considered sufficiently long to obtain trend indicators on the variability of observed meteorological phenomena and the study of climate changes, significant in the long term. The average values referring to the climatic period (thirty-year reference period) are called normal values or climatic values.

Total water losses. Percentage ratio between total water losses (difference between the volumes input in the public water supply and the water supplied for authorised uses) and the volume of water input in the public supply network.

Precipitation. In meteorology, precipitation is any product of the condensation of atmospheric water vapor that falls from clouds due to gravitational pull on the earth's surface. **Hydrogeological risk.** It can be defined as the product of the danger linked to a hydrogeological event and the potential damage it would cause to people and/or infrastructure (i.e. exposure). Hydrogeological risk is constituted by exposure to landslide events (landslide risk) and flood events (flood risk).

Termo-pluviometric stations. Certified measurement instruments (located on the ground), which allow physical conditions of the atmosphere in a given place to be measured, in relation to fundamental meteorological parameters for climate purposes.**Utilized agricultural area (UAA)**. Set of lands under arable land (including fallow land), agricultural woody crops (vines, olive trees, citrus fruits, fruit trees, nurseries, fruit chestnut groves, agricultural woody crops in greenhouses), family vegetable gardens, permanent meadows and pastures. It constitutes the surface invested and actually used in strictly agricultural crops. Forests, unused agricultural land and areas occupied by buildings, courtyards, farm roads and the surface cultivated with mushrooms in caves, underground areas and in special buildings are excluded.

Temperature. Thermal level of the atmosphere existing in a given place and at a given time. It represents the energy level of the air, i.e. the average kinetic energy associated with air molecules as a result of heating by solar radiation.

Land surface temperature. Temperature measured on the ground from satellite data and processed with SNAP/ESA software, which estimates temperature based on infrared radiation emitted from the ground in degrees Kelvin and converted to degrees Celsius (TCelsius=Tkelvin - 273.15).

Climatic value. Average value of a meteorological variable obtained through statistical processing performed on a large historical series (at least 30 years) of elementary data (daily measurements of parameters), detected by thermo-pluviometric stations located on the ground.

Useful links

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For technical and methodological clarifications

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