Renewables Energy Communities to Restore the City/Country Relationship: The Case of San Severo in the Apulia Region (Italy)

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Abstract. The interrelation between the processes of urbanization and global issues including climate change, energy shortage and food crisis have an influence on the interaction between the city and rural regions. Given the complexity of such processes, which are primarily the result of human activity, it is evident that innovative policy guidelines, as well as instruments, are needed to effectively address these issues within a multitude of territorial contexts.

To revitalize the "peri-urban agricultural" territory as a heterogeneous and dynamic space to be shared between citizens and farmers, with the aim of producing not only food but also energy, it is necessary to investigate potential urban-rural synergies for the adoption of new models according to a holistic and sustainable perspective. These models, also known as energy communities, share energy generated locally from renewable sources.

This paper examines EU, national and local instruments or regulatory initiatives in support of energy production from renewable sources, particularly renewable energy communities (RECs), with specific reference to the European and Italian contexts.

In this regard, an ecosystemic management model for a peri-urban area is proposed, using the Municipality of San Severo in the Apulia Region (Italy) as the study area. This model connects the spaces surrounding the cities to the rural territory by facilitating the diffusion of food models aimed at bringing local consumption and agriculture closer together (urban gardens). It also makes use of eco-sustainable energy systems, such as agro-photovoltaic, aiming at a proximity integration between these two dimensions for a new "city-country pact."

Keywords: peri-urban agriculture · renewable energy communities · agro-photovoltaic system

1 Introduction

Urbanisation in Europe is an evolving phenomenon, both in terms of urban sprawl and population growth, due to the rapid development of urban areas, industries, particularly the tertiary sector, as well as communication and transport infrastructures. It is generally

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recognized that cities will soon be the primary source of environmental issues, especially in terms of climate change and energy crisis, as a result of the population's natural tendency to concentrate in larger areas and the ensuing acceleration of country's urbanization [1]. Italy has experienced a significant growth in urbanization, with over 900 km^2 added to its urban area and about 2,500 km^2 added to its suburban area between 2006 and 2022 [2]. The degree of urbanization on a regional scale has also affected Apulia, where more than 500 hectares of land have seen a rise in the density of artificial cover and land consumption, shifting to urban (+13.3%) and suburban (+15.7%) regions. This provides a measure of an urban continuity and a decline in rural areas. The line between what is rural and urban, however, has gradually changed into a novel setting that is neither totally city nor country because urban expansion takes on diversified patterns [3]. These suburbs are located on the fringes of non-urban (rural) territory. They have grown to engulf the land, taking up space that could have been used for agriculture. As a result, there are now more marginal and abandoned agricultural areas, with biodiversity being lost, land and soil degrading and consumption, and environment and landscape changing [4]. They especially exhibit unpredictable and frequently highly de-qualified in-situ forms due to the extremely complex dynamics that developed them; these places are now known as "peri-urban zones" [5] or final periphery. A loss of connection among these spaces has often happened within this framework of physical dissolution of the interaction between the city and the agricultural land. The goals of the EU's energy and climate policy, the Territorial Agenda 2030 [6], the European Green Deal [7], and the 17 Sustainable Development Goals [8] are all in line with this crucial and increased interaction among rural and urban regions. Strong evidence supporting this can also be found in the scientific reports [10] of international bodies on the risks of climate change and the environmental agreements outlined in the framework of Climate Conventions [9]. These sources are relevant in steering the processes of urban quality regeneration, but they also need to be integrated and associated with environmental, urban and territorial planning, design strategies and procedures using self-sustainable local development models, and an integrated extra-strategic approach.

The current state of our cities has been characterized by a high demand for resources: the primary daily inputs from surrounding areas are water, electricity, raw materials and healthy food. The management of the connection between the two main urban subsystems of town and country, according to multi-sectoral standards, seems the ideal starting point to test out policies supporting equitable, sustainable and well-balanced rural and urban growth [11]. Through the implementation of modern agro-photovoltaic technologies on agricultural land, local communities can choose to produce clean, self-produced and sharable energy [12], consequently leveraging their role and stimulating the creation of new economic activities that can, on the one hand, conserve and recover peri-urban agricultural areas [13] by preventing the unrestrained growth of the city, and, on the other hand, identify possible alternatives to the current model of energy resource management. The concept of 'agro-photovoltaic systems' is widely used by the scientific community [14] and also by many government agencies [15] and public administrations [16].

In the light of the above, the goal of this paper is to identify the current EU, national and regional regulatory acts that are relevant to support renewable energy sources, while also taking into account the provisions on the support of the agricultural sector. This is

carried out by starting with the concept of the "multifunctionality" [17] of the primary sector, which can be defined as the production of positive externalities that have both direct and indirect effects on the territory to which they belong, such as renewable energies, and which improve the health of urban ecosystems and their inhabitants.

Based on a local scale analysis, the Municipality of San Severo (Foggia) in the Apulia Region will act as the study area for confirming the importance as well as the feasibility of urban sustainability implementation, or its possible declinations, in order to include "agro-urban parks" in the Apulian territory.

2 The Regulatory Framework

The regulatory framework study must include a comprehensive assessment of the impact that legislative and programmatic actions might have on the relative weights of the many factors influencing the region. Consequently, taking into consideration the existing regulations applying to regional and municipal spatial planning/landscape instruments, the content of recent major EU and national regulatory sources addressing the issue of renewable energy sources and supporting the agricultural sector will be examined.

2.1 Multifunctionality, Climate and Energy in the Common Agricultural Policy

In order to ensure that farmers have access to new sources of income and community-beneficial services, the EU's Common Agricultural Policy (PAC) emphasizes the diversification of the agricultural sector's economy. This approach not only produces agricultural goods but also public goods, such as improved environmental quality and more appealing rural areas [18].

A multifunctional view of agriculture is prevailing, with a focus on the preservation of ecosystems provided by agricultural practices and the need to support interventions in equilibrium with other territorial, energy, and climate policies [19], while at the same time respecting the complexity of agrarian landscapes. With full recognition of the concept of multifunctionality in rural development pro-grams, the PAC has embraced this need and identified environment conservation and landscape enhancement among the main objectives to be achieved, through primary sector activities geared towards multifunctionality, as a paradigm for sustainable rural development. The European Landscape Convention [20] recognized landscape enhancement as one of the most important challenges that national and community policies must respond to.

A role for agriculture is explicitly assigned in the most recent version of EU programming (2023–2027) by the PAC [21], with special emphasis on the targets and commitments made by the EU both internationally and within the framework of the 2050 climate and energy policy. This role extends beyond the productive function of agriculture to include support for the regions and the environment.

Italy has submitted its own version of the National Strategic Plan [22] within the framework of the Common Agricultural Policy to the European Commission, ensuring continuity with EU programming and, consequently, with the provisions of the 2023–2027 PAC, anticipating the implementation of the common objectives of environmental, economic and social sustainability in its various declinations. The Plan consolidates the

necessary financial resources and actions to improve synergies between the agricultural system and other territorial identities into a single programming document for the first time.

Table 1. Rural Development Programmes

INTERVENTION	TYPES OF INVESTMENTS
SRD01	- Productive agricultural investments for the environment, climate and animal welfare - Investments in agricultural companies for diversification into non-agricultural activities
SRD02	- Investments for climate change mitigation (reduction of emissions and/or increase of carbon sequestration capacity in the soil, construction of plants to produce energy from renewable source)
SRD03	- Investments for the maintenance of greenery and the territory also through the creation of environmental services carried out by the agricultural company for the care of non-agricultural spaces - Investments in support of social agriculture; educational/didactic activities; transformation of agricultural products and their processing and marketing in company sales points
SRD04	- Non-productive investments aimed at halting and reversing biodiversity loss and preserving the rural landscape
SRD07	- Investments aimed at integrated planning and integrated territorial planning methods, in compliancy with the Plan
SRD08	- Investments in infrastructures with environmental purposes: energy production (electrical and/or thermal) from renewable sources for collective use (energy communities)
SRD09	- Investments in favor of compromised and critical areas also in urban-rural transition spaces
SRD13	- Investments for the installation of electrical and/or thermal energy production systems using renewable sources, limited to company self-consumption, or for the recovery of heat produced by production plants
SRG06 - LEADER	- Investments for the implementation of the interventions planned in the integrated, multi-sectorial and innovative Local Development Strategies centered on the following thematic areas: 1. Ecosystem services, biodiversity, natural resources and landscape; 2. Local food systems, districts, agricultural and agri-food supply chains; 3. Services, goods, collective and inclusive spaces; 4. Energy, bioeconomic and circular economy communities; 5. Local socio-cultural and tourist-recreational supply systems

In order to achieve this, it is important to emphasize the solid support that the strategically based Rural Development Programmes (Table 1) can provide for policies of this kind through the significant European structural funds made available, in addition to other essential interventions offered by the National Recovery and Resilience Plan (see Sect. 2.2), which needs to be interpreted as an essential component of the national strategy.

Apulia has recently accepted the Regional Complement for Rural Development (CSR) [23] at regional level. This document outlines the strategic decisions and rural development interventions that will be implemented among the initiatives pro-posed by the National Strategic Plan 2023–2027. The program's goals coincide with national and EU policy objectives and guidelines, giving the rural area a strategic role in promoting greater resilience and providing tangible support for the sector impacted by climate change. This puts the value of local specificities and the socioeconomic fabric of agricultural areas at the center of the sector's regional policy.

2.2 Energy-Climate Challenges and the Current Regulatory Framework

It is increasingly evident that agriculture policy and energy-climate challenges are the core of all initiatives to provide competitive, se-cure and sustainable energy for the Community.

The European Union's renewable energy policy was launched in 1997 with the adoption of the White Paper [24]. The goal is to lower emissions that contribute to climate change and reform the European energy system through new technologies and the active participation of European citizens in both the production and consumption of energy. This will ensure that all consumers can access reasonably priced energy-related goods and services. The European Union mainly relies upon organizations with certain structural and functional qualities to enable proper horizontal subsidiarity in the energy sector. This means that the EU focuses on the abilities of its citizens to steer the EU towards a more sustainable development.

In this scenario, the European Commission started working at a package of policies, known as the "2030 Climate Target Plan" [25], on energy, land use and environment, that would reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. This would enable the continent to become a competitive and sustainable climate-neutral economy by 2050. The general EU policy framework was thoroughly reviewed to analyze the progress made towards reaching these goal values (Table 2).

One of the main goals of the "renewables" (2018/2001/EU) and "electricity market" (2019/944/EU) directives, in accordance with the Paris Agreement objectives, is to increase the number of stakeholders who can help Europe achieve its decarbonization targets by 2050. The two directives offer detailed descriptions for two forms of shared energy, i.e. "self-consumption" and "energy communities" (CERs), as well as a regulatory structure for individual and community involvement at European level. Each Member State of the EU must therefore fulfill its own matching objectives for the EU to reach its targets. Nowadays, the combined provisions of Legislative Decree No. 210/2021 Transposing Directive (EU) 2019/944 on common rules for the internal market in electricity and Legislative Decree No. 199/2021 implementing Directive (EU) 2018/2001

Table 2. Summary of Policies, Plans and Programs of the Energy and Climate Sector

Year	Title	Contents/Objectives
2017	**"Winter package" o "Clean Energy for all Europeans Package"**	Legislative package to equip the EU with the necessary tools to address the global energy transition - the foundations of which were laid in the Paris Climate Agreement. The measures introduced aim to create an Energy Union capable of making energy safe, sustainable, competitive and available to EU consumers at affordable prices, by setting additional energy and climate targets for the period 2021–2030
2019	COM(2019) 640, **"European Green Deal"**	The European Green Deal provides the EU with the plan and roadmap to achieve its climate ambitions and to make Europe's climate-neutral economy and society sustainable by 2050
2020	CCOM(2020) 562, **"2030 Climate target plan"**	The European Commission has started the path to make EU policies on the environment, energy, land use, transport and taxation suitable to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels
2021	COM(2021) 550, **"Fit for 55" Package**	The 'Fit for 55' Package adapts existing climate and energy legislation to the new EU target of a minimum 55% reduction in greenhouse gas emissions (GHG) by 2030, and aims to put the EU firmly on the path to climate neutrality by 2050
2022	COM(2022) 230, **"REPowerEU Plan"**	In response to the difficulties and disruptions in the global energy market caused by the Russian invasion of Ukraine, the European Commission presented the REPower Plan: saving energy, producing clean energy, diversifying energy supplies

have completed the general framework of national provisions about CERs. This regulatory framework will be completed and implemented with a focus on renewable energy communities, adhering to European objectives.

In order to facilitate sharing across various self-consumption configurations, including CERs, Legislative Decree No. 199/2021 reduced the restrictions, to expedite the nation's sustainable growth trajectory. The bill has essential requirements for executing the National Recovery and Resilience Plan (NRP) [26] for renewable energy sources, in alignment with the National Integrated Energy and Climate Plan (PNIEC) [27]. The

PNRR actively encourages the creation of energy communities where the prosumers approach can be advanced. To this end, each territory turns into a producer and consumer of redistributed renewable energy, and Mission 2 'Green Revolution and Ecological Transition' provides ample space for the topics of agro-voltaic development, hydrogen, renewable energy, sustainable networks, mobility and more (Fig. 1).

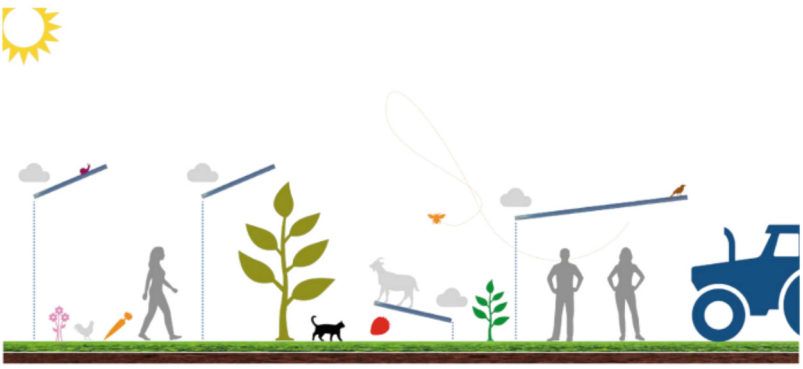


Fig. 1. Source: Ministry of Ecological Transition (MiTE), "Guidelines on Agrovoltaic Systems", June 2022.

The Apulia Region uses the Regional Environmental Energy Plan (PEAR), a strategic planning instrument, to schedule energy interventions within its area. The PEAR was established in 2015 and aims to create a differentiated energy mix by de-creasing the use of coal and increasing the use of renewable sources. It also included the concept of agri-voltaic in its regional legislation [16], permitting 'the installation of photovoltaic systems without allowing the consumption of ecologically productive land and, in particular, without precluding the agri-cultural use of the land itself'.

3 The Agro-Urban Park Between Spatial Government and Energy Policies: A Case Study

3.1 Study Area

This case study examines the Municipality of San Severo in the Region of Apulia (Fig. 2), which might serve as an experimental region encompassing many domains. In fact, the Regional Territorial Landscape Plan (PPTR) of the Apulia Region [28] and the General Urban Plan (PUG) of the Municipality of San Severo [29] present an environmental approach to territorial planning in a systemic vision of its naturalistic, territorial and socio-economic aspects. Agro-urban policies, which combine peri-urban agriculture and urban and suburban regeneration programs, are part of the spatial and landscape planning strategies of both Plans, despite their differing definitions and procedures.

This research aims to enable the analysis of the relationship between the rural and urban areas—referred to as a "green corridor"—which would facilitate the development of a multipurpose peri-urban agriculture model including the production of both food

and energy. This would result in the development of locally generated, renewable energy-based, eco-sustainable (agro-photovoltaic) and energy-sharing systems—also known as energy communities.

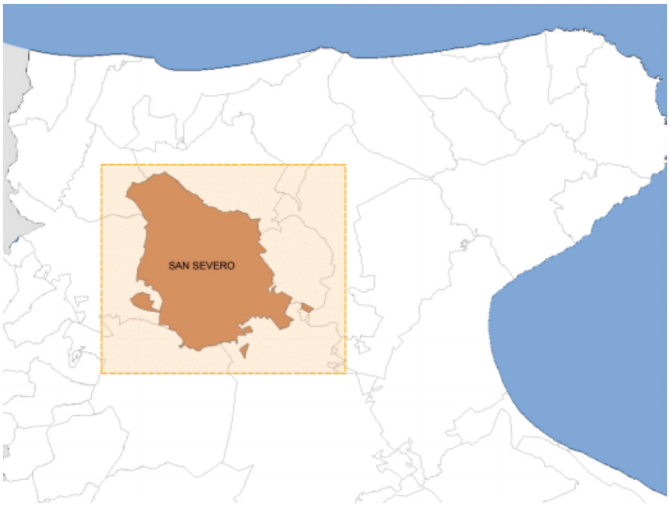


Fig. 2. General Urban Plan (PUG) of the Municipality of San Severo

3.2 Land-Energy Relationship

To understand the complex composition of the peri-urban agricultural space and its social and environmental roles, the Apulia Regional Territorial Landscape Plan (PPTR) focuses on the concept of the peri-urban that views the periphery of the city as project areas from which to restart in order to restore quality in urban settlements, considering rural landscape as a fully cultivable and liveable space.

To address these developments from such a perspective, the Apulia PPTR introduced a strategy and planning component that works by setting goals and recommending public and private actors and actions that can help transform the area. In order to achieve this, the traditional hierarchical regulatory and sequential approach to the planning process is abandoned in favour of continuous cooperation and interaction for the creation and implementation of projects, policies and interactions between public institutions and planning authorities, at local and regional levels, as well as the general public. By responsibly improving the declined landscapes of modern urbanization, such measures would result in a change of geography.

The strategic scenario includes spatial projects for local landscape, general and particular quality targets, and recommendations for the layout and location of renewable energy installations. The Plan takes the patrimonial values of the Apulian landscape and translates them into transformation objectives to counter its degradation trends and build the preconditions for forms of *"self-sustainable local development involving the*

strengthening of productive activities connected to the enhancement of the territory and local cultures" and *"development of local energy self-sufficiency in accordance with the raising of environmental and ecological quality"*.

Regarding the renewable energy component, the Plan focuses its energy-related efforts on maximizing the potential energy mixes unique to the area and developing public-private partnerships (energy community projects) that can effectively address environmental preservation, economic sustainability and regional spillover effects. These factors support the idea of a decentralized energy supply system in accordance with international laws by encouraging to reconsider a city and region with low consumption but strong output potential.

These core goals are reinforced and refined in the complex 'City-Country Pact' of the Apulian PPTR. The 'City-Country Pact' is one of the five territorial initiatives of regional landscape, which collectively embody the Apulian landscape plan's strategic vision (Fig. 3).

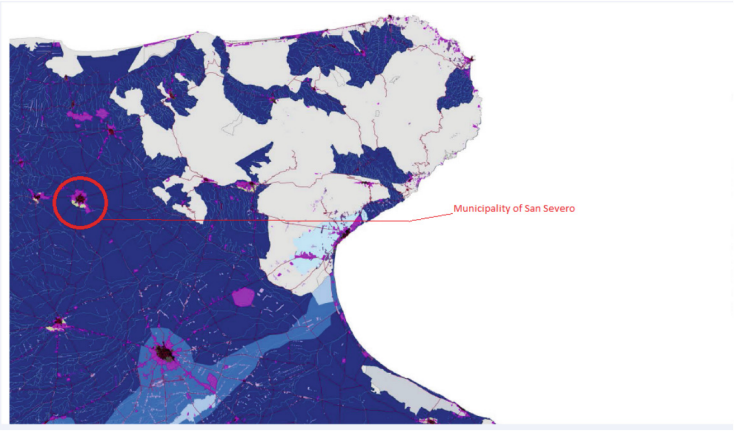


Fig. 3. The city-country pact, PPTR - Apulia Region

The 'City-Country Pact' aims to restore environmental and landscape quality to both territories, starting with the criticalities of modern urbanization and the processes of rural landscape degradation. The urban territory will be improved by clearly defining its boundaries, functions and public spaces, which historically defined it. The rural territory will be improved by reclaiming its unique characteristics and functional qualities, overcoming the double degenerative processes of rural landscape degradation and urbanization. These spaces are given a function in the design scenario that is connected to both enhancing urban quality and the productive component. Under the first point, which introduces the concept of multifunctionality, "agriculture is called upon to perform tasks that include not only producing food of high quality but also protecting hydro-geological systems, improving the quality of the environment and landscape, producing energy, and igniting locally based economic systems (zero-hectare, short production and consumption networks; ecological footprint reduction through the localization and closure of food, waste and energy cycles)."

In this regard, the multipurpose nature of peri-urban agriculture and its services acquire a special significance in the revitalization of suburbs, the enhancement of metropolitan regions' standard of living and the general urbanization process. The second is to enhance Urban quality is enhanced by redeveloping suburban open space that has been designated as "restricted areas" in the plan (peri-urban connection rings, multifunctional agricultural parks and CO2 parks), where standards of territorial and landscape quality can even be defined in relation to the development of renewable energy sources.

The Municipality of San Severo modified its own General Urban Plan (PUG) to comply with the superior regional planning tool in close conjunction and define the development guidelines for its future territorial transformation. The plan comprises programmatic section addressing the implementation of the PPTR's «City-Countryside Pact» and defines the extra-urban system and the areas designated for agricultural activities, to make them "likely to develop and be structured as a multifunctional park".

To achieve this and prevent soil consumption and erosion for the centrifugal urban expansion of non-coherent fabrics in proximity of the compact grid of valuable historical buildings characterising the local context, peri-urban areas have been identified on a municipal scale through the reconstruction of the urban margins with the creation of green belts (Fig. 4).



Fig. 4: Source: PUG Programmatic Part, Implementation of the Strategic Plan, City-Country Pact (PUG Table 3)

Given that the energy topic is becoming more and more important and is starting to heavily weigh on decisions made by territorial authorities, increasingly aiming at multi-sectorial interventions, this planning tool is innovative in comparison to traditional practices of territorial planning and programming, despite needing to be revised in its characterizations and declinations.

3.3 Energy Balance at Municipal Level

From these assumptions, it is essential to take into consideration electricity balance data starting at the supra-municipal level of the Municipality of San Severo to be able to consciously plan any actions to be taken in the territory with a view to energy transition. To this end, summary tables were drawn up, based on official statistical data, on demographic development [30] and electricity consumption in the municipal area [31]:

a) Demographic indicators:

People living in each area, along with their demographic traits and socio-behavioural trends (such as lifestyles, economic pursuits, etc.), form the essential source around which the supply and demand of electricity revolve. This makes it possible to analyse trends and evaluate the energy-related policies of both urban and rural areas. Within the region, the province of Foggia (with the greatest rural characteristics, covering 35.9% of the regional surface area) has the lowest density level, with a value of 86.0 inhabitants per km2. The Municipality of San Severo's territory is larger than the province's average, with an area of 336.31 km^2 and a population density of 148.20 people/km^2. As of January 1, 2022, the municipality of San Severo has 49,843 persons living in 20,338 homes. As shown in Table 3 below, the average number of members per household is 2.45, which is slightly higher than the 2.3 average for the entire country.

Table 3. Demographic indices

RESIDENT POPULATION BY GENDER. Census 2022. Absolute values.					
Year	Province	Municipality	Resident population		
2022			Males	Females	Total
	Foggia	San Severo	24.360	25.483	49.843

AVERAGE NUMBER AND SIZE OF FAMILIES, RESIDENT POPULATION							
Year	Province	Municipality	Families		Resident population		Total
			Number	Average size	in the family	cohabitation	
2019	Foggia	San Severo	19.539	2,52	49.315	181	49.496
2022	Foggia	San Severo	20.338	2,45	49.843	-	49.843

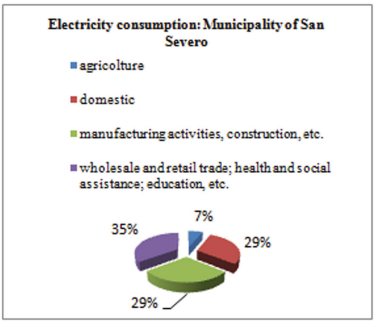
b) Energy data analysis:

For the comprehensive review of the demand energy system, energy consumption data for the year 2022 [31] were examined and processed based on the province of Foggia's per-capita electricity consumption relative to the population of the municipality of San Severo, divided into user categories (sectors). The estimated result was approximately 153. 82 GWh (refer to Table 4 below).

Using the analysed data, an energy balance for the current state may be created by quantitatively examining the energy flows that are used in the Municipality of

Table 4. Electricity consumption for Foggia and San Severo Municipalities

PROVINCE OF FOGGIA					
ELECTRICITY CONSUMPTION/year					
year	AGRICULTURE GWh	DOMETISC GWh	INDUSTRY GWh	SERVICES GWh	TOTAL CONSUMPTION GWh
2022	agricolture	domestic	manufacturing activities, construction, etc.	wholesale and retail trade; health and social assistance; education, etc.	
	118,5	543,3	537,1	649,8	1848,7



PERSONAL DATA(Istat 2022)		
	n. of inhabitants	n. of families
Prov. Foggia	599028	
San severo	**49843**	**20338**

MUNICIPALITY OF SAN SEVERO					
ELECTRICITY CONSUMPTION/year					
year	AGRICULTURE GWh	DOMETISC GWh	INDUSTRY GWh	SERVICES GWh	TOTAL CONSUMPTION GWh
	AGRICULTURE GWh	domestic	manufacturing activities, construction, etc.	wholesale and retail trade; health and social assistance; education, etc.	
2022	9,86	45,21	44,69	54,07	153,82

AVERAGE CONSUMPTION FOR DOMESTIC USE					
Population/families			Electricity consumption per inhabitant/year in kWh	Electricity consumption per family/year in kWh	Overall electricity consumption
year	number of families	average size	Kwh/year	Kwh/year	Kwh/year
2022	20338	2,45	907,50	2223,38	45219000,75

AVERAGE CONSUMPTION FOR AGRICULTURAL USE					
Land use of the agricultural unit - Used agricultural area (sau)					
agricultural units	arable land	vine	agricultural woody crops, excluding vines	family gardens	permanent meadows and pastures
surface-hectares	20259,2	3972,4	4009,9	15,8	393,9
Electricity consumption per hectare/year in kWh	344.15 Kwh/hectare/year (average value)				

San Severo. About 29% of the total is consumed at home, which is higher than what is consumed in industry. The agriculture industry necessitates 7% of all the power that is used. As a result, it is evident that the local level consumption of electricity, at 55.07 GWh, is larger when the household sector's consumption is added to the agricultural sector's (36%). While the typical home uses around 2,223.38 kWh of power annually, the per capita consumption of electricity per inhabitant is 907.5 kWh. The energy consumption shared by the agricultural and domestic sectors has been converted to CO2eq, according to the equivalent emission factor for the national gross thermoelectric production, with an estimated average value of 415.5 g CO2/kWh [32].

As a result, together, both sectors produced 228. 853.2 tCO2 equivalent greenhouse gas emissions in 2022. This is because of the concentration of population density and activities on the territory, which means that all cities are responsible for most energy consumption-related emissions.

3.4 The Project Scenario: The Agro-Urban Park

The project scenario, which derives its physicality from the land and connects regional and local spatial planning projections, is described in this section, based on the aforementioned assessments. Following the General Urban Plan (PUG), which promotes a corridor of public green space known as "the Green Walls" separating the urban area and serving as a link between the city and the countryside, the aim is to devote a portion of the land in the southern part of the Municipality of San Severo to the development of an "agro-urban park" (Fig. 5).



Fig. 5. Source: PUG Programmatic Part: Implementation of the Strategic Plan, City-Country Pact (PUG Table 4)

This scenario brings along the complexity of a city with an "uncertain urban identity in which the lack of homogeneous and coherent reference systems is felt, especially in the peripheral fringes" (PUG, 2019) and aims at transforming the indeterminacy of a peripheral part of the territory (peri-urban) into an opportunity, thus declining the concept of the "City of the Future" (COM(2014) 490): European cities must be (…) green, ecologically and environmentally regenerative places: (…) European urban spatial development must (…) enjoy a high level of environmental protection and quality in the areas surrounding cities [33]. In fact, according to the European guidelines [34] "*Bearing in mind both endogenous and exogenous factors, the sustainability and resilience of cities and regions cannot be addressed separately. This can be achieved through functional partnerships between urban and rural areas and through integrated projects aimed at enhancing the*

sustainability and resilience of the local economic, social and environmental systems of cities, their functional areas and their rural periphery".

With regards to design, the scenario consists of strategies and activities that refer to the 'Urban Margin Scheme' of the PUG City-Country Pact, to appropriate actions and to a system of relations:

a) Specific actions.

The project area (about 3.1 hectares, Fig. 6) has been split up into macro-sites, two of which will be kept as public spaces for social interactions and recreational activities while also serving as areas for the preservation of olive trees and other fruit-bearing plants. The third area is designed for productive-multifunctional agriculture. It includes urban gardens, social and didactic orchards, and an agri-voltaic system, which maximizes the integration of energy production and agrarian systems in order to promote multi-functional activity. Urban gardens serve as a primary productive activity, which is a prerequisite for the existence of agrarian use.

The project's added value is thus twofold: firstly, it aims to reorganize virtuous farming practices, which in turn leads to the recognition of the same rural, peri-urban areas as catalyst for a network of social, commercial and recreational activities as well as environmental benefits related to the greening of the city and the management of resources [35]. Secondly, it produces energy from renewable sources (solar) for community consumption and self-consumption, a model also known as renewable energy communities (RECs).

b) Relationship system.

With this initiative, the promotion of the network of zero-kilometre short supply chains and the relationship between town and country are developed and enhanced, by guarantying the following aspects:

- connections oriented to the rural-naturalistic enjoyment of the area; - sales of quality agricultural products in the peri-urban area; - public areas for recreational and social events; - places for environmental education; - improved relationship between city, citizens and environment; - direct access from the city to promote the use of the park

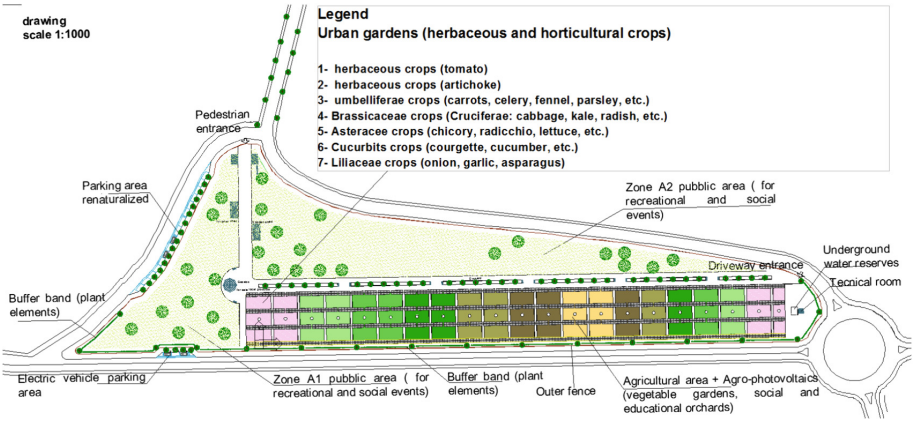


Fig. 6. Project "agro-urban park"

and the sale of local agricultural products, aimed at bringing agriculture and local consumption closer together.

Therefore, the agro-voltaic system's producibility within the agro-urban park (Fig. 7) is calculated as an annual electricity production of 922,030.2 kWh, which will be used for energy sharing as well as for self-consumption (area operation). This will benefit about 411 households by reducing their greenhouse gas emission by 3,831 tCO2 equivalent (Table 5).

Project: agro-urban park				
overall area of the site			**mq**	**31000,00**
Agricultural volume (or pore space)				
surface occupied by the agrivoltaic system	330,00	32,00	mq	10560,00
minimum height of the photovoltaic modules with respect to the ground		2,10		
total			**mc**	**22176,00**
Total footprint of the agrivoltaic system (Spv)				
number of panels		1312		
photovoltaic modules dimensions (active surface including frame)	1,10	1,80		
total			**mq**	**2597,76**
LAOR (Land Area Occupation Ratio): LAOR< 40%				
ratio of the total footprint of the agrivoltaic system				**0,25**
Nominal power system agrivoltaic				
number of panels		1312		
Rated power of each photovoltaic module	Watt	360		
			kW	**472,32**
Photovolatic electricity production (FVstandard)			**GWh/year**	**0,92**
The values for the average annual production were processed through the Photovoltaic Geographical Information System (PVGIS) of the European Commission, https://re.jrc.ec.europa.eu/pvg_tools/en/			**kWh/year**	**922030,02**

Fig. 7. Project "agro-urban park"

Table 5. Energy balance ex-post

ENERGY BALANCE EX- POST (Kwh/year)								
year	activity	energy consumption (Kwh/year)	year	agro-urban park (energy production kWh/year)	self-consumption for agricultural use	energy communities (energy sharing)	number of families (CER)	reduction of overall energy consumption in the area
2022	Agriculture	9860000,0	2024	922.030,2	1066,87	/		9858933,13
2022	Domestic	45219001,0	2024		/	920963,33	411,44	44298037,67

INVENTORY OF CO2 EMISSIONS			
	Agriculture (tCO2)	Domestic (tCO2)	Total (tCO2)
2022	40968,3	187884,9	228853,2
2024	40963,9	184058,3	225022,2
CO2 emissions saving			**3831,0**

4 Conclusion

Based on a multifunctional model of peri-urban agriculture and the use of eco-sustainable systems (agro-photovoltaic) for the production and sharing of locally generated energy from renewable sources, the project scenario offered some design ideas and, at a preliminary level, identified the theme of eco-systemic management of a peri-urban area in the municipality of San Severo.

High-quality agricultural output associated with multifunctionality, particularly in urban gardens, is sometimes seen as a niche phenomenon or as being small scaled. Over the past eight years, the proportion of Italian municipalities managing their green spaces including urban gardens has increased by 43% [36].

In this regard, the project scenario presented here aims to sketch a tangible and plausible alternative framework for the dismantling of agriculture and the surrounding rural areas, beginning with the development of new coalitions among industry participants, the public and institutions, especially in peri-urban contexts.

In contrast, the project scenario includes the concept of participation and the creation of an energy community open to all consumers in the neighborhoods that border the project area, including those who belong to low-income or vulnerable families, with regard to the topic of agri-voltaic energy production from renewable sources. Communities that rely on self-consumption and renewable energy sources have the potential to significantly accelerate the energy transition. An increasing number of local governments, residents and farmers can actively participate in the energy system as a result of the decentralization of energy production. This enables maximizing self-consumption and creating local advantages (such as lowering greenhouse gas emissions and using local energy sources) by taking full use of the opportunities presented by distributed generation.

Specifically, within peri-urban agricultural areas, agriculture assumes a landscape-environmental value that represents a form of active protection against land consumption on the part of the city. This idea of agriculture is proposed to produce not only primary

goods but also “public goods”, in terms of environmental and landscape quality and availability of public spaces, as well as in terms of service and territorial protection and valorization [37].

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