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GIS FOR VALUATION OF URBAN SPRAWL AND GREEN TRANSPORTATION

Transport Oriented Development to Face Sprawl

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ATTRIBUTIONS
Domenico Enrico MASSIMO conceived and set up the research and authored paragraphs: 2, 5, 8, 10. Mariangela MUSOLINO developed all valuation activities and authored paragraph: 1, 4. Antonino BARBALACE coordinated the research works of PAU GIS University Laboratory components, performed GIS and Geodatabase design, development and processing, and authored paragraphs: 3, 6, 7, 9.

ABSTRACT

Research deals with contemporary urban system and namely with urban sprawl phenomenon, examining one of the possible policy responses to worldwide city over-expansion, addressed by international organizations to wrestling sprawl to the ground, *i.e.* a better organization of public transport system crossing and serving directly settlements and their inhabitants.
Research, strategically supported by key GIS tools, investigates the eventual relationship between: urban expansions; demographic dynamics; territorial economy; degree of accessibility and mobility. Research is focused on a Case Study in Calabria region, Italy.
Alternative future scenarios in the real world have been designed for the chosen entire region, considering population, Gross Domestic Product, infrastructures, and transport system. Key role has been played by Geodatabase of all settlements that research has built-up.
Then research performs: sprawl measurements; economic analysis; valuations of transportation scenarios and related choices; cost estimate of infrastructure interventions.
First results of meta-analysis show that an integrated green infrastructure and transportation system can help treasuring the existing settlements and, so doing, reduce sprawl trend, improve territorial accessibility and their regional economy, lower energy consumption and CO_2 emissions.

1. RESEARCH GENERAL FRAMEWORK

The experimental research here presented deals with the complexity of European, and world, urban system and namely with urban sprawl phenomenon aiming to find-out and propose mitigation measures as policy responses to it.
Sprawl, *i.e.* the relevant phenomenon afflicting world settlements in the last half century, is conventionally defined as «the physical pattern of low density of large urban areas, under market conditions, mainly in the surrounding of agricultural areas as well as open land».
The inter-disciplinary analysis of this world-wide and impressive phenomenon has produced studies, researches and policy opinions deeply different, diversified and sometimes divergent.
A common ancillary and propaedeutical position to face urban sprawl phenomenon seems to be shared by all scientific community and ideological opinions: the categorical imperative to start-up,

without any hesitation, a general system of assessment and valuation (SGV) to understand the size of urban sprawl and therefore design possible solution to mitigate its negative impacts.
This should be done not only in sparse and fragmentary discontinued areas with *a pois* sampling and erratic Case Studies, but within a general framework by starting-up a diachronic observatory activity characterized by: objective scientific basis of analysis; impartiality; a wide time span of observation, total covering of territories.
Then, synchronic and systematic observations including vast, entire and continuous geographic areas should be performed.

2. RESEARCH STRUCTURE

Research here presented is focused on three main interconnected sub-objectives.

First. Meta-analysis at geographic level
Research conducts a meta-analysis at geographic scale of the relevant relationship between "urban sprawl and economic growth" by examining and indirectly investigating at geographic scale some of the institutional interpretations marking urban sprawl as a critical case of market failure. These interpretations are developed by research centers connected to Institutions such as Governments of European Union and the United States of America, running sub-continental territories where a significant part of the world economy as well as sprawl phenomenon are concentrated.

Second. Analysis at territorial level
Given the complex issue under investigation, present research has started-up a first parallel and synopsis between meta-analysis at geographic scale and a Case Study at territorial level, by directly investigating at locale scale the relationship between: urban over-expansions; underlain demographic dynamics; trend of territorial economy; degree of accessibility and mobility.

Third. TOD policy responses to sprawl
Research then tries to derive possible proposal for systematic interventions to redirect the urban sprawl phenomenon that is still consuming all the scarce and costly natural resources of the planet, namely it tries at local level the TOD international policy response to sprawl.
Research examines one of the possible policy responses to worldwide city over-expansion, addressed by international organizations to wrestling sprawl to the ground, particularly for negative impact constituted by dramatic increase of individual mobility by private car for daily and periodical commuting. TOD response is a better organization of public infrastructure system, mainly the railroad, crossing the greatest number of urban settlements and serving directly their residents.

3. GEOGRAPHIC SCALE

Meta-analysis outlining the positive or (more likely) negative impacts of urban sprawl. In the latter case, negative effects, Institutions and Governments, at different geographic levels, may suppose interventions of policy responses to mitigate sprawl either on negative impacts (of neutralization) or on causal elements.
The meta-analysis conducted in the four continents identifies in some driving forces the causes of the world wide phenomenon of the sprawl. Some of them are:

- economic growth;
- demographic boom;
- re-localization of complex activities in semi-urban areas;
- housing shortage in central urban areas;
- high index of crowding, *i.e.* population filled in small areas.

Researches agree to identify and assess the following negative effects:

- environmental, in terms of land, water and air consumption, and also acoustic pollution;
- social, in terms of dramatic increase of individual commuting by private car, time people spend for it, and the high human costs: psychological, health, mobility and familiar.

In the last decades strong policy responses have been addressed, in particular in Europe, to mitigate sprawl. Among them there are:

- consolidation, *i.e.* treasuring and revamping of the existing cities;
- containment, *i.e.* re-urbanization of suburban areas by enhancing street connectivity and reducing the enormous dimension of urban blocks;
- new urbanism, *i.e.* construction of new compact and dense settlements characterized by a mix of various urban functions and only if served by heavy urban rail system;
- heavy urban rail system, *i.e.* collective sustainable infrastructure on rail.

One paramount response at large scale, detected through meta-analysis, to face sprawl is a public urban rail transport policy. Advocates call communities to build future development only and only if a public urban rail system crosses or\and serves directly new settlements and its inhabitants. This response to sprawl is world-wide defined as Transport Oriented Development (TOD).
International analysis pay special attention to this world-wide response which makes a great difference in criteria to evaluate public transport, emphasizing the number of residents and settlements directly served by urban rail or other green transport.
In fact, since now investment cost and speed results have been the only important evaluation criteria and solely leverages for decision, omitting the most relevant relationship between transport and inner settlement core, *i.e.* basic accessibility, as structural change for city, *versus* mobility that could be the individual solution, often the most socially and ecologically inefficient, for commuting.

4. TERRITORIAL SCALE

Present research has started-up in the Case Study area, Calabria region, a deep investigation, supported by key GIS tools, about the eventual causal relationship between: urban expansions; demographic dynamics; territorial economy; degree of accessibility and mobility.
In particular, the sub-objectives pursued by the research are: 1) documentary-geographic; 2) analytical-economic *i.e.* explanatory-hermeneutic.

Documentary Geographic Sub-Objective

The **documentary-geographic** sub-objective of Case Study research is to disaggregate and deepen the *a pois* sample researches performed at continental level by institutions, centers, pools and investigation groups of European Union, Usa and other countries of developed economies. Case Study takes up the challenge of: higher details of geographic scale; comprehensiveness of examination; total covering of territories; much wider time span of urban history.
In fact, research performs systematic investigations (not sampling), on regional settlements (of Case Study area) by considering all the inhabited places at un-precedented detailed scales. Afterwards, the square meters are calculated for each inhabited settlement, even the smallest one, by taking a picture of the urban dynamics at different dates: 1870; 1954; 2001; 2009.

Analytical-Economic Sub-Objective

The **analytical-economic** sub-objective *i.e.* the explanatory-hermeneutic part of the Case Study research examines if a causal relationship exists, first of all between topographic urban enlargement dynamics of each settlement between 1870 and 2009, and their population increase; and then with present level of income *i.e.* GDP ranking.
All this, to verify the existence or not of a demographic motivation or an economic-productive explanation for the recorded impressive urban over-expansions.

Territorial Economy

Research has then compared the results concerning sprawl measurement, population dynamics and economic growth with other Italian regions as Trentino, Valle d'Aosta, Friuli and Tuscany, so called "*Italia intermedia*" [*i.e.* "Intermediate Italy"] for their medium size in terms of population, economy, production, inter-sectoral mix, way of life.

Sprawl in the Case Study area has distinctive characteristics. Its causes seem to be different to those identified at geographic international scale. In fact, the driving forces are not confirmed and sprawl in the Case Study area is not connected to the level of income *i.e.* GDP ranking singled out as the causes in other contexts at geographic scale, as it is described in the following paragraphs.

Local policy responses

Further objective concerns the possibility to address policy response to the analyzed phenomenon. A possible goal might be to start-up a valuation framework based on geographic meta-analysis to verify if TOD is a possible local response to sprawl in terms of popular consensus and Institutional approval.

5. CASE STUDY

In order to verify existence and consistence of urban sprawl, perform objective measurements and derive hermeneutics of the possible causal relationship, research has designed and built-up a geographic information system of the historic settlements of the entire Calabria region in ArcGIS environment articulated in cartography and demography, within the framework of a more general valuation system (SGV).

Local research has begun with the Case Study concerning all the settlements of one of Calabria five provinces. The overall settlement expansion at provincial level is expressed in square meters and derived from the analytical summing-up of the expansion of each urban settlement and it is compared to its demography dynamics as well as to its provincial income in order to understand whether the exponential open land and farmland consumption in the central area

All this is motivated by a proportional increase of population, or anticipated and caused by a growth of production and income at provincial level.

Documentary-Geographic Sub-Objective

Main element of the entire research strategy is the cartographic measurement of the diachronic insediative perimeters (original and sub-sequent). References have been made to spatial "scientific" representations at total coverage with the higher details if compared to the traditional seventeenth century "chorographic" maps. In fact, Case Study research adopted and used the "modern" topographic maps at scale 1:50.000, 1:25.000, up to 1:10.000, that are of course much more detailed than the traditional synthetic "chorographic" historical representation at scales around 1:200.000-1:400.000. In between "chorographies" (XVII century) and "topographies" (XIX-XX century) there is the extraordinary Map of Two Sicily Kingdom, at 1788 (XVIII century), scale 1:88.000, the most advanced "scientific" in the world at that age. The perimeterization stage of the historic settlements has been focuses on three main dates: 1870 (Unification of Italy); 1954 (post-war); 2001 (present).

Each of the 694 settlements (previously censused and localized in ArcGIS environment) has been perimetered, on the cited systematic and total coverage maps, at the three different dates and the square meters of their extension of the built-up areas have been calculated.

Analytical-Economic Sub-Objective

Once the documentary-geographic research has been set-up, the interpretation and the hermeneutics of the urban sprawl phenomenon has begun in the specific Case Study. The crucial point is in terms of management of the territory and government of the settlements is to analyze the relationship between built-up square meters for inhabitant: this represents a great result of the research. It makes possible the assessment, at least to a first approximation, of a demographic motivation of the urban over-expansion analyzed and reported in the first result and also cartographically represented in the figures.

The integrated analysis performed looks towards the future urban development. It can derive a preliminary ratio between built-up land and amount of future forecasted settled population. In fact, it is useful to assess in advance the demographic reasonableness, or not, of possible further urban expansion envisaged by urban planning.
In particular, research has investigated sprawl and demography and their relationship with economic growth at territorial level by implementing a Case Study in the entire Calabria region, with a specific focus on the central isthmian area (the narrowest part of Italy: 40 km) where the second (Catanzaro) and third (Lamezia Terme) towns of the region are located.
The result of the comparison between built-up square meters and related inhabitants (m^2\inhabitants) is impressive for all Calabria region.
In the specific Case Study concerning the province of Catanzaro, this ratio goes from 24 m^2\inhabitants in 1870, to 32 m^2\inhabitants in 1954, to 333 m^2\inhabitants in 1991, to 416 m^2\inhabitants in 2001. Furthermore, a ratio of 720 m^2\inhabitants is forecasted and granted in local urban planning tools. The latter is alarming because demographic projections do not support hypothesis of significant regional population growth, and to the diminishing population corresponds the prevision of a building over-expansion. All this is worsened by the spread (= sprawl) of building construction allowed in agricultural, arable, forestry and open land by urban planning tools.

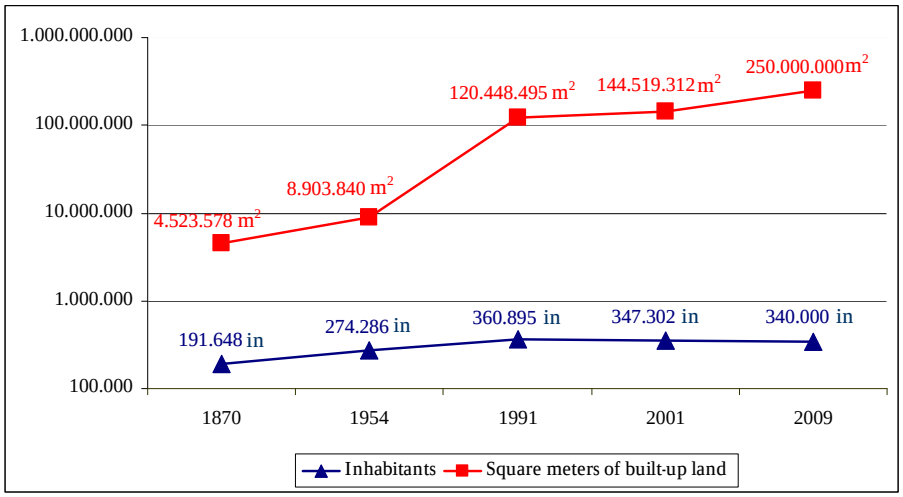
Table 1. Province of Catanzaro. Valuation of urban evolution. Diachronic analysis 1870-2009: built-up land; population; ratio m^2\inhabitant

Year	Built-up Land	Urban Population	m^2\ Inhabitant
	m^2	*inhabitants*	
1870	(a) 4.523.578	(b) 191.648	23,60
1954	(a) 8.903.840	(b) 274.286	32,46
1991	(a) 120.448.495	(b) 360.895	333,74
2001	(a) 144.519.312	(b) 347.302	416,12
Prg2009	(c) 250.000.000	(d) 340.000	719,84

Source: (a) work-out of the authors on the basis of official historic cartography at 1870, 1954, 1991, 2001; (b) Istat; (c) urban plans; (d) Town Halls

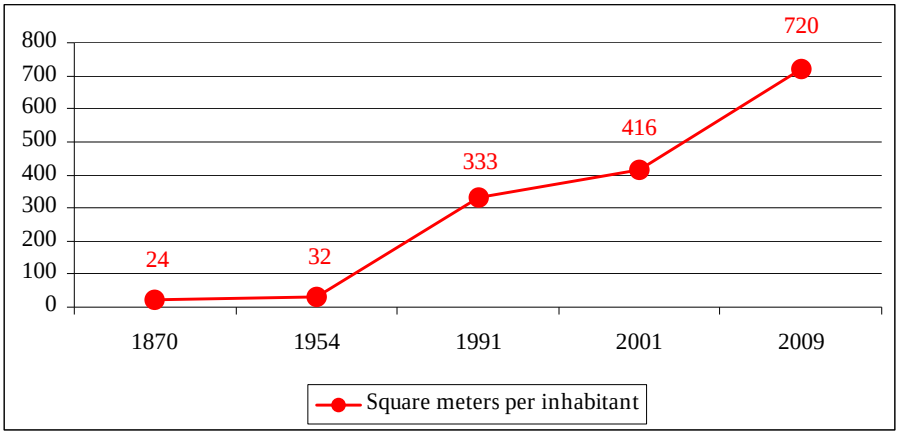
The transformation of the table in the diagrams with a logarithmic (y) axes makes evident the absence of demographic motivation of the urban and building over-expansion.

Graph 1. Province of Catanzaro. Diachronic analysis 1870-2009. Trends: population (blue triangles); built-up land (red squares) [(y) axis, logarithmic]



Source: work-out of the authors on the basis of official historic cartography at 1870, 1954, 1991, 2001; Istat; urban plans; Town Halls

Graph 2. Province of Catanzaro. Valuation of urban evolution. Diachronic analysis 1870-2009. Trends: square meters per inhabitant (green squares)



Source: work-out of the authors on the basis of official historic cartography at 1870, 1954, 1991, 2001; Istat; urban plans; Town Halls

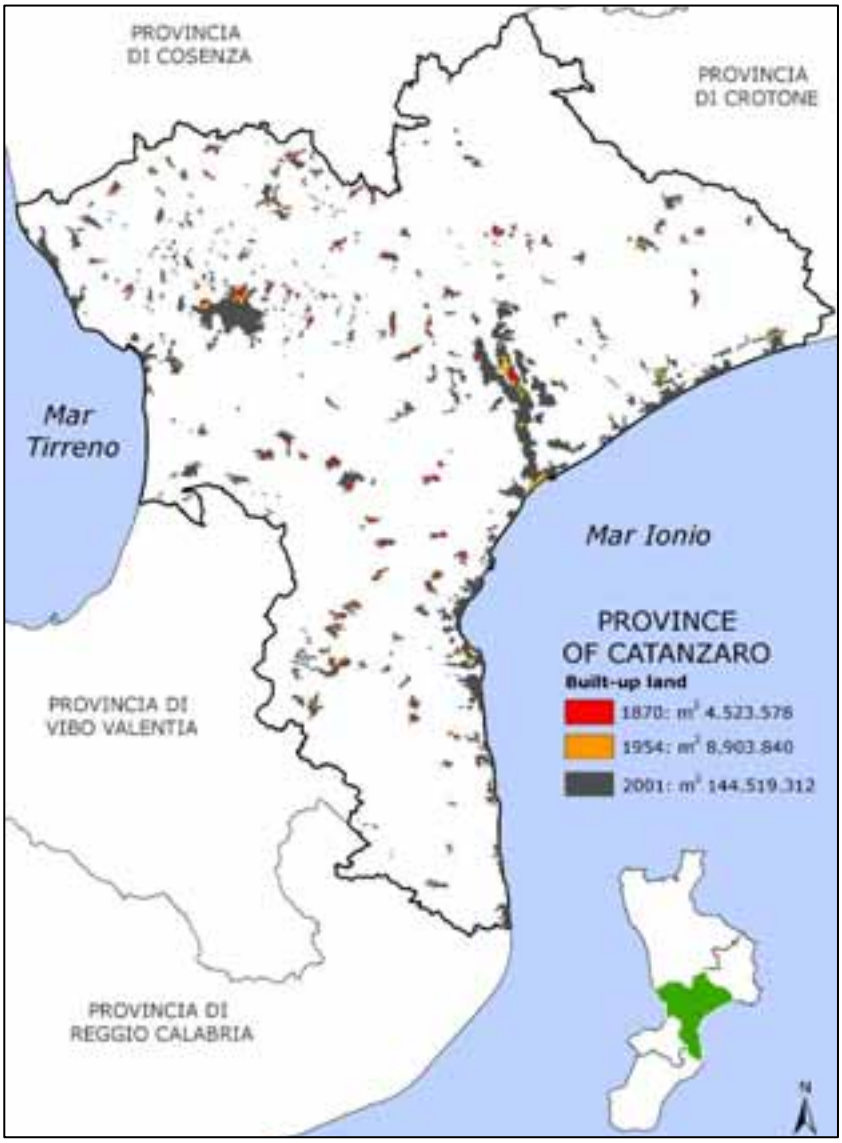


Figure 1. Urban sprawl assessment. Original settlements at 1870 (red) and 1954 (orange) within the sprawl of today expansion at 2001 (grey). Entire province of Catanzaro

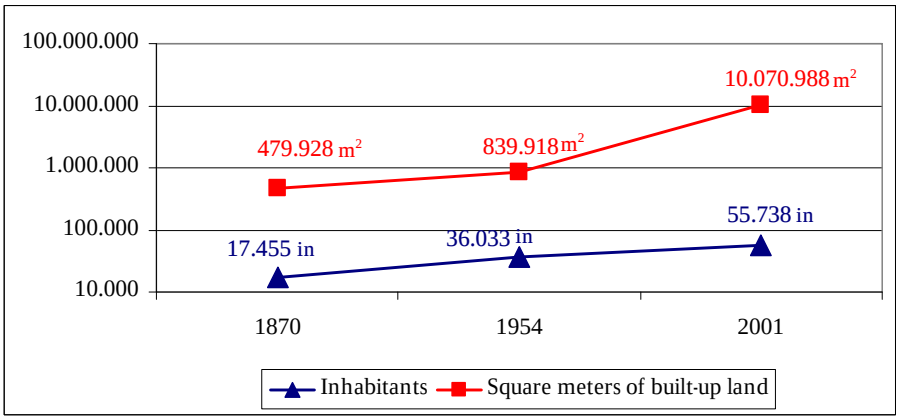
Research has then focused on the Municipality of Lamezia Terme, established in 1968, the second and widest town in the province of Catanzaro. In particular, it has been analyzed both spatially and demographically the three main original settlements of: Sambiase; Bella; Nicastro.
The square meters related to the built-up areas and to the demographic dynamics confirm the aggregate trend already found at provincial scale. In fact, while in the period 1870-1954 the ratio m^2\inhabitants was quite constant, differently in the last fifty years (1954-2001) land consumption has increased ten times, in comparison with a double population growth in the analyzed centers. The trend goes from 27,49 m^2\inhabitants in 1870, to 23,30 m^2\inhabitants in 1954, with a peak of 180,68 m^2\inhabitants in 2001, as shown in the following Tables.

Table 2. Municipality of Lamezia Terme. Valuation of urban evolution. Diachronic analysis 1870-2001: built-up land; population; ratio m^2\inhabitant. Settlements of: Sambiase; Bella; Nicastro

Year	Built-up Land	Urban Population	m^2\ Inhabitant
	m^2	*inhabitants*	
1870	(a) 479.928	(b) 17.455	27,49
1954	(a) 839.918	(b) 36.033	23,30
2001	(a) 10.070.988	(b) 55.738	180,68

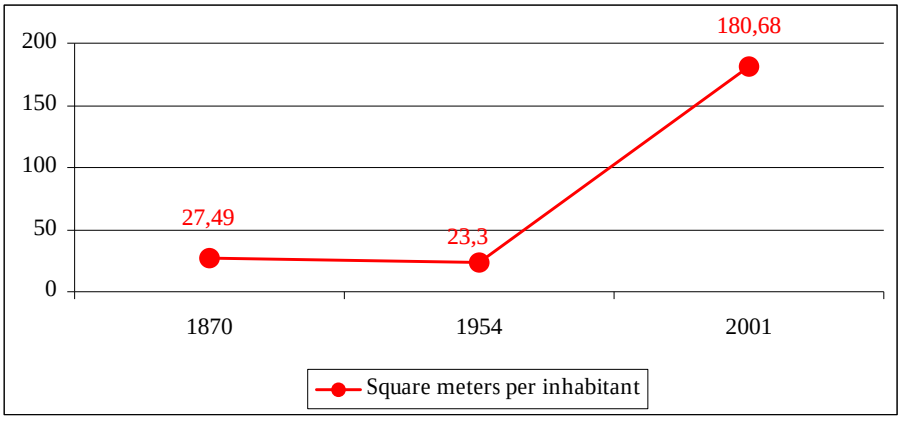
Source: (a) work-out of the authors on the basis of official historic cartography at 1870, 1954, 2001; (b) Istat

Graph 3. Municipality of Lamezia Terme. Settlements of Sambiase; Bella; Nicastro: Diachronic analysis 1870-2001. Trends: population (blue triangles); built-up land (red squares) [(y) axis, logarithmic]



Source: work-out of the authors on the basis of official historic cartography at 1870, 1954, 2001; Istat

Graph 4. Municipality of Lamezia Terme. Valuation of urban evolution. Diachronic analysis 1870-2001. Trends: square meters per inhabitant (green squares)



Source: work-out of the authors on the basis of official historic cartography at 1870, 1954, 2001; Istat

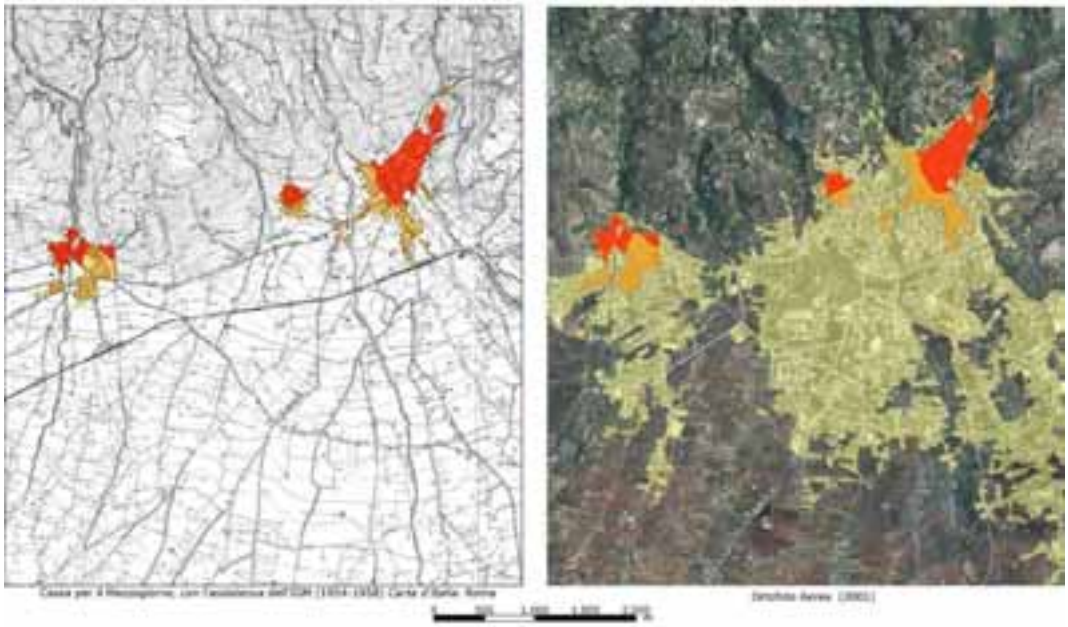


Figure 2. Urban sprawl assessment. Focus on the settlements of Sambiase, Bella, Nicastro, within the Municipality of Lamezia Terme. Original settlements at 1870 (red) and 1954 (orange) within the sprawl of today expansion at 2001 (grey)

Previous analyses compare forecasted expansions of urban tools (up to 250.000.000 m^2) not with a lull but with a demographic decline.
The integrated analysis performed looks towards the future, for it can derive a preliminary ratio between built-up land and amount of future forecasted settled population. In fact, it is useful to assess in advance the demographic reasonableness, or not, of possible further urban expansion envisaged by urban planning.

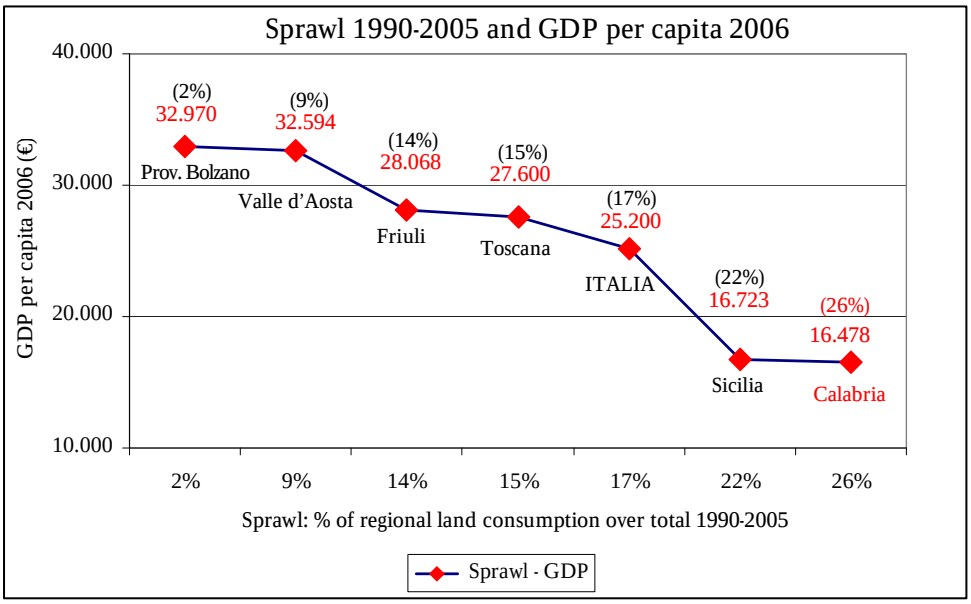
Territorial economy: sprawl-GDP. Calabria compared with "*Italia Intermedia*"
Economic analysis aiming to discover the causal relationship between physical sprawl and GDP must be performed comparing the region with other regions and provinces. In fact, economic hermeneutics is mainly comparative in similar cases.
The diagrammatic comparison between regions such as Trentino, Valle d'Aosta, Friuli and Tuscany with Calabria, investigated in the Case Study, highlights an unexpected truth: the most virtuous regions in terms of smallest sprawl (the least land consumption 1990-2005) have the highest growth of GDP per capita (2006); the most vicious region, Calabria, in terms of highest sprawl (the largest land consumption 1990-2005) has the lowest growth of GDP per capita (2006).
Additionally, a specific parallel proxy, such as highly important foreign tourist percentage over the total of the country, validates the above outcome: Trentino shares 20% of the Italia total; Valle d'Aosta 18%; and Calabria only 2%.

Tab. 3. Case Study. Ratio sprawl\GDP per capita in some Italian regions

Regions \ Provinces	***Sprawl* % 1990-2005**	**GDP 2006 per-capita**
Bolzano	2,86	32.970
Valle d'Aosta	9,31	32.594
Friuli	14,42	28.068
Toscana	15,71	27.600
Italia	*17,06*	*25.200*
Sicilia	22,00	16.723
Calabria	**26,13**	**16.478**

Source: Istat; Unioncamere; research by authors

Graph 5. Does sprawl induce economic growth? No! Ratio: sprawl 1990-2005; GDP per capita 2006



Source: Istat; Union Camere; author direct investigation

First results of Case Study research. Toward policy responses

Case Study research conducted to some surprising results about sprawl in Calabria, that differ from the conclusions of continental geographic analyses.

- Sprawl is not proportional to GDP. In Calabria there is the most relevant percentage of sprawl of all Italy (26,13% of more built land from 1990 to 2005, *versus* Italy average of 17,06%) to which corresponds the lowest regional GDP per capita. According to the Italian Department of Statistics, in 2006 Calabria GDP per capita was equal to 16.478 Euro, beneath Italian average of the same year (25.200 Euro), and far beneath one of the richest such as Bolzano province (32.970 Euro), according to reference data.
- Sprawl is not connected to population boom because in the last decade it hasn't been recorded a demographic increase in Calabria.
- Sprawl has not an employment motivation, because endemic and increasing is the unemployment in the region, the worst of all Italy.
- The area has one of the highest percentage of unoccupied houses of Italy, and therefore there is not any shortage in the real estate supply.
- Notwithstanding, the urbanized land per resident has increased from about 30 m^2\inhabitant in 1954 to over 400 m^2\inhabitant in 2001, and therefore there is not overcrowding at any latitude.

6. KEY ROLE OF GIS

The availability of powerful GIS tools made possible to analyze with a computer science support: land use dynamics on an entire region; relationship between settlements and farm land from 1783 to 2010; mobility data; transport alternative designs.

The built-up Geodatabase has therefore made possible to store and connect in a comprehensive framework many information layer, such as: georeferenced historical cartographies from 1783-1870 to present date; boundaries of each settlement at different dates; calculation in m^2 of land consumption over time (1870-2010) on scientific cartographic basis; demographic data reconstructing population dynamics for each settlement in the last two centuries; economic data;

information about mobility; design of alternative scenarios of intervention to wrestling sprawl to the ground.

7. SPRAWL AND MOBILITY: INCREASE OF PRIVATE CAR USE AND TOD RESPONSES

Research has highlighted at territorial scale the similar sprawl paramount negative impacts identified at geographic scale, consisting in a pervasive increase of the individual mobility.
At international level, some directions have been drawn-up to face this dreadful impact that is the skyrocketing of individual mobility by private car for daily and periodical commuting.
International policy is synthesized in TOD alternative, Transit Oriented Development, that is a better organization of public infrastructure, specially urban railroad crossing urban settlements and serving directly residents, that may help the modal shifting of commuters as well as urban travelers.
Furthermore, research at territorial scale in the Case Study area has found out that the main commuting concentration of the entire region is the isthmian corridor Lamezia-Catanzaro, characterized by the largest volume of traffic with private cars (over 28.000 each day), *versus* a potential supply of already existing (but inefficient) sustainable green urban rail system.
Then, research focused on the need and urgency to address policy responses, *i.e.* to design specific interventions against one of the most negative impacts of sprawl, namely congestion.
Research has detected how important are the interventions aiming to enhance and ease the potential interactions and the potential exchanges between people and places (structural accessibility) in a region characterized by a very fragile economy: they might stimulate opportunities of productive growth and economic development.
Transport infrastructure can be an “engine” for local development, contributing to Pareto optimality by: improving intrinsic accessibility of territory and among territories; bridging the gap of infrastructure deficit; saving social costs of inefficient individual mobility; avoiding resource consumption such as time and fuel; avoiding CO_2 and other pollutant emissions.
According to international analyses and studies, the enhancement of collective transport system might represent one of the best ways to wrestling sprawl to the ground by: strengthening the compact and consolidated cities; creating a polycentric structure; avoiding further settlement dispersion; enhancing potential exchange between people and places (accessibility).

8. ENHANCEMENT OF EXISTING BUT INEFFICIENT URBAN RAIL. PLANNING FRAMEWORK

In updated transport valuation approaches, new variables are taken into account in additional to traditional costs and speed data, such as the number of residents served directly in their settlements and, also, the double consensus toward the infrastructure investment: first, social consensus; second, the convergence with transportation and accessibility planning.
In the Case Study area, the enhancement of already existing urban rail system has been considered in several transportation plans at different Government and Institutional level.
It follows a review plans and programs for transport and logistic at state, regional, provincial levels.

National Plan for Transport and Logistic (January 2001)
[Piano Generale dei Trasporti e della Logistica (Gennaio 2001) nazionale e dei corridoi paneuropei e magrebino]
The “National Plan for Transport and Logistic” (PGTL) issued by the Ministry of Transportation and Navigation in January 2001, refers to the planning activity of European Union.

During the nineties of XX century, European Union defined the Trans European Network (TEN), and singled out the paramount corridors and the main hubs within the whole transport system inside and outside the European Union, to be considered as invariants for the strategic choices of the plans at country and at a more detailed scale.
The Plan records the increase of the individual mobility with private cars, and considers as strategic priority the re-launching of railroads.
For Italy the Plan gives recommendations as follows about tracks to be enhanced:

> "TEN network at 2010; Ferrovie dello Stato [State Railroad] "strong network", on which transits 89% of the total passengers and goods; Ferrovie dello Stato main and secondary national routes; routes not belonging to Ferrovie dello Stato connecting and completing goods and passengers routes with a national interest".

With these criteria the Plan defines the priority National System of Infrastructures for Transport (SNIT) in which it includes explicitly the "rail track" of present Case Study from Lamezia Terme Central Station, to Nicastro, Sambiase, Germaneto and then to Catanzaro Lido, considered as strategic because it connects the Tyrrenian international corridor with the Adriatic one, through the Ionian side. Then the transversal railroad is part of the European main network.

National Operative Program for Transport (2000-2006)
[*Programma Operativo Nazionale, PON. Settore Trasporti. Periodo di Programmazione 2000-2006]*
The "Operative National Program, PON. Transport Section. Plannning period 2000-2006" issued by the Ministry of the Treasury in September 2001, concerning South Italy, prefigures the mobility and transport trend scenario at 2010, taking element from the Monitoring and Planning Information System of Transports, SIMPT. The result, particularly worrying, confirms for Calabria the absolute, and not desirable, prevailing (beyond 90%) of the mono-modal transport system road \ "vehicles" both for passengers and good traffic. It is highlighted (p. 36) the lack of necessary inter-modal transversal connections between airports, railroad and roads.
PON Transport addresses as strategic for Southern Italian regions: modal re-equilibrium; increase of attention toward planning and investments for railroad network (pp. 11-12); railroad investment to improve territory integration (p. 49) through the connection of local areas and transversal-longitudinal corridor as well as passenger railroad connections between urban areas and Trans-European Network (TEN) intended as an answer to the accessibility-mobility problems of the internal areas of South Italy.
In the analysis of the railroad network, PON takes from the PGTM the network of the National System of Infrastructure for Transport (SNIT) and confirms the clear (p. 17: "railroad sections of South Italy included in the present SNIT network") inclusion of the strategic railroad section called "Lamezia Terme – Catanzaro Lido".
In conclusion, PON Transport: highlights the modal disequilibrium due today present preference to road \ "vehicle" choice; catches as an opportunity the forecasted growth of global demand of mobility-transfer-transport; wishes for a strategic choice in favor of the railroad \ "iron" modality to answer to the increasing need of transfer; foster-up the modal shifting from road \ "vehicle" to railroad \ "iron".
Moreover it submits the specifications to the Regions recommending to:

- strengthen the transversal connection between the Adriatic and Tyrrhenian international and national corridors (where Sambiase, Nicastro and Catanzaro track is included);
- connect railroads with airports, inter-ports; ports;
- plan railroad connections for passengers between local and trans-European networks, with reference to inter-regional connections, crossing and directly serving settlements;
- organize railroad to cross settlements and to serve directly their residents.

Regional Operative Program for Development of Calabria 2000-2006
[POR. Programma Operativo Regionale 2000-2006. Asse VI: Reti e Nodi di Servizio (2001)]
The Regional Operative Program, POR 2000-2006, for Economic Development of Calabria is the most important UE financial act 2000-2006 containing European structural investments in

Calabria region. It has been integrated in 2001 by Calabria Region with the POR Programming Complements.
The Chapter VI "Networks and Nodes of Service" of the POR Programming Complements follows the recommendations of the PGTM and of Transport PON.
It immediately synthesizes, in a direct and exemplary way (pp. 3-4), the intervention for:

> "Rehabilitation and strengthening of the Transversal Ionian–Tyrrhenian railroad between Lamezia Terme and Catanzaro Lido",

by emphasizing:

- its geo-strategic function to manage possible national crisis, and overcome bottleneck by connecting the two national Tyrrenian and Ionian-Adriatic corridors;
- its potential function to integrate the activities of Gioia Tauro Port with railroad network, Lamezia Terme International Airport, inter-port system.

Calabria Regional Plan for Transport. Updating 2003
[Piano Regionale dei Trasporti. Aggiornamento 2003]
From the analysis and forecast of future scenarios, the Regional Plan for Transport 2003 takes the neat consequences that are textually reported and directly regard regional transversal infrastructures and specially the **mobility-transport system Lamezia-Catanzaro**.

> "Transversal line Ionian-Tyrrhenian: Lamezia Terme – Catanzaro Lido. The growth of potentiality and improvement of the service are considerable and may be developed by the mean of a rehabilitation intervention of the same track and with some small and localized changes." (I, 136)

The plan refers textually to Chapter VI of important POR 2007-2013, regarding the strategic role of the transversal railroad Lamezia-Catanzaro, having among its positive effects:

> "the considerable improvement of the relationships with Gioia Tauro Port and Apulia",
> "the connection with the main Calabria commercial ports of Reggio Calabria, Gioia Tauro, Crotone, Corigliano", (I, 137).

It adds the policy regarding the railroad direct connection, so-called "metropolitan", between Lamezia Terme Central Station and Lamezia Terme Airport:

> "[…] positive effect for a metropolitan connection between […] the railroad national Tyrrhenian corridor (Lamezia Terme Station) and Lamezia Airport." (I, 137)

Regional Operative Program for Economic Development of Calabria. FESR 2007-2013
[POR. Programma Operativo Regionale. FESR 2007-2013. Asse VI: Reti e Collegamenti per la Mobilità]
The Regional Operative Program for Economic Development of Calabria 2007-2013 is the most recent financial programming tool.
It sets in its chapters the main objective for Networks and Mobility in Calabria region.

> "Improve external as well as internal accessibility of Calabria, enhance Regional System of inter-modality and logistics, promote regional and urban sustainable mobility and better accessibility to internal and peripheral areas".

This general objective is regressed in a more detailed way and the plan gives specific directions for the enhancement of existing railroad Sambiase, Nicastro, Catanzaro treasuring and not changing the present track, and serving directly urban centres easing the modal shifting of residents from individual to public transport. Treasuring of existing railroad is ranked among the principal priority of interventions:

> "Catanzaro Lido – Lamezia Terme railroad transversal with completion in the same track with some localized improvements (no radical location change) and crossing and serving urban areas".

Spatial Territorial Plan 2010 for Catanzaro Province
[Piano Territoriale di Coordinamento Provinciale, PTCP, 2010, Catanzaro]

The PTCP is the Spatial Territorial Plan 2010 for the Province of Catanzaro, the central of Calabria, where the railroad Sambiase - Nicastro - Catanzaro is located.
The PTCP is a general planning tool for the Province, including all most important economic as well as spatial aspects, trying to design the future of local society, environment, economy and its spatial projections in land use and in structure of provincial settlements.
A relevant part of PTCP is the specific plan regarding "Structure, infrastructure, transport and mobility" for which the most important accessibility infrastructure in the Province is the railroad connecting settlements and urban centres of Sant'Eufemia, Sambiase, Nicastro, Catanzaro and some important scientific and technological poles. The PTCP gives the direction for the enhancement of the existing railroad, of Sambiase, Nicastro, Catanzaro, the building-up of the second parallel track, the powering by electrical network, and the amelioration of cuspidal parts, according to all other accessibility plans at regional, state and European Union levels.

9. THREE INFRASTRUCTURE ALTERNATIVES: WHICH ONE FACES SPRAWL?

The overview has provided information about the full convergence of European-international, country, macro-regional, regional, provincial plans and programs in advocating the intervention for a more efficient and modern railroad in the existing trial in the Case Study area, without change in location.
In the new approach of transport valuation there is the positive assessment of existing institutional consensus toward TOD policy and intervention.
In the Case Study area, the contents of the various transportation plans, analytically examined, have all indicated as preferable the strengthening of the existing railroad infrastructure (Alternative B) by integrating it with the existing settlement system, serving directly around 250.000 inhabitants and by improving and amplifying the objective structural accessibility of towns as well as the service also to other nearby centers through small, cheap and agile vehicles called feeders.
All this against two alternatives.
First, Alternative A or *status quo* that is doing nothing, which lays upon the individual mobility with private cars in the narrow isthmus through a highway parallel to inactive existing railroad in the track just connecting the two national Tyrrenian and Ionian-Adriatic rail corridors, parts of the pan-European (TEN) Trans European Network rail corridors.
Second, Alternative C that is a more expensive railroad, southern from the existing track, having the fatal characteristic to be far away from all settlements, and just connecting the regional capital (Catanzaro) directly to International Airport. This alternative does not help at all to face sprawl because it doesn't constitute in any extension an alternative to individual commuting by private cars, instead it will worse-down it.

10. FIRST CONSIDERATIONS

One of the worst negative consequence of urban sprawl is the huge increase of individual mobility for daily commuting by private cars. International analysis of continental sprawl and draw-up of directions for policy responses worked-out one strategy to face over-expansion by strengthening consolidated settlements serving them with urban railroad. The Case Study sub-area (province of Catanzaro) is interesting for the coexistence of two parallel alternatives: the largest private car commuting corridor; a parallel railroad inefficient but with high potentialities.
Research has therefore concluded that at territorial scale in the Case Study focus (the province of Catanzaro) it is possible to design enhancement of existing infrastructure to address the policy responses to sprawl, by empowering the transversal railroad of the isthmus having the following rail stations: International Airport; Central Station; Sambiase; Nicastro; Pianopoli; Marcellinara; Settingiano; Policlinico – Università – Mercati Generali – Regione; Lido; Catanzaro. A relevant spill-over will be the inter-modal connection between airport and train

network. In the new Transport Oriented Development approach, new criteria are the number of concentrated inhabitants directly served in inner core settlement and, then, the number of individual rides by private cars that are potentially avoided thanks to the availability of less risky and cheaper public rail transport. In the Case Study a strong motive in favor of the intervention for enhancement is the connection it realizes among several of the main settlements (with about 250.000 residents) and some scientific and technological poles of the Case Study area.
Furthermore, this transversal railroad will enhance the connection between the two national Tyrrenian and Ionian-Adriatic rail corridors that are respectively part of First and Eighth pan-European corridors: Palermo-Berlin; Skopie-Varna. Since now main criteria to enhance railroad have been costs and speed. From now new criteria are assumed such as number of inhabitants directly served, empowering of existing settlements, inter-modal connection with airport, strategic link with Transport European Network.

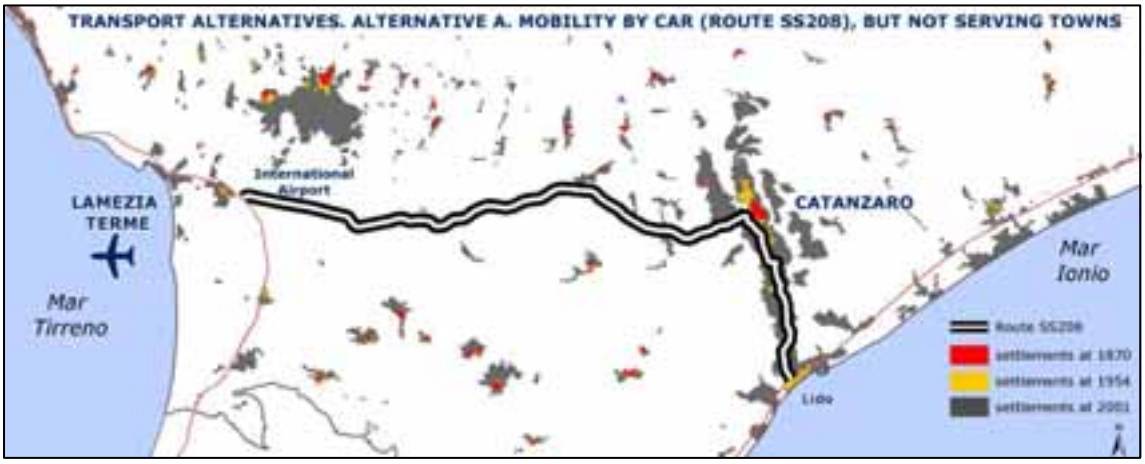


Figure 3. Central area of Calabria: Lamezia Terme – Catanzaro. Transport alternative. Mobility by private cars on route SS208, not serving towns (28.000 cars each day)

Figure 4. Central area of Calabria: Lamezia Terme – Catanzaro. Transport alternative. Improvement of the existing urban railroad (green) crossing urban settlements and serving more than 250.000 inhabitants in towns

Figure 5. Central area of Calabria: Lamezia Terme – Catanzaro. Transport alternative. Railroad far from settlements

Figure 6. Impact of the alternative transport at regional level. Infrastructures to connect and unify Calabria. The isthmus connection between the two national Tyrrenian and Jonian-Adriatic rail corridors and narrowest part of Italy (40 km)

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