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Review

Sustainability Potential of Marginal Areas for Food, Feed, and Non-Food Production in the Puglia Region, Southern Italy: Part II: A Review

Salem Alhajj Ali, Gaetano Alessandro Vivaldi, Anas Tallou *, Giuseppe Lopriore, Anna Maria Stellacci, Francesco Fabiano Montesano, Andrea Mazzeo, Giuseppe Ferrara, Agata Gadaleta and Salvatore Camposeo

Department of Soil, Plant and Food Science, University of Bari Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy; salem.alhajj@uniba.it (S.A.A.); gaetano.vivaldi@uniba.it (G.A.V.); giuseppe.lopriore@uniba.it (G.L.); annamaria.stellacci@uniba.it (A.M.S.); francesco.montesano@uniba.it (F.F.M.); andrea.mazzeo@uniba.it (A.M.); giuseppe.ferrara@uniba.it (G.F.); agata.gadaleta@uniba.it (A.G.); salvatore.camposeo@uniba.it (S.C.)
* Correspondence: anas.tallou@uniba.it

Abstract: There is considerable unused and unproductive land in rural areas of the Puglia region, Southern Italy. These areas and their local cultivators/growers have always been overlooked by academic, policy, and investment circles despite their potential to improve food security and the livelihood of rural communities. Therefore, it is crucial to evaluate the sustainability potential of these areas to produce food, feed, and non-food products. This evaluation will play a vital role in the sustainable development of rural regions such as the Puglia region. In this review, we highlighted important aspects regarding the management potential and the expected contribution that various types of marginal areas (MAs) could add to the regional economy of Puglia. The authors focused on the extent to which Puglia's marginal lands can realistically be utilized to meet Italy's food production targets, considering the economic, social, and environmental potential of different marginal area types within the Puglia territories. In writing this review, we have been inspired by the lack of sufficient information necessary to carry out a plan for the revitalization of MAs and the sustainable development of regional rural areas. Although Italian scholars have not extensively researched MAs, the available data suggest that they could significantly contribute to the development of regional economy and food security, despite their complexity and low-input nature. The scientific evidence suggests that the main challenge associated with using MAs for food and/or non-food production is balancing biodiversity conservation with local residents' social and economic development. Presently, some small-scale or family farms are already operating within MAs. However, they still contribute minimally to the overall agricultural production in the region, even though they have the potential to play an important economic role for numerous rural communities in Puglia. Furthermore, the available data indicate that over 40% of existing farmers in MAs require greater support to sustain their activities. Such support should be tailored to the local context, built on and, where appropriate, improved upon existing practices, while addressing various threats to these areas. In this regard, sustainable development policies should shape MAs' landscapes through the support of initiatives aimed at the recovery of traditional agricultural activities, the use of local varieties, the protection of the environment, and the conservation of biodiversity. The authors believe that this review provides policymakers with recommendations to consider when supporting the sustainable use of MAs as a potential source of food security and sustainable development for people living in these areas.

Keywords: rural development; marginal areas; Puglia; food security; sustainability

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1. Introduction

The term "marginal lands" or "marginal areas" (MAs) has been in use since the 19th century [1]. It refers to land with little or no agricultural or industrial value, also known

as unproductive lands. Over the years, other terms such as "less favored areas", "degraded lands", "unproductive lands", "wastelands", "underutilized lands", "idle lands" and "abandoned lands" [2,3] have been used interchangeably with marginal lands. MAs refer to lands with various limitations and challenges (Table 1) that hinder their potential for agricultural use, thereby restricting their development prospects [2]. It is widely accepted that land is a finite natural resource [4], and the utilized agricultural area in Europe has shown a general decline during the last decades [5]. Recent estimates indicate that the increase in demand for food, feed, bioenergy, and bio-based products is projected to worsen the land scarcity situation [6], particularly under climate change scenarios. Moreover, the decrease in arable land in MAs of Europe is due to global developments. Land that is too marginal is abandoned, and only the best soils are used for arable cultivation [7]. Therefore, different types of land are required to produce various goods, including food, fiber, and critical environmental services [8]. Until recently, the topic of agricultural use of rural lands has been neglected in favor of policies directed towards urbanization [9]. Nevertheless, today, the development of rural areas is gaining considerable global attention as a solution to cope with land scarcity scenarios, providing economic, social, and environmental returns. Additionally, marginal lands have become a major management target in countries, especially with food shortages, within the framework of land quality assessment programs [10,11].

Table 1. The most common limitations that characterize different marginal area types based on literature.

Physical Constraints	Climate Constraints	Biophysical Constraints	Socio-Economic Constraints
- Distance from roads and other means of transportation - Land with limited soil drainage - Land with a high concentration of salt (salty soil) - Unfavourable soil texture and stoniness - Land with steep terrain (severe slopes) - Brownfields (Land with industrial pollution)	- Land with extreme temperatures (low or high temperature) - Land with limited/no rainfall - Dryness (ratio of annual precipitation to annual evapotranspiration) - Excess soil moisture (number of days at or above field capacity)	- Land with low soil fertility levels - Land with low yield potential - Land with limited/no water recourses - Shallow rooting depth - Land with pathogen outbreaks	- Restrictive land tenure - Smallholdings - Poor infrastructure - Unfavourable output/input ratios. - Inadequate support for agriculture - Lack of institutional framework - High cost of rehabilitation - Lack of investment - Competition for land from other sectors - Lack of accessibility to inputs, market, and credit facilities. - Population density - Remoteness and rent paid/low land prices

It is believed that decision-makers have several reasons to be interested in rural development programs. For one, these programs can create job opportunities, and researchers are also drawn to them because of new scientific and technical developments that could benefit rural areas in the future [12]. The revitalization of MAs has become an important issue within the framework of rural development programs. Marginal lands have recently garnered global attention due to their potential to improve food security, support bioenergy production, and enhance ecosystem services [3]. Some studies [13,14] have shown that additional food production to enhance food security will need to come from agricultural lands located in MAs, where most poor people reside [15]. However, achieving this requires crop varieties and cropping systems adapted to marginal lands that can gradually rebuild over-utilized and nutrient-deficient soils [16]. Marginal lands are essential resources that

provide vital functions for local communities, particularly in developing countries, and the loss of such lands can damage their food security and livelihoods [4,17]. Despite significant improvements in agricultural productivity due to technological advancements, local communities in agricultural MAs were overlooked until recently [18]. Addressing marginal agriculture systems is believed to play a crucial role in achieving the Sustainable Development Goals defined by the United Nations [19]. However, the future challenge of the publicly funded agricultural research community will be to refocus its efforts on marginalized farmers and agroecosystems and assume responsibility for the welfare of their agriculture [18].

In this context, Italy is one of the largest agricultural producers and food processors in the European Union; however, nearly two-thirds of the national territories are defined as marginal and scattered throughout the country, with varying degrees of marginality [20]. These areas lack rational infrastructure and services, making them less suitable for cultivation, especially under given conditions, cultivation techniques, and agriculture policies [21,22]. In that case, they may represent a threat to the enhancement and safeguarding of these areas [23], thus restricting their revitalization for production, social, and cultural aspects. For a long time, Italian MAs have not been involved in the dynamics and political development strategies at national and regional levels, leading to unequal comparison with urban and arable land realities [24]. Today, MAs in Italy are seen not only as a problem and critical issue but also as a resource and potentially positive space due to the potential economic, social, and environmental gains necessary for the sustainable development of these areas.

More precisely, in Southern Italy, agriculture plays a key role in the Puglia region from an economic and social point of view, representing 4% of the regional gross domestic product and 9% of the regional employment according to the National Research Center for Policies and Bioeconomy (CREA) [25]. In recent years, Puglia's agriculture sector has displayed a distinct regional distribution of production values in comparison to the national data. The production values of herbaceous and fruit tree crops account for 72% (compared to the national value of 50%), while livestock production only makes up 7% (compared to the national value of 31%). Despite the marked pedoclimatic heterogeneity and the wide crop species biodiversity of the Puglia region, the competition for land use, along with the limitation in resources, is making the region's economic situation more challenging, especially under the projected climate change and the increase in population. Moreover, Puglia was identified as a less developed region during the 2014–2020 European Union programming cycle [26]. With this in mind, it has become increasingly important to use innovative approaches in agricultural lands within MAs and optimize land use to meet this challenge [27]. Marginal land, where a minimum of agricultural activity can persist, can support local communities through farm services, local production, packaging, conservation of biodiversity, reduction of energy consumption, greenhouse gas emissions, and global warming mitigation and adoption [28,29]. Various food-chain stakeholders such as researchers, activists, farmers, and public administrators were involved in strengthening or rehabilitating areas affected by different forms of marginality [30]. Similarly, an innovative solution for developing rural regions was proposed [31] concerning establishing "Smart Villages". This initiative was also based on a participatory approach with the involvement of local communities in rural areas to develop and implement site-specific strategies to improve their economic, social, and environmental conditions. Both efforts focus on the commitment of local people towards local action by gathering around a common problem and sharing the same vision for implementing some kind of 'action plan' to achieve sustainable development goals. This review aims to showcase the potential of MAs in the Puglia region, Southern Italy, to contribute to food security and rural livelihoods. It emphasizes also the need to evaluate the sustainability of these MAs for food, feed, and non-food production and highlights their importance for the region's economic, social, and environmental development.

2. Research Methodology

An extensive literature search was conducted to evaluate the state-of-the-art development of MAs in the Puglia region (Southern Italy). In particular, we systematically reviewed the literature on MAs and similar conditions, and identified related studies dealing with different types of MAs and their potential for sustainable rural development. The search was conducted using three databases: Web of Science®, Scopus®, and the free database provided by Google Scholar®. The focus was on studies carried out in the last ten years (2013–2023). However, some significant regional, national, and international studies that fall outside of this timeframe were also considered to provide the study with potential international inspiration.

The literature search was carried out to identify the key potential for sustainable food, feed, and non-food production in Puglia's unused/MAs without limitations that characterize the different MA types in the region. The main focus was given to the three pillars of sustainability (social, economic, and environmental), highlighting their prospects to optimize the agro-ecosystem services in marginal areas, therefore enhancing their production potential. MAs was the main keyword in this review; however, other terms such as "less favored areas", "degraded lands", "unproductive lands", "wastelands", "underutilized lands", "idle lands" and "abandoned lands" were also considered. In addition, the following keywords/phrases were used for our search: "Puglia", "Rural development", "Southern Italy", "sustainable development", "Revitalization potential", "agrotourism", "job opportunity", "Biofuel production", "local residents", "Biodiversity conservation", "Local Genetic Varieties", "Ecosystem services", "carbon sequestration", and "Land Constraints/handicaps". As a result, the screening process obtained a total of 194 research papers and technical reports that were included in the present review.

3. Sustainability Potential of Puglia MAs

Marginal lands have the potential to improve socio-economic conditions and landscapes while preserving the environment [32]. However, there are concerns about their sustainability, including their impact on the environment, ecosystem services, and climate change mitigation [33]. To understand their potential use, it is crucial to define different types of marginal lands. In the following subsection, we briefly describe the sustainability potential of these areas, considering the three main pillars of sustainability: environment, economic, and social.

3.1. Economic Potential

The Sustainable Development Goals identified by the United Nations are gaining increasing importance on the global stage. They encompass various economic and social areas, including land management. Proper management of MAs can lead to protecting the terrestrial ecosystem, reducing activities that can cause climate change, and creating employment opportunities to support rural communities' prosperity [34]. Unfortunately, policymakers still do not take the situation of MAs seriously. For instance, farms that operate in rural MAs often struggle to achieve adequate profits due to low productivity and a lack of income opportunities [35]. Additionally, the EU-Common Agriculture Policy (CAP) is not sufficient to achieve economic balance. Often, social factors are linked to the potential for economic development in MAs. The literature predominantly highlights the socio-economic benefits of combining agriculture, tourism, and energy production in marginal lands. This synergy can create employment opportunities and increase profits from tourism activities and biomass production for bioenergy in rural areas that are typically marginalized.

3.1.1. Job Opportunities for Local Residents

Job opportunities in rural agricultural areas are closely linked to the social aspects of the local communities, which is particularly important when considering the sustainable development of these areas. Despite the updates on the workforce situation in Southern

Italy that showed a fall of 1 million and 18 thousand people (−12.9% compared to −15.8% in the Centre-North and −14.3% in Italy) in 2022 compared to 2021, and a decrease in the unemployment rate of 14.3 [36], there is still some room for improvement if the regional authorities consider the job opportunities that may arise from the wide range of unused marginal lands within Puglia territories. Recently, given the current energy prices, marginal land is viewed as an opportunity for cultivating biomass crops for energy, as they do not require prime land [3]. Several studies [37,38] have concentrated on the economic aspects of bioenergy production from MAs. In recent work [39], Panoutsou and Chiaramonti considered both the economic and social aspects following an input-output analysis and used an econometric model to investigate the impact of crop-yielding performance in marginal land on jobs and profit from the cultivation and supply of Miscanthus in low-quality, marginal land in Italy and Greece. Their work shows that there are opportunities to generate employment and create financial profit from the cultivation and supply of Miscanthus using low-quality, marginal land. Similarly, tourism can be a beneficial economic and social venture [40]. Areas with exceptional natural beauty, like marginal landscapes, can be especially valuable for tourism [41]. However, infrastructure issues such as a lack of accommodation and inadequate communication routes continue to impede the development of tourism [42]. This is particularly true in the Puglia region, where areas with high-quality natural and agricultural landscapes have not been able to capitalize on tourism fully. Puglia was the first region in Italy to regulate the institution of community cooperatives through Regional Law No. 23 of 20 May 2014. The law considers community cooperatives as the preferred entity for implementing active labor policies aimed at creating new jobs by enhancing the tangible and intangible assets of the region. This is done to meet the needs of local communities and create social capital in general [43]. These policies should focus, however, on protecting local identities, promoting tourism, and supporting private initiatives such as quality restaurants and farms.

3.1.2. Source of Biofuel Production

The availability of land to grow feedstocks on a large scale is a significant concern for the bioenergy industry. Utilizing marginal land, where growing conventional crops is not possible, is often considered an ideal solution [44]. However, we currently have a limited understanding of the characteristics, amount, and distribution of such marginal lands in the Puglia region. In recent years, there has been increasing attention given to the potential of marginal lands to support bioenergy production and increase food security in the face of limited arable land resources [45]. In fact, with the expansion of the biofuel sector, the term "marginal land" has emerged as a common phrase associated with the promotion of agrofuels [46]. The sustainability of non-food biomass usage, particularly for crop-based resources, has become a significant issue in both policy and scientific debates due to direct and indirect impacts on land use, competition with food production, biodiversity conservation, and other ecosystem services, as demonstrated by several studies [21,47–49]. However, various obstacles must be overcome before biofuel production from marginal land can play a significant role in Italy's fuel supply. To achieve a sustainable source of biofuel production, it is essential to identify the best options for growing industrial crops on land that is not suitable for food production due to different limitations. This can be achieved by (1) identifying marginal lands based on their biophysical characteristics to determine the industrial crop options and economic feasibility, and (2) ensuring that the available options for growing industrial crops can help create co-benefits such as improving soil health and restoring long-term productivity, particularly in the case of degraded lands [50]. Producing bioenergy from dedicated crops in MAs can promote rural development and economic growth while creating alternative energy systems and markets [51]. In Italy, cost-benefit analyses have shown promising results for crop cultivation to produce biomass feedstocks for renewable energy in marginal lands [52].

3.1.3. Cultivation and Wild Collection of Local Plants

It is widely accepted that the cultivation and wild collection of medicinal and aromatic plants (MAPs) can help conserve biodiversity and improve livelihoods in MAs while providing a sustainable economic return to the local communities. Italian–German teams have conducted several collecting missions since the 1970s, highlighting the ancient and widespread practice of gathering wild plants in Italy for food or other purposes [53]. In the past, villagers would collect MAPs from the wild for personal use or to sell, but the harvesting process was often carried out by untrained and unskilled daily wage workers, resulting in significant damage to the plants and loss of income [54]. In recent years, MAPs have gained popularity worldwide as a source of raw material for pharmaceuticals and traditional healthcare systems. Several studies have shown that over 85% of herbal medicines used in traditional healthcare systems are derived from medicinal plants [55]. In the MAs of Foggia (Puglia region), particularly in the Gargano area, foraging for wild vegetables used to be a specialized skill, practiced by a specific group of people known as Terrazzani [56]. These individuals, considered to be on the outskirts of society, have historically, and still do today, participated in gathering and foraging wild food plants, mushrooms, snails and frogs, and illegally captured wild birds and small mammals like wild rabbits, hedgehogs, and badgers, for food. In the past, Terrazzani gathered and sold these items to the local agrarian bourgeoisie. Nowadays, the few remaining Terrazzani sell their foraged foods on the street corners of Foggia [56]. Changes in societal behavior, lack of markets, and urbanization can threaten such activities and result in more land abandonment, immigration to the big cities, and losses of important economic income to a significant portion of indigenous people.

In addition, several studies have demonstrated that there is a possibility to introduce some wild plants in the MAs of the Puglia region as a potential source of income and for biodiversity conservation. For example, according to a previous study [57], the plant *Salicornia patula*, which has been traditionally gathered from the wild as a source of food, could potentially become a profitable cash crop for marsh marginal lands in the Puglia region. In addition, the Cardoon plant (*Cynara cardunculus* L.) is known for its high production of biomass and secondary metabolites, and its ability to adapt well to changing climates. It can be used in the green chemistry, nutraceutical, and pharmaceutical industries. These plants have demonstrated the ability to grow in stressful environments, which leads to an increased production of biologically active compounds [58]. Exploiting marginal lands for the cultivation of wild plants or local landraces can be a useful tool in the context of climate change and environmental pollution. However, for the successful adoption of these plants in Puglia's MAs, it is necessary to select superior genotypes and establish the right agro-technique. To sum up, effective management, cultivation, and collection of MAPs as a natural resource can serve as a tangible demonstration of economic potential and research prospects.

3.1.4. Resilient Fruit Tree Systems

The initial considerations lead us to point out that the character of economic marginality is no longer distinctive only of mountain-hilly areas (i.e., those areas where climate, presence of old plantings, old varieties, etc., hinder the achievement of economically acceptable production quantities) but it starts to be the distinctive character also of many olive-growing areas in the plains, even those set up with rationality and modernity [59]. According to the definition of marginal area adopted by the "*Piano di Sviluppo del Settore Olivicolo*" ERSAP (Bari, November 1987, p. 89): "MAs are defined and as such proposed for cadastral declassification and inclusion in the band of territories provided for by the Resolution of the Puglia Regional Council No. 151 of 13/05/1986 (Delibera del Consiglio Regionale Pugliese del 13.05.1986, n 151)", those olive-growing lands which, because of gradient, outcropping rocks, lack of labor (even part-time), low value of cultivar and difficulties of various kinds (Table 1), are not judged suitable to be brought to such economic levels of productivity as to justify community investments. Actions to safeguard

these MAs are justified only when they aim to recover a heritage that takes on ecological value since in these areas, olive groves fulfill the important role of protecting the soil from hydrogeological disruption and maintaining the landscape [59].

Italy has several rural and MAs, particularly in the southern regions, which are known for their "historical landscapes". These landscapes are made up of hills and plains that are still managed using traditional methods. They are also home to ancient fruit trees that are a testament to local culture and landscape history [60]. These trees play a crucial role in preserving biodiversity in agroecosystems and providing various ecosystem services [61]. They also help preserve unique genetic diversity [62]. However, the survival of these trees largely depends on human activities and their resilience against threats and disturbances [60]. Land use planning is crucial to conserve these old trees and restore connectivity in economic land uses in the eco-cultural context of rural MAs. In hilly and mountainous areas, the Terraced Agroforestry System (TAS) is a dominant feature which can be proposed in MAs of the Puglia territory. The TAS involves planting fruit trees alongside vegetables and/or cereals in the form of multifunctional terraced agroecosystems. These systems ensure biodiversity conservation, as well as water and soil preservation [63–65]. The terraced landscapes embody the traditional culture and practices of locals and are one of the most stable land uses [66], built to last for generations. However, many farmers fail to appreciate the value of these croplands due to their marginality and low economic returns [67,68]. Hence, it is crucial to prioritize the preservation of terraced landscapes in landscape research, land planning, and governance.

In the Puglia region, woody fruit tree crops are distributed in a large area of the regional territories [69] (Figure 1). According to ISTAT, 2023 [70], olive growing is shared over 24% of total regional cultivated areas, with about 345,000 ha. Other important fruit tree species in the Puglia region (both for cultivated areas and production) are grape, almond, and cherry [70]. A significant percentage of these fruit tree crops are located in MAs such as inner, valleys, coastal, and hilly areas; 40% of olive orchards are placed in hilly areas. It is believed that the importance of olive cultivation goes even further as its cultivation promotes landscape enhancement and the recovery of MAs that would otherwise go unused [71]. In addition, neglected and underutilized crop species (NUCS), including fruit trees, have shown tolerance to various environmental stresses. Therefore, they should be promoted in areas where agriculture is challenging, such as MAs [72]. NUCS has always been a livelihood strategy for small-scale farmers in these areas. Hence, promoting NUCS in MAs is crucial as their diverse genetic pool contributes to agro-biodiversity, supporting landscape diversity in these regions [73]. A recent study [69] identified the suitability of underutilized fruit tree crops such as figs, almonds, and pistachios in MAs of Southern Italy, to maintain the long-term viability and productivity of these agricultural lands. Their results indicate that the cultivation of NUCS can help in (i) minimizing the environmental and economic losses; (ii) maintaining biodiversity components of the marginal landscapes at a reasonable level; (iii) ensuring sustainable food production systems; (iv) the management of the infected areas; (v) increasing the resilience of marginal agro-ecosystem [69]. However, an important question would be which modern planting system can be applied to the resilient cultivated genotypes selected in MAs [74]. From an environmental point of view, the water footprint (WF) of different olive-growing systems has been assessed [75], showing that traditional low-density olive orchards have a higher WF than intensive and super-intensive planting systems.

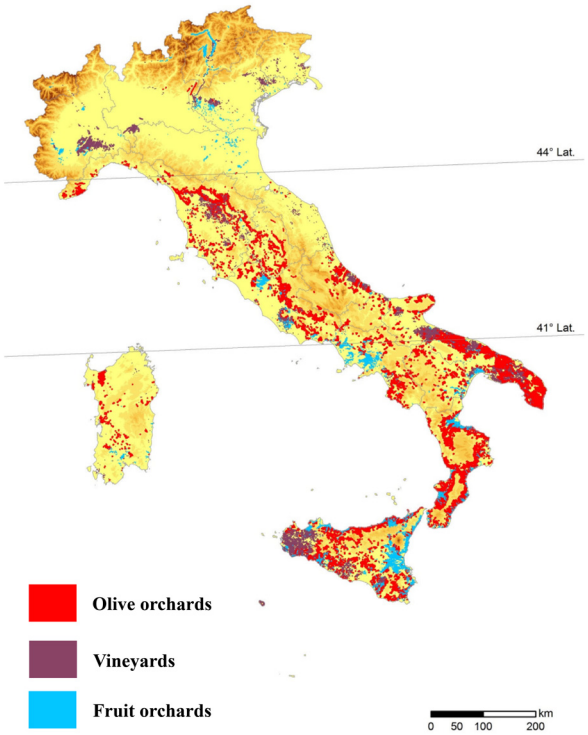

Figure 1. Geographical distribution of woody fruit tree crops according to CORINE land cover 2018 (https://land.copernicus.eu/pan-european/corine-land-cover; accessed on 25 June 2023) (adopted from Dettori et al. [76]).

3.1.5. Eco-Certification of Food and Non-Food Products from MAs

Certification is a useful method for promoting the sale of ecological agricultural goods [77]. Eco-certification standards are being increasingly used to restrict imports of foreign goods produced using unsustainable practices [78]. This includes preventing consumers from purchasing foreign goods derived from endangered species, harvested through unsustainable practices [79] and produced using genetically modified organisms. As a result, eco-certification is becoming a popular tool for reducing environmental impacts [80]. MAs like mountain areas have unique values such as scenery, biodiversity, water reserves, and cultural resources that require protection from harmful development pressures [81]. Therefore, eco-certification can be applied to agricultural products and byproducts coming from these areas to promote their conservation and revitalization prospects. However, producers in MAs may face challenges in implementing sustainability practices because the changes they need to make must be in accordance with sustainability criteria [82]. In this context, food and non-food producers in MAs need to choose the right eco-certification and coordinate it with eco-labels to increase their prices for sustainability. Eco-certification standards can also help increase consumer recognition of these products and encourage producers to improve their quality. The introduction of eco-certification standards for products from MAs in the Puglia region, especially mountain areas, can be a powerful strategy for the sustainable development of rural areas. Such a strategy can ensure a decent income for farmers, protect natural resources, promote sustainability practices, preserve the local identity of the area, and enhance product traceability.

3.2. Social Potential

The Puglia region has areas with different degrees of agricultural productivity. Some areas reach excellent yields, while others face environmental factors that limit agronomic performance and hinder the development of other productive sectors. This has led to poor employment and income prospects for local populations and regressive demographic dynamics. Social agriculture can help promote sustainable development and resilience

in these areas. However, understanding the local social issues and challenges is essential to designing a sustainable rural development plan and its projects [83]. In this regard, it is vital to consider that the development interventions can result in social and power changes, leading to positive and negative consequences experienced by communities in the intervention area [84]. Therefore, it is crucial to assess, predict, mitigate, monitor, manage, and understand the social impacts of any development policy, program, or project. This should be done before, during, and after the design, construction, operation, and completion phases [83,85].

In Italy, the culture and traditions of a particular area can have an effect on the development process, particularly on the way farmers are viewed by the rest of the community [83]. Another study indicated that agriculture can be a powerful catalyst for community development in the MAs of Puglia [86]. The cultivation of typical crops creates shared spaces and fosters social bonds, leading to a collective sense of identity and pride. It is not just an economic endeavor but also a contribution to establishing resilient and closely-knit communities. In Puglia's MAs, cultivating social capital is crucial to unlocking the social potential of agriculture. A previous paper discussed how networks and cooperatives formed around agricultural activities become vital platforms for knowledge exchange, collective decision-making, and the creation of a supportive social infrastructure [87]. These networks strengthen the social fabric and contribute to the overall resilience of agricultural communities and identities, which must be accurately preserved. Moreover, another research paper shows that sustainable agricultural methods not only mitigate the impact of environmental stressors but also enhance the resilience of local communities in terms of their capacity to adapt and prosper in the long term [88]. The concept of Social Farming (SF) has emerged as a way to harness the social potential of agriculture. SF introduces activities that support the competitiveness of the production system and meet the growing needs of urban and rural populations. A recent study [89] highlighted the potential and value of companies engaged in SF activities. SF can significantly benefit society and the environment and help address vulnerabilities in rural areas [90]. It creates viable and sustainable rural and peri-urban areas while providing a range of other well-being and cultural ecosystem services to rural and urban inhabitants [91]. According to this paper, SF can also provide opportunities for older people to be engaged in activities stimulating social behaviors. A recent study [92] indicates that SF in Calabria (Southwest Italy) is making a valuable contribution to the cultural change required to overcome the predominance of the Mafia, in addition to being successful in economic and social aspects. The previously cited studies suggest that SF has the potential for future growth in MAs by supporting competitiveness, providing societal and environmental benefits, and contributing to sustainable rural development [93]. These findings contribute to a better understanding of the driving forces affecting SF performance and provide policymakers and practitioners with information for scaling up SF [94]. Furthermore, maintaining social cohesion between multifunctional farmers is crucial to sustaining a multifunctional farming system [94]. The following subsections will explore the potential for farmers and farming activities in MAs to contribute to implementing sustainable development strategies in rural areas.

3.2.1. Rural Tourism and Agrotourism

MAs are of significant environmental value, but their low productivity and other limitations and challenges (Table 1) hinder their potential for agricultural use. This often leads to rural migration toward cities [95], causing land abandonment, further degradation of natural resources, and more pressure on urban management. In Puglia, olive orchard abandonment is prevalent due to the spread of *Xylella fastidiosa* and difficult environmental and social conditions. While conventional agronomic techniques can overcome low productivity levels caused by climate and soil, they cannot increase income sufficiently to avoid migration and fix people in these fragile rural areas. Several agronomic actions have been taken to limit land migration, but there are obstacles due to the physical environment. Rural communities often do not perceive the effectiveness of these interventions and seek further

income growth and lifestyle improvements. Agrotourism is a new approach that develops links between land-use planning, agriculture, and the modern economy. It is a way to maintain the economic convenience of enterprises in MAs. Rural activities are linked to the modern economy, and these activities include farm tourism with accommodation and restaurant services, in-farm sales of high-quality foods, farmers markets in small towns, game hunting, and several educational and health services offered to school children and retired people [96]. The terms "rural tourism" and "agrotourism" are often confused and used almost as synonyms. However, according to the OECD [97], agrotourism, or farm tourism, is a part of rural tourism. Rural tourism is divided into agrotourism, ecotourism, adventurous tourism, and countryside tourism. Among the latter, agrotourism is the tourism activity organized on the farm and by the farmers. In contrast, other segments of rural tourism are mainly organized by other subjects who do not carry out agricultural activities, and farmers are minimally involved [98,99].

In southern Italy, archaeological analysis showed that almost 58% of Bronze Age sites are concentrated in the Puglia region [100]. These sites have significant value in the tourism sector and could contribute to maintaining dynamic economic activity in the region. Some Puglia areas have particular characteristics that could make them of great importance to the regional economy. For instance, the territory of Gargano is recognized for its stunning landscapes and the ecological variety of its natural spaces, both within and outside the boundaries of the National Park, especially in small villages like Vico del Gargano [101]. Several towns in the "Monti Dauni" sub-region, a pilot MA identified by Puglia regional authorities within the National Strategy for Inner Areas (SNAI), provide an excellent example of a creative bottom-up enhancement process being implemented [43]. In these small towns, local players aim to maximize opportunities for sustainable, experiential tourism by offering an uncontaminated environment, ancient knowledge, genuine flavors, and deep emotions to all visitors who wish to gain deeper insights into the territorial identity instead of being mere spectators. Visitors can better understand the local culture by adopting an active and engaged attitude. Furthermore, agritourism, which combines agriculture and tourism, has become a transformative force in rural economies, and a unique experience for travelers. It includes various activities, from farm visits to hands-on participation in agricultural processes, offering a blend of recreation and education. It is obvious that the visitors are willing to pay more for a company located in a region with many tourist attractions, such as the Puglia region. Additionally, companies located in such areas tend to have higher productivity levels, which is an external attribute that creates positive externalities for tourism firms. The concentration of these firms creates a synergetic effect. In recent years, there has been a significant increase in agritourism farms (Figure 2). According to ISTAT [102], there were 23,406 licensed agritourism farms that provided accommodation in 2017, which was 745 more than the previous year (+3.3%). In Puglia, the natural heritage is a significant factor in attracting tourists, and serves as a distinctive identifier of the region. In fact, in the MA of Puglia, agritourism has emerged as a powerful engine for economic growth [103]. A previous study [104] highlighted that hosting tourists on farms provides additional revenue streams for local farmers. The establishment of agritourism enterprises, such as farm stays and culinary experiences, not only contributes to the financial well-being of farmers but also stimulates the broader local economy. Furthermore, agritourism serves as a means to preserve and showcase Puglia's rich cultural heritage. The region's traditional practices and culinary delights become integral components of the agritourism experience as tourists engage in activities such as olive oil harvesting, traditional bread making, and wine tasting, fostering an appreciation for the region's unique cultural identity [105]. Moreover, agritourism in Puglia's MAs aligns with the principles of sustainable development. The integration of eco-friendly practices not only enhances the visitor experience but also promotes environmental stewardship [43] because sustainable agritourism practices contribute to the preservation of natural resources, biodiversity, and the overall ecological balance of the region.

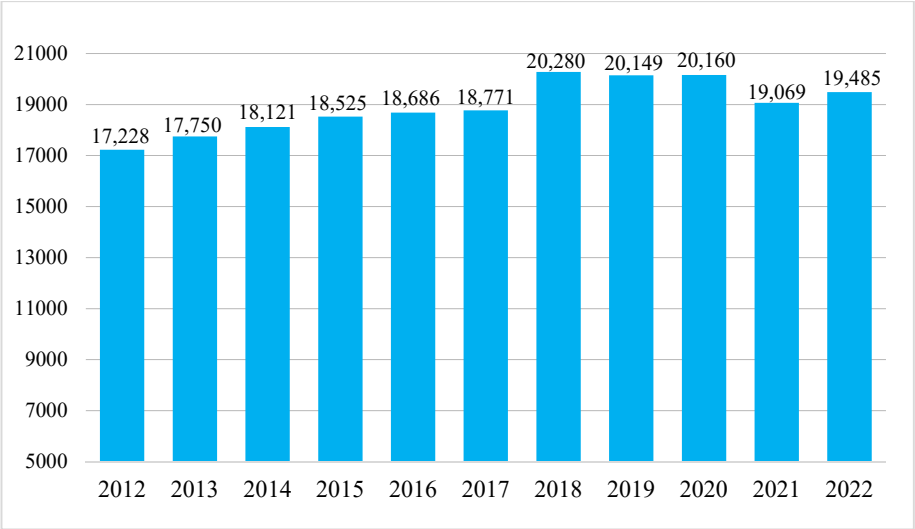

Figure 2. Number of agritourism establishments in Italy by year (from 2012 to 2022). (Adopted from Statista [106]).

3.2.2. Social Events

Social events are becoming a transformative strategy in the often-overlooked landscapes of marginal agriculture. They can play a significant role as a catalyst for community development and sustainable agriculture in the Puglia region. Social events go beyond the conventional scope of agricultural activities by fostering social cohesion, knowledge exchange, and economic opportunities within these agriculturally significant areas. They provide a platform for community engagement, knowledge exchange, and economic empowerment. Festivals, farmers' markets, and communal gatherings are examples of social events that provide platforms for social interaction and networking [107]. These events contribute to creating shared spaces, improving a sense of community identity and belonging. Social events also offer platforms for farmers to share expertise, learn about innovative practices, and enhance their agricultural skills [108]. This knowledge dissemination contributes to the modernization and sustainability of agriculture in MA. The shared and coordinated organization of social events in rural villages, such as festivals, historical reconstructions of agrestic moments, farmers' markets, show-cooking, and courses on preparing local traditional peasant dishes, could not only increase public awareness of local agricultural products but also contribute to the establishment of vibrant, close-knit communities. Moreover, social events, particularly farmers' markets and agrotourism initiatives, create economic opportunities for farmers in Puglia's MAs [109]. These events provide avenues for direct sales, market exposure, and collaborative marketing, contributing to the financial well-being of local farmers and stimulating local economies. Social events also become vehicles for preserving cultural heritage and promoting authentic agricultural experiences [110]. They showcase traditional practices, culinary delights, and cultural elements, preserving cultural roots and attracting visitors interested in authentic and immersive agricultural experiences.

Apart from economic considerations, the well-being of agricultural communities is a crucial aspect of sustainable development. Social events play a significant role in the cultural and recreational aspects of community life. Participating in communal activities promotes mental health and a sense of belonging, thereby countering the isolation that is often prevalent in remote agricultural settings [111]. However, social events in such areas face challenges such as seasonality, infrastructure limitations, and effective promotion. Overcoming these challenges and ensuring the sustainability of social events requires strategic planning, collaboration between stakeholders, and investments in infrastructure.

3.2.3. Spirituality

Spirituality is a broad concept that can be defined in many ways. Some people view it as a connection to a higher power or a sense of purpose in life, while others see it as a way of finding meaning and fulfillment through relationships, nature, or art. In marginalized areas, spirituality can play a crucial role in people's lives by providing hope and connection and helping them cope with the challenges of living in such communities. Historical and ethnographic studies have shown that spiritual practices have a lasting impact on the agricultural traditions of the Puglia region. Rituals associated with planting, harvesting, and seasonal transitions are deeply ingrained in the cultural fabric, reflecting a harmonious coexistence between spirituality and farming [112]. Agricultural spiritualism aligns with principles of environmental stewardship, influencing the adoption of sustainable agricultural practices. The belief in a sacred duty to care for the land motivates farmers to implement eco-friendly techniques, contributing to soil health, biodiversity, and overall sustainability [113]. The preservation of cultural heritage is a significant outcome of agricultural spiritualism [114]. Spiritual practices become conduits for transmitting cultural values across generations, preserving the identity of communities in the face of modernization and external influences. Some examples of how spirituality can be expressed in MAs include:

- Religious practices: people in MAs may find meaning and connection through religious practices. This could involve attending church, mosque, or synagogue, or it could include praying or meditating at home or in some intriguing locations.
- Art: people in MAs may find expression and meaning through art. They may create art themselves that could be a source of additional income but, at the same time, can be a way to connect with others, explore their own identity, or express their feelings for their territory.
- Music: it can be a powerful source of inspiration. It can provide comfort, relaxation, and a sense of community. People in MAs may enjoy listening to music, playing music, or singing alone or during social events.

The spirituality in rural MAs can provide comfort and inspiration for city dwellers. There are several reasons why city inhabitants may be drawn to the spirituality of rural MAs. For some, it may serve as a means to escape the hustle and bustle of city life. For others, it may be a way to reconnect with their roots or to find a sense of belonging. Additionally, individuals may simply find that the spirituality of rural MAs is more conducive to their personal spiritual growth. The slower pace of life, the closer connection to nature, and the sense of community can all contribute to spiritual development.

3.2.4. Green Care and Therapy Farm Initiatives

There is growing evidence that being exposed to nature, whether it is in the countryside, forests, street trees, allotments, or gardens, can have a positive impact on a person's health [115–117]. In the last decades, the European Union has been focusing on promoting multifunctional farming practices that combine agriculture with therapy and alternative ways to help people in difficult situations [118]. Several studies [119–122] have shown that contact with nature can improve psychological health by reducing stress levels, enhancing mood, and providing a restorative environment. Furthermore, research findings [123–125] have also indicated that engaging in physical activities while being directly exposed to nature, also known as "green care/exercise" or social farming [126] can lead to significant improvements in self-esteem and mood measures, as well as significant regulation of blood pressure. Social farming is an innovative approach that benefits public health and improves social health status [127]. It has become a popular practice recently, especially for those with behavioral or health issues [118]. The concept of using farms for green care has evolved over time. Initially, it was considered a way to reintroduce a sense of normality to participants and keep them occupied. However, it has since been found that it can also provide a sense of responsibility and help with rehabilitation and reintegration into society [128]. Gaining a deeper insight into the effects of therapeutic interventions in social farming could lead to the development of innovative tools for promoting healthy lifestyles [129].

In addition, this knowledge could also serve as a strategic element for the advancement of multifunctional farming practices. Several other nature-based solutions (NbSs), such as therapeutic horticulture [130], ecotherapy [117,124], and care farming [131], have also been found to effectively promote health and well-being. Therapeutic farm communities (TFC), or care farms (CF), for example, are community-based initiatives that have been proven to help mentally ill individuals regain stability and independence [132]. Previous papers suggested that animal-assisted therapy (AAT) using farm animals for individuals with psychiatric disorders can lead to a reduction in depression and state anxiety, while also increasing self-efficacy [133]. Moreover, CF was found to have positive effects on individuals in psychological, physical, and social aspects. However, TFC and CF services for the disabled, transportation disadvantaged, and socially disadvantaged are limited [134] despite their advantages.

In southern Italian regions like Puglia, there has been a shift from traditional agriculture to a multiservice model, known as "rural restructuring" [135,136]. As part of efforts to revitalize MAs, there is great potential for the establishment of community-based initiatives, in the framework of green care, in some Puglia MAs. This is especially true for areas with extreme handicaps that make crop cultivation impossible, yet they are unique with their beautiful and diversified landscapes. Apart from the therapeutic use of some medicinal plants typically grown in some of Puglia's MAs [137], different marginal landscapes can be organized as places where disabled, disadvantaged, elderly and/or mentally ill people can regain their active lives. The role of such NbSs, which should be inspired and supported by the different community-based initiatives as well as regional policies and local authorities, is to help build community robustness and engage a great number of regional residents with regional activities and, as a result, improve their well-being and, at the same time, develop the regional economy.

3.3. Environmental Potential

Marginal lands are often delicate and environmentally vulnerable [138]. With limited available arable land resources, there is a growing interest in utilizing these lands for different agricultural purposes on a global scale, i.e., bioenergy biomass production [139,140]. However, there are multiple concerns regarding the sustainability of this approach, including its impact on ecosystem services, environmental issues such as erosion and land degradation, as well as effects on biodiversity and climate change mitigation [33,141]. Nevertheless, several methods/techniques can be implemented in MAs for their revitalization potential while reducing any potential impacts on their sustainability potential. The following subsections contain an overview of some important environmental potential that can help in the revitalization effort of MAs in Puglia.

3.3.1. Biodiversity Conservation

Crop biodiversity is the outcome of various interacting factors that include the plant itself, the surroundings, and human actions, as illustrated by the domestication triangle. Genetic diversity within these species is not only the foundation for plant breeding but also a crucial element in ensuring the productivity and stability of agriculture [142–145]. The importance of plant genetic diversity is now being recognized by researchers as a specific area since the exploding population with urbanization and decreasing cultivable lands are the critical factors contributing to food insecurity in the developing world [146]. From the very beginning of agriculture, natural genetic variability has been exploited within crop species to meet subsistence food requirements, and now it is being focused on surplus food for growing populations; thus, the significant importance of crop biodiversity will increase in the future because of additional qualitative or quantitative demands on agricultural production, as in the case of the olive tree, the most important fruit crop in Puglia [147].

Biodiversity loss is a process that has greatly affected Europe since the middle of the last century. The intensification of agricultural land use for various purposes has caused the gradual decline of many semi-natural habitats [148–150]. Besides, with an increase in

temperature, a warming of 2 °C or higher would lead to deep changes in Mediterranean land ecosystems [151]. This process of change has led to the abandonment of traditional farming systems in favor of specialized ones in many marginal systems, either inland or in mountainous areas [152–156]. The biodiversity-based agriculture may lead to high diversification of the farming system in terms of crop genetics diversity (both at species and genotype level) and management practices with beneficial effects on the ecosystem as a whole. Common Agricultural Policies (CAPs) have not only contributed to fostering crop specialization [150,157,158] but also to support the economy and extensive farming in marginal and disadvantaged areas [159,160].

In Italy, especially in most inland and many MAs of the southern regions, there are many species with high genetic variability, often referred to as minor ones. These areas practice simplified agriculture with little mechanization due to various reasons such as orographic conformation, distance from inhabited centers, and small plot sizes. Therefore, the protection of native species and varieties often happens in family gardens, along the edges of plots, and even on the dry-stone walls that divide the plots, even in the case of more intensive agriculture. The protection of local biodiversity is also due to culinary and religious traditions that mark certain times of the year [161–163]. This confirms the potential that these species have, particularly in MAs that are currently devoted to unprofitable agricultural activities [164,165]. Two main strategies are used to conserve plant genetic resources: ex situ conservation in gene banks (i.e., the collection, transfer, and storage of a population sample of a certain species away from its original location) and in situ conservation known as on-farm conservation [166]. In the Puglia region, for several species, farmers known as 'custodians' are earning income by exploiting and maintaining native species/varieties present for many decades. These species are well adapted to the specific environments and called landraces which help to protect and safeguard the agricultural landscape from an environmental standpoint. The use of native species/varieties allows for discrete productions even with limited agronomic inputs [167], such as deficit irrigation (e.g., RDI, PRI), which reduces vegetative development but does not affect fruit quality, and may even improve it in some cases [168]. Several tree species, including the common fig, pomegranate, jujube, carob, winegrapes, pear, almond, and olive, have good resistance to water stress and can be cultivated in environments with limited rainfall [169–171]. Some of them have also shown good tolerance to salinity [172,173]. In olive groves, instead, cultivar biodiversity represents a potential source in breeding programs in order to face phytosanitary epidemics and climatic changes [174].

On the other hand, applying agrivoltaic systems would allow not only greater gains from agricultural activity but also a supply of 'clean' electricity to be used on the farm or released on the market. In MAs, the biodiversity-agrivoltaic combination would optimize soil use and water resources, making them better utilized and available for longer periods [175,176]. Some shrubs, such as blackberry, raspberry, and blueberry, can also be considered among the highly adaptable species in MAs with less fertile soils [177]. These species respond well to deficit irrigation (RDI) and can take advantage of the shade, including photovoltaic panels, which would allow better vegetative and productive development because of lower stresses [60]. Recent research has shown that selecting and crossbreeding local species/varieties with greater resistance to environmental stresses can ensure adequate production, especially in the face of climate change [178–181].

3.3.2. Restoration of Local Genetic Varieties

Nowadays, the biodiversity loss issue at a global scale is becoming an alarming challenge that needs to be addressed. Regarding this debate, the EU launched a biodiversity strategy with new measures to evaluate and preserve European biodiversity. Within this challenge, different aspects were taken into consideration for a sustainable interest, such as cultivated species and landraces, wild flora, restoration of local genetic varieties, soil micro-organisms, pollinators, the relative interconnections between plant and environment, and agricultural management practices. Furthermore, the local community's knowledge

and culture have an important role and should be considered as part of biodiversity [182]. The characterization and clarification of possible synonyms, homonyms, and labeling errors in original local genetic varieties is also another challenge for conserving and preserving the local varieties [183]. This problem can be solved using genetic tools. In fact, in recent years, an increasing number of works have been focusing on molecular characterization and genetic diversity assessment of several species by using different classes of molecular markers such as SSR (Simple Sequence Repeats) [184].

In the last decades, modern agriculture has resulted in intensive farming systems and new bred cultivars. This massive and large use of the new cultivars consequently reduced the genetic biodiversity of local species, especially in MAs. In contrast, Italy preserved many local genetic varieties due to the limited intensive crop orchards, but the coexistence of new and ancient species ended in confusion and interference between commercial and sustainable production.

An example is the valorization of the minor fruit such as Pomegranate. The successful adaptation of these species to the Mediterranean climate, including Puglia, allowed a wide diffusion in various countries, thus originating several local genotypes over the centuries. A morphological and biochemical characterization of a set of pomegranate genotypes collected in the Puglia region has been conducted in order to investigate genetic diversity by microsatellite markers and identify new genotypes with superior quality characteristics [185,186]. Landraces and wild relatives can provide genetic traits that can improve biotic resistance and tolerance to abiotic stress for more sustainable and resilient production systems [182]. Landraces of many species evolved as the result of adaptation to highly diversified growing environments [186]. For example, wheat landrace collections contain wider genetic diversity than most breeding programs, including adaptation to different conditions according to the place of origin. Knowledge of the genetic diversity and population structure of landraces is essential for their conservation and efficient use in breeding programs, especially concerning the field of adaptation to climate change [187]. Today, climate change is causing species to experience new environmental pressures, leading to changes in species distributions and affecting species' ecological niches [188].

A large amount of germplasm of many plant species is still being conserved on farms in Southern Italy, where a great number of accessions have been collected and are now conserved in ex situ gene banks [189]. Common fig, grape, and olive are three classical fruit trees associated with the beginning of Mediterranean horticulture; Puglia was characterized by a wide germplasm of edible figs and caprifigs, probably originating from different Eastern areas of the Empire and thus became a sort of natural fig repository [190]. Puglia is characterized by a wide germplasm of both edible (female) figs and (male) caprifigs. Over 100 different fig genotypes, mainly collected in Puglia, are located in the fig repository at the P. Martucci experimental station, University of Bari 'Aldo Moro'. The collection has been investigated to understand the biological behavior of these fig genotypes and to valorize this biodiversity [190,191].

Over the last years, many collecting missions have been organized in regions such as the Basilicata region (Southern Italy) [186]. The results of the collecting missions conducted over the last 30 years across the Basilicata region have shown that genetic erosion has been swift in cereals and other major field crops, while it is less pronounced in horticultural and minor garden crops which are often preserved in home gardens and at the boundaries of larger cultivations [186]. It has been reported that genetic erosion is usually more intense in the lowlands [163], a statement that highlights the role of marginal highlands such as hilly and mountainous lands in restoring the local genetic varieties. As it is already known, the continuing erosion of crop genetic diversity hampers agro-ecosystem function as well as provisioning (food and fresh water production), regulating (pest and disease control, pollination, carbon sequestration), and cultural (traditional knowledge, spiritual/religious and aesthetic values) ecosystem services [192]. In the Puglia region, vegetable biodiversity is still maintained in MAs such as hilly and mountainous areas [193]. The survival of agro-ecotypes occurs in areas where traditional forms of agriculture are still being practiced

and are often associated with the presence of old farmers and their traditions, such as dishes prepared with local varieties, religious traditions, or therapeutic applications [194,195]. A previous study [186] reported higher agro-biodiversity conservation in MAs in southern Italy. For example, it has been highlighted that multicolored carrots were present through the 13th and 14th centuries. In the Puglia region, these carrot landraces are cultivated by local farmers in different places. In addition, they have been officially inserted in the list of species at high risk of genetic erosion as well as other species (Purslane, *Salicornia* spp., Roquette, etc.), according to the Puglia Rural Development Program (2007/2013) [182].

3.3.3. Reduction of GHG Emission and Climate Mitigation Potential through Carbon Sequestration

In recent times, there has been a growing focus on the potential of sustainable management of marginal lands. This is aimed at reducing greenhouse gas (GHG) emissions, mitigating the impact of climate change, and providing ecosystem services. A recent study [196], based on a large temporal and spatial dataset, referred to the Puglia region, one of the most important Mediterranean olive-growing areas. It showed that the traditional organic orchards have the highest level of GHG emissions (266 × 103 kg CO_2eq/ha) compared to the super-intensive integrated orchards, which had the smallest environmental impact (132 × 10 kg CO_2eq/ha) (Figure 3). This suggests that implementing agricultural intensification can combine modern agriculture with high environmental performance, thereby improving natural resource use efficiency [197]. Recent research suggests that optimizing agricultural practices that have high levels of GHG emissions will be necessary to increase resilience in MAs [196]. Paradoxically, the modern high tree density is essential for the environmental sustainability of newly growing fruit tree systems, which has proven to reduce water footprint, e.g., in the olive groves [75]. This is an example of sustainable intensification, which embodies the concept of "producing more with less". By considering key aspects such as economic, landscaping, and social considerations, this information can provide a starting point for formulating guidelines for rational management of the marginal orchard and regional, national, and community agricultural policies.

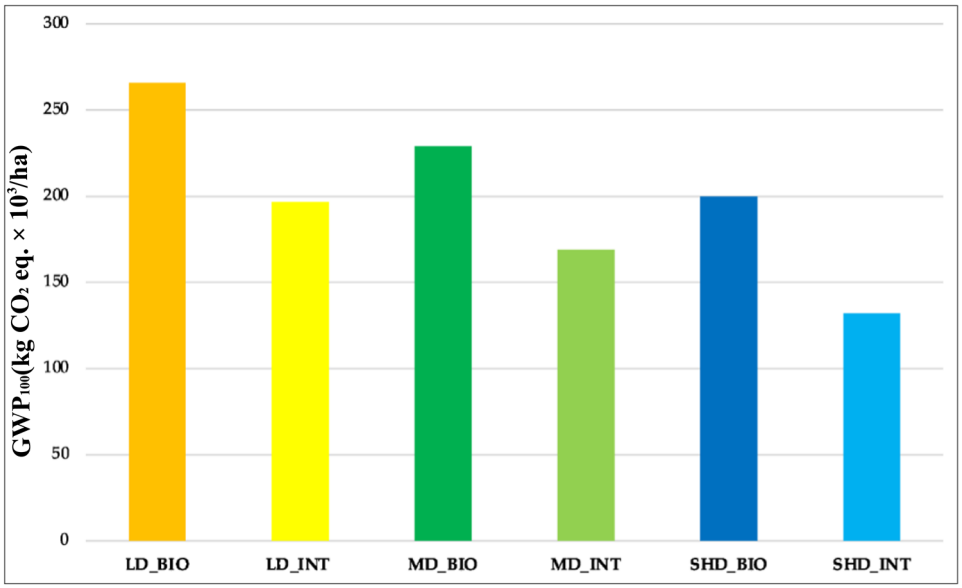

Figure 3. Value of global warming potential per hectare for the three olive-growing systems in both integrated (INT) and organic (BIO) farming methods: traditional systems (LD), intensive systems (MD), and super-intensive systems (SHD) [196].

On the other hand, carbon sequestration represents one of the most critical ecosystem services because a significant amount of CO_2 emissions result from human activities, especially fossil fuel combustion and deforestation [198]. MAs can be a strategic resource for

this purpose. Optimal land use and agronomic management can help overcome specific constraints related to physical (limited soil drainage, high salt concentration), biophysical (low soil fertility levels, low yield potential, limited/no water resources, shallow rooting depth), and climate (low rainfall water availability, frequent drought events) factors (Table 1). This can reestablish the quality and health of these soils and improve crop productivity and carbon fixation potential. Additionally, these surfaces are often extensively managed and are therefore particularly suitable for encouraging or sustaining the incentivization of new crops in place of the current crops and the adoption of conservative agricultural practices such as reduced or no-tillage, cover cropping, organic amendment, and dry farming techniques [198]. According to the previous study [199], converting marginal lands into restorative land uses, adopting conservation tillage with cover crops and crop residue mulch, implementing nutrient cycling practices like using compost and manure, and utilizing other sustainable systems for managing soil and water resources can restore a significant portion of depleted SOC pool. Another study highlighted the importance of improving the soil quality of marginal lands using innovative technologies to enhance agricultural productivity and ensure food security [200]. Soil tillage and fertilization are two agronomic strategies that have a significant impact on soil carbon balance. They directly affect the type and amount of carbon inputs supplied (such as crop residue incorporation and organic amendment supply), the rate of soil disturbance, and the rate of organic matter mineralization. Soil tillage also modifies soil aggregation and structural stability, porosity, and hydrological properties, which affect the soil's ability to store and transmit water and air [201–205]. Additionally, tillage management plays a crucial role in soil organic matter turnover, microbial abundance and diversity, carbon storage, and thus CO_2 emissions [206]. Reduced tillage, in particular, as reported by several studies [206,207], can provide lower energy consumption and increased soil carbon sequestration and organic nitrogen accumulation when compared to conventional tillage strategies. This is because reduced tillage can help preserve soil structure and promote microbial activity, which in turn leads to better carbon storage and therefore lower CO_2 emissions. Several long-term field experiment (LTE) platforms have been established over the Puglia region, and more generally in southern Italy, in recent decades. These platforms aim to monitor the effect of reiterating agronomic practices over time and assess their sustainability [201,205,208,209]. In particular, previous studies [201,208] have shown that no-tillage practices increase soil labile organic carbon fractions, such as water-extractable carbon content, reduce energy consumption, and increase the amount of CO_2 stored as carbon in soil when compared to conventional soil management. Furthermore, the use of organic amendments can be viewed as a central strategy in the sustainable management of MAs. This can help restore the productivity and quality of degraded or abandoned soils [210,211] and revitalize ecosystems on contaminated lands. The use of organic amendments is a viable strategy to reclaim saline and sodic soils. Soil salinity and sodicity are severe land degradation processes that significantly affect soil quality, plant productivity, and carbon storage potential. A recent analysis of literature indicates that supplying different organic amendments at rates not exceeding 50 t ha^{-1} can improve both physical-hydrological properties (soil structure, permeability, water holding capacity, etc.) and chemical properties (pH, cation exchange capacity, etc.) of soil. This, in turn, enhances plant growth and microbial activity without any risks of subsoil and groundwater contamination [212]. Furthermore, the increased hydraulic conductivity that results from organic amendments can favor the application of corrective treatments in low-permeability alkaline soils. Biochar, which is also a stable and recalcitrant carbon compound that is formed by pyrolyzing organic materials under low or no oxygen conditions, can also be used for soil carbon storage [213,214], remediation of contaminated soils [215,216], greenhouse gas emission mitigation [217,218], and improving soil fertility and crop yield in problem soil [219] due to its stability. Compost, on the other hand, as a stable product obtained from the aerobic decomposition of raw organic materials like yard trimmings, food residuals, or animal by-products, can be used as a sustainable solution for managing particular organic materials and biomasses that can

negatively impact human activities (e.g., municipal solid waste, sewage sludge, beached residues of seagrass in coastal areas) [220,221]. Composting allows for managing and recovering large amounts of organic waste, which is a strategic solution for the circular economy. Compost has a low decomposition rate and a slow release of organically bound nutrients, making it less susceptible to large nutrient losses. It is also a strategy to increase organic carbon content in the soil. In addition to other targeted land-use and management efforts, adopting conservative agricultural practices such as reduced or minimal tillage and organic amendment can be a key strategy for improving the management of marginal or abandoned soils. This can help restore soil quality and productivity, as well as increase the potential for carbon sequestration and storage.

3.3.4. Optimization Potential for Agro-Ecosystem Services

Biodiversity is critical to the productivity of different land ecosystems, including MAs where a diverse range of animals, plants, and micro-organisms that provide various benefits for food, feed, and non-food production, exists. This includes the genetic resources variation such as different varieties and breeds of species used for food, fodder, fiber, fuel, and pharmaceuticals. Marginal landscapes can have multiple land uses, including livestock breeding, forestry, and cultivation, creating ecosystems that are of great importance for their environmental and socio-economic value [222]. Studies have emphasized the social and economic advantages of biodiversity, which offers alternative and additional sources of income in such areas [223]. Land-use change in agriculturally marginal landscapes has significant impacts on rural areas economically, socially, and environmentally [224]. In this context, the ecosystem service (ES) approach has become an essential part of land use and policy planning [225,226]. Depending on the goals and context of the case, the use of ESs can involve various tools and approaches [227,228]. Although the importance of ESs is increasingly being recognized in environmental policy at the EU, further integration of the ES concept is required in the implementation of existing EU policies at both national and regional levels [229]. Agriculturally marginal landscapes are believed to play a significant role in providing regulation, maintenance, and cultural ecosystem services at a regional level [230]. These landscapes, which have been developed through centuries of low-intensity farming systems, are important for the conservation of specific habitats and species [231]. Landscape scenarios can be especially valuable in MAs, where the impacts of change can be more severe, and the resources available for adaptation and resilience may be limited. These scenarios help to create plausible descriptions of potential future directions of the development of complex systems [232]. Exploratory scenarios, for example, are used to explore potential outcomes or impacts of different management approaches or policy interventions and can examine how different land-use patterns and management practices may influence the distribution of ecosystem services potential in marginal agroecosystems [233]. A recent study has highlighted the multiple benefits of low-intensity agroecosystems in marginal landscapes [224,234]. The study examined the potential supply of ecosystem services in various scenarios and emphasized the advantages of low-input land use in marginal landscapes. The benefits of low-intensity agroecosystems include the provision of habitats for pollination, habitat maintenance, climate control, and medicinal herbs. Additionally, these agroecosystems can provide ecosystem services in the form of reared animals, fodder, and biomass for energy, as well as ecosystem services related to soil such as weathering, accumulation, and bioremediation. The study shows that when it comes to agricultural land-use planning and policy recommendations in marginal mosaic-type landscapes, choosing the most sustainable or beneficial scenario is not always feasible. Instead, a management plan that incorporates elements from multiple scenarios is recommended, as it allows for the range of multifunctional values that are disclosed under diverse scenarios to be considered in the context of social-ecological sustainability. Another example of revitalization or sustainable utilization of cultivated land resources and agricultural development in China [235], is where the authors assessed the impact of heavy metal-contaminated cultivated land treatment (HMCLT) on Agricultural Development

Resilience (ADR). This study examined HMCLT's influence on ADR over time and space, using data from Hunan province in China between 2007 and 2019. In 2014, China initiated the pilot policy of HMCLT to boost the circulation of arable land and mitigate the adverse effects of environmental pollution on agricultural productivity and sustainable development. This included initiatives like fostering collaborative efforts to enhance technological innovation and conducting research aimed at restoring cultivated land. In general, results indicated that the HMCLT policy effectively boosts ADR in pilot cities and neighboring areas. Furthermore, financial aid for agriculture, agricultural disposable income, and rural population density are significant factors for ADR, albeit with a crowding-out effect on neighboring cities. Such initiative can be cloned in the case of Italian contaminated MAs due to the different industrial activities.

4. Conclusions and Recommendations

Based on the information provided in the literature, the existing data on MAs in the Puglia region served to assess their sustainability potential to provide guidelines for better management of these areas. This review provided insights into the economic, cultural, and environmental aspects that could participate in the revitalization of Puglia's MAs for sustainable rural development.

On one hand, the analysis of the information indicates that the implementation of technological advancements such as climate-smart agriculture, agroecology, and crop management can transform unproductive lands into fertile areas. However, it is crucial to identify the type of marginal land (whether it is biophysical, economic, or related to ecosystem services) to plan and execute site-specific management strategies effectively. On the other hand, the highlighted information suggests that the social aspect of farming in MAs is crucial to their activation/revitalization. It is important, therefore, to develop these areas to preserve their socio-economic value, contribute to food security and energy production, and maintain ecosystem services. As a result, activities that promote socio-employment integration for disadvantaged workers and people, increase social services and activities for local communities, and facilitate medical, psychological, and rehabilitation therapies using farm animals and medicinal and aromatic plants should be encouraged. Furthermore, since each type of MA in the Puglia region is unique, it is the responsibility of local authorities to provide support and funding for specific projects aimed at preserving biodiversity, promoting environmental conservation, and educating people about food and farming. To achieve this, high nature value farming, bioenergy crops, and afforestation as well as establishing social and educational farms that help raise awareness about the region and its unique characteristics are recommended. For the Puglia region to achieve sustainable development goals related to poverty, food security, and the environment, marginal lands need to be increasingly recognized in future policy frameworks. However, local authorities in the Puglia region should consider the perceptions of marginal land change over time and space; therefore, flexible policies and practical solutions are needed to ensure their non-degrading use, which should support nature-based socioeconomic development. The main outcomes from the present review paper are:

- Unused and unproductive lands in rural areas of the Puglia region are abundant but often overlooked or not exploited.
- Evaluating the sustainability potential of MAs for food, feed, and non-food products is crucial for rural development.
- MAs in Puglia can significantly contribute to the regional economy and food security.
- Support for small-scale farms within MAs is essential for sustainable rural development.
- Technological advancement applications can be the best management strategies for MAs.
- Social aspects of farming in MAs are crucial to ensure their activation and revitalization.
- Marginal lands should be recognized in future policy frameworks for sustainable development.

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