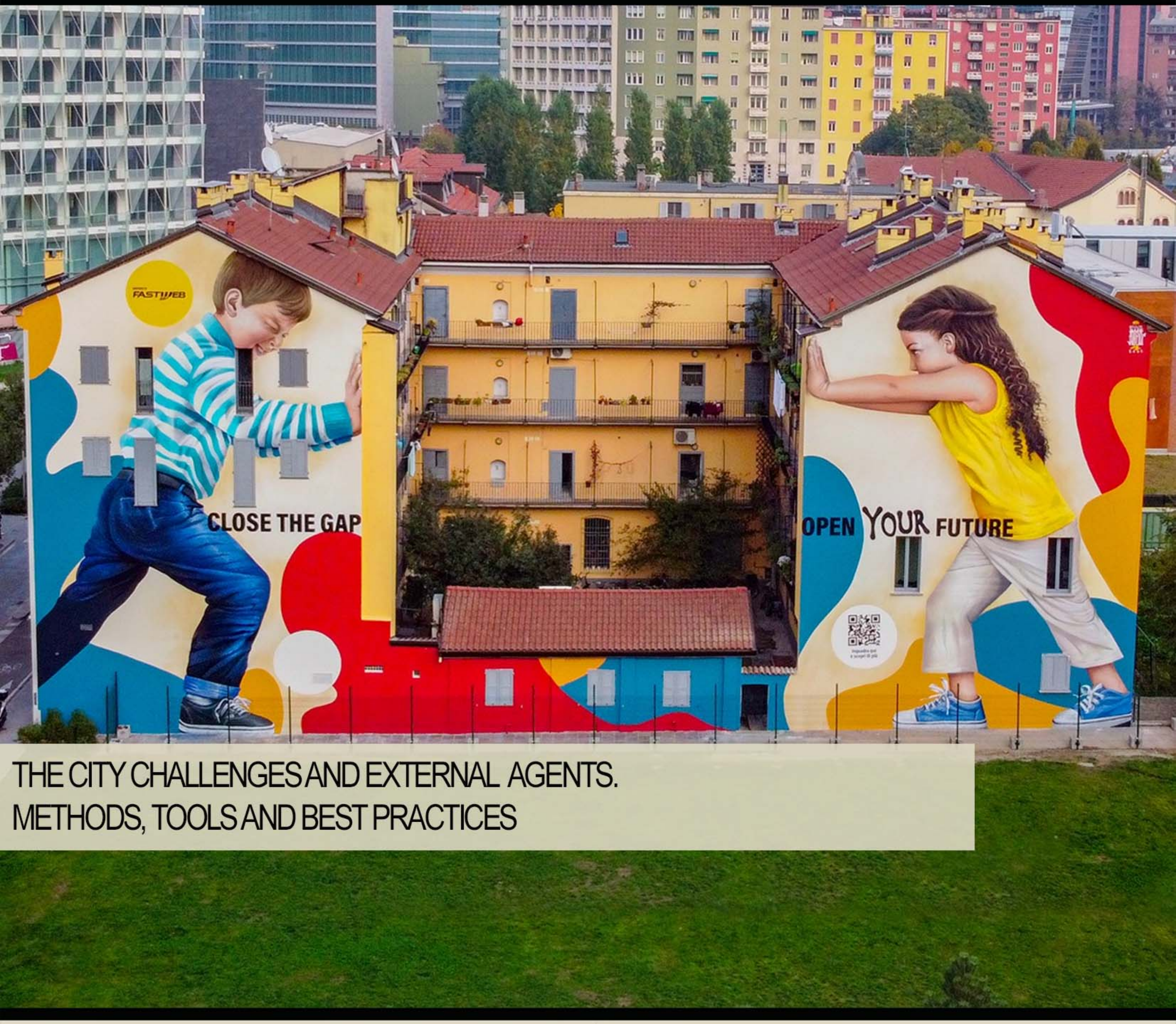
TeMA

Journal of
Land Use, Mobility and Environment

The climatic, social, economic and health phenomena that have increasingly affected our cities in recent years require the identification and implementation of adaptation actions to improve the resilience of urban systems. The three issues of the 15th volume will collect articles concerning the challenges that the complexity of the phenomena in progress imposes on cities through the adoption of mitigation measures and the commitment to transforming cities into resilient and competitive urban systems.

TeMA is the Journal of Land Use, Mobility and Environment and offers papers with a unified approach to planning, mobility and environmental sustainability. With ANVUR resolution of April 2020, TeMA journal and the articles published from 2016 are included in the A category of scientific journals. From 2015, the articles published on TeMA are included in the Core Collection of Web of Science. It is included in Sparc Europe Seal of Open Access Journals, and the Directory of Open Access Journals.



THE CITY CHALLENGES AND EXTERNAL AGENTS. METHODS, TOOLS AND BEST PRACTICES

Vol.15 n.1 April 2022

print ISSN 1970-9889 e-ISSN 1970-9870
University of Naples Federico II

TeMA

Journal of
Land Use, Mobility and Environment

THE CITY CHALLENGES AND EXTERNAL AGENTS. METHODS, TOOLS AND BEST PRACTICES

1 (2022)

Published by
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"

TeMA is realized by CAB - Center for Libraries at “Federico II” University of Naples using Open Journal System

Editor-in-chief: Rocco Papa
print ISSN 1970-9889 | on line ISSN 1970-9870
Licence: Cancelleria del Tribunale di Napoli, n° 6 of 29/01/2008

Editorial correspondence
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"
Piazzale Tecchio, 80
80125 Naples
web: www.tema.unina.it
e-mail: redazione.tema@unina.it

The cover image shows redeveloped building in the Garibaldi neighbourhood in the city of Milano (Picture by Fastweb, retrieved from: https://www.facebook.com/Fastweb/photos/10158794132149472).

TeMA. Journal of Land Use, Mobility and Environment offers researches, applications and contributions with a unified approach to planning and mobility and publishes original inter-disciplinary papers on the interaction of transport, land use and environment. Domains include: engineering, planning, modeling, behavior, economics, geography, regional science, sociology, architecture and design, network science and complex systems.

With ANVUR resolution of April 2020, TeMA Journal and the articles published from 2016 are included in A category of scientific journals. From 2015, the articles published on TeMA are included in the Core Collection of Web of Science. TeMA Journal has also received the *Sparc Europe Seal* for Open Access Journals released by *Scholarly Publishing and Academic Resources Coalition* (SPARC Europe) and the *Directory of Open Access Journals* (DOAJ). TeMA is published under a Creative Commons Attribution 4.0 License and is blind peer reviewed at least by two referees selected among high-profile scientists. TeMA has been published since 2007 and is indexed in the main bibliographical databases and it is present in the catalogues of hundreds of academic and research libraries worldwide.

TeMA
Journal of
Land Use, Mobility and Environment

THE CITY CHALLENGES AND EXTERNAL AGENTS. METHODS, TOOLS AND BEST PRACTICES

1 (2022)

Contents

Covid-19 vs City-22

REVIEW NOTES

TeMA

Journal of
Land Use, Mobility and Environment

TeMA 1 (2022) 5-24
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/8391
Received 23rd September 2021, Accepted 2nd February 2022, Available online 30th April 2022

Multiple components in GHG stock of transport sector: Technical improvements for SECAP Baseline Emissions Inventory assessment

Luigi Santopietro [a]*, Francesco Scorza [b], Beniamino Murgante [c]

[a] Laboratory of Urban and Regional Systems Engineering,
School of Engineering, University of Basilicata, Italy
e-mail: luigi.santopietro@unibas.it
ORCID: https://orcid.org/0000-0001-9175-0525
* Corresponding author

[b] Laboratory of Urban and Regional Systems Engineering,
School of Engineering, University of Basilicata, Italy
e-mail: francesco.scorza@unibas.it
ORCID: https://orcid.org/0000-0001-6149-7346

[c] Laboratory of Urban and Regional Systems Engineering,
School of Engineering, University of Basilicata, Italy
e-mail: beniamino.murgante@unibas.it
ORCID: https://orcid.org/0000-0003-2409-5959

Abstract

The issue of the greenhouse gas emission is one of the main targets for the Covenant of Mayors initiative within the structure of the Sustainable Energy and Action Plans (SECAP).

The computation of CO_2 emissions for SECAP transport sector was tackled in practice through several methods producing not comparable results and even not reliable scenarios. Considering SECAP as a voluntary planning tool suitable for the management of ecological transition in small municipalities, in this work a computational proposal for transport sector emissions is proposed. The methodological proposal represents an operative guideline, providing accurate results based on easy-accessible data customized for the small Municipalities (i.e. with a resident population under 10.000 inhabitants). Such approach is characterized by the analysis of two components of emissions stock: a fixed one connected with the vehicles' fleet of resident population; a variable one depending on the tourism flows generated by specific environmental/cultural attractors. The case study of Castelsaraceno Municipality (Italy) is discussed highlighting the robustness of the proposed approach compared with existing Municipal energy plan evidences and additional checks based on unconventional information sources.

Keywords

CO_2 emissions reduction; SECAP; Transport energy consumption; Territorial planning.

How to cite item in APA format

Santopietro, L., Scorza, F. & Murgante, B. (2022). Multiple components in GHG stock of transport sector: Technical improvements for SECAP Baseline Emissions Inventory assessment. Tema. Journal of Land Use, *Mobility and Environment*, *15* (1), 5-24. http://dx.doi.org/10.6092/1970-9870/8391

1. Introduction

On 12th December 2019 the European Council endorsed the objective of making the EU climate-neutral by 2050 (European Commission, 2019), in line with the objectives of the Paris Agreement (United Nations, 2015). In this scenario the efforts to improve the reduction of Greenhouses Gas (GHG) are supported by several European initiatives such as the Covenant of Mayors (CoM). The CoM supports the volunteer Municipalities that submit a common CO_2 emission target (actually the 40%), developing a Sustainable Energy and Climate Action Plan (SECAP). These plans represent operative tools promoting extensive modifications of urban environment following climate change adaptation issues and, as discussed in previous works by the authors, represent an informal alternative to traditional urban regulations strictly constrained by the current urban national and regional laws (Corrado et al., 2020; Santopietro et al., 2020; Santopietro & Scorza, 2020; Scorza et al., 2017). The extensive participation of Italian Municipalities to the CoM initiatives is representative of the level of commitment that local authorities gained towards climate/green goals. On the other hand, the heterogenous attitude in SECAP planning, implementation and monitoring expresses the absence of a clear technical framework allowing comparability among experiences and an extensive transferability of methodological approaches and tools. However, SECAP is an effective support for Municipalities decision-making process oriented to implement environmental and climate responsive interventions on urban components. In the perspective of the planning process, SECAPs engage Municipalities to develop planning actions with specific road-map of the interventions defining: actors involved, timeframe and responsibilities of the processes and a subsequent monitoring campaign of them.

The design of specific actions is a strength of the SECAP process; however, these actions are more linked to the implementation of interventions on selected urban areas than to an integrated urban vision.

Investigating the structure of the SECAP, the knowledge of the Municipal context is organized in different sectors, each one with a specific CO_2 contribution (Paolo Bertoldi & Rivas, 2020; D'Orso et al., 2020; Rivas et al., 2021). SECAP sectors are: buildings, transport, energy, water, waste (related to the energy saving issues), territorial planning, agriculture & forestry, environment & biodiversity, health, civil protection & rescue and tourism (related to the climate adaptation and mitigation issues).

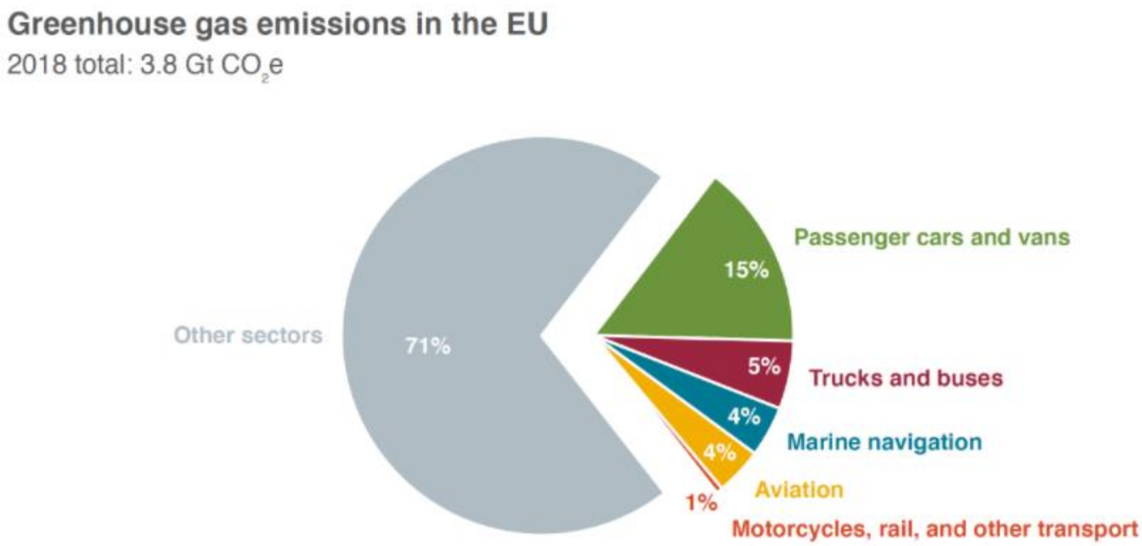


Fig.1 Share of EU-27 economy-wide greenhouse gas emissions in 2018 by transport subsector, including domestic and international components. Land use, land-use change, and forestry are included in the other sectors category

In this paper we focus on the computational approach applied to the transport sector CO_2 emissions assessment in the SECAP Baseline Emissions Inventory (BEI) analysis. Among the CoM sectors, the transport one is considered one of the main target sector (Croci et al., 2017; Kona et al., 2017). Furthermore, according to The International Council of Clean Transportation (see Fig.1) in 2018, domestic and international transport were responsible for 29% (on a total of 3.8 Gt CO_2eq) of total economy-wide greenhouse gas emissions in the EU, while for European Environment Agency (EEA) the average carbon dioxide emissions from new passenger cars for the period 2000-2019 has decreased from 172.2 gCO_2/Km to 122.3 gCO_2/Km considering that in 2019, as in 2018, petrol cars were the most sold passenger vehicles.

Current technical practices concerning the assessment of the baseline emission for this sector include an heterogenous set of approaches and also CoM guidelines or other EU handbooks do not provide a unique way to compute different components of CO_2 emission connected with public and private transports means.

Additionally, no distinctions are made between systematic transport movements and other typologies connected for instance with tourism flows, seasonal events etc.

For the accuracy of CO_2 emissions due to transport sector, methodologies should take into account the size of the cities for which they are designed. The CoM identifies the small size Municipality with the XS acronym and such group includes CoM Signatories with a population under 10,000 inhabitants. This group represents a remarkable share of the whole CoM Signatories by September 2021: 4,334 Signatories, in percentage 63%.

The research suggests a method to estimate the CO_2 emissions from the "transport" sector specifically oriented to the XS CoM Signatories group. For this group of Municipalities, the components of systematic transport movements are not a considerable share of the whole emissions. In facts, the presence of cultural/environmental attractors or other specific destinations for daily or seasonal flows of people and goods in a Municipality, can generate extraordinary traffic flows that generally are not included in the computational approach for CO_2 emissions adopted in the SECAP.

The transport sector is divided into three subsectors, according to the CoM classification in order to compare the results: Municipal fleet, Public Transport and Private and commercial transport. The computation of the CO_2 emissions is very different among those categories and not always easy to do.

Indeed, the availability of transport data is generally not enough for small Municipalities and the computational model has to consider medium values derived from regional datasets. In facts no specific studies on the transport topics are available for that Municipalities size, allowing to estimate the data on CO_2 emissions with a high resolution. Thus, data for the Municipal fleet and Public Transport could be retrieved by Municipal Offices or Public Transport Plans developed at national or local level, while data from private and commercial transports are always estimated using benchmarks or top-down approaches related to regional or national level properly sized to Municipal level.

A specific focus of this the subsector private and commercial transport. We describe method providing affordable accuracy results based on easy-accessible data.

The paper is organized as follows: in the next section are explained some interesting statistics for the XS Municipalities and in the section 3 are presented the official CoM European Guidelines proposed by the Joint Research Centre to compute the CO_2 emissions of the transport sector. Section 4 explains some selected experiences on the estimation of private transport sector CO_2 emissions deriving from the EU XS SECAP Signatories framework.

In section 5 is explained the methodological proposal related to the computation of transport consumption while in section 6 is presented the application of the methodological proposal to the case study of the "small" XS Italian Municipality of Castelsaraceno.

The conclusions regard the main outcomes obtained by the application of the methodology on the case study of Castelsaraceno, limitations of the approach and future research perspectives.

2. CoM Signatories comprehensive figures

Before starting to explore some interesting European experiences of EU XS CoM Signatories, it could be useful look at the structure of this class of CoM Signatories.

The XS CoM Signatories are a relevant percentage (63%) on the whole of the CoM Signatories. Investigating data from the CoM database on its website, some interesting figures come out:

1. Population Size

The XS class counts the Signatories under 10,000 inhabitants, that by September 2021 are 4,334. Dividing them into two subclasses (under or over 5000 inhabitants see Tab.1) the Municipalities with higher percentage (75%) are under 5,000 inhabitants. Among them, Municipalities under 1,000 inhabitants are no. 1,052 (corresponding to 24% on the total XS signatories).

Population Size of XS Signatories	No.	Percentage on total XS Signatories
>= 5,000	1,121	26%
< 5,000	3,213	74%
<1,000	1,052	24%

Tab.1 XS CoM Signatories divided per population size

2. Commitment classes of the XS Signatories

The commitment chosen by XS Signatories are divided in 4 classes: 2020, 2020 & ADAPTATION, 2030 & ADAPTATION and 2020,2030 & ADAPTATION. First, 2020: towns, cities and regions voluntarily committed to reducing their CO_2 emissions beyond 20%, below 1990 levels, by 2020, describing mitigation actions in the SECAP template. Second, 2020 & ADAPTATION or 2030 & ADAPTATION: the initial greenhouse gas emission reduction commitment and integrating adaptation to climate change were strengthened by three pillars: mitigation (an at least 40% emission reduction target by 2030); adaptation to climate change; and secure, sustainable and affordable energy. The label ADAPTATION is related to the Mayors Adapt initiative, which supports local authorities to develop and implement local adaptation strategies. Third, 2020, 2030 & ADAPTATION: this class includes the signatories that signed up to CoM and strengthened their commitments to decreasing CO_2 emissions from 20% by 2020 to 40% by 2030 with the development and implementation of local adaptation strategies.

Among the 4,334 XS CoM Signatories, in September 2021 the 36% have a SECAP that couple the reduction of CO_2 emission reduction with the adaptation to climate change (see Tab.2). The remaining part (64%) is still stuck in CO_2 reduction of 20% by 2020, waiting an upgrade of the SECAP's strategies that improve the reduction of CO_2 and include the adaptation of climate-change.

Commitment	No.	Percentage on total XS Signatories
2020	2,763	64%
2020 & ADAPT	74	2%
2030 & ADAPT	949	22%
2020, 2030 & ADAPT	548	13%

Tab.2 XS CoM Signatories divided per commitment

3. Country of origin of the XS CoM Signatories

It is useful understand what the geographical distribution of the XS CoM Signatories is, counting for each population size and for each Country the number of XS CoM Signatories. The results coming out from the CoM database show that XS Municipalities are mostly concentrated in Italy (58%) and Spain (33%), and the two Countries together reach almost the whole of XS Signatories. This is representative of the high widespread to opt for European tools in planning - such as SECAP - in these Countries, opposite to institutional urban planning tools. In Tab.3 are reported for each CoM Country the number of Signatories divided per Population Size and the corresponding percentages related to XS CoM Signatories for each Country and the total XS CoM Signatories

Country	XS Signatories	Percentage of XS CoM Signatories per each Country	Percentage on the total XS CoM Signatories
Albania	0	0%	0.0%
Armenia	3	27%	0.1%
Austria	6	46%	0.1%
Azerbaijan	1	50%	0.0%
Belarus	1	5%	0.0%
Belgium	101	31%	2.3%
Bosnia-Herzegovina	4	13%	0.1%
Bulgaria	6	24%	0.1%
Croatia	30	45%	0.7%
Cyprus	9	38%	0.2%
Czechia	2	22%	0.0%
Denmark	2	6%	0.0%
Estonia	2	40%	0.0%
Finland	0	0%	0.0%
France	18	21%	0.4%
Georgia	0	0%	0.0%
Germany	2	3%	0.0%
Greece	20	14%	0.5%
Hungary	16	25%	0.4%
Iceland	0	0%	0.0%
Ireland	0	0%	0.0%
Italy	2,507	75%	57.8%
Kazakhstan	0	0%	0.0%
Latvia	5	24%	0.1%
Lithuania	0	0%	0.0%
Luxembourg	1	100%	0.0%
Macedonia	0	0%	0.0%
Malta	23	96%	0.5%
Mexico	1	33%	0.0%
Moldova	15	58%	0.3%
Montenegro	2	67%	0.0%
Netherlands	0	0%	0.0%
Norway	0	0%	0.0%
Poland	10	24%	0.2%
Portugal	34	29%	0.8%
Romania	19	28%	0.4%
Serbia	0	0%	0.0%
Slovakia	1	17%	0.0%
Slovenia	17	57%	0.4%
Spain	1,445	77%	33.3%
Sweden	9	16%	0.2%
Switzerland	1	11%	0.0%
Tajikistan	0	0%	0.0%
Turkey	0	0%	0.0%
Ukraine	21	13%	0.5%
United Kingdom	0	0%	0.0%

Tab. 3 XS Signatories classified by Country with related percentages on each Country and whole XS CoM Signatories

3. Estimation of road transportation emissions by main CoM official guidelines

The official CoM guidelines (P. Bertoldi, 2018; European Comission, 2010) propose a specific characterization of the road transportation emissions for BEI into two parts:

Urban road transportation, which includes road transportation on the local street network that is usually under the competence of the local authority;

Other road transportation, which includes road transportation in the territory of the local authority on the roads that are not under its specific competence. An example are highways that go through the municipal territory and are managed by specific national authorities; railways infrastructures.

These last one emission category can be included in the BEI if the local authority intends to include measures to reduce these emissions in the SECAP. Anyway, for the road transportation sector the data to be gathered is the amount of fuel consumed in the territory. Usually, the amount of fuel used is not equal to the amount of fuel sold. Indeed, for small Municipalities there are various reasons that support the previous quote such as the lack of the filling stations in that Municipality, different prices of fuels or modifications on fuel sales due to others factors. Also if Kennedy et al. (2009) have shown that use of fuel sales data is appropriate for cities for which the number of vehicle trips over the border of the city is small relative to the number of trips within the city, for small Municipalities this path may not reflect the effective CO_2 road emission to be address to local authority. Therefore, according to CoM official guidelines the estimation of the fuel used has to be based on:

- mileage driven in the territory of the local authority [km]
  The mileage driven (total amount of kms) on the street network of the local authority can be estimated on information of traffic flows and length of the municipal street network. Other common data sources are the transport department of the local authority, national or local street administration, household transport surveys (origin and destination surveys), private database on mobility in cities;
- vehicle fleet registered in the territory of the signatory local authority (cars, buses, two-wheelers, heavy and light-duty vehicles);
- average fuel consumption of each vehicle type [l fuel/km]
  Average fuel consumption of each vehicle category is related to several factors such as engine supply, age or driving cycle. A source of these data could be local or national auto clubs to perform data on the local level. Use of national level average fuel consumption for each vehicle category may produce not detailed estimates, in particular for urban areas.

Data for each fuel type and vehicle category can be estimated by the following equation (1):

$$\begin{aligned}&\text{Fuel used in road transportation [KWh]}\\&= \text{mileage [Km]} * \text{average consumption } \left[\frac{\text{l}}{\text{Km}}\right] * \text{conversion factor } [\frac{\text{KWh}}{\text{l}}]\end{aligned} \quad (1)$$

The most typical conversion factors used come from European Environmental Agency or Intergovernmental Panel on Climate Change(European Enviromental Agency, 2019; Intergovernmental Panel on Climate Change, 2006). Usually, on the basis of the estimation of "Fuel used in road transportation" the CO_2 emissions are computed according to the emission factors described as follows.

There are two different approaches to compute CO_2 emissions using "standard" emission factors in line with the Intergovernmental Panel on Climate Change (IPCC) principles; or using LCA (Life Cycle Assessment) emission factors.

Standard emission factors cover all the CO_2 emissions that occur due to energy consumption within the territory of the local authority, either directly due to fuel combustion within the local authority or indirectly via fuel combustion associated with electricity and heat/cold usage within their area. This approach takes into account that CO_2 is the most important greenhouse gas, and the emissions of CH_4 and N_2O do not need to be calculated. The standard emission factors according to CoM guidelines (P. (editor) Bertoldi, 2018; European Comission, 2010) are based on the IPCC 2006 Guidelines (Intergovernmental Panel on Climate Change, 2006). The tons of CO_2 emitted are computed using the following equation (2):

$$\begin{aligned} &\mathrm{CO_2}\ \ \text{emissions [ton]} \\ &= \text{IPCC standard emission factor} \left[\frac{\mathrm{CO_2}}{\text{ton}}\right] * \text{ fuel consumption [ton]} \end{aligned} \tag{2}$$

LCA (Life Cycle Assessment) emission factors, take into consideration the overall life cycle of the energy carrier. This approach includes not only the emissions of the final combustion, but also all emissions of the supply chain. It includes emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion. This hence includes also emissions that take place outside the location where the fuel is used. In this approach, other greenhouse gases than CO_2 may play an important role. LCA emission factors are based on a European Reference Life Cycle Database (ELCD) developed by the Joint Research Centre and are available online. Therefore, the local authority that decides to apply the LCA approach can report emissions as CO_2 equivalent. Equivalent tons of CO_2 emitted are computed using the following equation (3):

$$\begin{aligned} &\mathrm{CO_2}\ \text{Equivalent emissions [ton} - \text{eq]} \\ &= \text{LCA emission factor} \left[\frac{\mathrm{tCO_2-eq}}{\text{MWh}}\right] * \text{ fuel consumption [MWh]} \end{aligned} \tag{3}$$

4. An outlook on CO_2 estimation approaches for "Transport" sector in XS CoM Municipalities

The computation of the CO_2 emissions from the transport sector derives from multiple components: public, private, commercial and other. The authors focus on the different approaches adopted to estimate the consumption from the private component of transport, considering that this component is not easily evaluable as public one and it represents a considerable weight among the overall CO_2 emissions from transport sector. The methods to estimate the CO_2 emissions selected from the XS CoM Municipalities are heterogeneous, but some clusters could be recognized. On this track, the authors have gathered some experiences deriving from European XS CoM Municipalities. In tab.4 have been highlighted the main features, pros and cons, of each country, dealing with transport-based CO_2 emissions.

Belgium

Burdinne, Martelange and Rouvroy municipalities have used to compute transport consumption the data provided by FPS MT (the Belgian Society of Transport). So, in this case, a national company provided official data suitable for SEAP elaboration. In particular, consumption data have been computed taking into account the petroleum sales, the traffic share in 2000 and 2005 evaluated by the FPS MT and the different driving modes of motorists related to the different road typology. Petroleum sales have been derived from petroleum sales of gas stations since 1990. Data related to the distribution of traffic share has evaluated by FPS MT for each municipality as the vehicles*kilometers travelled on the roads, in 2000 and 2005 considering the distribution of traffic on the municipal road network and the motorway network at provincial and regional level. In order to be coherent with the context, data related to transport have been revised taking into account only the specific traffic amount of the single municipality. Traffic on national or provincial roads crossing the Municipality have been excluded from the computation of transport consumption.

Malta

Gharb Municipality is an enclosed town and has a single major entry and exit point (only one road allowed the accessibility to the whole municipal territory). The absolute majority of the internal transit is due to vehicles arriving and departing from the town and the intervillage transit is very low. The values for private transport consumption were estimated using figures provided by National Statistics Office for vehicle ownership in the town. An average mileage through the village was estimated and this provided the total mileage travelled through the town per annum. It was assumed that all commercial vehicles operated on diesel fuel while a mix of diesel and gasoline is used for other private vehicles.

Qala and Ta' Xbiex Municipalities have performed an analysis of the vehicle stock for the baseline. Thus, a fuel consumption weighting factor has been assigned to each type of vehicle based on the engine capacity and estimated activity. From this, the annual energy consumption and CO_2 emissions allocated to the locality have been calculated.

Macedonia

Kolasin and Zabljac Municipalities have assessed their energy consumption for the transport sector considering data coming from different local sources such as the traffic conditions of the Municipality were deducted from registered documents of European Agency for Reconstruction; the energy consumption at national level were collected from the 2006 National Energy

Strategy for Development; fuel sales at local fuel stations within the municipality were gathered through interviews; distances between locations were calculated during the surveys; other data were assumed based on interviews with the municipal staff, the team's experience and reliable forecasts. The emission factors for the vehicles and the heating values of the fuels were taken from the World Resources Institute (WRI) guide of the GHG Protocol. In this case, in absence of a specific data source the estimation is based on the integration of different sources of information.

Italy

Roccaraso, Lucoli and Caprariva del Friuli Municipalities have chosen to start from the data on provincial sales of fuels (petrol, diesel, LPG) obtained from the Ministry of Economic Development. Dividing these values by the number of petrol, diesel and LPG vehicles registered in the province, they obtained the data relative to the "2005 vehicle fleet" - ACI sales of the three fuels per vehicle [litres/vehicle] in the provincial territory.

The distinction of passenger cars by fuel was obtained by assuming a constant percentage distribution by fuel type at provincial level for all municipalities.

Multiplying the value of provincial sales per car of the three fuels each by the respective number of cars in the municipality we obtain, for the three energy vectors considered, the quantity of fuel for private transport in the municipality. Only at this point is it possible to take into account the number of kilometers travelled on the roads for which the local authority is responsible, multiplying the value of consumption [liters], which has just been obtained, by the share relative to the number of kilometers travelled on the urban network, thus excluding the percentage of kilometers on the motorway network. Finally, the emission factors (in those cases the IPCC ones) were used to obtain the CO_2 tons emitted by private transport.

Brogliano Municipality choose a top-down approach starting from provincial and regional emission data. The public database chosen is "Inemar-Veneto" where are collected data for vehicle type (cars, light vehicles, heavy vehicles, mopeds and motorbikes), road type (urban and suburban) and fuel type (car, light vehicle, heavy vehicle, moped and motorbike).

Despite the fact that estimation of fuel consumption is affected by different level of uncertainty for the private component of transport sector, all selected approach from XS CoM Municipalities show a common baseline based on the investigation of the vehicle fleet provided by the National Agencies. However, the approach chosen by Italian and Maltese XS Municipalities seems to be more reliable while Macedonian approach depends on multiple estimation hypothesis that could provide a final estimation amount far from the local reality; the Belgium case is characterized by the availability of a national structured database delivered by a qualified authority that simplify the estimation process producing comparable results in different application cases.

Country	Pros	Cons
Belgium	Transport consumption provided by a National Society of Transport and based on different driving modes of motorists related to the different road typology	Petroleum consumption derived from petroleum sales of gas stations and exclusion of the traffic on national or provincial roads crossing the Municipality
Malta	Consumption estimated using figures provided by National Statistics Office for vehicle ownership	Fuel consumption weighting factor assigned to each type of vehicle based on the engine capacity and estimated activity
Macedonia	Traffic conditions of the Municipality were deducted from registered documents of European Agency for Reconstruction while energy consumption at national level were collected from the 2006 National Energy	Fuel sales at local fuel stations within the municipality and other data were assumed based on interviews with the municipal staff, the team's experience and reliable forecasts
Italy	Data about fuel consumption and vehicle fleet retrieved from National Agencies	Uncertainty about the distinction of passenger cars by fuel and assumption of a constant percentage distribution by fuel type at provincial level for all municipalities

Tab. 4 Pros and cons, of each country, dealing with transport-based CO_2 emissions

5. A computational proposal for the estimation of the CO_2 emissions for the transport sector

The official CoM guidelines define how compute the fuel used in road transportation starting from detailed data, but for the small Municipalities often these data are not accessible or not easy to collect. Therefore, the authors have developed a computational proposal for the CO_2 emission of the transport sector, based on the fuel consumption using some specific databases available in Italy. The database examined are:

- sales related to the annual oil consumption and the major oil products of the internal market, provided by the Italian Ministry of Ecological Transition. These data are divided for each Italian Province, specifying also the monthly sales;
- vehicle fleet (cars, buses, two-wheelers, heavy and light-duty vehicles) in the territory of the Municipality and its Province searching on the Italian National Automotive Club (ACI) database;
- number of resident inhabitants in the Municipality and its Province searching on the Italian National Institute of Statistic (ISTAT).

The computational proposal is structured as follows:

1. the annual oil consumption per Province is divided for the number of vehicles per Province. The result is the fuel consumption expressed as the number of the fuel tons per Province vehicle;
2. ACI provides the vehicle fleet for each Italian Municipality but it does not classify the vehicles by type of power supply. Therefore, starting from the Province classification of the vehicle fleet has computed the percentage of the vehicles divided per class (cars, buses, two-wheelers, heavy and light-duty vehicles) and type of power supply (gasoline, gasoline & lpg, gasoline and natural gas, diesel, lpg, electric). This percentage has been considered constant for each Municipality inside the Province;
3. the percentages of the vehicles divided per class and type of power supply have been multiplied by the number of vehicles of the Municipality. The result is the number of the vehicles classified for each class and type of power supply;

4. the fuel consumption per Province vehicle is multiplied by the number of the vehicles classified for each class and type of power supply. The result is the fuel consumption for each Municipality classified per type of power supply;
5. the fuel consumption is multiplied by the CO_2 emission factors developed by Institute for Environmental Protection and Research (ISPRA) (Romano et al., 2018) in order to achieve the tons of CO_2 emitted for each type of power supply and for each class of vehicles.

The overall computational process is presented in Fig.2

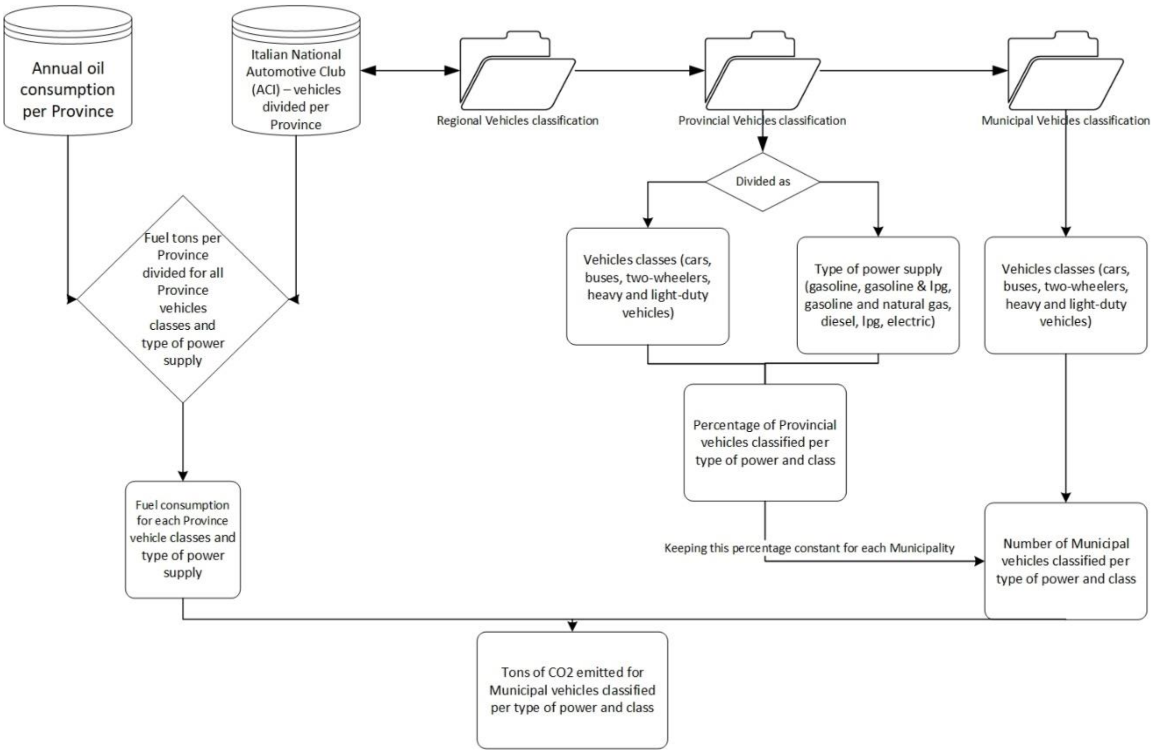


Fig.2 Computational process

Additionally, some private databases (db) can be used to add a meaningful check-step to the proposed methodology: UnipolSai and ACEA.

The first was developed in 2018 by the Italian insurance company UnipolSai, the second was developed in 2019 by European Automobile Manufacturers' Association (ACEA).

UnipolSai database is structured on the data coming from the black-box installed on the cars insured by the company so a small but relevant share of the total vehicles), and data are disaggregated per Italian Regions, Provinces and regional capital cities. Additional information regards some interesting features regarding the driving behavior such as days of car's usage, time spent driving or Km driven per year or per day. A technical report is available: "UnipolSai observatory on the driving habits of Italians" (UnipolSai, 2019).

It is possible to exploit this data to compute the CO_2 emissions per year in the case study region according to the equation (4):

$$\begin{aligned} &\mathrm{CO_2\ emissions\ [ton]} \\ &= \mathrm{CO_2\ average\ emission\ factor} \left[\frac{\mathrm{tonCO_2}}{\mathrm{Km}}\right] * \mathrm{Km\ driven\ (UnipolSai)} \\ &* \mathrm{no.\ of\ total\ \ cars(methodological\ proposal)} \end{aligned} \quad (4)$$

The CO_2 average emission factor comes from the Institute for Environmental Protection and Research (ISPRA) using the COPERT methodology. We compared this estimation with the results of previous approach.

The European Automobile Manufacturers' Association (ACEA) is the advocate for the automobile industry in Europe, representing the 16 major manufacturers of passenger cars, vans, trucks and buses with production sites in the EU. Each year, ACEA publishes its Automobile Industry Pocket Guide (ACEA 2020) in order to provide a complete overview of EU auto industry, as well as data on the production, sales, international trade and taxation of motor vehicles. Among the data published, ACEA provides the average CO_2 emissions of new passenger cars by each EU country. Thus, using ACEA CO_2 average factor and Km driven per year provided by UnipolSai it is possible compute CO_2 emissions according to equation 4 obtaining a second comparative estimation to check the results of the proposed methodology.
In the following paragraph the application of the proposed methodology on a specific case study area is described.

6. The case study of Castelsaraceno Municipality

Castelsaraceno Municipality, is a "small" Municipality with 1,274 inhabitants of the South of Italy, in Basilicata Region. This Municipality signed up to CoM in 2012, then has developed its SEAP (Sustainable Energy Action Plan) and the Monitoring Report, and now is engaged on the new CoM with the elaboration of the SECAP. Castelsaraceno Municipality represents a relevant case study because it is representative of XS CoM Municipality, it is located in an inland area of Basilicata Region and the only transport infrastructure of the territory is the road network (see Fig.3), thus the CO_2 emissions for the transport SECAP sector has to be related only to the vehicle transport.

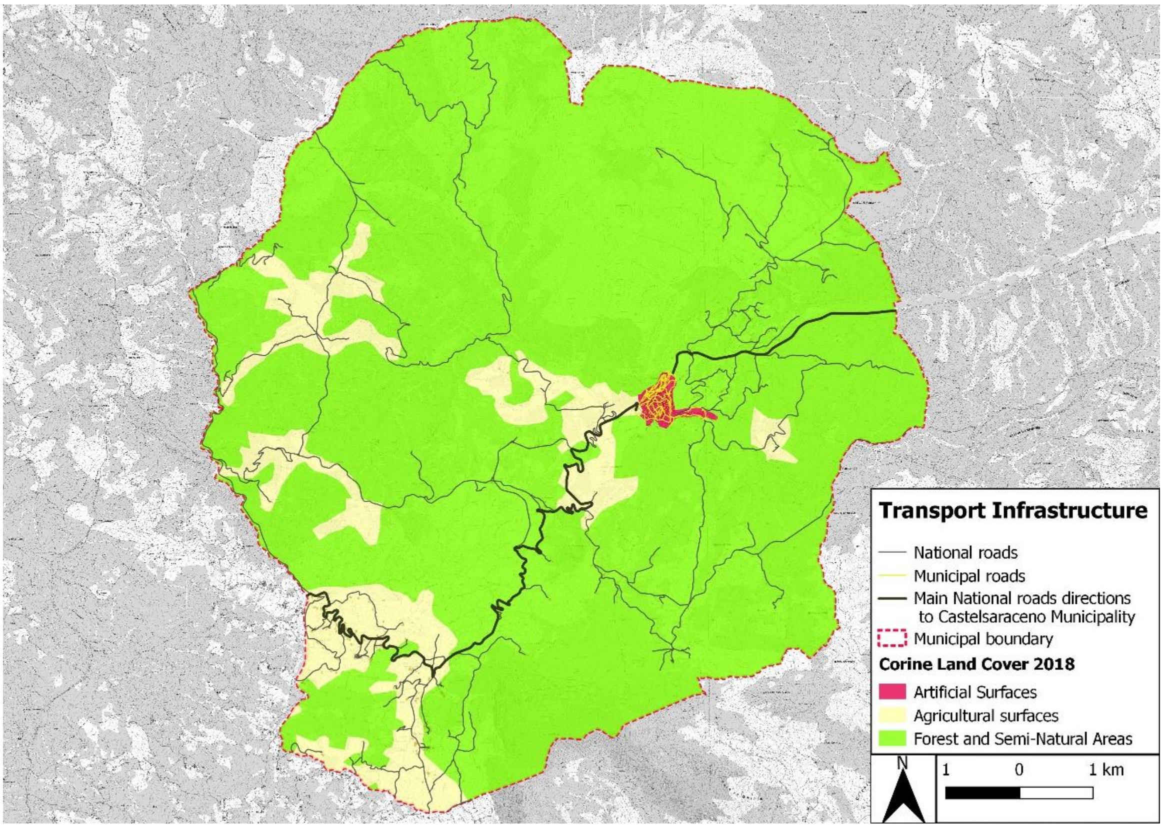


Fig.3 Transport infrastructure and Land Use data of Castelsaraceno Municipality

Furthermore, the Municipality recently realized a tourism attraction according to a tourism development strategy (Fistola et al., 2019; R. Papa & La Rocca, 2017): since in August 2021 "The world's longest Tibetan bridge" (see Fig.4) operates in Castelsaraceno. The bridge links two National parks (Pollino and Appennino Lucano Val d'Agri Lagonegrese National Parks) and, as a direct consequence the tourists flow exponentially increased up to a number of the daily presences that only on the August 2021 rises up to 30,500 with a monthly number of tickets sold for the Tibetan bridge of 11,000.

Fig.4 The Tibetan bridge of Castelsaraceno Municipality, the world's longest with a length of 586 m

This huge amount of tourism presence represents a relevant source of CO_2 emission due to the vehicles transit connected to the tourism flow. Therefore, in the SECAP framework. We affirm that, according to this new scenario, it is necessary to design a tool to compute the transport sector CO_2 emissions related to two emission stocks (ESs):

1. a constant emission stock (ES) given by the vehicle fleet of the Castelsaraceno inhabitants;
2. a variable ES given by the tourist flow.

These issues may also be a recursive condition for many XS Municipalities where the presence of attractive natural and cultural heritage generates seasonal tourism accompanied with a relevant share of energy consumption that has to be appointed in the process of SECAP elaboration. According to this, specific actions have to be included in order to mitigate/reuse such CO_2 emission sources: an interesting domain for the elaboration of sustainable tourism development strategies.

The fuel consumption and the resulting CO_2 emissions related to the vehicle fleet of the Castelsaraceno inhabitants are obtained using the computational process explained in section 5. The vehicle fleet classified by power engine of Potenza Province have been imported by Italian National Automotive Club and referred to 2019 (see Tab.5).

Vehicle fleet of Potenza Province									
	G	G & LPG	G & CNG	Electricity	D	Hybrid G	Hybrid D	Others	NC
Number of vehicles	121,249	12,766	5,575	68	175,966	358	92	2,181	8

Tab.5 Number of Potenza Province vehicles classified by power engine The abbreviation used for the power engine are the following: G=Gasoline, G & LPG =Gasoline and Liquefied Petroleum Gas, G & CNG = Gasoline and Compressed Natural Gas, D =Diesel, Hybrid G =Hybrid Gasoline, Hybrid D = Hybrid Diesel, NC Not Classified

In Tab.6 have been counted the vehicles for Castelsaraceno Municipality classified for power engine and Euro classification. From computation have been excluded the Electricity, Hybrid Gasoline and Hybrid Diesel cars for Castelsaraceno Municipality due to their low percentages (under 1%) related to the whole vehicle fleet of Potenza Province.

Vehicle fleet of Castelsaraceno Municipality												
	Cars [No.]				Light-duty vehicles [No.]				Heavy vehicles [No.]			
	G	D	G & LPG	G & CNG	G	D	G & LPG	G & CNG	G	D	G & LPG	G & CNG
Euro 0	99	24	6	1	13	0	0	0	16	1	0	0
Euro 1	27	11	2	0	3	0	0	0	13	1	0	0
Euro 2	70	43	4	1	3	0	0	0	12	1	0	0
Euro 3	59	102	2	1	3	0	0	0	14	0	0	0
Euro 4	48	120	11	3	1	0	0	0	4	0	0	0
Euro 5	19	78	5	4	1	0	0	0	4	0	0	0
Euro 6	24	53	8	5	0	0	0	0	1	0	0	0
Subtotal	345	431	39	15	23	0	0	0	63	4	0	1
Total	831				23				68			

Tab.6 Vehicle fleet of Castelsaraceno Municipality classified per power engine and EURO classification

The two-wheelers have been considered powered by gasoline and collected in Tab.7.

Two-wheelers of Castelsaraceno Municipality					
Euro Classification	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4
Number of two-wheelers	17	6	6	16	2

Tab.7 Two-wheelers of Castelsaraceno Municipality

According to computational process in Tab.8 have been collected the fuel consumption for each class of vehicles takes into account for Castelsaraceno Municipality.

Fuel consumption of Castelsaraceno Municipality [tons]			
Engine power / Vehicle class	Gasoline	Diesel	LPG
Cars	82	335	14
Light-duty vehicles	0	18	0
Heavy vehicles	1	49	0
Two-wheelers	11	-	-
Total		510	

Tab.8 Fuel consumption of Castelsaraceno Municipality

In order to compare the results with the tCO_2-eq suggested by the SEAP of Castelsaraceno Municipality, the CO_2 emissions have been computed according to LCA approach.
Final tCO_2-eq emissions have been computed according to Equation 3 and collected in Tab.9

CO_2 transport emissions of Castelsaraceno Municipality [tCO_2 eq]

Vehicle class \ Engine power	Gasoline	Diesel	LPG
Cars	301	1,130	71
Light-duty vehicles	0	60	0
Heavy vehicles	3	163	0
Two-wheelers	41	-	-
Total		1,769	

Tab.9 TCO_2 emissions for the transport sector of Castelsaraceno Municipality

In Tab.10 have been compared the CO_2 emissions of Private and commercial transport Sector collected for the 2013 SEAP to the results from author's proposal.

CO_2 transport emissions of Castelsaraceno Municipality [tCO_2 eq]				
Private and commercial transport \ Engine power	Gasoline	Diesel	LPG	Total
2013 SEAP	1,176.03	1,793.57	65.19	3,035
Results from authors' proposal	345	1,353	71	1,769

Tab.10 Comparison among total CO_2 transport emissions of Castelsaraceno Municipality

The differences between the total CO_2 emissions are nowhere near to 50%, a remarkable amount compared to data available of the 2013 SEAP. This demonstrate how variable can be the results of the estimation depending on the adopted methods. In this case the previous SEAP adopted a simplified approach based on annual Kms estimated at municipal level on the basis of national medium data. The proposed approach is more related to specific municipal data and thus allow to have a more reliable picture of the vehicle emission according with the specific characteristics of the registered private fleet. Those relevant differences may generate huge overestimation of mitigation actions that in the case of public investments could also bring to an over expenditure of funds without achieve expected CO_2 reduction effects.

In order to check the results (see Tab. 11), it was applied the Equation 4 adopting the CO_2 average emission factors proposed by UnipolSai and ACEA and the number of the private cars of Castelsaraceno inhabitants. (see Tab.10)

CO_2 emissions by cars of Castelsaraceno Municipality			
Database	CO_2 average emissions [gCO_2/Km]	Km driven	2019 tCO_2 emissions
UnipolSai	166	12,812	1,767
ACEA	119.4	12,812	1,271

Tab.11 CO_2 emissions by cars of Castelsaraceno Municipality according to UnipolSai and ACEA methodology

The CO_2 emissions from cars computed using the methodological proposal (1,769 tCO_2 eq.) are quite similar to the UnipolSai benchmark while for the ACEA, there is a difference of 28% from the methodological proposal. This represents good reliability of the methodological proposal, but it is limited only to a single class of vehicles in the Municipality. The evaluation of the variable emission stock given by the tourist flow becomes necessary considering that the number of arrivals to Castelsaraceno. The available data counts only for the month of August 2021 over 30,000 presences.

On the basis of this single information we developed a basic forecasts about the trend of annual arrivals (not only from Italy but also from several EU Countries) according to some specific hypothesis: to account for the numbers of booked tickets provided by the Tibetan bridge website for the months September, October 2021; the prevision of 6 months of Tibetan brings yearly operation as it represents a form of open-air activity and it is conditioned by seasonal weather conditions; an increasing trend of arrivals due to the effectiveness of the tourism attractor.

This scenario suggests an increase of the CO_2 emissions amount from the transport sector of Castelsaraceno, and it requires monitoring reports about the CO_2 emissions from vehicles flows in order to pursuit sustainable goals and achieve the reduction of 40% of CO_2 emissions according to the CoM objectives.

Thus, we provided a first assessment of the CO_2 emissions on the data about arrivals provided by the Castelsaraceno Municipality through the database provided by UnipolSai and ACEA for cars and European Environmental Agency (EEA) for buses. In this first assessment, we consider only transports inside the Municipal territory with a hypothesis on vehicles and roads typology because of now more accurate information are not available.

Hypothesis of presences in Castelsaraceno Municipality			
Month	Presences	Car Arrivals	Bus Arrivals
May	5,338	1,201	12
June	10,675	2,402	25
July	21,350	4,804	50
August	30,500	6,863	71
September	4,000	900	9
October	1,000	225	2

Tab.12 Hypothesis of presences and arrivals by car and bus to Castelsaraceno Municipality

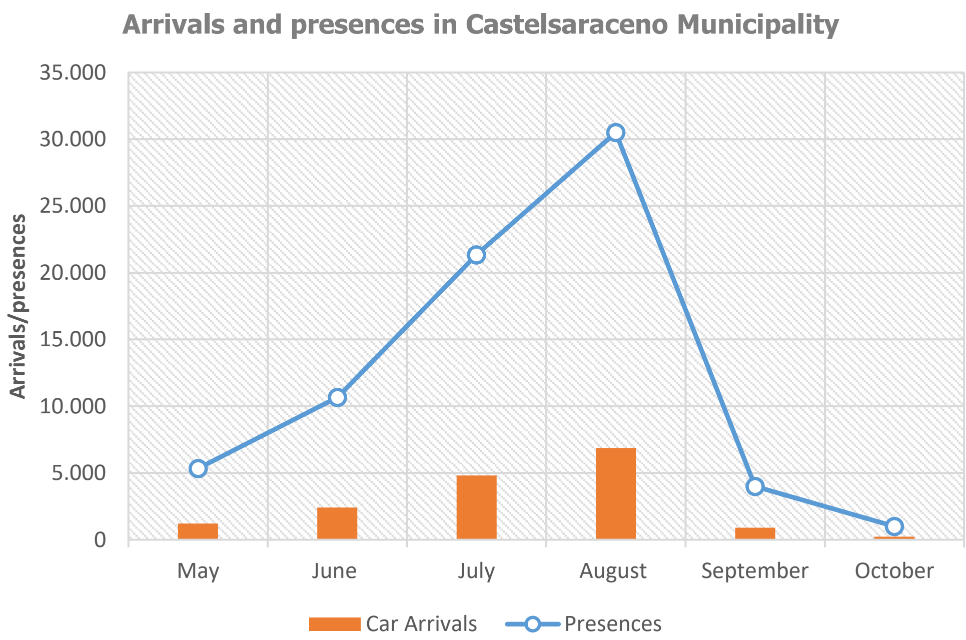


Fig.5 Graph of the Hypothesis of presences and arrivals by car to Castelsaraceno Municipality

Data used are as follows:

- The vehicles considered are cars and buses. The number of car seats considered are 4 while for the buses the seats are the 80% on a total of 54, according to the Italian Ministry of Transport measures against the Covid-19;

- Km driven on the roads are equals to the total measure of the length of National and Municipal roads inside the Municipality, according to the directions for arrival suggested to Castelsaraceno on Tibetan bridge website.

Number of arrivals to Castelsaraceno has divided into two groups, 90% of them has arrived to Castelsaraceno by car and 10% by bus. According to this hypothesis 71 buses and 6,863 cars arrived for the August 2021. The choice of the high percentage related to the arrivals by cars is based on the preference of Italian people to use car as main transport vehicle highlighted by the 2020 annual report by ISFORT acronym for High Institute for Transport Education and Research, that support the development of the technical knowledge and to the public debate about mobility and logistics in Italy. The complete trend for the months considered (from May to October) is presented in Tab.12 and in Fig.5.

In order to compute the variable ES of CO_2 by tourism flow and without the availability of detailed data the proposed methodology has been simplified. The car arriving to Castelsaraceno have been distinguished (see Tab.13) by power engine according to relative percentages suggested by the annual report of the Italian Automobile Club and relative CO_2 ES has been computed using data available on database of average emission factors for road transport in Italy elaborated by Italian National Institute for Environmental Protection and Research (ISPRA).

ES of CO_2 by tourism flow in Castelsaraceno Municipalities

Vehicle class \ Engine power and CO_2 emissions	Gasoline [No.]	Diesel [No.]	Total ES [tCO_2 eq]
Cars	9,181	7,214	109
Buses	-	170	5
Total	9,181	7,384	114

Tab.13 ES of CO_2 by tourism flow in Castelsaraceno Municipalities

In Tab.14 they have been collected the CO_2 emissions by tourist cars and buses computed using the benchmark provided by the EEA's annual Transport and Environment Reporting Mechanism (TERM) report (EEA, 2014).

Variable CO_2 ES by tourist flow of Castelsaraceno Municipality

Database	CO_2 average emissions [gCO_2/Km]	Total Km driven	Total CO_2 ES on tourism period (May-October)
UnipolSai (for cars)	166	40	109
ACEA (for cars)	119.4	40	78
EEA (for buses)	230	40	2

Tab.14 CO_2 emissions by touristflow of Castelsraceno Municipality

Combining the results UnipolSai & EEA and ACEA & EEA, promising evidences come out from the comparison between them and the total ES of Tab.13. The differences from the results of Tab.13in term of total ES CO_2, are only about 0.03% for the UnipolSai & EEA while for ACEA & EEA are about 30%; they are remarkable results considering that the proposed methodology has been simplified and the data used are based on national data without more specifications at local level.

Finally, the overall CO_2 ES of Castelsaraceno Municipality is equal to 1,883 tCO_2 (see Fig.6); in this amount the variable ES represents a relevant percentage considering the scenario of the CO_2 emissions growth from the transport sector of Castelsaraceno related to tourism flow, and it requires the planning of measures in order to pursuit sustainable goals, according to the current EU2030 targets.

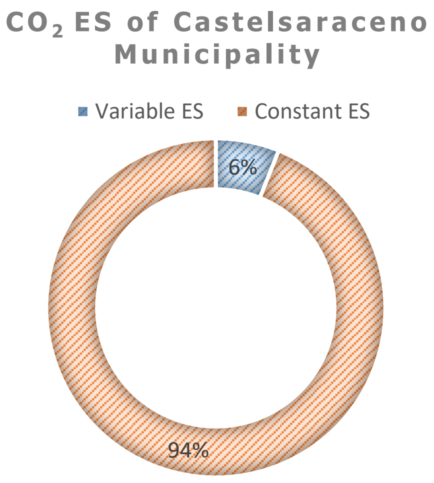


Fig.6 The overall CO_2 ES of Castelsaraceno Municipality

7. Conclusions

XS Signatories are representative of a wide share of EU Municipalities belonging to the EU lagging regions where urban development represents a challenge both in terms of demand for investments and new tools to boost effectively local development strategies(Casas et al., 2014; de Gregorio Hurtado et al., 2015). The EU 2030 strategies required the same commitments both to medium and large EU cities and small municipalities but the gap of capacities is evident (technical skills, funds availability, private in investments etc.). in terms of numbers it is possible to highlight a widespread success of the CoM policies for EU small Municipalities and both SEAP and SECAP had been intended as alternative planning instruments for the management of energy and climate investments and transformations in the urban areas (Santopietro & Scorza, 2021).

Previous researches (Campagna et al., 2018; Campagna & Deplano, 2004; Lai et al., 2019; Santopietro et al., 2020; Santopietro & Scorza, 2020; Scorza et al., 2017) remark the fruitful aspect of the sectorial approach, facing the climate-change, however the cities should not be considered by sectors but by set of systems (Rocco Papa et al., 2015)(such as green spaces, green infrastructures (Gargiulo et al., 2018; Lai et al., 2018, 2021) waterproofed soils, energy system (Scorza, 2016) , active mobility (Fortunato et al., 2020; Scorza et al., 2021; Scorza & Fortunato, 2021) etc..). Among these aspects, this paper focused specific issues connected to the procedure for the estimation of CO_2 emissions from transport sector in small Municipalities. The proposed approach organizes an analytical framework based on data available in main national databases (in Italy but also in other EU Countries), not asking specific additional technical specifications; providing reliable estimation base on Constant and Variable Emissions Stock (ES). The case study highlighted how the contribution of tourism arrivals has to be included in the SECAP BEI as private transport components of CO_2 emissions. This is a recurrent condition for XS Municipalities where are based tourism attractors (environmental, Historical, cultural, etc.). Traditionally, Small XS Municipalities do not include in the computation of CO_2 emissions those generated by tourist flows.

This is the case of the Castelsaraceno, a small XS Municipality where the construction of a tourist attraction produced a surplus in terms of CO_2 transport emissions. Considering the growth of the number of the vehicles travelling inside the Municipality, compensatory and mitigation measures should be taken into account for effective SECAP implementation: limitation of the automotive traffic inside the urban area, implementation or strengthening of the greenways, promoting sustainable mobility (Scorza et al., 2021; Scorza & Fortunato, 2021; Vinci & Cutaia, 2019), etc. Specific actions or measures can be implemented on the carbon-tax model

in order to provide funds for mitigation actions oriented to a local application of the sustainable territorial development principles (European Commission, 2016; Garau & Pavan, 2018; Las Casas et al., 2019; Las Casas & Scorza, 2016; Pilogallo & Scorza, 2022; Pontrandolfi & Scorza, 2016) and climate adaptation/mitigation(Zucaro & Morosini, 2018).
The computational proposal is oriented to give to Municipalities a concrete guideline to easy perform this assessment suggesting a way to upgrade and check the current SEAP/SECAP transport sector emission estimations adopting consequent measures both in policymaking and urban/territorial actions.
Limitations of the approach depends on the necessity to testing multiple cases the working hypothesis described in this research also selecting not Italian case studies in order to verify the availability of national and European data sources and eventual adjustments to reinforce the transferability of the approach.
Future developments are oriented to integrate these results with all emissions sectors required by SECAP in according with recent methodological framework (Scorza & Santopietro, 2021) oriented to include systemic approach in SECAP development promoting the principle of integration against sectorial disaggregation.

References

ACEA (2020), The automobile industry pocket guide 2020 / 2021. Retrieved from: https://www.acea.auto/files/ACEA_Pocket_Guide_2020-2021.pdf

Bertoldi, P. (editor). (2018). *Guidebook "How to develop a Sustainable Energy and Climate Action Plan (SECAP)."* https://doi.org/10.2760/223399

Bertoldi, Paolo, & Rivas, S. (2020). *Covenant of Mayors: 2019 Assessment Drought Team EU-JRC-ISPRA View project Covenant of Mayors View project*. https://doi.org/10.2760/775755

Campagna, M., & Deplano, G. (2004). Evaluating geographic information provision within public administration websites. *Environment and Planning B: Planning and Design*, *31*(1), 21–37. https://doi.org/10.1068/b12966

Campagna, M., Di Cesare, E. A., Matta, A., & Serra, M. (2018). Bridging the gap between strategic environmental assessment and planning: A geodesign perspective. In *Environmental Information Systems: Concepts, Methodologies, Tools, and Applications* (Vol. 2, pp. 569–589). IGI Global. https://doi.org/10.4018/978-1-5225-7033-2.ch024

Casas, G. Las, Lombardo, S., Murgante, B., Pontrandolfi, P., & Scorza, F. (2014). Open Data for Territorial Specialization Assessment Territorial Specialization in Attracting Local Development Funds: an Assessment. Procedure Based on Open Data and Open Tools. *TeMA - Journal of Land Use, Mobility and Environment*. https://doi.org/10.6092/1970-9870/2557

Corrado, S., Giannini, B., Santopietro, L., Oliveto, G., & Scorza, F. (2020). Water Management and Municipal Climate Adaptation Plans: A Preliminary Assessment for Flood Risks Management at Urban Scale. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12255 LNCS*. https://doi.org/10.1007/978-3-030-58820-5_14

Croci, E., Lucchitta, B., Janssens-Maenhout, G., Martelli, S., & Molteni, T. (2017). Urban CO2 mitigation strategies under the Covenant of Mayors: An assessment of 124 European cities. *Journal of Cleaner Production*, *169*, 161–177. https://doi.org/10.1016/j.jclepro.2017.05.165

D'Orso, G., Migliore, M., Peri, G., & Rizzo, G. (2020). Using AHP methodology for prioritizing the actions in the transport sector in the frame of SECAPs. *2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe)*, 1–6. https://doi.org/10.1109/EEEIC/ICPSEurope49358.2020.9160591

de Gregorio Hurtado, S., Olazabal, M., Salvia, M., Pietrapertosa, F., Olazabal, E., Geneletti, D., D'Alonzo, V., Di Leo, S., & Reckien, D. (2015). Understanding How and Why Cities Engage with Climate Policy. *TeMA Journal of Land Use, Mobility and Environment*, *8*(Special issue ECCA), 23–46. https://doi.org/http://dx.doi.org/10.6092/1970-9870/3649

EEA. (2014). Focusing on environmental pressures from long-distance transport. In *TERM 2014: transport indicators tracking progress towards environmental targets in Europe* (Issue 7).

European Comission. (2010). *How to develop a Sustainable Energy Action Plan*. https://doi.org/10.2790/20638

European Commission. (2016). Urban agenda for the EU - Pact of Amsterdam. In *Urbanagenda*.

European Commission. (2019). Communication from the Commission: The European Green Deal. In *COM(2019) 640 final*.

European Enviromental Agency. (2019). EMEP/EEA air pollutant emission inventory guidebook 2019: Technical guidance to prepare national emission inventories. *EEA Technical Report*, *13/2019*, 23. https://doi.org/10.2800/293657

Fistola, R., Gargiulo, C., Battarra, R., & Rocca, R. A. La. (2019). Sustainability of Urban Functions: Dealing with Tourism

Activity. *Sustainability 2019, Vol. 11, Page 1071*, *11*(4), 1071. https://doi.org/10.3390/SU11041071

Fortunato, G., Scorza, F., & Murgante, B. (2020). Hybrid Oriented Sustainable Urban Development: A Pattern of Low-Carbon Access to Schools in the City of Potenza. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12255 LNCS*. https://doi.org/10.1007/978-3-030-58820-5_15

Garau, C., & Pavan, V. M. (2018). Evaluating urban quality: Indicators and assessment tools for smart sustainable cities. *Sustainability (Switzerland)*, *10*(3), 575. https://doi.org/10.3390/su10030575

Gargiulo, C., Ayad, A., Tulisi, A., & Zucaro, F. (2018). Effect of urban greenspaces on residential buildings' energy consumption: Case study in a mediterranean climate. *Green Energy and Technology*, *PartF12*, 109–125. https://doi.org/10.1007/978-3-319-77682-8_7

Intergovernmental Panel on Climate Change. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme* (N. T. and T. K. Eggleston H.S., Buendia L., Miwa K. (ed.)). Institute for Global Environmental Strategies.

Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havránek, M., Pataki, D., Phdungsilp, A., Ramaswami, A., & Mendez, G. V. (2009). Greenhouse gas emissions from global cities. *Environmental Science and Technology*, *43*(19), 7297–7302. https://doi.org/10.1021/es900213p

Kona, A., Melica, G., Bertoldi, P., Rivas, S., Koffi, B., Iancu, A., Zancanella, P., Janssens-Maenhout, G., & Dallemand, J. (2017). *Covenant of Mayors in figures: 8-year assessment*. Publications Office of the European Union. https://doi.org/10.2760/64731

Lai, S., Isola, F., Leone, F., & Zoppi, C. (2021). Assessing the potential of green infrastructure to mitigate hydro-geological hazard. *TeMA - Journal of Land Use, Mobility and Environment*, 109–133. https://doi.org/10.6093/1970-9870/7411

Lai, S., Leone, F., & Zoppi, C. (2018). Implementing green infrastructures beyond protected areas. *Sustainability (Switzerland)*, *10*(10), 3544. https://doi.org/10.3390/su10103544

Lai, S., Leone, F., & Zoppi, C. (2019). Assessment of municipal masterplans aimed at identifying and fostering green infrastructure: A study concerning three towns of the metropolitan area of Cagliari, Italy. *Sustainability (Switzerland)*, *11*(5), 1470. https://doi.org/10.3390/su11051470

Las Casas, G., & Scorza, F. (2016). Sustainable Planning: A Methodological Toolkit. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 9786, pp. 627–635). Springer Verlag. https://doi.org/10.1007/978-3-319-42085-1_53

Las Casas, G., Scorza, F., & Murgante, B. (2019). New Urban Agenda and Open Challenges for Urban and Regional Planning. In F. Calabrò, L. Della Spina, & C. Bevilacqua (Eds.), *New Metropolitan Perspectives. ISHT 2018* (Vol. 100, pp. 282–288). Springer. https://doi.org/10.1007/978-3-319-92099-3_33

Papa, R., & La Rocca, R. A. (2017). New forms of mobility for an alternative territorial fruition: The rediscovery of tourist footpaths. *Transport Infrastructure and Systems - Proceedings of the AIIT International Congress on Transport Infrastructure and Systems, TIS 2017*, 669–676. https://doi.org/10.1201/9781315281896-87/TERMINAL-OPERATOR-LIABILITY-FRANCESCA-ORSI

Papa, R., Galderisi, A., Vigo Majello, M. C., & Saretta, E. (2015). Smart and resilient cities. A systemic approach for developing cross-sectoral strategies in the face of climate change. *TeMA Journal of Land Use, Mobility and Environment, 8*(1), 19-49.. https://doi.org/10.6092/1970-9870/2883

Pilogallo, A., & Scorza, F. (2022). Mapping Regulation Ecosystem Services Specialization in Italy. *Journal of Urban Planning and Development*, *148*(1), 4021072. https://doi.org/10.1061/(asce)up.1943-5444.0000801

Pontrandolfi, P., & Scorza, F. (2016). Sustainable Urban Regeneration Policy Making: Inclusive Participation Practice. In O. Gervasi, B. Murgante, S. Misra, C. A. M. A. Rocha, C. Torre, D. Taniar, O. B. Apduhan, E. Stankova, & S. Wang (Eds.), *Computational Science and Its Applications - ICCSA 2016, Lecture Notes in Computer Science book series, volume 9788* (pp. 552–560). Springer International Publishing. https://doi.org/10.1007/978-3-319-42111-7_44

Rivas, S., Urraca, R., Bertoldi, P., & Thiel, C. (2021). Towards the EU Green Deal: Local key factors to achieve ambitious 2030 climate targets. *Journal of Cleaner Production*, *320*, 128878. https://doi.org/10.1016/j.jclepro.2021.128878

Romano, D., Arcarese, C., Bernetti, A., Caputo, A., Contaldi, M., De Lauretis, R., Di Cristofaro, E., Gagna, A., Gonella, B., Taurino, E., & Vitullo, M. (2018). *Italian Greenhouse Gas Inventory 1990-2016*. Institute for Environmental Protection and Research - Communications Area.

Santopietro, L., Faruolo, G., Scorza, F., Rossi, A., Tancredi, M., Pepe, A., & Giordano, M. (2020). Geovisualization for Energy Planning. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12252 LNCS* (pp. 479–487). https://doi.org/10.1007/978-3-030-58811-3_35

Santopietro, L., & Scorza, F. (2020). A Place-Based Approach for the SECAP of Potenza Municipality: The Case of Green Spaces System. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12255 LNCS* (pp. 226–234). https://doi.org/10.1007/978-3-030-58820-5_18

Santopietro, L., & Scorza, F. (2021). The Italian experience of the covenant of mayors: A territorial evaluation. *Sustainability*

(Switzerland), *13*(3), 1–23. https://doi.org/10.3390/su13031289

Scorza, F. (2016). Towards Self Energy-Management and Sustainable Citizens' Engagement in Local Energy Efficiency Agenda. *International Journal of Agricultural and Environmental Information Systems*, *7*(1), 44–53. https://doi.org/10.4018/IJAEIS.2016010103

Scorza, F., & Fortunato, G. (2021). Cyclable Cities: Building Feasible Scenario through Urban Space Morphology Assessment. *Journal of Urban Planning and Development*, *147*(4), 05021039. https://doi.org/10.1061/(asce)up.1943-5444.0000713

Scorza, F., Fortunato, G., Carbone, R., Murgante, B., & Pontrandolfi, P. (2021). Increasing urban walkability through citizens' participation processes. *Sustainability (Switzerland)*, *13*(11), 5835. https://doi.org/10.3390/su13115835

Scorza, F., & Santopietro, L. (2021). A systemic perspective for the Sustainable Energy and Climate Action Plan (SECAP). *European Planning Studies*, 1–21. https://doi.org/10.1080/09654313.2021.1954603

Scorza, F., Santopietro, L., Giuzio, B., Amato, F., Murgante, B., & Casas, G. Las. (2017). Conflicts between environmental protection and energy regeneration of the historic heritage in the case of the city of matera: Tools for assessing and dimensioning of sustainable energy action plans (SEAP). In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 10409 LNCS*. https://doi.org/10.1007/978-3-319-62407-5_37

UnipolSai (2019). Comunicato Stampa – Osservatorio UnipolSai 2019.

United Nations. (2015). Paris Agreement. *Conference of the Parties on Its Twenty-First Session*, *December*, 32.

Vinci, I., & Cutaia, F. (2019). Implementing the environmental dimension of the EU's urban agenda 2014-2020. *TeMA Journal of Land Use, Mobility and Environment, 12(2)*, 139–146. https://doi.org/10.6092/1970-9870/5888

Zucaro, F., & Morosini, R. (2018). Sustainable Land Use and Climate Adaptation: A Review of European Local Plans. *TeMA Journal of Land Use, Mobility and Environment*, *11*(1), 7–26. http://dx.doi.org/10.6092/1970-9870/5343

Image Sources

Fig.1: Retrieved from the article published on International Council of Clean Transportation website, 9th April 2021:

https://theicct.org/blog/staff/eu-carbon-budget-apr2021

Fig.2,3,4,5,6: Authors

Author's profile

Luigi Santopietro

PhD student in "Engineering for Innovation and Sustainable Development" at University of Basilicata. His research interests are in regional development, urban and regional planning, impact assessment of plans and projects, energy plans, Geographic Information Systems and European Environmental Policies.

Francesco Scorza

Associate Professor of Urban and Regional Planning at University of Basilicata and PhD in "Sciences and Methods for the City and the European Territory" at Pisa University. His research interests are in regional development, urban and regional planning, impact assessment of plans and projects, advanced KMS, spatial analysis, participation, technologies as DSS.

Beniamino Murgante

Professor of Urban and Regional Planning at the University of Basilicata. He obtained his PhD in "Sciences and methods for European cities and territory" at the Department of Civil engineer of the University of Pisa. He carried out other researches in Lyon at the Laboratoire d'Ingénierie des Systèmes d'Information at the Institut National des Sciences Appliquées (INSA) directed by Robert Laurini. His main research interests are focused on the use of technologies in supporting spatial decision.