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Farm-level sustainability assessment in Mediterranean environments: Enhancing decision-making to improve business sustainability

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ABSTRACT

In typical Mediterranean settings farming systems are key components and have an impact on the community structure and the environment in which they take place hence it is important to develop tools for Sustainability Assessment (SA). To enable positive change it is necessary to effectively allocate resources. Thus, it is important to understand how farmers' decision-making impacts their farm's sustainability performance and their awareness and use of Decision Support Tools (DST) for sustainable management.

Twenty representative farms were selected from the National Farm Accountancy Data Network (FADN) for the regional unit of Argolida (Peloponnese, Greece). To investigate sustainability on these farms an indicator-based method, RISE 3.0, was employed to evaluate the current situation and semi-structured phone interviews were used to identify and analyse patterns and attitudes within the data regarding decision-making, sustainability performance and DST with the help of thematic analysis.

The results demonstrate that the decision-making process was poorly informed and not always evidence-based while the concept of sustainability was not well understood by most of the farmers. The sustainability assessment illustrated the specific strengths and weaknesses of farm businesses in the area whereas the correlation of the RISE assessment with perceptions of farmers on decision-making and sustainability performance identified the challenges of moving towards more sustainable systems in typical Mediterranean environments.

1. Introduction

Climate change, the scarcity of natural resources, human and animal welfare issues and societal challenges (e.g. food security, demographic change, population rise etc.) suggest the need to adopt more sustainable farming practices to reflect upon the challenges (Coteur et al., 2016). In a wider context sustainability issues relate to applied agricultural practices and thus the development of farm sustainability is strongly associated to the management approaches used by farm owners and managers. Within this context agribusinesses are adapting their production practices so they may remain profitable and are undertaking short- and long-term decision-making to both enhance environmental sustainability and business viability (Öhlmér et al., 1998). It is argued that the development of farm sustainability practices will be necessary to ensure businesses' survival and that farm sustainability performance can serve as a unit of measurement for effective decision-making and vice-versa. Hence, sustainability assessment (SA) tools have been designed to promote the monitoring and evaluation of agricultural practices using key performance indicators and therefore enable more sustainable development (Hajer, 1995). SA can be conceptualised as *'a range of processes that all have the broad aim to integrate sustainability concepts into decision making'* (Pope, 2006).

SA can therefore be described as a process aiming to use sustainable development as an underpinning decision-guiding strategy useful for decision-making by anticipating the future outcomes of current and planned actions (Hugé et al., 2013). There remains a need for improved guidance and compliance in strategic decision-making, but the selection of available tools and actions to measure and assess sustainability progress are often uncoordinated. (Russillo & Pinter, 2009). The growth of literature on SA over the last two decades re-enforces the interest and potential utility of this approach to decision-making. For example, Marchand et al. (2014), Gasparatos and Scolobig (2012) and Binder et al. (2010) each consider SA (the process) and SA tools (the methods and applications available to run SA projects) to support decision-making.

To evolve towards more sustainable futures, and to remain competitive, farmers need to adapt their decision-making and management approaches to meet the challenges of the constantly changing global environment (Darnhofer et al., 2010). Robert et al. (2016)

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suggested that two basic fields dominate decision-making in the farm management spectrum, firstly agricultural economics and secondly agronomy. For economists longer-term (strategic) decision-making is generally of greater interest, while agronomists focus largely on shorter-term (tactical) decisions affecting everyday crop and animal health and productivity. Agronomists aim to organise farm practices in terms of the bio-physical context in the short run usually to ensure optimal farm production in a single or small number of production cycles (Martin et al., 2013). Economists though strive to use resources efficiently in the long run and offer solutions for utilising available farm resources in accordance with farmers' objectives and constraints, usually within an optimising framework.

For the members of the European Union (EU) it is acknowledged that Common Agricultural Policy (CAP) support can influence the decision-making processes of farmers in terms of resource use, labour allocation, production choices and investment (Hennessy, 1998; Sckokai & Moro, 2009). This shapes decision-making and influences the nature of the wider farming system and can provide differential impact on, for instance, food production, enhancement of rural community and/or the promotion of environmentally sustainable farming.

Considering the Mediterranean region, the importance of agricultural systems in the area in terms of biodiversity and species conservation is evident (Myers, Mittermeier, Mittermeier, da Fonseca and Kent, 2010). According to them endemic species such as citrus and olive trees that dominate the plantation orchards in the area are threatened from diseases and present exceptional loss of habitat. Since 1962, the EU member states have benefited from the CAP subsidies. Due to the financial, technical, and administrative support their agricultural infrastructure has been upgraded and modernised and their agricultural output has increased (Eurostat, 2009). Initially, the CAP subsidies focussed on improving agricultural productivity by promoting technical progress and ensuring the optimum use of the factors of production, in particular labour, while also ensuring a fair standard of living for farmers in the member countries (Massot, 2017).

The gradual removal of agricultural market protection measures has led to a more market-orientated sector characterised by increased competition and imports, reduced statutory subsidies, export supplements and intervention measures (Galanopoulos et al., 2006). The CAP for the period 2021-27 (European Commission, 2021), focuses on:

- ensuring stability and income support for farmers,
- setting higher green ambitions for environmental and climate action,
- placing farmers at the heart of Europe's society.

These broad goals align with the three pillars of farm sustainability and point towards the transition to a new farmer centred structure of the farming system. As such, the development of farm sustainability will be a necessity for business survival. Therefore, it is imperative to underline the need for SA as part of an enhanced decision-making processes.

Farm sustainability (economic, social, and environmental) has always, for a multitude of reasons, been a challenge within agricultural systems. Especially in the Mediterranean basin, a range of factors potentially undermine farm sustainability:

- small size of agricultural holdings (DG Agriculture and Rural Development, 2018),
- spatial characteristics of the area (Hellenic Statistical Authority, 2021),
- dependency on CAP subsidies for small and medium holding farms (Massot, 2017),
- an ageing rural population (Doignon, 2019)
- farmers' low level of education (Grasso & Feola, 2012; Harmanny & Malek, 2019),
- an enduring tradition of providing women with a dowry (Nikolajeva, 2014),

A SA of agricultural production at the farm-level can provide a robust approach for mitigating the inherent challenges and problems occurring in the sector at present. Such an approach would provide decision-making information that in turn would advance and apply innovation and technological uptake, where appropriate, at the farm level (Rivera, 2011). This would influence a multitude of decision-making processes, bring about changes in the structure of farming systems or collective decision-making on rational resource use (van den Ban, 1998). The potential for a substantive improvement in performance should provide a driver and encourage farmers' participation, along with other stakeholders, in the design of tools and policies so that challenges can be tackled collectively and efficiently.

The research reported herein investigates farmers' perceptions of the importance of effective decision-making in relation to the sustainability performance of their farming businesses. Farmers' behaviours and attitudes towards decision-making and the subsequent correlation with sustainability performance are presented in a case study for the Argolida region in the Peloponnese, Greece. This paper evaluates the sustainability performance of farm businesses in the region and how farmers perceive that decision-making affects the sustainability performance of their farms. Even though farm sustainability is an important concept in Greece and the Mediterranean basin there is a paucity of research which links sustainability assessment with thematic analyses exploring farmers' views and perceptions on decision-making, farm sustainability and DST awareness and use. To provide a new perspective on addressing the sustainability challenges in these environments a multi-method approach has been implemented and the findings outlined in this paper.

2. Scope of the research

Several studies have examined SA of agricultural production systems in the Mediterranean basin (Casas et al., 2015; Dantsis et al., 2009; Giourga et al., 2008; Manos et al., 2011; Stylianou et al., 2020). Using a variety of frameworks for the assessment of farm businesses' sustainability the performance of agricultural production systems has been evaluated and optimal practices have been proposed for enhancing the sustainability of these systems.

Building on and extending this, the research reported here assesses farm sustainability performance based on a sample of farm businesses in a southern region of Greece, an area with features typical and representative of the Mediterranean basin, using an indicator-based assessment method. The research then extends this to correlate the results of the SA to the attitudes and behavioural patterns of farmers that emerged from a thematic analysis, based on the outcomes of the semi-structured interviews with the same sample.

The research combines the use of the RISE 3.0 tool in Greece as an SA tool at the farm-level with effective evidence-based decision-making to enhance sustainability performance. This paper is focused on a case study of a Mediterranean area specialised in citrus and olive production. This farming system has a prominent role in terms of what is defined Mediterranean and hence Greek agriculture, composed of small size farms that are gaining importance in numerical terms and concentrating increasing shares of the total agricultural output, labour and land of the country, the region and worldwide (Lowder et al., 2016).

3. Materials and methods

3.1. Identifying an appropriate sustainability assessment tool

With the development of over 100 sustainability assessment tools in the recent years (Smith, 2017), selecting one should follow specific criteria that are based on the nature of the research project and the aims and objectives of the analysis. For this research project, the criteria taken into consideration for choosing the appropriate tool were the following:

- The tool needed to evaluate sustainability at farm level with the use of an indicator-based questionnaire.
- All aspects of sustainability (economic, environmental, and social) were required to allow an integrated assessment of the farm.
- The tool needed to be applicable and useable in the context of the range of Mediterranean farming systems
- Ideally the tool used would have been published in a peer-reviewed scientific journal and/or peer-reviewed scientific report to ensure scientific rigour.

After reviewing the literature in the context of the above, four tools emerged as most appropriate: RISE (Response-Inducing Sustainability Evaluation), SAFA (Sustainability Assessment of Food and Agriculture systems, FAO, 2018), PG (Public Goods) and IDEA (Indicateur de Durabilité des Exploitations Agricoles) (de Olde et al., 2017; Hayati, 2017; Schindler et al., 2015; Smith, 2017). From the tools that cover this convention, RISE was perceived to include all important elements by offering farm level sustainability assessment but also taking into consideration the specific features of each farming system along with the opportunity of making on site decision-making/management interventions to potentially improve farm sustainability performance (Marchand et al., 2014). RISE combines a high user-friendliness, high complexity (de Olde et al., 2018) and is at the same time consistent with the principle of transparency associated with uncertainties and trade-offs (Arulnathan et al., 2020).

RISE has also the broadest coverage of SAFA (FAO SAFA Guidelines, 2015; Padel et al., 2015), subthemes and a high level of coverage of subthemes included in PG (Public Goods) and IDEA (Indicateur de Durabilité des Exploitations Agricoles) (de Olde et al., 2017; Hayati, 2017). Recently the assessment has been adapted to align with the SAFA framework. The PG tool focuses on public goods instead of sustainability, but some consider it a suitable tool for assessing sustainability because of its compliance with the selection criteria and because data are more accessible. The RISE, PG and IDEA tools are adapted specifically for measuring the sustainability at farm level, whereas SAFA has a broader scope in that it extends to supply chains in agriculture, forestry and fisheries (De Olde, Oudshoorn, Sørensen, Bokkers and De Boer, 2016). Also, SAFA and PG are organic farming focused (Smith, 2017). In the study of Röös et al. (2019), RISE showed the ability to capture the social features of farmers while at the same time SAFA and IDEA both failed to identify aspects of the social situation of Swedish farmers. SAFA also includes questions that seem to be less-relevant to Mediterranean and Greek small/medium-scale family farmers such as child and forced labour (Röös et al., 2019).

To date RISE has been applied around the world in 57 countries and more than 3300 agricultural operations on different farming systems in terms of size and orientation. This, suggests it is a tool that can be adapted to regional conditions and circumstances at farm level. The approach adopted in RISE encourages farmers to act in the direction of improving sustainability of their farms. It allows farmers to "*situate themselves within a benchmark*" and provides the basis for identifying successful farm management practices (Binder et al., 2010). The report generated is useful as the results are easy to understand. Though lengthy it uses less categories, so it is easier to interpret, compared to other multi-criteria sustainability assessment tools (Smith, 2017). A strong point of the application of RISE, is that it allows for farm-level research and development to occur at the same time (Urutyan & Thalmann, 2011).

To conclude, RISE presents certain advantages that make it an appropriate sustainability assessment tool to choose in this research. It assesses sustainability in a holistic way, considering the three main pillars of sustainability. It is a tool to evaluate sustainability at farm level and focuses on stimulating discussion as part of the feedback process with farmers. These results can be used by farmers for establishing an action plan but also by stakeholders for initiating policy-making procedures that will facilitate the improvement of farm sustainability in the agricultural systems of the region (European Commission, 2019).

3.2. Research region

The regional unit of Argolida, Peloponnese, Greece was selected as the area for field research (Fig. 1).

This area has features typical of a humid mid-Mediterranean climate (Kavvadias et al., 2013). It is also of interest given its predominant cultivation of olive and citrus trees which are typical crops for southern and eastern Greece and the wider Mediterranean area. Argolida, is one of the major suppliers of oranges for the Greek and export market (Kavvadias et al., 2013; Kelepertzis, 2014). Olive cultivation, primarily for oil, is considered particularly important for Greek farmers according to the Food and Agriculture Organization, (FAO) (2018). Greek olive oil production in 2014 was estimated to account for roughly 7% of global production, placing Greece third in the world by volume. Collectively, the countries of the Mediterranean basin account for approximately 96.5% of global olive oil production (Niavis et al., 2018) while the EU's Mediterranean area is responsible for approximately 20% of the worlds citrus production and 70% of global citrus exports (European Commission, 2019).

3.3. Research participants

3.3.1. Sampling and recruitment

The Greek Ministry of Rural Development and Food provided access to a list of farm holdings based in the regional unit of Argolida. Data derived from the FADN (Farm Accountancy Data Network) database for Greece for the year 2017 was provided for research purposes. FADN is an EU-wide survey that monitors the income and general farm business activities. Based on national surveys that cover holdings that can be characterised as commercial it is essentially a data source for the annual realisation of farm incomes, analysing the economic operation and investigating econometrically the effects of direct and indirect subsidies and design and implementation of the new CAP 2021-27. It is essentially a data source for the annual evaluation of farm incomes (European Commission, 2021). A homogenous group based on production characteristics and farm business structure were selected for the purpose of this research.

3.3.2. Sample size

Sustainability performance assessment presents specific challenges related to time and resource management (de Olde et al., 2016). Therefore, to reach the explanatory power, the decision over sample size was important. It had to be small enough to handle yet large enough to provide robust evidence so that most or all perceptions of the wider population were uncovered (Mason, 2010). The information saturation point, that is, the time when new evidence can no longer be gleaned from the information source (Guest et al., 2006), was identified by other studies as occurring after six or between 12 and 15 individual interviews (Isman et al., 2013; Latham, 2013). A sample of 20 participants was thus selected to be representative of crop type, holding size and farming system. Research methods and ethics were approved in line with institutional protocols.

3.4. Interview structure

For the purpose of the thematic analysis and the RISE 3.0 assessment two sets of questions were employed. For the thematic analysis the interviews were conducted via telephone due to the Covid-19 pandemic restrictions. Eighteen open-ended questions were asked in a semi-structured interview format with each of the participants. Interviews began with questions about the demographic characteristics of the farm managers/owners such as their age, gender, marital status and agricultural training. Questions then addressed the aspects of decision-making, sustainability awareness and assessment and DST awareness and use.

Fig. 1. Map of Argolida, adapted from https://greece-map.net/greece-argolida-maps/.

Finally, the interviews concluded with questions about the ongoing challenges they believed agriculture will be facing in the coming years. The interviews were recorded with the permission of the participants, transcribed verbatim, and translated into English. These interviews took place between the 21st April and the May 15, 2020 with each interview taking between 15 and 30 min.

The RISE 3.0 questionnaire was applied to the same sample. This time the farm data were collected through face-to-face and in-depth interviews on farm based on RISE's 10 themes (ranging from biodiversity and energy use to economic viability, farm management, quality of life and working conditions) and the 47 indicators under assessment. Answers were entered into a computer program (www.farmrise.ch) during the interview with the researcher working in both online and offline modes. The procedure included the collection of information on the ecological, economic, and social aspects of the visited farm through a questionnaire-based interview with each farmer. FADN data were entered into the program prior to the interview for time management reasons so as to reduce the length of each on-farm visit. The interviews were conducted between the 1st July and the August 3, 2020 and on average each interview took 2 h and 30 min.

3.5. Data analysis

3.5.1. Thematic analysis

The data from the first questionnaire was analysed with the use of thematic analysis (TA), as this qualitative analysis method makes it possible to identify and analyse patterns and attitudes within a given data set (Braun and Clarke, 2006). According to Braun and Clarke, TA is a flexible tool that can provide a rich and complex account of a data set. The TA structure was based on Braun and Clarke (2006): familiarising with the data, generating initial codes of interesting features, searching for themes in all relevant data, reviewing themes, defining, and naming themes and producing a report relating back to the research question. Data analysis was a recursive process. NVivo 12 software was used for the data analysis and identifying themes.

The themes were identified within the data using an inductive process and a bottom-up approach to the analysis. Since semi-structured interviews were employed for collecting the data, no conceptual framework was present; so, the analysis was conducted without any preconception or advance knowledge. This made inductive coding the best choice. In this case, given that the inductive approach was data-driven, there was no specific frame for coding. As far as the decision concerning the 'level' at which themes were identified, a semantic/explicit approach was adopted. Because of the rich, verbatim transcriptions provided by the participants, themes were identified solely based on what the participants reported. No attempt was made to theorise or interpret interview replies.

3.5.2. Applying the RISE 3.0 method

To calculate the sustainability performance of a farm, four types of data were used: quantitative farm data (e.g., crop areas, yields, amount of fertilisers, number of working hours, and debts), qualitative farm data (implementation of water-saving measures, level of satisfaction, and impact of farm strategy on social aspects), regional reference data (e.g., moisture index, humidity zone) and global reference data (e.g., toxicity of plant protection products, energy density of energy carriers and water consumption of different livestock categories). The farms' raw data were entered into the RISE 3.0 software program, before and during the interview in offline mode. The RISE tool then compared these data with threshold values and normalised them onto a scale that ranges from 0 to 100 points. The scores follow a colour scale which is depicted in Fig. 2.

3.5.3. Data triangulation

Fig. 3 illustrates how the three sources of research data were integrated within this research. The FADN data were used to inform the RISE 3.0 analysis with the economic data as well as with the use of inputs (fertilisers, plant protection products etc.) and outputs (sales, yields etc.) of the farming systems under study. Findings of both analyses, RISE 3.0 and thematic, and the data from the FADN dataset were then triangulated to provide an analysis of decision-making, sustainability and DST awareness and use.

4. Results and discussion

4.1. General characteristics of the sample

The vast majority (90%) of the farmers cultivate olive trees, for oil production or table olives, while 85% cultivate a species of citrus trees (oranges, mandarins, and lemons) or/and a mix of them. This cropping pattern is similar to that reported by others (FAO, 2018; Kavvadias et al.,

Degree of Sustainability	Problematic 0 - 33	Critical 34 - 66	Positive 67 - 100

Fig. 2. RISE 3.0 degree of sustainability.

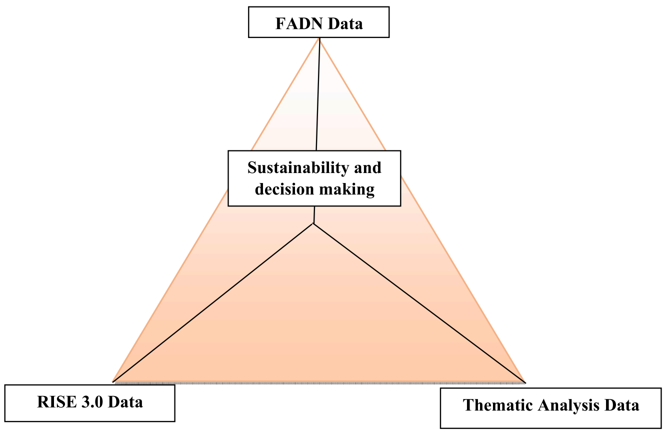

Fig. 3. Data triangulation.

2013; Kelepertzis, 2014). Moreover, crops such as apricots, vegetables, vine, and pomegranates were grown but in smaller areas, acting as supplementary income to that from olive and citrus trees. 85% of holdings in the sample were below 10 ha in area which aligns with the region's statistical data which shows that farms with less than 10 ha of agricultural land (86,550 farms) represent 93.6% of the total number of farms in the region of Peloponnese in 2013 (European Commission, 2019).

Table 1 provides a broad characterisation of the 20 farms under study.

Table 2 illustrates features derived from the questionnaires and the FADN data of the sample farms in comparison to the Northern Mediterranean region countries (Eurostat, 2021).

4.2. *Research findings*

4.2.1. *Effective decision-making*

The link between effective decision making and agricultural production practices has been recognised as one of the most important factors for farmers based on the thematic analysis. High quality/quantity of production was seen as a crucial determinant for achieving higher market prices and gaining negotiating power to ensure favourable sales.

Table 1
Selected sample from FADN Greece. Adapted from FADN dataset Greece.

Sample	Holding Size (ha)	Crop Type	Type of Farming
Farm 1	5.12	Citrus, Olive, Apricot, Vine	Conventional
Farm 2	4.6	Citrus, Olive	Conventional
Farm 3	3	Citrus, Olive	Conventional
Farm 4	10.39	Citrus, Olive	Conventional
Farm 5	4.2	Citrus, Olive	Conventional
Farm 6	8.93	Citrus, Olive, Vegetables	Conventional
Farm 7	14.03	Citrus, Olive	Conventional
Farm 8	16.8	Citrus, Olive, Apricot	Conventional
Farm 9	4.4	Citrus, Olive	Conventional
Farm 10	3.55	Citrus, Olive, Apricot	Conventional
Farm 11	3.58	Citrus, Olive, Apricot	Conventional
Farm 12	6.05	Olive, Apricot, Vegetables	Organic
Farm 13	7.25	Olive, Apricot, Vine	Conventional
Farm 14	6.9	Citrus	Conventional
Farm 15	3.1	Citrus, Olive, Pomegranate	Conventional
Farm 16	1.4	Citrus, Olive	Conventional
Farm 17	1.75	Olive, Apricot, Vegetables	Conventional
Farm 18	32	Olive	Organic
Farm 19	6.07	Citrus, Olive, Apricot	Conventional
Farm 20	2.3	Citrus	Conventional

Table 2
Features of the sample farms. Adapted from questionnaires and FADN.

	Organic farming as part of UAA (2019)	Farmers over 40 years (2019)	Comprehensive agricultural training (2019)
Research Sample	10%	95%	15%
Greece	10.20%	91.70%	0.60%
Spain	9.70%	91.40%	1.90%
Portugal	8.20%	95.60%	2.50%
Italy	15.20%	92%	6.10%
Cyprus	5%	96.80%	0.60%
Malta	0.50%	93%	1.70%

Nevertheless, the RISE 3.0 assessment indicated that 95% of farmers had not conducted a soil analysis in the past 10 years. Therefore, although their fertilisation management process scores were high, suggesting good cultivation practices and professional fertilisation application, the process was not informed and planned using data enhanced by an evidence-based application, but rather based solely on previous experience and knowledge. In contrast all farmers were using irrigation methods such as sprinklers and drip irrigation and they determined their irrigation needs based on evidence related to weather conditions and plant developmental stage.

20% of the farmers interviewed identified that spatial characteristics shaped their decision-making. Weather variability, land morphology and water scarcity directly influenced farmers decision-making process. Hence, either when designing the long-term strategy for the sector, or during the annual harvest and sales time, these parameters affected their actions. Cooperation with exporters and traders also emerged from the thematic analysis as a sign of effective decision-making in terms of establishing good relationships to aid product marketing. The RISE 3.0 analysis illustrated that 45% of farmers characterised their relationships with customers as 'positive' and nearly one third (approx. 33%) described them as 'satisfactory'. The remaining 25% indicated that their relationship could be defined as 'negative' as their dependency on current markets and customers does not favour their farm's future business plans.

During the interviews, 20% of farmers noted the need for effective financing of their production processes. Emphasis was placed on business planning and control parameters, such as liquidity and solvency. Turnover was identified as playing a crucial role in farms' business viability. Data on farms' liquid assets at the end of the year were taken from the FADN dataset. The vast majority [95%] of the participant farms returned a profit, with just one farm demonstrating a net loss. CAP subsidies, the holding size and the type of farming all played an important role in determining farm profitability. Even with the existence of CAP subsidies the durability of small farms is often only possible due to unpaid family work. Many of them would not be considered profitable if the labour provided by family members was valued at the same rate paid to casual workers (Mylonas, 2015). Larger holdings and those based on organic farming systems presented higher profit levels. This was also documented in similar Northern Mediterranean research, for instance in Spain (Pardo et al., 2014; Torres et al., 2016).

A dependency on CAP subsidies was evident in the farms' profitability as in many cases the amount of money from these policies made a significant contribution to overall profitability. Some farms received higher levels of subsidy per hectare because of their geographic location (i.e., higher altitude) and these were particularly reliant of the CAP payments to maintain profitability. Organic farms received additional payments for implementing agricultural practices beneficial for the climate and the environment in addition to those from the basic payment scheme. Even though CAP subsidies are largely decoupled from production there were still some active payments connected to production for the period 2014–2020 although these were due to expire at the end of 2021. Such examples are the subsidies connected with oranges intended for juicing or the subsidies for abandoning tobacco cultivation. The cessation of these will also have a negative impact on profitability as projected in other studies (Pardo et al., 2014) too.

Farmers linked effective decision-making to a set of determinants such as agricultural practices, product sales, area characteristics, economic reasons, their own attitudes, goals, and sustainability. In addition, most of farmers indicated that their decision making was correct, but external factors were affecting implementation and their ultimate characterisation of 'effective'. It was evident in the RISE 3.0 indicators 'business goals, strategy, implementation' and 'personal freedom and values' results that farmers' ideas about their own management efficiency were of a high standard. Yet, external factors such as weather conditions, diseases, prices, state guidance and policymaking were attributed to determining the success of the farm business. For example, in relation to the national agricultural insurance agency for crop production, the provisions by the agency related to their plant capital and produce were considered inadequate and in need of restructuring.

In the context of agricultural practices the commonest recurring theme was that farmers linked the quality and quantity of their products to measures of the effectiveness of their decision-making. Detailed analysis of the data showed they relied mainly on experience and existing practices to make decisions so they were rarely well-informed about new advances related to agronomy or the use of a range of newer technologies. For example, a lack of soil and crop nutrient demand analyses for fertilisation and a reliance on "*how it has always been done*" is illustrative of this.

Farmers' attitudes and vision, goals set, sustainability-minded processes and even statements such as *'there is no effective decision-making when I am not in the position to determine the price of the product'* all emerged from the interviews related to effective decision-making. During the thematic analysis interviews 90% of farmers reported that they take the advice of agronomists/advisors to make informed decisions about their production practices or processes while 60% also make decisions based on their own experience or after discussions with family members. Less often (only 15%) they accept peers' recommendations or address their questions to extension officers. The importance of state guidance was noted, but the lack of guidance from the region's Directorate of Agriculture was also commented upon. Based on this, using a scale from 1 to 10, with 1 being the least informed and 10 totally informed, half of farmers answered that their decision-making was 'totally informed' by good agricultural practices. The remaining 50% answered between 6 and 9 on that scale. The RISE 3.0 analysis also showed that farmers believe they have sufficient access to expert information and all the necessary information about their farms' financial situation, water and energy consumption and the future demand for labour. At the same time the use of advice on biodiversity species, conservation management and habitat conservation was limited in all businesses. All scored 0 in this respect. This is interesting as research shows that the inherent diversity and heterogeneity of the area, supports high levels of biodiversity and promotes ecological resilience (Babai et al., 2015; Konvicka et al., 2016).

In relation to farmers' views of what constituted a successful farm business more than half (60%) of them consider good agricultural practices to be an especially important attribute. Emphasis was placed on the quality of the produce and thus in the decisions associated with the organoleptic properties of fresh produce and the use of crop-protection practices. The participants justified their decision-making approaches with their final higher yields, market prices and farm incomes. Finding the appropriate marketing channels for trading their products seemed equally important to all interviewees. This helped them to mitigate their dependency on a small number of traders, or even how their products were traded; this was also evident in the RISE 3.0 results.

A fifth of farmers recognised that the crop species they grew was a key determinant of business success. Early or late ripening as well as the introduction of new varieties have been considered as offering added value to their product mix, allowing flexibility amid supply and demand concerns. Farmers also identified their holdings' size as an attribute of success. All of them noted the significance of farm size, especially during times of low prices and increased production costs. The fragmentation of agricultural land was viewed as a factor that adversely impacted farm' success due to increased production costs arising mainly from the duplication of activities which essentially doubles the time spent and the equipment and machinery moving around to perform tasks such as harvesting, spraying, ploughing etc. At the same time this fragmentation and generally the small size of holdings can present an opportunity to develop innovative business models (Koutsou et al., 2011) and this may still be the only realistic structure for farms situated in areas of high altitude and can offer a diversification in terms of varieties and crops (Karantininis, 2017).

Farmer concerns, expressed in both the interviews for the thematic and RISE 3.0 analyses, were linked to their management approach and decision-making processes. Due to the predominant crop types for the area most of the farm businesses encounter the bulk risk that arises from a significant proportion of their income coming from one or two crops. In this case they were vulnerable to adverse impacts of, for instance, bad weather and disease which are common underlying challenges within the agriculture sector. Ensuring that their decision-making is well-informed and evidence-based may help reduce risk associated with these challenges in the future. Further, decision-influencers such as agronomists and advisers need to be equipped with the latest skills and knowledge set to promote sustainable agriculture (Charatsari and Lioutas, 2016), suggesting that regular continued professional development is essential in these roles.

Other features, such as farmers' attitudes, innovation adoption and state guidance were noted but less frequently. Nevertheless, attributes such as personality, hard work, passion for the profession, as well as luck, were also mentioned. Avoidance and management of Citrus Tristeza Virus (CTV) was considered relevant to the success of the farm business as the disease affects the robustness and the yields of citrus trees. The adoption of new technology and several other innovative steps available to farm businesses were seen as helpful for achieving multiple benefits. For example, deploying contemporary irrigation methods and harvesting machinery were indicated as sources of enhancing the business' success. In this context, farmers ranked their own businesses in terms of success on a scale from 1 to 10 with 1 being the least successful and 10 being the most successful. Marginally more than the two thirds situated their businesses between 7 and 8 on the scale. The remaining third ranked their farms between 5 and 6.

4.2.2. *Sustainability*

The majority (90%) were unaware of the term 'farm sustainability'. Ten out of the 18 farmers in this category had never heard the term, while the other eight had heard it but were unaware of its meaning. Only two stated they knew the term and could explain the concept. Furthermore, 19 of the 20 farmers had never assessed their farm's sustainability; one stated that they had once had a carbon footprint measurement taken by a trader who marketed his produce. Nevertheless, the farming systems' sustainability performance assessments that followed, completed using the RISE 3.0 tool, generated interesting results, as shown in Fig. 4. This illustrates the assessment of the average scores of the 20 farms in the study for each theme.

According to calculations from the RISE 3.0 model, three out of nine

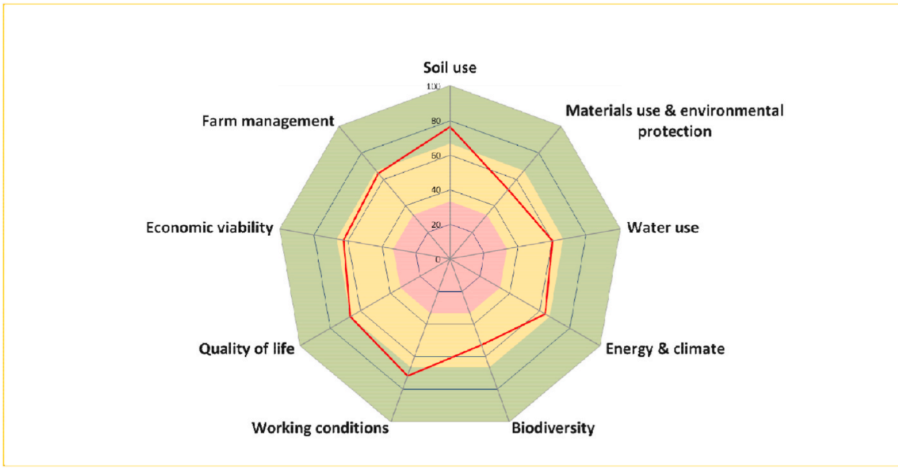

Fig. 4. Farm sustainability polygon, adapted from RISE 3.0.

themes — soil use, working conditions and quality of life — were assessed in the green (positive) area of sustainability performance with scores over 67, while the remaining six were evaluated in the yellow (critical) area. From these six themes, three — energy & climate, economic viability, and farm management — scored marginally lower than the positive area. It must be noted that some individual farms scored in the red (problematic) area.

According to the FADN data and the results of the thematic analysis, farmers who were aware of the meaning of 'sustainability' had a higher educational background than others. As indicated by Kountios et al. (2018), in Greece, the delay in the adoption and implementation of precision agriculture (PA) and more sustainable agricultural practices is due to a multitude of reasons, among them, education. Although farmers have a range of training opportunities, the existence of a feeling of 'impunity' to use past harmful practices, economic interests weigh greater in their decision-making than any other factor (Aznar-Sánchez, Velasco-Muñoz, López-Felices, & del Moral-Torres, 2020).

There has been a misconception between farmers' attitudes and beliefs towards their approach on sustainability and the results of the RISE method. In terms of agricultural practices, the main pattern observed was a routine based on experience and existing practices rather than on evidence and planning. Decision-making was indicated as associated with financial sustainability, but the general lack of awareness of environmental sustainability hindered farmers' understanding of the change in processes required to strengthen the bond between the two.

Fig. 5 illustrates the range of farm scores in each theme and shows that a number of farms in the themes of energy & climate and economic viability fell in the problematic category.

For the purposes of the thematic analysis an explanation of the term 'farm sustainability' was provided. Even though the participants scored low on sustainability awareness and assessment when called upon to answer to what degree elements of overall sustainability performance are a part of their farm's decision-making process they indicated that it does affect them via different means and mechanisms. A relationship was noted between farm sustainability and decision-making in the context of agricultural practices. For instance, in the context of environmental sustainability concerns about the use of agrochemicals, mitigation of the use of highly toxic plant protection products (PPP), overcoming water scarcity via appropriate irrigation systems and the possibilities of organic farming or the techniques used were raised by 40% of respondents.

The impact of education was also evident in the biodiversity theme of the RISE assessment. The non-use of biodiversity advice to promote species and habitats resulted in negative scores in this area. The analyses indicated that no measures were implemented for the conservation of species and native habitats. A lack of education and knowledge on the

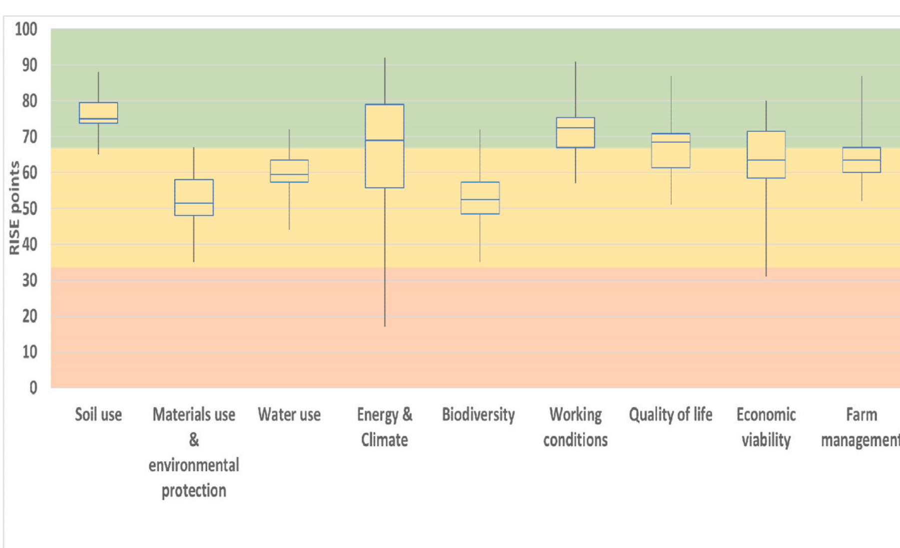

Fig. 5. Farm sustainability assessment, adapted from RISE 3.0.

benefits of biodiversity prevented farmers from understanding the value of species and habitat conservation towards environmental sustainability. Even though concerns were raised by farmers in the thematic analysis related to environmental issues resulting from the use of fertilisers and PPP, the RISE assessment showed that farmers' use of high levels of fertilisers and PPP led to low sustainability scores, due to the frequency, environmental toxicity and the persistence of herbicides and insecticides used. This suggests that farmers' perceptions and concerns were not well-aligned with their practice, mirroring well-known inconsistencies between farmer attitudes to key practices and subsequent behaviour (Munoz et al., 2019). Highlighting and aiding the bridging of the gap between farmers' perceptions and real-life practices is thus key in evolving toward more sustainable systems.

The materials use and environmental protection scores ranked in the 'critical' area of sustainability performance for 19 of 20 farms, with only 1 farm scoring only marginally in the 'positive' area. Material flows indicators had low scores (10–49 points), due to low nitrogen and phosphorus self-sufficiency in fertilisers, with 19 of 20 farms lacking their own resources (manure), and hence relying on inputs from locally sourced materials, or sometimes from further afield. Furthermore, fertilisation intensity scores also raised concerns with 40% scoring in the 'low' area of sustainability performance and a further 25% scoring medium in the 'critical' area. In short, 65% of the farms use nitrogen at levels which can potentially damage groundwater, soil, and plant communities.

The preference for using mechanical weed control was expressed by only 4 of 20 farms, while another six used pesticides and mechanical pest management. Half of the farms reported spraying for pest control. The use of PPP resulted in 80% of farms scoring 'low' and being in the 'problematic' zone; the remaining 20% scored 'medium' thus being in the critical zone. These RISE 3.0 results reflect the high environmental toxicity and persistence of herbicides and insecticides used and the high number of applications.

The thematic analysis demonstrated that 35% of farmers follow decision-making processes that are driven by mainly financial and social sustainability performance concerns as shown in their desire to pass the property on to their children to farm in the future. The organic farmers in the sample noted that their choice to adopt organic farming was based on holistic sustainability criteria not only to stand out among their competitors, but also to be environmentally and socially sensitive.

A few (15%) interviewees said that they take into consideration sustainability performance in their decision-making, but not always. One interviewee said that the sustainability performance of their farm does not affect their decision-making process.

4.2.3. DST's use and future trajectories

The answers to the DST awareness question were triggered by an explanation of the term. Initially, 85% of interviewees did not understand the concept so the term "DST" had to be explained. The explanation given was derived from Rose et al. (2016) '*Decision* support *tools (DST) are designed to help users make more effective decisions by leading them through clear decision stages and presenting the likelihood of various outcomes resulting from different options'*. Only 15% were initially aware of DSTs. After explaining the term in more detail, half of the interviewees said they had never heard of DST. Some asked why they should use DST, while others suggested that in the regional unit of Argolida, such tools could only be used by farms with greenhouses and not by the other sectors. The remaining 50% realised they have heard of DSTs but did not use them.

The reasons hindering DST awareness and use were found to be familiarity/technology adoption, financial concerns and practical issues. Interviewees indicated that they would not use a DST because they were unfamiliar with technology. Financial reasons hindered their use by others. The purchase and use costs also appeared to be a deterrent against DST. Even if DSTs were subsidised interviewees still argued that the current situation of Argolida's agriculture does not favour their use. It was suggested that high production costs, low prices and market uncertainty following the economic crisis and during the pandemic make DST investments uneconomical. These reasons resonate with the research of Rose et al. (2018).

The interviewees raised several practical issues that would prevent them from using a DST, such as their small holding size, land fragmentation and their own experience — *'no need of a machine to tell me when the trees need irrigation'* — and an unwillingness to change. The latter was evident in the RISE 3.0 findings where only one farmer reported being dissatisfied with their own farm management performance and wanted to change something about it.

Interestingly, as far as changes were concerned, more than half (60%) of farmers recognised CTV (Dimou et al., 2002) as one of the main challenges that will impact Argolida's agricultural sector. They noted it would impact their incomes because citrus trees, and especially oranges, are the predominant crop in the region; they are also considered emblematic of the area. The RISE 3.0 results also show that CTV is regarded as one of the major threats in the risk management indicator.

More than half (60%) of farmers mentioned land abandonment as another concern, as young people are not entering the profession preferring instead to join different sectors. This fact, in correlation with the presence of CTV, has increased production costs. Lack of state guidance was also cited as an additional reason that has led many farmers to abandon the sector, so their properties were subsumed by a small number of farmers or remained uncultivated. For a significant number of farmers this is a second profession, so they see it as a supplementary source of income. Furthermore, even among existing farmers the issue of attitude and vision was highlighted, with 30% stating that they want to evolve their approach but the rest were uninterested in changing their existing production practices.

Water scarcity was predicted by 20% of farmers as a problem in the region in 10 years' time. Over-pumping from existing wells and drilling or pumping from greater depths along with delays in the progress of the irrigation duct network from the Anavalos River, are the main reasons for this. Finally, 20% of farmers predict that only limited changes will occur; only one farmer projected that things will be better in the years to come, due to the new programmes such as the one concerning the settlement of young farmers (sub-measure 6.1) and policies launched by the state.

An unwillingness to change was noted. Farmers predicted CTV and land abandonment would be the main changes in the region along with water scarcity. The fact that the vast majority foresaw these "external" changes occurring in a 10-year period but only 30% were interested in adjusting their approach to tackle them, is indicative of limited vision and a general resistance to change. It is evident that the routines the farmers have always followed were well established and the majority were reluctant to change practices.

There was some misalignment between the results of the two analyses. For instance, the findings of the thematic analysis suggested that effective decision-making and farm sustainability were connected. Even though it was implied that there was a connection between them, the findings from the RISE 3.0 assessment indicated that there is a lack of evidence-based decision-making. Furthermore, a lack of awareness and assessment of sustainability enhanced the notion that decision-making and farm sustainability were concepts unfamiliar to a majority of the sample.

Further, decision-making related to achieving the desired quality and quantity of production, along with marketing and the trading of produce (i.e., what was seen to relate to financial sustainability) was claimed to be informed and in accordance with the advice of the agronomist/adviser. In fact the RISE 3.0 analysis suggests that in each step of the production process there is a lack of decision-making based on factual information and evidence from available data, such as soil analyses, nutrient demands estimations, GHG emissions, biodiversity advice and financial indicators.

5. Conclusions

This research illustrates the inherent challenges that the agricultural sector faces in Greece and the wider Mediterranean region. Differences identified between the perceptions of farmers in relation to financial and environmental sustainability and their actual practice provide a basis for suggesting mechanisms that can enhance the sustainability of farming systems in the Mediterranean basin. Consequently, the methodology utilised in this research can be appropriately adapted to other similar crops and areas in the Mediterranean basin. Therefore, provide a useful tool for decision-makers and stakeholders to prioritise interventions in farm management practices. Moreover, it aids the identification of efficient mechanisms to evolve towards more sustainable agricultural production at a regional level.

In relation to the research questions, the RISE 3.0 sustainability assessment provided benchmarked sustainability assessments for the Argolida region. Benchmarking against the wider RISE dataset illustrated the strengths and weaknesses of farm businesses in the area. In relation to farmers' perceptions of the importance of effective decision-making in relation to the sustainability performance of farming systems, the results from the thematic analysis, the sustainability assessments and the FADN data highlighted important sustainability characteristics of farm businesses in the region. Finally, the DST awareness and their (limited) use suggested the need for further research to identify the needs and requirements of stakeholders in relation to DSTs, but also consideration of how the use of such tools could be encouraged as a mechanism to enhance sustainability.

Overall, this research indicates a gap in the understanding of wider sustainability issues within the context of farm decision-making. While just a few farmers had a clear grasp of the dimensions of sustainability and just one farmer had ever undertaken a sustainability audit, it was clear that in order to enhance the sustainability of the production process, the educational, technological and consultancy framework needs to be reformed to address the challenges indicated previously. Farming systems were considered sustainable as long as they were profitable. Distinctions between economic and other aspects of sustainability were not made and this is an element that could be tackled through training and workshops that address the concept of agricultural sustainability. The findings highlighted that even though farmers believed their existing cultivation practices were in line with the preservation of the environment, the promotion of biodiversity and the protection of soil and water properties, the results of the sustainability assessment indicated that these were the factors that farmers should focus more attention on, to improve their overall farms' sustainability performance. The absence of adequate advisory services or the paucity of provision of independent advice, are also potential areas for improvement.

Orientation towards holistically addressing the practicalities of incorporating sustainability into the farmer decision-making process is of increasing importance as options for change narrow (i.e., climatic change, environmental degradation, water scarcity). The findings of this research via the sustainability assessment and the thematic analysis illustrates the need to encourage farmers and advisers to change their actions in order to enhance wider agricultural sustainability. One element of this is the formulation of educational and professional development frameworks and networks to facilitate and enable the change to more sustainable systems. Key elements that would raise the general profile of sustainability are related to, for instance climate resilience, soil quality improvements, water use efficiency and a reduction in environmental pollution.

Farmers will need to change or be encouraged to change for instance by diversifying their production using new varieties and crops to efficiently address the challenges that will occur in the future such as CTV, land abandonment, and water scarcity. Changes in policy such as the decoupling of payment schemes as part of the CAP subsidies and continued 'greening' of the CAP may aid this transition but the additional support via farmer advisory services, opportunities for continuing professional development (CPD) and the introduction of DSTs will potentially all have a role to play in these change processes.

Thus, to aid the change process this research recommends:

- A review and update of the educational framework for both farmers and advisers to tackle the challenges of sustainability awareness and performance, and technology uptake.
- The creation of vocational training programs oriented towards enhancing the continuing education of farmers on contemporary methods and skills.
- An enhancement of the role of the extension services to provide responsible guidance and advice possibly from a restructured network of extension officers that can support the change to more sustainable systems.

Further research is needed to explore the methods and tools through which decision-making can be informed and lead towards more sustainable farming systems in the Mediterranean region. Revitalising, and reorganising training for both farmers and advisers needs to be taken into consideration and be incorporated into future policies. Finally, the identification of the needs and requirements of stakeholders (farmers, advisers, extension officers, policy makers, industry representatives) to promote DST use and adoption is likely to be needed in order to enhance the decision-making towards the improvement of sustainability performance of farming systems in Argolida, Greece and the wider Mediterranean area.

Declarations of interest

Ethics approval

This project has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable opinion for conduct. APD Ethical Clearance Application Reference Number: 001279.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [D.I], upon reasonable request.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Consent for publication

The authors affirm that human research participants provided informed consent for publication in scientific journals but only in the form of average values for the group.

Authors contribution

Conceptualisation, D.I., Y.G., J.P.; Data collection, sustainability assessment, thematic analysis, writing—original draft preparation, D.I.; writing—review and editing, Y.G., J.P., D.I.; visualisation, D.I.; supervision, Y.G., J.P.; All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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