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Proposal of a Bioregional Strategic Framework for a Sustainable Food System in Sicily

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Abstract: The alignment of food systems with the Sustainable Development Goals (SDGs) is generally envisaged to make a positive impact on sustainability. This paper outlines some critical environmental and socio-economic indicators for Sicily in order to compare and explore the outcomes of two juxtaposing key drivers in a scenario planning exercise, where the extremities are *Industrial* versus *Regenerative Agriculture/Agroecology* and a *Proactive* versus *Reactive* government response. The most rational and less risky scenario becomes the most sensible sustainable development option, around which a 2030 vision is projected for a bioregional sustainable food system for Sicily, which is aligned with the SDGs and related policies. To accomplish the 2030 vision, a holistic education-led developmental approach is outlined with a supporting bioregional strategic framework, whose key milestone deliverables are projected through a backcasting process. This paper therefore highlights the importance of consistency and alignment of a development vision with its strategic framework and ensuing implementation, failing which, the holistic bioregional approach is compromised by activities that are shown to negatively impact environmental and socio-economic indicators. For this reason, all public and private sector development plans and associated resources ought to be aligned with a bioregional strategic plan for a sustainable food system for Sicily.

Keywords: diversified agroecological systems; participatory stakeholders; bioregional development program; backcasting process; agroecology

1. Introduction

A sustainable food system (SFS) is a food system that delivers food security and nutrition for all people in such a way that the economic, social and environmental basis to generate food security and nutrition for future generations is not compromised [1]. To accelerate the shift towards food security and nutrition, a new science of sustainable food systems is needed [2] as well as practical changes in all processes and interactions involved in global food production.

According to a line of thinking widely reported in scientific literature, food production—based on the model of economic development of so-called advanced countries—has been profoundly transformed to meet specific and growing food needs of an expanding population. Furthermore, it often makes use of marginal land that is not well suited for agriculture due to the pressure of growing urbanization, migration, poverty and land conflicts, as well as international investment and trade policies.

As a result, the impact of food production on resource exploitation has grown from a strictly local and low-input system to an intensive industrial model, which is able to respond to global demands, but consequently, has a high negative impact on the environment and community well-being. This global food production threatens climate stability and ecosystem resilience and constitutes the single largest driver of environmental degradation [3].

To reverse these trends, diversified models of agriculture and holistic understanding of sustainability are required, as well as forward thinking and adaptable educational approaches. In this regard, education for sustainable development (ESD) is an enabler towards achieving the sustainable development goals (SDGs) through skills development and knowledge transfer towards a better understanding of how to apply the SDGs and to bring about the necessary transformation in meaningful sustainable development [4].

To tackle these challenges, the International Panel of Experts on Sustainable Food Systems (IPES-Food) [5] in "From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems" emphasise the importance of reforming food and farming systems by moving away from industrial orientation and organization, towards diversified agroecological systems. Agroecology is, in fact, widely recognized to be the most suitable approach to address all these problems, and even the High Level Panel of Experts on Food Security and Nutrition (HPLE) report [6], highlights the necessity for stakeholders involved in food systems to learn from agroecological and other innovative approaches, as well as distinct ways to foster transformation of food systems by improving resource efficiency, strengthening resilience and securing social equity/responsibility [7]. Accordingly, agroecology, regenerative agriculture, organic farming and permaculture, are models with a common approach that integrates environmental, social and economic facets to establish resilient local food systems.

Diversity at every level enhances the capacity of agricultural systems to cope with both external and internal shocks, and to adapt to change, thereby establishing resilience. This diversity manifests at every scale, from an individual organism, to a field, to a farm, to a landscape, to a bioregion, and, to the planet. However, environmental resilience is also the foundation for socio-economic resilience, such as, household livelihoods and community food security. Herein, it is noted that simple human intervention to increase biodiversity is the foundation upon which resilience is built.

Monoculture systems can thus be more vulnerable than biodiverse systems, which are more resilient to severe shock impact arising from the likes of, diseases, pest outbreaks and weed invasions, all of which usually results in dramatic production losses. Consequently, if livelihoods are heavily dependent on a monoculture crop, the risk of crop failure can be disastrous, with this vulnerability having been documented on several occasions [8,9].

The transition from an intensive monoculture system to a diversified agroecological system requires time, resources and motivation, and is widely recognized as the most effective way to increase the resilience and sustainability of an agri-food system. For example, integrating agroforestry within crop production systems, helps to establish favourable microclimates for crops by moderating extreme temperature and solar radiation, as well as, retaining soil moisture content [10]. Additionally, trees, hedgerows and wildflower banks are able to host populations of insects for pollination and biological control, which also provide essential ecosystem services [11–13].

This comparison forms the basis for engaging with a scenario planning exercise to determine the rationale for the most sustainable and risk-free scenario for the development of the agricultural sector. The ensuing development vision for this scenario is then aligned with international institutions and scientific research works on the topic of sustainable food systems, such as, the United Nations with its 2030 Agenda for Sustainable Development, the IPES-Food, the Barilla Center for Food and Nutrition (BCFN) with its "Food Sustainability Index", and several others. The United Nations Food and Agriculture Organization (FAO) is also included among these initiatives, especially for its active efforts in: fighting against hunger and malnutrition; searching for solutions to achieve the sustainable development goals, in particular the second "hunger eradication"; collaborating with the authorities of different countries; developing approaches and tools based on sustainability and the transformation of food systems and populations of rural areas through the "Sustainability Assessment of Food and Agriculture systems", the SAFA framework.

Community health and wellbeing do not merely depend on the nutritional value of food products, but rather, on identity, nature and tradition. More especially, the focus on the relationship between the traditional Mediterranean diet, the Sicilian food culture and local tradition. The Mediterranean diet has always been an expression of culture and now it has also been recognized by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a part of the intangible cultural heritage of humanity [14]. Furthermore, the Mediterranean diet has been positively linked to sustainability benefits affecting all the three dimensions of sustainability, namely, environmental, social and economic [15]. Nevertheless, despite these positive sustainability attributes, numerous sources testify that more and more people among Mediterranean nations are relinquishing the Mediterranean diet.

For example, Grosso et al. [16] have shown that although adherence to the Mediterranean diet is still mostly representative for the adult population in Sicily, a slow but steady move away from such traditional cuisine has been observed in younger people. Another study, which has analyzed the diets of centenarians from the Sicani Mountains and from residents of Palermo, reported a close adherence to the Mediterranean diet in the countryside, and the contrary in larger towns [17]. The loss of traditional diets can be seen as a consequence of the major changes in food consumption that has occurred over the last fifty years in all Italian regions, including Sicily, which is affected by cultural and socio-economic changes.

This paper postulates that one of the major reasons for the relatively limited success of sustainable agricultural solutions, is that the paradigm shift which has taken place these last 100 years, has created too huge a gap and a loss of institutional memory between the former timeless traditional agriculture and industrial specialized agriculture. This gap has only been bridged by the ever-increasing complexity of modernity, which has now resulted in a "complexity gap". This complexity is further complicated by the interwoven dynamic nature of many tipping points of the various earth systems [18]. The wide coverage of this paper presents a "complexity gap" and its focus is the island of Sicily, since this will provide a more tangible bioregional context to test the proposals of this research. More specifically, the paper is an attempt to mobilize proactive public and private sector stakeholders towards a coordinated approach for a sustainable food system for Sicily. To this end, this paper lays out the process for how such a proactive stakeholder group can develop a Strategic Framework for the implementation of a bioregional development program for a sustainable food system in Sicily (BDP-SFSS). Given the emerging environmental and socio-economic challenges of the Mediterranean nations, the positive outcomes of this paper can well be replicated at scale throughout the Mediterranean region.

2. Materials and Methods

The crux of this paper is inherent in its title, to propose a bioregional strategic framework for a sustainable food system in Sicily. More specifically, the "Strategic Framework" is derived by piecing together the research approach plus the methodology of the paper, that is, the research flow as shown in Figure 1. In turn, the resulting strategic framework, which in Figure 1 now appears as a blank canvas on which the content to be painted, is a high-level presentation of a proposed BDP-SFSS, that has been detailed in Figure 5.

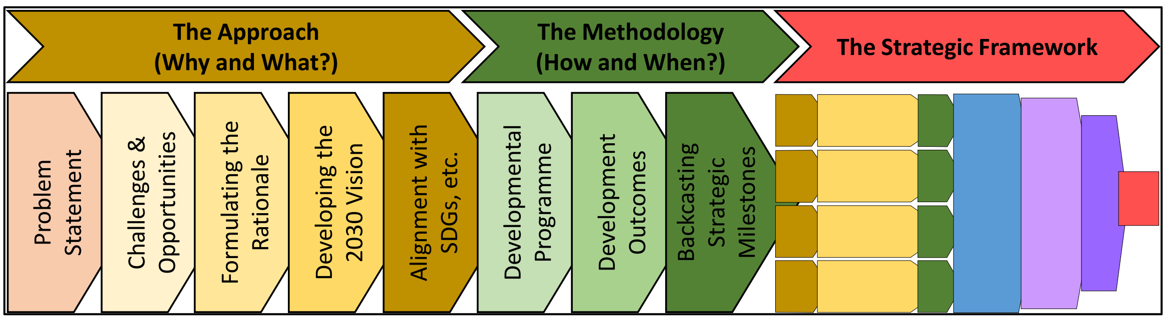

Figure 1. The Research Flow.

The discussion of the results raised from the research approach and methodology essentially assembles the strategic framework for the BDP-SFSS. The conclusions then highlight the importance for a clear strategic framework based upon whole-systems thinking to achieve the required developmental impact at a bioregional level.

However, the strategic framework for the BDP-SFSS needs to be presented to relevant stakeholders to solicit feedback, critique, and a way forward. For this reason, a participatory planning process with stakeholders is essential. To this end, a participatory strategy was chosen based on the involvement of different categories of stakeholders involved through the organization of focus groups [19,20].

2.1. The Research Approach

The research approach provides the background context and problem statement which tabulates and discusses some key environmental, social and economic indicators.

The key indicators were selected on the basis of:

- indexes used in the literature and tested in different territorial and productive contexts;
- consultation of the main sustainability tools in the online databases;
- stakeholder surveys and expert meetings in Sicily.

The problem statement opens the comparison of the dominant form of industrial agriculture with regenerative agriculture, together with their respective challenges and opportunities. This comparison forms the basis for engaging with a scenario planning process to determine the rationale for the most sustainable and risk-free scenario for the development trajectory for the agricultural sector. The research approach basically provides the goal, values and overarching objectives for the strategic framework, in other words, the "why" and the "what" reasoning.

2.1.1. Problem Statement: Tabulating the Key Indicators

The starting point is the identification of the main environmental, economic, social and cultural problems through appropriate key indicators. In this regard, Tables 1–3 show the most relevant data emerging through the consultation of different regional and national official sources.

Table 1. Indicators for the environmental dimension.

Indicators	Description
Average temperature (°C)	The average temperature trend in Sicily from 1924 to 2003 increased by about 1.38 °C [21]. In the period 2004–2018, there was a further increase ranging from a minimum of 0.2 °C to a maximum of 0.9 °C in the various provinces in Sicily [22].
Average Rainfall (mm pa)	From 1921 to 2009, the trend in the rainfall pattern was characterized by a sharp average annual decline with an average decreasing trend of about 19 mm per decade [23]. This trend continues undaunted, with 2017 compared to the climate reference 1981–2010 in Sicily, there is a value <-30 [24].
Extreme events (No. pa)	The Sicilian climate also confirms its great variability in 2018, with alternating extreme drought and heavy rainy periods [25].
Soil carbon	Sicily is one of the regions with the poorest soil carbon content in Italy, with 40.43 pg of CO [26].
Local breeds	The local breed of cattle, sheep, goats and pigs in Sicily, are now at risk of extinction, as evidenced by the current very low number of animals.
Local varieties	Sicilian local varieties of fruit, vegetables and cereal have suffered a serious reduction in the last 50 years.
Greenhouse production (ha)	The area occupied by protected crops in Italy has increased from 8500 ha in 1970 to 28,853 ha in 2018, wherein Sicily is the region with the largest area for horticultural production in greenhouses, rising from 6687 ha in 2000 to 9237 ha in 2018 [24,27].

Table 1. *Cont.*

Indicators	Description
Wildlife	Sicily is the first region in Italy for total net area of the sites of Rete Natura 2000 with 639,135 ha, hosting a great number of plant and animal species. The region is very important in the national context because more than 10% of its flora is composed of endemic species, of which the majority are also exclusive of the territory [26].
Forest cover	Forests in Italy amounted to 11.8 million hectares in 2017. The forest cover in Sicily has increased from 101,678 ha in 1947 to 365,224 ha in 2006 [28]. In Sicily, the 2017 indicator for, "Forest areas in relation to land area", was 11.2%, compared to 30.8% for Italy, whilst, the "Woodland Coefficient", was 14.8%, compared to 36.8% for Italy [29].
Conservation areas	The protected area of Sicily in 2010 amounted to 270,725 hectares, i.e., the 8.6% of the total Italian protected area [26]. In 2017, the protected areas in Sicily represented 20.2% of the surface area, compared to 21.6% for Italy [29].
Desertification (ha)	The analysis, conducted on two distinct historical series (1990 and 2000), highlighted that about 70% of the surface of Sicily has a medium-high degree of environmental vulnerability [26].
Water erosion	In Sicily there is an increase in water erosion, mainly due to extreme rainfall events; the relatively steep slopes of the land and due to the incorrect soil adaptation techniques.
Polluted waterways	An analysis conducted in the years between 2011 and 2017, established that 46% of underground water bodies in Sicily are in a poor chemical state [30].
Polluted sea	According to Agenzia Regionale per la Protezione dell'Ambiente—Sicilia (ARPA), in 2018, 23 out of 30 bodies of marine-coastal waters were in good ecological condition and seven in sufficient condition. For the same water bodies, instead, there was a good chemical state in 23% of the cases, and a poor state in 77% of cases [31].
Pesticides	The amount of pesticides distributed in Sicily for agricultural use has decreased from 20,061.836 kg in 2003 to 10,939.663 kg in 2017. Despite this, Sicily is still the third highest region (after Veneto and Emilia Romagna), for pesticide distribution, as a result of a significant presence of intensive agriculture [27].
GHG emissions (kt CO2eq)	Regional emissions of total greenhouse gases in Sicily has decreased from 42,073.2 in 1990 to 35,412.3 kt CO_2eq in 2015 [26]. The emission of greenhouse gases from agriculture in Sicily in 2017 is some 1,669,147 tons, which equates to about 5.4% of the total emissions of this sector in Italy [26].

Table 2. Indicators for the economic dimension.

Indicators	Description
Arable farmland (ha)	The total arable farmland has decreased by 22.1%, from 1,891,155.22 ha in 1982 to 1,549,417.34 ha in 2010 [27]. In 2016 the figure increased to 1,612,010 hectares (9.8% on the Italian data) [27].
Cultivated farmland (ha)	The cultivated farmland has decreased by 22.1%, from 1,694,094.13 ha in 1982 to 1,387,520.77 ha in 2010 [27]. In 2016 the figure increased to 1,438,685 hectares (11.4% on the Italian data) [27].
Organic farmland (ha)	From 2010 to 2017, the organic farming area in Italy increased by almost 800,000 hectares and the largest extension was registered in Sicily, with 427,293.79 hectares or 53.4% of the total area [32].
Livestock	Livestock farms in Sicily have decreased by 143.5%, from 37,274 in 1982 to 15,308 in 2010 with a generally increasing number of livestock units [27]. In 2016 the figure was reduced to 13,500 units [27].
Farming enterprises	The number of farming enterprises has decreased by 179%, from 428,263 in 1982 to 219,677 in 2010 [27], and further to 153.503 in 2016 [26].

Table 2. *Cont.*

Indicators	Description
Agricultural jobs	The percentage of agricultural workers in Southern Italy has decreased from 19.3% in 1977 to 6.7% in 2010. In Sicily, the number of farm workers has decreased by 31.1%, from 156,000 in 1993 to 119,000 in 2018 [27].
Exports	Exports of agricultural products have increased by 58.6%, from EUR 170,511,202 in 1993 to EUR 411,810,511 in 2016 [27]. In 2019, the figure increased to 511 million EURO [33].
Imports	Imports of agricultural products have increased 26.7%, from EUR 148,587,087 in 1993 to EUR 202,736,279 in 2016 [27]. In 2019, the figure increased to 386 million EURO [33].
Export to import ratio	In the period 1993–2016, a positive increased export to import ratio for agricultural products was observed against an opposite, negative trend for processed food products [27].
Agricultural/food price trends	The ratio between the consumer price and the production price in Sicily in 2018 was: bread/hard wheat: 969; bread/hard wheat: 516; potatoes: 289; olive oil: 89 [27].

Table 3. Indicators for the social dimension.

Indicators	Description
Longevity	The life expectancy at birth has increased from 79.3 years in 2002 to 81.8 years in 2016, whilst only 57.8 years are spent in good health [27].
Malnutrition	The southern regions of Italy show a higher prevalence of obese people. In 2017, in Sicily, 39.1% of people were overweight and 12.6% obese. Additionally, the percentage of children and adolescents (6–17 years) with excess weight is particularly high in Sicily, reaching 27.8% in 2017 [27].
Dread diseases	In Sicily, the main causes of death are diseases of the circulatory system, neoplasms, cerebrovascular diseases, diseases of the respiratory system, and, endocrine, nutritional and metabolic diseases. In 2015, Sicily was the second highest region in Italy for the standardized mortality rate in adulthood (35–69 years) due to the main causes, with 73.4 deaths per 10,000 inhabitants [27].
Irregular labour and exploitation	The value of the irregular labour and gangmaster system in agriculture amounts to approximately 4.8 billion euros to some 400,000 to 430,000 Italian and foreign agricultural workers throughout Italy who are victims of the "*caporalato*" system [34].
Agromafie	Agromafie business in Italy has increased by 50.8% from 12.5 billion in 2011 to 25.4 billion in 2018 [35].
Loss of cultural identity	Radical changes in consumption models in the last 50 years have broken links between communities and local farmers, with serious consequences for food traditions and loss of cultural identity.
Food habits	Adherence to the Mediterranean diet is higher than the national average [36].

2.1.2. Challenges and Opportunities

The next step of the proposed research flow is the comparison between the challenges the Sicilian agri-food system must cope with, and the opportunities to take advantage of to start a process of sustainable and regenerative development. Herein, the Sicilian challenges are mostly associated with industrial agriculture, a lack of environmental education of the local population, and a general indifference of sustainability issues among the main roleplayers in society. The latter indifference prevents the application of sustainability principles and a good performance with respect to the SDGs. The identified challenges are the results of a participatory process to which the stakeholders involved have contributed in the following categories, namely:

- Environmental: climate change, risk of desertification, loss of biodiversity, disruption of habits and landscapes, water and air pollution.

- Economic: a relatively large number of industrial farms, dependence on external inputs, fragmentation of production, small negotiating position of producers, low selling prices versus high production costs, dependence on retailers and distributors, low presence of multifunctional activities.
- Societal: unemployment, abandonment of Sicilian rural areas, reduction in farmers, exploitation and undeclared work, mafia interests in agri-food sector, rise in non-communicable diseases, a culture of indifference, loss of institutional memory, progressive disappearance of traditional diets and cultural knowledge.

The opportunities were defined on the basis of the literature review, on studies and research carried out by the Department of Agriculture, Food and Environment (Di3A) of the University of Catania over sixty years, as well as through consultation of the political and regulatory documentation of regional agri-food governance.

Despite these formidable challenges, the main opportunities lie in:

- Changing production and distribution methods by adopting sustainable models;
- Supporting transparent, innovative and sustainable business ideas for the regeneration of the local food economy;
- Promoting sustainable, healthy and responsible food consumption;
- Educating all stakeholders towards sustainability and actively involving them in all these developmental processes.

Similar challenges and opportunities can also be found in examining the global context, by comparing industrial versus regenerative agriculture, in Tables 4 and 5, respectively. These tables are built on the paradigm of the IPES-Food Report [5], which clearly defines key characteristics of specialized industrial agriculture and diversified agroecological farming.

Table 4. Development challenges of industrial agriculture at the global level.

Challenge	Explanation
Dependent on external inputs	Highly dependent on fertilizers, pesticides and herbicides, and their associated storage, handling and application requirements.
Resource intensive	Major resource inputs for the operation and maintenance of farm machinery, as well as, related technical expertise and energy requirements.
Major irrigation requirements	Highly dependent on capital intensive irrigation schemes, such as, dams, reservoirs, cannels, boreholes, pump stations, as well as sophisticated irrigation such as, center-pivot and drip irrigation.
Monoculture	Economies of scale have rendered farmlands to vast monoculture environments in order to enhance production efficiencies.
Loss of soil organic carbon	Machine intensive farming compacts the soil whilst the application of fertilizers, pesticides and herbicides poisons the living organisms in the soil, which renders the soil infertile, ineffective in holding moisture, and results in major release of soil organic carbon [37]
Genetically modified seeds (GMO)	GMO plants reduce biodiversity and promotes monoculture environments which have less resilience, besides being dependent on a heavy regime of fertilizers, pesticides and herbicides.
Feedlot systems for livestock	High density livestock systems are force-fed imported feed that is not the normal diet of livestock, thereby resulting in illnesses that are treated with high doses of antibiotics, which in turn, find their way into food products and waste streams.
Declining yields	Yields among maize, rice, wheat and soybean have declined consistently since the 1960s.
Loss of biodiversity	Increasing monoculture farmlands has led to a significant loss of biodiversity through loss of significant soil life, biomass, wildlife and insect habitat.
Species extinction	Researchers have shown a severe loss of insect populations across Europe since the 1950s due to the loss of wildlife and insect habitat arising from a loss of plant biodiversity and use of harmful pesticides and herbicides [38].
Loss of riparian zones	Riparian zones alongside water courses are often removed to make space for marginal gains in monoculture farmlands. This exacerbates the loss of biodiversity, wildlife and insect habitat, stability of river embankments and ingress of water impurities from farmlands. Even occasional heavy rains will lead to flooding and tend to scour out and deepen water courses without a vegetated riparian zone. Consequently, the ensuing gullies or dongas drop the overall water table in the adjacent landscape which then exposes crops to increased heat stress and higher irrigation needs, all at great cost.
Soil erosion	Farmlands often have no biomass cover which damages the remaining soil organisms; promotes the release of soil particulates (dust) that cause global dimming; results in loss of topsoil with just occasional heavy rains and scours the landscape to show exposed bedrock.
Desertification	Desertification is accelerated through unmanaged livestock grazing which results in uneven grazing patterns, whilst the combination of soil erosion, loss of biodiversity and loss of riparian zones also accelerates desertification.

Table 4. *Cont.*

Challenge	Explanation
Broken hydrological cycle	The loss of biomass cover reduces evapotranspiration whilst the loss of soil organic carbon reduces soil moisture retention, both of which dries out soil. However, any irrigation or rains are quickly evaporated into storm clouds with consequential downpours, often on other areas, thus leading to patchy intense rainfall which exacerbates flooding and droughts within the same regions. Furthermore, these heavy rains fall on exposed soil surfaces which are hotter that the air above, resulting in less rainfall penetration and rapid flows of flood waters that erode topsoil. This rainfall regime with wide variations effectively breaks the hydrological cycle.
Extreme weather cycles/events	The broken hydrological cycle results in rapid evaporation, intense storm cloud build up, with consequential heavy downpours that exacerbates flooding and erosion of topsoil. The typical 1:50 year floods have now been witnessed on a more frequent basis, requiring revisions to extreme weather event predictions.
Export of agricultural commodities	The monoculture farmlands are prone to focus on high income export crops, the best of which is often exported instead of being consumed in the local region.
Import of food necessities	The concentration of export crops often takes advantage of scarce farmland that would otherwise be used for local food crops, thus often resulting in the import of the most basic commodities, such as, cooking oil, grains, fruits and vegetables.
Low nutritional food values	The basic commodities either grown locally or imported have been produced from sterile soils with low humus content and thus relatively low nutritional value. Furthermore, imported crops have reduced nutritional content arising from the lack of freshness.
Loss of agricultural jobs	Intensive industrial forms of agriculture have reduced the need for general manual labour to specialist technical labour and artificial intelligent systems. This has resulted in a loss of agricultural jobs, with consequential migration of people to urban areas to seek out better livelihoods and/or government support.
Uninterested youth	With the loss of jobs in the agricultural sector, it becomes onerous to attract youth to rural based agricultural livelihoods, thus resulting in an aging rural population.
Loss of institutional memory	The elderly farmers who still practice traditional farming systems have few youths around to transfer this wealth of knowledge. Instead, the emerging new farmers who have moved away from traditional farming systems and have adopted industrial forms of agriculture, are referred to as "agriculturists". This has resulted in the loss of invaluable institutional memory about time tested resilient traditional farming systems.
Loss of cultural landscape	The loss of institutional memory exacerbates the loss of cultural landscapes wherein the functional knowledge of the how and why of certain terra forms becomes lost forever. A classic example is the loss of the institutional memory about the functioning of terraces and related micro-climates, wherein the stone surfaces attracted vital moisture that fed healthy vibrant soils which supported tree crops. This cultural landscape forged resilient settlements that created meaningful rural livelihoods which managed to subsist within the bioregional economy.

Table 5. Development opportunities of regenerative agriculture/agroecology.

Opportunity	Explanation
Keyline landscape rainwater harvesting	Keyline design is the backbone of regenerative agriculture and entails the harvesting of rainwater throughout the farm landscape in small catchment dams that are interconnected via contour-based swales and which are designed to slow down, spread and sink rainwater, thereby sustaining the water table and recharging the underlying aquifers, which in turn, also moderates river flows and alleviates flooding.
Establishment of forest belts	The interconnected swales are integrated with access roads/footpaths which further harvest rainwater which is forms a water plume on the downslope of a swale, thereby enhancing conditions for supporting forest belts that add biodiversity and habitat for wildlife and insect pollinators, besides creating effective wind breaks and micro-climates.
Intensive livestock mob grazing	The concept of holistic management from the savoury institute is well entrenched in regenerative agriculture wherein livestock mimics the grazing patterns of nature's roaming herds in the savannahs. Herein, livestock grazes intensively on a short rotational basis in small paddocks, thereby recycling vital waste nutrients which enhances soil humus.
Limited till systems	Another anchor in regenerative agriculture is the keyline plough, which promotes limited till systems that does not disturb the soil unduly, but rather cuts the soil open, thus promoting air circulation, water penetration and the growth of crops in a niche micro-climate.
Crop diversification	Planting of complimentary crops, ally-cropping and crop rotations are promoted in order to use the specific attributes of plants to naturally fertilize the soil. For example, the classical three-sisters grouping of maize, beans and squash can be replicated ad infinitum since the soil drained from the heavy feeding maize is replenished by the nitrogen-fixing beans whilst the large squash leaves provide ample green mulch coverage. Another example is the overhead sowing of winter wheat, rice or soy seeds over maize crops just before harvesting so that the post-harvest maize stalks that are cut provides the mulch cover through which the seeds grow. A key aspect of crop diversification is continuous cover crops to retain soil moisture and to protect and nurture the soil from drying out and heating up.
Restoration of soil humus	All aspects of regenerative agriculture are designed with one end objective, namely, restoring soil humus or soil organic carbon. Humus is the life of soil which continually builds soil and restores lost topsoil. Humus also creates a spongy context in the soil that allows for much soil water retention, which in turn, mitigates drought-, flood- and fire-risk since moist soil will sustain biomass to cushion these risks.
Massive carbon sequestration	Soil organic carbon is able to sequestrate the carbon that is otherwise lost through unsustainable forms of industrial agriculture [39].
Wholistic design process	Regenerative agriculture is based on Yeomans Scale of Permanence which sets out a sequential wholistic process to establish resilient farms with humus rich soils that can support local livelihoods and contribute towards the local economy.
Restoration of riparian zones	The second aspect in the design process of regenerative agriculture deals with "Geography" by understanding the terrain, underlying geology and water courses. The riparian zones around water courses are critical in that they provide the biodiversity, habitat for wildlife and insect pollinators, and a natural barrier to arrest soil erosion. The restoration of eroded gullies in water courses is critical to raising the water table in the adjacent slopes thereby hydrating soils, as well as, moderating the flow of water during heavy rains.
Reforestation	The forest belts that are established downslope of swales is a means of introducing forests and biodiversity into the farmland, whilst major reforestation can be allowed to develop naturally for areas set aside for this purpose between forest belts.
Enhanced biodiversity	The restoration of riparian zones, the establishment of forest belts downslope of swales and the restoration of humus rich soil contribute towards an enhanced biodiversity which can support habitat for wildlife and insect pollinators.

Table 5. *Cont.*

Opportunity	Explanation
Species conservation	The onset of the sixth great extinction [40] is a great cause of concern which regenerative agriculture can help mitigate by establishing resilient ecosystem services which conserve species by providing the biodiversity environment for species habitat.
Restoration of hydrological cycle	Regenerative agriculture rehydrates the landscape through its keyline design whilst continuous cover crops and soil humus improvements further enhances soil moisture retention. This allows the farm landscape to act as a great sponge to soak up and hold water after heavy rains and then release it slowly into the water courses. These attributes moderate the ground temperature so that it is cooler than the rainfall, thereby creating a positive temperature gradient which enhances the deep penetration of rainwater into soils.
The farm as an ecosystem	All aspects of regenerative agriculture are designed to create resilience by mimicking the farmland as an ecosystem through the rehydration of landscapes, establishment of forest belts, crop diversity, cover cropping and enhancing soil humus, all of which contributes towards an improved biodiversity which provides ongoing ecosystem services.
Resilient local food economy	The conversion of farmland with regenerative agriculture provides opportunities for rekindling traditional crops from an era that were grown prior to the global food system. This will reduce the dependence on imported food from the global food economy since it can be provided from locally grown sources, besides stimulating rural livelihoods and the local economy.
Enhanced nutritional food values	Crops that are locally sourced have less food miles than crops imported from the global food system. Long food miles reduce the nutritional value of crops, hence the better nutritional value of locally grown crops. The nutritional value of crops can be measured by the Brix index which calibrates the sap density of crops. Brix values are enhanced when crops are grown in healthy humus rich soils, whilst values tend to deteriorate as freshness recedes.
Supply of niche Organic food markets	The organic food sector has achieved continuous growth as a result of consumer choices that value healthy nutritious food. Organically certified products can continue supplying this growing market on a bioregional level instead of relying on importing these niche products from the global food system. This will also contribute towards the local economy instead of leaking profits to the global food economy.
Restoration of cultural landscapes	Regenerative agriculture does not only create an environment for farmland to provide essential ecosystem services to sustain crop production, but also provides the opportunity for rekindling the introduction of traditional crops for local markets. This creates the platform to restore the cultural landscapes of a bygone era but in this modern era wherein the value of ecosystem services and locally grown nutritious food are well understood as a means towards supporting a resilient way of life.
Job creation	The establishment of regenerative agriculture opens up new local economic development opportunities, such as: the rehabilitation of fallow farms; the conversion of farms towards Organic certification; the supply of farm services (for example: earthworks, forestry, nurseries, etc.); the creation of small markets in old town centres and the overall stimulation of rural livelihoods.
Attraction of youth	Regenerative forms of agriculture provide greater opportunities for job creation and is thus able to attract the youth to this vocation, who in turn, will find it attractive to establish families in rural areas, thereby reversing the aging population of these rural areas.
Influence on Mediterranean region	The Mediterranean region is recognized as one being rich with diversity, but also extremely fragile and threatened by unsustainable development and climate change [41]. Sicily is in the centre of the Mediterranean region, and any bold island-based bioregional regenerative plans which are successfully implemented in Sicily, can be replicated within the Mediterranean bioregion to achieve greater environmental and socio-economic benefits.

2.1.3. Formulating the Rationale

To engage stakeholders with the pros and cons of industrial versus regenerative agriculture, a scenario planning technique is used to clearly justify the rationale for the ensuing vision of this initiative [42]. The stakeholders were engaged in the manner described below in Section 2.3. The first key driver is apparent in the choice of industrial versus regenerative agriculture, which was earlier compared. The second key driver is not so apparent but is assumed to comprise either a reactive or proactive response from the stakeholder group among the public, private and non-governmental organization or community-based organization (NGO/CBO) sectors involved in the food system value chain, from growers, producers, distributors, wholesalers, retailers, investors and funders. By juxtaposing these two drivers, four scenarios emerge, whose intrinsic outcomes and risks are outlined in Figure 2.

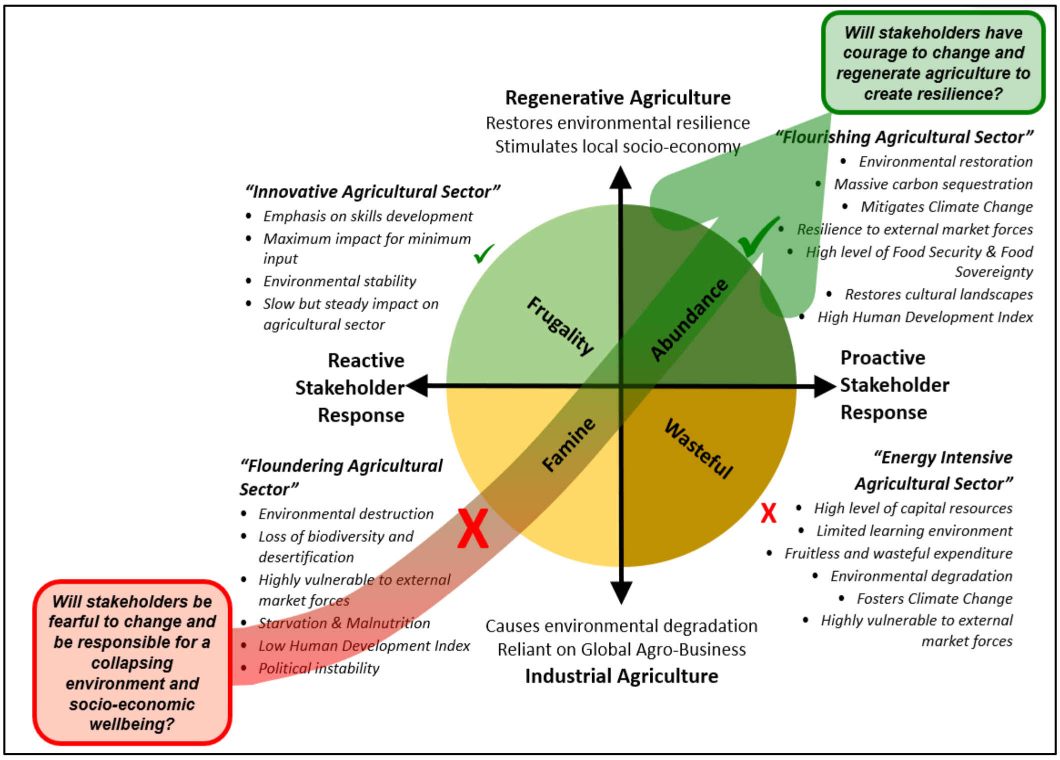

Figure 2. Scenario planning rationale.

On one end of the vertical axis, is regenerative agriculture, whose attributes restores environmental resilience and stimulates the local socio-economy, whilst on the other end is industrial agriculture, which causes environmental degradation and is reliant on global agro-business. Meanwhile, the horizontal axis splits a reactive and proactive stakeholder response from among the public, private and NGO/CBO sectors. Herein, reactive is taken to reflect indifferent and crisis response driven stakeholders, whilst proactive is taken to reflect concerned and forward-thinking stakeholders. This gives rise to four appropriately named scenarios which are postulated below:

- Abundance" scenario: this scenario enjoys a proactive stakeholder response which supports regenerative agriculture with the ensuing attributes of environmental restoration, massive carbon sequestration, climate change mitigation, resilience to external market forces, high level of food security and food sovereignty, restoration of cultural landscapes, and, has a relatively high Human Development Index. The "Abundance" scenario combines the most sustainable and riskless approach with the most beneficially proactive stakeholders which leads to a "Flourishing Agricultural Sector". To achieve environmental restoration and protection, the "Flourishing

Agricultural Sector" scenario could entail some initial relative higher production costs and food prices as the agricultural sector transitions towards sustainability, but it is an opportunity for sustainable practices to become the norm in all sectors. This cannot only be achieved through political, institutional and civil commitment, but above all, through the commitment of both critical consumers, who want to express their sovereignty by means of purchases and small and large producers. Cultural changes in families who live in the region must serve to recognise the value of the local product and the benefits associated with it (less transport pollution; biodiversity conservation; consumption of seasonal and nutritious products; health care; support for the local economy; protection of land and the fight against abandonment; etc.) and to promote beneficial innovations in food systems. Producers are called upon to internalize the previously outsourced costs and, for this reason, they, especially during the transition stage, need to make investments with practical and concrete tools, such as sustainability certifications, which are generally appreciated by consumers who are willing and able to pay a "premium price" [43–46]. Furthermore, the establishment of local distribution systems will allow a shift of the product value chain towards farmers, instead of large intermediaries and retailers. The assumed premium prices are only relevant during the initial transition stage from industrial to regenerative agricultural systems. In time, as the environmental integrity is restored, carbon sequestration will increase, and consequently, additional farming income through carbon investments, which in turn, should realise a reduction in food prices as farm costs are supplemented by such carbon investments.

- "Famine" scenario: this scenario has a reactive stakeholder response which is more aligned with industrial agriculture with attributes of environmental destruction, loss of biodiversity and desertification, vulnerability to external market forces, starvation and malnutrition, political instability and has a relatively low Human Development Index. Pursuing the "Famine" scenario by reactive stakeholders following a risky pathway to further environmental degradation leads downhill towards a "Floundering Agricultural Sector".
- "Frugality" scenario: this scenario has a reactive stakeholder response which is more aligned with regenerative Agriculture with attributes that emphasise skills development, maximum impact for minimum input, environmental stability and a slow but steady positive impact on agricultural sector. The "Frugality" scenario will in all likelihood make the best of limited resources, thus leading towards an "Innovative Agricultural Sector".
- "Wasteful" scenario: this scenario enjoys a proactive stakeholder response which supports industrial agriculture with attributes of high level of capital resources, limited learning environment, fruitless and wasteful expenditure, environmental degradation, fosters climate change and is highly vulnerable to external market forces. The "Wasteful" scenario quickens the pace of environmental degradation despite mitigating resources, and ultimately, leads to an "Energy Intensive Agriculture Sector". This arises due to the use of heavy farm equipment which compacts the soil, thereby requiring even more energy intensive equipment to loosen the soil; the increasing use of chemical fertilizers in response to lifeless disturbed soil; the increasing use of pesticides to mitigate pests and disease; a dependence on more intensive irrigation infrastructure and the increasing intensity of transport and value chain logistics. Moreover, these issues are collectively responsible for the increase in direct and indirect causes of community ill-health arising from harmful trace chemicals and pesticides, be it through airborne distribution, ingress into waterways or through ingestion. These causes of community ill-health will in turn increase public and private medical costs, which can be deemed wasteful since they could have been avoided in the first place if a regenerative approach to agriculture was undertaken.

The above scenario planning exercise delves deeper into the simple comparison between industrial and regenerative agriculture by exploring the possible developments given a reactive and proactive stakeholder response. Herein, an indifferent and crisis response driven reactive stakeholder group is unlikely to achieve much, whereas a concerned and forward-thinking stakeholder group is more likely to achieve results, whether through industrial or regenerative agriculture. However, the defining question that is posed to the stakeholder group is: will stakeholders be fearful to change and be responsible for a collapsing environment and socio-economic wellbeing by pursuing industrial agriculture, or, will stakeholders have courage to change and embrace regenerative agriculture/agroecology to create a resilient sustainable food system? If this deep probing question is not posed, then stakeholders will most likely remain reactive. In other words, by presenting the rationale of the scenario planning exercise with the two simple key drivers, stakeholders should be jolted towards becoming more proactive. This is particularly pertinent in that, given the negative environmental and socio-economic impact of continued industrial agriculture, is not the precautionary principle a valid reason for proactive stakeholders to urgently embrace regenerative agriculture/agroecology before any further environmental damage occurs.

Then, a much deeper probing question is presented, namely, how far to extend the approach of regenerative agriculture. Herein, a bioregional approach is introduced to give rationale impetus for regenerative agriculture on a large scale. By definition, a bioregion is usually defined by physical and environmental features, most commonly watersheds. Therefore, an entire bioregion dedicated to regenerative agriculture will have better results than an ad hoc regional mixture of industrial and regenerative agriculture. It is therefore critical for an entire bioregion to be dedicated to regenerative agriculture, failing which, the bioregion will be compromised by areas that fly against the rationale for a flourishing agricultural sector. By implication, the concept of scale-linkage, wherein several adjacent bioregions all implement regenerative agriculture, will have a large synergistic impact over a wide geographic region.

In order to draw some inspiration as to charting the key variables for a scenario planning exercise, the authors have looked to how Cuba has established its sustainable food system. According to [47], Cuban agriculture prior to 1990, was based on the global agro-industrial model which was reliant primarily in the export of commodities, namely, tobacco, sugarcane and citrus, and as such, was heavily reliant on external inputs, such as, fertilizers, pesticides, fuel and equipment. However, after the collapse of the Berlin Wall in 1989, Cuba underwent significant changes to its agricultural model. More specifically, the import of agricultural external inputs, were severely curtailed, and as a result, its export-based model of agricultural commodities collapsed [47–49], whereupon, Cuba entered its special period, which lasted some 10 years. The special period in Cuba was particularly harsh, with the significant evidence of weight loss and malnutrition among its population as most basic food items had to be imported, not to mention a GDP reduced to a third [47]. It suffices to state that Cuba emerged from this special period by a shear instinct for survival and strong political will. During this special period, the Cuban government relaxed many policies and encouraged the repopulation of rural areas by farmers, who were given land ownership, besides reserving land around towns and cities for urban agriculture [47]. Eventually, and by default, Cuban agriculture took on a completely new model, based on Organic agriculture, which provided for food sovereignty and rekindled traditional farming systems.

The above island-based backdrop of Cuban agriculture is a valid example for a sustainable food system for Sicily, to be developed through a holistic bioregional island approach. The bioregional scale-linkage concept follows systems theory wherein a whole island bioregional system can be more than the sum of the individual bioregions within the island if all implement regenerative agriculture/agroecology.

2.1.4. Developing the 2030 Vision

The strategic framework, that will be informed by an appropriate 2030 development vision for the abundance scenario, can be construed in two parts. The first part comprises the goal, values and overarching objectives as articulated within the approach of this research paper, whilst the second part comprises the critical success factors, action plans and key performance indicators as will be explored later in the methodology of this research. In other words, the research approach in the first part of the strategic framework therefore provides the "why" and the "what", whilst the research methodology in the second part presents the "how" and "when". Furthermore, the thrust of the strategic framework is couched in development terms which will contribute towards the regeneration of the agricultural sector for Sicily. With this developmental mindset, the paper postulates the content of the strategic framework that will most likely be the outcome of a high-level consultation process with key stakeholders, which is a necessary requirement should this initiative be implemented.

The overall "goal" of the strategic framework is therefore aligned with the title of the paper and is simply stated as "To establish a Bioregional Development Program for a Sustainable Food System in Sicily (BDP-SFSS)". However, the values need to draw in appropriate sustainability ethics which sets the bedrock for the strategic framework. At this point, the key word "sustainability" is defined by the Brundtland Commission "as development with sustainability that meets the needs of the present without compromising the ability of future generations to meet their own needs". The word sustainability can often be misconstrued to mean something that is sustained perpetually, like economic growth, which clearly can conflict with the Brundtland definition of sustainability.

For this reason, the ethical values enshrined in the strategic framework must appeal to a high level of reasoning and consciousness. To this end, the ethical values for the strategic framework draws from the work by Hawkins who calibrated levels of consciousness, and, the work from Mollison who developed the Permaculture ethics. In particular, the choice of specific words within Hawkin's level [50] consciousness is interwoven with the permaculture ethics of "Earth Care, People Care and Fair Share" to yield the following set of values:

- to have courage to support lifestyles within the bioregional carrying capacity;
- to trust stakeholders to act fairly in the interests of the bioregional food economy;
- to be willing to restore the bioregional environment as the foundation for a positive future;
- to forgive past injustices and accept the present urgency to establish resilient communities;
- to understand the reasoning for protecting life on land and life below water;
- to revere the love for one's health, wellbeing, home, community and bioregion.

In support of the goal and values of the strategic framework, the "overarching objectives" become the cross cutting more tangible principles which draw from the above values in order to enrich the environmental, social, economic and cultural aspects of this initiative as outlined below:

- to promote trans-disciplinary stakeholder co-operation;
- to empower stakeholders with ecoliteracy;
- to embed education in sustainability, knowledge sharing and experiences;
- to avoid the use of harmful pesticides and chemical inputs;
- to rehabilitate eroded landscapes;
- to restore biodiversity;
- to enhance soil humus;
- to embed regenerative agricultural practices;
- to promote the local food economy;
- to stimulate job creation and youth development;
- to restore the traditional value of cultural landscapes, since the tradition represents the basis on which the innovation of a sustainable agri-food system is grafted;
- to support carbon funding investments.

The above goals, values and overarching objectives are aligned with a developmental agenda for the "Abundance" scenario which concludes the research approach for this paper. These objectives are achievable with the commitment of public and private actors, on the demand side and on the supply side and constitute a perspective towards which the economic and social system of the territory should be pushed.

2.1.5. Alignment with International Institutions and Scientific Research References

To give validity to the 2030 development vision and conform it with SDGs set by United Nations and other similar visions, an overview of the most recent literature about sustainable food systems has been carried out.

FAO [51] states that food and agriculture, the prime connection between people and the planet, can help achieve multiple SDGs. In this connection, the Stockholm Resilience Centre [52] in 2016 reported a new way of viewing the SDGs and how they are all linked to food, by considering economies and societies like embedded parts of the biosphere. According to FAO [53], this awareness must urgently be translated into investment in rural people, family farmers, fishing communities, foresters and pastoralists; in food systems that are better balanced, more equitable and less wasteful; in agricultural innovation and in an approach to natural resources that allies environmental concerns to the pursuit of food security and decent livelihoods for all.

The United Nations Environment Program (UNEP) [54], in fact, has assessed that food systems are responsible for 60% of global terrestrial biodiversity loss, around 24% of the global greenhouse gas emissions, 33% of degraded soils, the depletion of 61% of "commercial" fish populations, and the overexploitation of 20% of the world's aquifers. The total inefficiency of a such food system results also in food waste and losses, with around one-third of food lost or wasted, hunger and other forms of malnutrition [55].

The Research Institute of Organic Agriculture (FiBL) and IFOAM-Organics International in the 20th edition of "The World of Organic Agriculture" [56] demonstrate the contribution of the organic agriculture to the SDGs, to tackling climate change, ensuring food and nutrition security, halting biodiversity loss and promoting sustainable consumption. Nevertheless, Ciccarese and Silli [57] highlighted that it is important to keep in mind that no single approach can alone resolve food security but rather, it needs a combination of organic and other innovative alternative farming systems, like agroforestry, agro-ecology, integrated farming, conservation agriculture and intercropping. Lamine et al. [58] focus on the issue of how approach to agri-food systems transitions, stating that in the agricultural and food sciences, most conceptual approaches tend to tackle agriculture, food, environment, and health separately, usually linking them in pairs.

Similarly, the International Council for Science [59] underlines the importance of understanding all possible trade-offs as well as synergistic relations between the different SDGs for achieving long-lasting sustainable development outcomes. Dooley et al. [60] confirm that every part of the food system will need to be transformed to equitably reach the 1.5 °C goal, not only transformations in food production, but also changes to the ways in which food is planned, distributed, eaten and disposed of.

For example, a new emerging issue is that of sustainable and healthy diets, capable to contribute to the reduction in the overall impact of food systems and guarantee food security and nutrition [61–64]. The Intergovernmental Panel on Climate Change (IPCC) [65], in fact, affirms that policies that operate across the food system, including those that reduce food loss and waste and influence dietary choices, enable more sustainable land-use management, enhanced food security and low emissions trajectories.

It is for all these reasons that recently more and more authors advocate a more holistic, trans-disciplinary and long-term approach to achieve sustainable food systems. This also calls for reforms the global food system to be increased [66,67]. For these reasons, a whole-systems thinking approach must not be sacrificed in order to deliver quick wins that end up deferring, rather than accelerating, the systemic change that is required [68]. To this end, Figure 3 shows the alignment between the proposed objectives of the bioregional strategic framework and SDGs.

Bioregional Strategic Framework	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Economy																	
To promote the local food economy	x	x	x		x			x	x	x	x	x	x				x
To restore the traditional value of cultural landscapes				x					x		x					x	x
To support carbon funding investments							x	x	x			x	x		x		
Society																	
To stimulate job creation and youth development	x			x				x	x	x	x	x				x	x
To ensure food security and food sovereignty	x	x	x	x	x			x				x				x	x
To promote the well-being and Mediterranean diet		x	x	x								x	x	x	x	x	x
To empower stakeholders with ecoliteracy				x							x	x	x			x	x
To embed education in sustainability, knowledge sharing and experiences				x				x	x		x	x				x	x
Biosphere																	
To avoid the use of harmful pesticides and chemical inputs			x			x					x	x	x	x	x		
To rehabilitate eroded landscapes	x					x					x		x	x	x		x
To restore biodiversity		x	x			x		x			x	x	x	x	x		
To enhance soil humus		x										x	x	x	x		
To embed regenerative agricultural practices	x	x			x	x	x	x		x	x	x	x	x	x		x

Figure 3. Alignment of the bioregional strategic framework with SDGs.

2.2. The Research Methodology

The research methodology for the paper proposes an appropriate developmental program based upon four components that will be able to deliver the BDP-SFSS by 2030, in other words, the "how" and the "when" details. Initially, the four developmental program components are outlined before expanding the key actions for each outcome. In turn, the outcomes and associated actions are aligned with the development vision to postulate key performance indicators via a backcasting process to derive interim developmental impacts.

2.2.1. Developmental Program

The complexity gap introduced at the outset of this paper presents a key challenge which can be addressed through the ecoliteracy of stakeholders involved in the food system. Herein, a knowledge management process should be used to engage stakeholders through transparent and open dialogue to unpack complexity issues through continuous deep reflections around the challenges and potential solutions. This process should be approached in a manner which inculcates a trans-disciplinary whole systems thinking approach which at least better understands, the earth systems, the agricultural sector, the greater food economy, the circular economy, food value chain, food and nutrition, health and wellbeing, education and cultural issues.

The Methodology for the whole-systems thinking approach is rooted in ecoliteracy capacity building and empowerment of stakeholders with education taking a lead role in the ensuing development outcomes. In other words, ecoliteracy among stakeholders is a key deliverable to unravel the complexity gap. Furthermore, in order to take ecoliteracy to a higher level of understanding, it becomes imperative to formally embed education in sustainability among the universities, as well as to promote informal or vocational training in sustainability among beneficiary communities, such as farmers and related industries. Therefore, education in sustainability, especially with respect to regenerative agriculture, should be a lead and a cross-cutting component to the overall development outcomes.

2.2.2. Developmental Outcomes

However, education in sustainability will alone not be enough to support a major bioregional development program for a sustainable food system in Sicily. For this reason, this paper develops a wholistic trans-disciplinary based regenerative methodology which encompasses four key outcomes wherein education is strongly embedded. The four developmental program outcomes are listed below:

- an eco-literate institutional governance structure among public, private and NGO stakeholders;
- education in sustainability within the universities and tertiary colleges, as well as vocational training for the agricultural sector at large;
- a dedicated program management office (PMO) to provide administrative and technical support to align public and private sector programs, budgets and projects with sustainable agriculture, as well as specialist agricultural mentorship;
- an independent monitoring and evaluation component which can draw independent progress reports for all stakeholders involved.

The above developmental outcomes begin to inform the "Critical Success Factors" and associated "Action Plans" which are unpacked below in more detail.

2.2.3. Backcasting the Development Vision Milestones

The 2030 vision is driven by the rationale for all stakeholders to proactively embrace regenerative agriculture before the environment is further damaged and is at grave risk of not recovering. In other words, the 2030 vision sees an abundant future with a flourishing agricultural sector. The 2030 vision uses the backcasting approach to expand on the 2030 vision and then draw up a reasonable timeline with milestone achievements designed to arrive at this vision in a programmatic manner. To this end, a wholistic development program for achieving the 2030 vision encompasses the following four components:

- an institutional governance structure led by a unified public sector in consultation with all other stakeholders;
- an education in sustainability initiative designed to facilitate trans-disciplinary studies within the education sector, from universities to schools and to vocational training;
- a dedicated program management office established to guide, align and direct public sector programs, projects and budget allocations, as well as a team of agricultural specialists to support regenerative agriculture and its value chain;
- a dedicated monitoring and evaluation service that will establish the initial baseline and thereafter report progress and communicate results to various stakeholders.

2.3. Participatory Planning Model and Selected Stakeholders

The focus group (FG) methodology represents a participatory tool to achieve strategic orientation assessments, with guided group comparisons focusing on defined topics. The method is characterized by its dynamic nature and synergistic effects and leads to the definition of an information-rich system [69]. The approach makes it possible to deal with complex issues, using knowledge belonging to different scientific disciplines or specific stakeholder knowledge, to provide decision makers with a comprehensive and integrated bottom-up view [70]. The whole process is divided into three phases [71]:

- *Phase 1:* consists in the "planning" of the whole activity. During this phase, it is necessary to establish: the number of sessions and the time devoted to each one; the selection/recruitment of participants; the creation of an interview guide to conduct the discussion, ensuring that all planning issues, for which information is requested, are sufficiently taken into account; the preparation of material to be presented to participants; etc.;

- *Phase 2:* This consists of the "running" of the whole activity, based on the pre-established interview guide. It starts with the presentation of the supporting material, prepared specifically to introduce the issue under consideration and to stimulate discussion and interaction of the participants. During this phase, different ideas/opinions are acquired that represent the reactions of the participants involved in the issues raised;
- *Phase 3:* This consists in the elaboration of the "qualitative results" and the production of the final report. In this respect, several qualitative analysis tools may be useful.

Focus groups can be considered as social experiments, based on intentionally prepared inputs and specific rules, able to produce collective opinions, reveal communication barriers, study conflicting behaviour, acquire local information, create acceptable options, synthesize information etc. [72,73]. Their key advantage over other participatory techniques lies in the deep interaction between the participants, which highlights their being fundamental tools to support a "mutual learning process" for all participants in this issue [74,75]. Such a process allows to reveal new dimensions of the issue under examination, thus highlighting the possibility for focus groups to increase opinions rather than produce generalized results.

Stakeholders involved are shown in Figure 4: among them there were public actors (representatives of the regional offices of the Department of Agriculture and Forestry), private actors (organic production, processing and marketing companies; representatives of the organic and solidarity organized distribution; academic world; etc.), NGOs (through the offices operating in southern Italy and the Mediterranean; etc.) and other institutional actors with an active role in the territory (organic certification operators, organic consumers' associations, trade associations and other representatives of civil society).

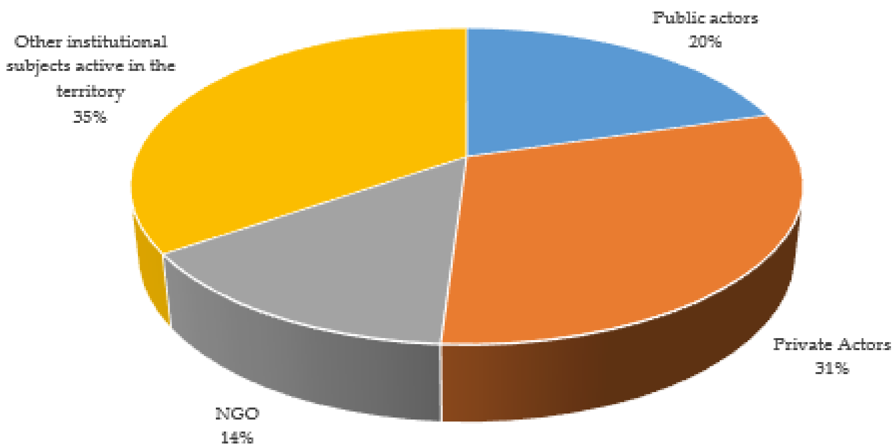

Figure 4. General structure of the sample of stakeholders involved in the research.

A total of 30 stakeholders was involved in two workshops, lasting 4 h each. The workshops were held at the Department of Agriculture, Food and Environment of the University of Catania. During these occasions, the aims and objectives of the study, a list of pre-selected indicators on which to express qualitative and quantitative assessments (with a scale of Likert), the guarantee of anonymity and the level of future sharing of the results of the choices were explained to the participants.

3. Results and Discussion

The research flow reported in Figure 1, outlined how a research approach and ensuing research methodology formulates the proposed strategic framework for a BDP-SFSS. More specifically, the research approach of the paper determines the goals, values and overarching objectives for the BDP-SFSS, or in other words, the "why" and the "what". In turn, the research approach sets up the

2030 vision which informs the research methodology regarding the developmental program outcomes, high level actions and key performance indicators (KPIs), in other words, the "how" and "when".

3.1. Developmental Program Outcomes

3.1.1. Outcome No. 1—Stakeholder Management of the Institutional Governance Structure

To establish "an eco-literate institutional governance structure among public, private and NGO stakeholders", an appropriate critical success factor is the "Stakeholder management of the institutional governance structures". This will include the broader stakeholder consultation in order to present this proposal, such as, educational institutions; public sector entities involved in environmental affairs, agriculture and economic development; farmers associations; entities involved in food value adding logistics, distribution and sales and investors. In this respect, it would be desirable to involve the many associations and organizations that already play an important role in the regional context. The main outcome of this approach is to seek consensus towards the establishment of an institutional governance structure that will guide the overall BSF-SFSS. An appropriate action plan to achieve the "Stakeholder management of the institutional governance structures" is as follows:

- Establish sector oversight forums—There are many civil society entities that are involved with agriculture that will need to be consulted about this program so that they can add value to the program with identifying "bottoms up needs and solutions";
- Establish the governance structure forums—Representatives from public and private sector entities need to be formally organised with accountability for the overall program through "top down policies and strategies";
- Embed the strategic framework for the BDP-SFSS—All public and private sector entities ought to align their own specific mandates with this program and allocate the necessary resources;
- Technical support provided by the Program Management Office (PMO)—One of the duties of the PMO will be to advise and administer the higher echelons of the governance structures;
- Terms of reference developed for the forums—The processes for engagement, organising, administering, reporting and accountability among the forums needs to be clearly delineated in order for this program to sustain its developmental strategic framework.

3.1.2. Outcome No. 2—Institutionalize Education in Sustainability/Regenerative Agriculture

To achieve an outcome with "education in sustainability within the universities and tertiary colleges, as well as vocational training for the agricultural sector at large", the suitable critical success factor is to "Institutionalize Education in Sustainability/Regenerative Agriculture". This entails universities and technical colleges to develop "wholistic sustainability design programs" with a regenerative bioregional emphasis, as well as the promotion of vocational training and mentoring of organic farmers with the likes of, permaculture, regenerative agriculture, holistic management, etc.

By embedding education in sustainability with its whole systems thinking, it is envisaged that the themes of student dissertations will straddle trans-disciplines, such as, civil/environmental engineering, agronomy, life sciences, commerce, project management, humanities and arts, all of which adds value to bridging the complexity gap. An appropriate action plan to achieve the "Institutionalize Education in Sustainability/Regenerative Agriculture" is as follows:

- Embed bioregional design education program at universities—This process expands the opportunity of universities to embrace a trans-disciplinary whole systems educational approach which will enrich the quality of student dissertations that embellish bioregionalism;
- Embed education in sustainability within schools—Schools are the nurseries to incubate regenerative agriculture and thus promote livelihoods in this sector;
- Promote life skills training in sustainable agriculture—The bulk of the stakeholders will not be privileged to attend university or technical colleges, and, will be too old to be sensitized about

regenerative agriculture at schools, which means that a massive effort will be required in the form of vocational training courses;

- Promote ecoliteracy campaigns—The BDP-SFSS will be worth nothing without a major ecoliteracy campaign that continually sensitizes the actors in the food system value chain, such as, distributors, wholesalers, retailers, but more importantly, the consumers, so that conscious decisions are made which supports the local bioregional agricultural sector.

3.1.3. Outcome No. 3—Establish a Program Management Office (PMO)

In order to establish an outcome with "a dedicated program management office (PMO) to provide administrative and technical support to align public and private sector programes, budgets and projects with sustainable agriculture, as well as, specialist agricultural mentorship", the critical success factor is to "Establish a Program Management Office (PMO)". This entails the engagement of key public sector stakeholders to resource a PMO staffed with green development professionals who will provide dedicated support to public and private sector entities, as well as support the alignment and packaging of programs and budget allocations. Moreover, the PMO should monitor and evaluate the portfolio, program and project progress across the project cycle for all projects. An appropriate action plan to "Establish a Program Management Office (PMO)" is as follows:

- Resource the PMO with development professionals—A major initiative such as the BDP-SFSS will require a dedicated PMO staffed with competent development professionals which will support the overall implementation;
- Provide technical and admin support to the governance structures for the alignment of plans, budgets and projects—This alignment must be managed through an acknowledged project cycle that continually adds value for money at each stage to ensure the maximum development impact;
- Provide agricultural mentorship to farmers and agri-business—Specialist advisors in regenerative agriculture, local economies and food value chain will be required to provide support to all stakeholders in this program.

3.1.4. Outcome No. 4—Progress Reporting against Baseline Indicators

To establish "an independent monitoring and evaluation component which can draw independent progress reports for all stakeholders involved", the appropriate critical success factor will read, "Progress reporting against baseline indicators". This is a trans-disciplinary function which will measure the overall impact of the BDP-SFSS. However, the ultimate indicator is about carbon sequestration, which measures a range of indicators that determine soil health since everything else stems from this. Moreover, carbon investment mechanisms which rewards efforts of carbon sequestration is the key for the BDP-SFSS. Nevertheless, this component should explore the spectrum of baseline indicators from among the SDGs and local public sector agencies, as well as, engage other entities that can provide additional baseline data, including, remote sensing, satellite surveys, footprint indicators, etc. Various protocols for measuring all the indicators need to be established at the outset to set the baseline for the BDP-SFSS. The data should then be analyzed and consolidated so that the program baseline reporting indicators use the data to determine developmental targets for the overall BDP-SFSS. Once the BDP-SFSS is initiated, then regular reports can be published in the form of development reports, news reports and specific reports to the governance structures. The typical development impact reporting indicators are as follows:

- Economic: Exports, imports, circular economy, job creation, youth development, private and public sector spend, carbon investments, etc.;
- Environmental: Precipitation, river flows, aquifers, biodiversity, ecosystem restoration, pollution levels, water quality, etc.;
- Agriculture: Farming units, organic certification, soil humus, crop production, distribution, plant vitality, carbon sequestration, etc.;

- Educational: Dissertations, training courses, farmers trained, greening of schools, etc.;
- Wellbeing: Health, nutrition, dreaded diseases, mortality, etc.;
- Composite: Human Development Indices, poverty levels, ecological footprint, biocapacity, Happy Planet Index, etc.

3.2. Developmental Achievements

By 2030, encompassing the above four developmental outcomes, it is envisaged that the impact of the BDP-SFSS has resulted in the following achievements to transform the Sicilian agricultural sector to support a flourishing and sustainable food system, which means:

- Stakeholders have been empowered and capacitated with ecoliteracy and worked in unison to support the overall 2030 Vision by providing dedicated oversight to achieve value for money investments for the greater good;
- Universities have embraced and embedded trans-disciplinary studies in bioregional whole systems thinking with many student dissertations adding value to development program and projects;
- Schools are teaching agroecology and demonstrating practically through their vegetable gardens and food forest examples;
- Schools have established seed bank exchanges which scholars and the community are using to add value to home-based vegetable gardens;
- Vocational training in regenerative agriculture and related subjects have permeated the agricultural sector with the development of local trainers and mentors to support farmers;
- The success of the program management office to direct and manage resources towards regenerative agriculture has resulted in its own redundancy as the public sector has been capacitated and empowered to continue this momentum. In turn, the program management office has been requested to support this same regenerative agriculture-based development program in other regions of Italy and several Mediterranean nations;
- The monitoring and evaluation of the 2030 vision has produced reports with relevant indicators, supported by different key milestones. For example: soil humus on all arable land in Sicily has doubled to an average 2% which is estimated to sequestrate all of Italy's entire CO_2 emissions; attracted carbon investments have recouped the initial farm conversion costs; waterways show no trace of pesticides; biodiversity has improved significantly; personal health has improved through better food nutrition; Sicily exports its organic certified niche crops whilst its food imports have decreased from 80% to 20%;
- Sicily is by default all certified organic with chemical fertilizers and pesticides banned;
- Overall health and wellbeing have improved significantly with a drastic reduction in dreaded diseases and a noticeable increase in longevity.

The realization of these developmental achievements by 2030 have been backcasted into the progressive milestones for 2022, 2025 and 2030 as outlined in Table 6, together with the high-level KPIs.

Table 6. Backcasting the key performance indicators.

Development Components and Key Performance Indicators (KPIs)	2022	2025	2030
An **Institutional Governance** structure led by a unified public sector in consultation with all other stakeholders. KPIs include: Roster of meetings Bioregional Strategic Plan approved Public sector plans endorsed	The institutional governance structure defined with terms and references and staffed with responsible officials. Broader stakeholders consulted and co-opted into the governance structures.	Meetings are held regularly at all levels with the focus of agenda being the approval of development plans and associated resources, as well as improved co-ordination and transparency among all stakeholders.	Meetings are held regularly at all levels with the focus of agenda being the analysis of progress reports and ongoing refinement and adoption of policies. Elements of the institutional leadership of the BDP-SFSS have been called upon to share their experiences with other areas of Italy and internationally.
An **Education in Sustainability** initiative designed to facilitate trans-disciplinary studies within the education sector, from university, to schools, to vocational training. KPIs include: Dissertations completed Schools greened Vocational training courses People trained	Universities facilitate inter-departmental co-operation in order to facilitate whole systems thinking approaches for education in sustainability. Schools adopt policies to "green" their schools through education in sustainability. Vocational training is promoted for regenerative agriculture.	University students start completing trans-disciplinary dissertations on bioregional whole systems approaches for regenerative agriculture. Schools are teaching permaculture/agroecology and have established school vegetable gardens with supporting infrastructure. Regular vocational training courses are being held related to regenerative agriculture.	Sicilian Universities start transferring their knowledge and skills related to bioregional whole systems approaches to other Mediterranean universities. Scholars have influenced the "greening" of communities and homestead food gardens. Sicilian-based trainers in regenerative agriculture are called upon to train farmers in Italy and other Mediterranean nations.
A dedicated **Program Management Office (PMO)** established to guide, align and direct public sector programs, projects and budget allocations, as well as a team of agricultural specialists to support regenerative agriculture and its value chain. KPIs include: Value adding analysis, projects supported, farming units created, jobs created	A PMO is established and staffed with green professionals who support various departments to align their policies, strategies, resources, plans and standards with the BDP-SFSS. The PMO conducts extensive training of public and private sector officials and professionals to align with the requirements of the BDP-SFSS. A dedicated sub-program to establish small organic farms is initiated. A dedicated sub-program to convert farmland to organic certification is initiated.	The PMO extends its support to municipalities and private sector entities to align their plans with the BDP-SFSS. Public sector officials have embedded the requirements of the BDP-SFSS within their core business. The small organic farms sub-program is extended countrywide. The conversion of farmland to organic certification is extended countrywide. Various sub-programs are initiated to add value to existing projects. A sub-program of emerging best practice Learning Centres are initiated countrywide.	Public entities have embedded the BDP-SFSS within their core business, as the PMO has created their own redundancy. The PMO is called upon to capacitate and support similar initiatives elsewhere in Italy and the Mediterranean nations. The entire country is certified organic with pesticides and harmful chemicals banned. Learning centres have become internationally renowned and attract growing numbers of farmers from other nations to undertake training courses on regenerative agriculture.
A dedicated **Monitoring and Evaluation** service that will establish the initial baseline and thereafter report progress and communicate results to various stakeholders. KPIs include: Land certified organic, biodiversity indicators, soil humus, water quality	A full spectrum of milestone indicators is determined together with protocols that will collect, measure and assess the data. The baseline is set upon which the impact of the BDP-SFSS is evaluated. Data collection is started and evaluated against the baseline. Carbon funding mechanisms are established and calibrated against the baseline data.	The baseline data are extended countrywide and regular performance reports are distributed among all stakeholders. Positive carbon sequestration results start emanating which begins to extend the funding of the BDP-SFSF on a countrywide basis. The indicators for the baseline bioregional evaluation of this type of program are being shared with other Mediterranean nations.	A significantly positive bioregional impact is measured from the countrywide BDP-SFSS. Organic soil humus and biodiversity indicators keep on growing and have reached an average 2% out of the 4% target. The baseline bioregional indicators for this type of program are acknowledged worldwide as best practices and are replicated at scale.

3.3. The Bioregional Strategic Framework

The assembly of the research approach and research methodology results in the strategic framework for the BDP-SFSS, as shown in Figure 5.

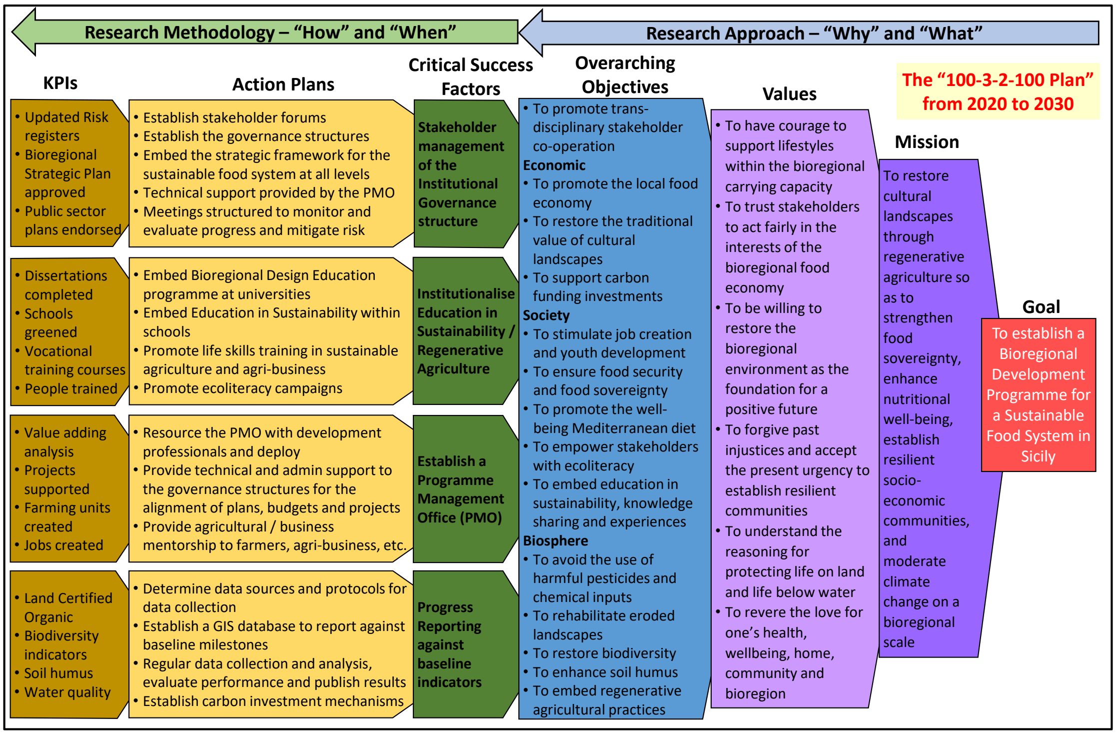

Figure 5. A Bioregional Strategic Framework for a Sustainable Food System in Sicily 2030.

Embedded within the strategic framework, is a unique overall KPIs signature, referred to as the "10-3-2-100 Plan". This signature is established by reflecting upon the 2030 vision and is derived through a unique number which can measure the overall performance of the BDP-SFSS. It should be understood as an example since the effective targets will be really chosen and established only at the specific moment of the BDP-SFSS implementation. However, the overall "100-3-2-100 Plan" sets the following targets for the four development outcomes, respectively:

- Outcome 1: 100% of stakeholders in the governance structure are on board and have aligned themselves with the BDP-SFSS;
- Outcome 2: Three Universities (Catania, Palermo and Messina) have embedded a bioregional development educational process;
- Outcome 3: An average 2% organic soil humus has been achieved across Sicily;
- Outcome 4: 100% of the organic soil humus that has been validated as carbon sequestration has been realised in monetary value through direct payments to farmers who have improved their soils and biodiversity.

The "100-3-2-100 Plan" is intended to be a quick "finger on the pulse" performance measurement of the BDP-SFSS. For example, it will be easy to assess this overall performance target with a "healthy" indication of "100-3-3-100", with an extra 1% humus, or, a "negative" indication of "50-1-1-50", wherein half of the key stakeholders are co-operating, only one university has embedded a bioregional development educational process, only 1% humus is achieved, and, only 50% of carbon sequestration benefits have been paid to beneficiary farmers. To sum up, this unique KPIs signature is a powerful way to demonstrate the overall performance of any plan.

The primary reason for articulating how the strategic framework for the BDP-SFSS is derived, is to highlight the consistency and necessary alignment with the likes of the SDGs and related initiatives for a sustainable future. In particular, the postulated bioregional developmental impacts can only be realized if the strategic framework is fully honoured and its values upheld so there can be no compromise with any form of agriculture that is not at least truly sustainable, or better, regenerative. The key to supporting such a bioregional strategic framework is through the potential carbon funding mechanisms which reward agricultural initiatives which restores organic soil carbon since this is essentially what supports life. In simple terms, putting the humus back in the soil will restore biodiversity, soil life, water quality, food nutrition, wellbeing and quality of life.

The participatory process outlined at the outset of the paper, was used to present the above strategic framework for the BDP-SFSS at several stakeholder events in Sicily wherein it was very well received, notably, in December 2019, the "Distretto delle Filiere e dei Territori di Sicilia in rete" approved the 2030 vision proposed by the authors and committed itself to its dissemination and promotion among its many members. This achievement has highlighted how complex developmental challenges can be synthesized and appropriate solutions presented to empower and better inform stakeholders with decision-making authority.

4. Conclusions

Moving towards sustainable food systems is a multidimensional and complex process wherein many environmental, social, economic and cultural challenges need to be overcome. Moreover, food is central to human and planet health and the current way people produce and consume food is the root cause of many problems. Consequentially, a major question in recent years, is how to transform and make our food and farming systems sustainable [76].

In this regard, this paper has been designed to articulate the process towards a bioregional strategic framework for a sustainable food system in Sicily. The bioregional approach highlights the importance of a local food economy and the mechanism to influence stakeholders in the agricultural value chain to support local farmers and rural livelihoods.

This paper provides a sound argument, through a scenario planning process, to justify the most sensible sustainable option for agriculture, which attracts the least risk in the form of regenerative agriculture and, in turn, enhances biodiversity, organic soil carbon and promotes the local food economy. This justification forms the basis for the construction of a strategic framework which is fully aligned from its goal to its KPIs and with the SDGs and related initiatives [77]. This makes for a compelling bioregional whole systems development approach in which no compromises can be made in the pursuit of the most rationale development option, failing which, the whole strategic framework will be flawed with unsustainable initiatives. This may appear controversial, but then, our environment is at stake and there can be no more compromises for our future.

The results have shown that there is a basis for establishing a dialogue on ecological farming systems in Sicily [78,79], especially in light of the positive attitudes shown towards the adoption of organic farming, and, therefrom, the opportunity of creating a new, equitable, more resilient and sustainable food system, through the following initiatives:

- Companies' commitment to health and sustainability;
- The adoption of healthy and sustainable food choices;
- Developing regeneration models that promote soil health, biodiversity and farmers' profitability and productivity;
- Increasing awareness of information.

The work carried out is in line with the recent European Sustainable Food "Farm to Fork" Strategy and the European Biodiversity Strategy for 2030 together with associated action plans, and therefore, future research will focus on the assessment of ecosystem services and profitability for farmers compared to an external input intensive production model.

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