

Article

Exploring Farmers' Management Practices and Values of Ecosystem Services in an Agroecosystem Context—A Case Study from the Eastern Cape, South Africa

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Abstract: Globally, farmers remain the key ecosystem managers responsible for increasing food production while simultaneously reducing the associated negative environmental impacts. However, research investigating how farmers' agricultural management practices are influenced by the values they assign to ecosystem services is scarce in South Africa. To address this gap, a survey of farmers' agricultural management practices and the values they assigned towards ecosystem services was conducted in the Eastern Cape, South Africa. Results from the survey show that farmers assign a high value on food provisioning ecosystem services compared to other ecosystem services. Irrigation and fertiliser decisions were mostly based on achieving maximum crop yields or good crop quality. The majority of farmers (86%) indicated a willingness to receive payments for ecosystem services (PES) to manage their farms in a more ecosystems-oriented manner. To encourage farmers to shift from managing ecosystems for single ecosystem services such as food provision to managing ecosystems for multiple ecosystem services, market-oriented plans such as PES may be employed. Effective measures for sustainable intensification of food production will depend on the inclusion of farmers in the development of land management strategies and practices as well as increasing farmers' awareness and knowledge of the ecosystem services concept.

Keywords: best management practices; agriculture; food security; irrigation; fertiliser

1. Introduction

Agroecosystems provide a variety of benefits to humans, such as food, fiber, timber, and recreation. These benefits, whether direct or indirect, are defined as ecosystem services and contribute significantly to the wellbeing of human societies [1]. In agroecosystems, the supply of ecosystem services depends not only on the biophysical processes that regulate ecosystem function (e.g., climate, soil) but also on the way humans manage the ecosystem and related decision-making processes. In addition, challenges including climate change, increasing resource needs from a growing population have a significant effect on the ability of agroecosystems to continue generating ecosystem services. For example, based on projections from the Food and Agriculture Organisation (FAO), food production is expected to double by 2050 to meet the needs of an estimated world population of 9 billion [2]. However, achieving this increase in food production while simultaneously maintaining the integrity of the environment within an agroecosystem presents a significant challenge, particularly in areas where land and water resources are already limited.

This agricultural production challenge, known as 'sustainable intensification' (SI) is defined as producing more food from the same piece of land while minimizing negative environmental impacts and maintaining ecosystem function [3]. Historically, the food needs of society have been met through

agricultural expansion and the intensive use of inputs, such as chemical fertilisers and pesticides, to boost crop production. However, competing land uses such as the expansion of urban areas now makes it difficult for agriculture to expand into new areas and the expected food demand will have to be met through increased agricultural productivity [4]. The overuse of agricultural inputs, such as chemical fertilisers and irrigation water, has had negative impacts on the environment often causing problems such as eutrophication of water bodies and salinisation of soils respectively. In addition, climate change threatens the sustainability of agricultural systems through changes in factors influencing crop production such as temperature and precipitation. To increase food security, farmers are increasingly expected to increase agricultural productivity while minimizing land degradation through improved farm management and, at the same time, manage the risks associated with climate change and extreme weather through tools such as agricultural insurance [5,6].

To help achieve SI in agricultural systems, the use of agricultural ‘best management practices’ (BMPs) has gained interest in agricultural research [7,8]. BMPs are defined as a variety of site-specific farm management practices that have been field-tested to improve crop yields and minimise environmental pollution. BMPs, such as integrated irrigation and fertiliser management, can minimise the negative impacts of agriculture on the environment while maintaining agricultural productivity. This is in contrast to extractive agricultural intensification practices such as over-application of chemical fertilisers that can lead to environmental problems such as eutrophication and significantly undermine sustainable intensification efforts [9]. In practice, BMPs are therefore meant to enhance the provision of multiple ecosystem services while maintaining the integrity of the environment. Hence, the use of BMPs is central to the principle of SI [10] and key to guiding agroecosystems management towards the goal of SI.

While BMPs are meant to enhance the provision of multiple ecosystem services, the final decision to adopt BMPs rests with the farmer. Although BMPs have been developed for agriculture, farmer adoption of BMPs remains low [11,12]. This low adoption of BMPs often reflects practical concerns by farmers such as lack of compatibility of proposed management with existing farm management, financial reasons, and insufficient knowledge on the recommended management practice [13]. Several approaches have been explored to encourage sustainable agricultural land management. Economic instruments, such as payments for ecosystem services (PES), have been proposed as a viable option to encourage the conservation and restoration of ecosystems. PES are generally defined as voluntary transactions where a well-defined ecosystem service is bought by a buyer if and only if the provider secures the provision of such service [14]. In this study’s context, PES can be defined as the direct or indirect incentives offered to farmers or landowners in exchange for managing their land to enhance the provision of ecosystem services. However, research on PES in South African farming systems is still limited [15]. Other approaches include government subsidies, command and control regulations, and farmer education [16]. This study suggests that a better understanding of the reasons behind farmers’ management practices and the values they assign to ecosystem services is needed to develop effective strategies for SI and BMPs that farmers are likely to adopt.

At the farm scale, farmers remain the key decision-makers in agricultural land management and therefore, play an essential role in sustainable agricultural intensification [17,18]. Complementary approaches, such as climate-smart agriculture [4,19] that have the potential to increase food security while minimizing land degradation, all depend on farmers taking a central and active role in agricultural land management. Several studies have shown that farmers’ decisions are complicated, driven by personal factors (e.g., farm traditions) as well as external factors (e.g., markets) [20,21]. Vanday [22] further adds that, while farmers are influenced by the resources they possess to manage their lands—e.g., machinery—they are also motivated by the social and traditional farming practices of the farming community. In such cases, trade-offs often exist between what ecosystem services are biophysically necessary to maintain production and those valued by farmers in a socio-cultural context [23,24].

Consequently, the existence of trade-offs suggests an important link between what ecosystem services farmers value and the way farmers manage their farms. For example, farmers valuing food

provisioning services may implement measures that enhance food provisioning (e.g., high fertiliser use), whereas farmers valuing cultural services, may adopt measures that favor cultural services outputs (e.g., biodiversity conservation). These values farmers assign to different ecosystem services have important implications for sustainable intensification efforts as a failure to take into account farmers' values of different ecosystem services may result in mismatches between land management policies and what farmers practice. In turn, this mismatch between policy and practice may lead to further ecosystem degradation and low adoption of BMPs that may impede sustainable intensification efforts. It is therefore important to explore farmers' values of ecosystem services and how these values may influence farmers' local land management practices.

In South Africa, current challenges such as declining crop yields due to low soil fertility and agricultural water pollution indicate that there is still an incomplete understanding of how management practices affect agroecosystem services at the farm scale. However, studies exploring the links between farmers' values of ecosystem services and their local land management practices are scarce. The few studies on conventional farmers have focused mainly on enhancing crop varieties [25,26], improving irrigation and on-farm water use efficiency [27,28] or determining crop fertiliser requirements [29,30]. However, if the goal of sustainable intensification is to be realised, it is critical to explore the reasons behind farmers' land management practices decisions and whether the values farmers assign to agroecosystem services influence farmers' land management practices. Such exploratory studies can contribute perspectives and insights that can inform land management policies and strategies aimed at optimizing agricultural production in a sustainable manner.

Therefore, the objective of this preliminary study was to explore whether farmers' land management practices are influenced by the values they assign to agroecosystem services at the farm scale. To achieve this objective, a questionnaire-based survey targeting conventional farmers in the Eastern Cape was conducted to evaluate a) the reasons behind the current agricultural management practices being used by farmers in the Eastern Cape; and b) the values conventional farmers in the Eastern Cape assigned to different ecosystem services in agriculture. The results of the study can provide useful insights into farmers' decision making and help develop strategies to increase food production while minimizing environmental degradation and enhancing the sustainable provision of multiple ecosystem services from agricultural lands.

2. Key Definitions, Assumptions, and Conceptual Framework

2.1. Classification of Ecosystem Services

Various classifications of ecosystem services exist because of the specific biophysical and socio-cultural contexts in which they are defined or the scientific discipline of the researcher [31]. A review by de Groot et al. [32], found that most ecosystem services categories feature in mainstream classifications such as those by the Millennium Ecosystem Assessment [33] and *The Economics of Ecosystems and Biodiversity* [1]. For this study, the MEA definition of ecosystem services and classification is adopted. The MEA defines ecosystem services as the benefits people obtain from ecosystems [33]. The MEA classifies ecosystem services into four broad categories: (1) provisioning services—biotic resources derived from ecosystems that can be removed such as food and timber; (2) regulatory services—services that help to sustain an environment suitable for human life such as climate regulation, water purification, and flood regulation; (3) cultural services—these are mostly human-centred and refer to ecosystem components that are sources of inspiration for art, culture, and spirituality; and (4) supporting service—these are services that support the other three categories but are not a direct service to people for example nutrient cycling and soil formation [33]. Dietze et al. [34], explain that in literature, although various definitions and classifications of ecosystem services exist, the concept of ecosystem services is well known by scientists but not by practitioners such as farmers.

2.2. Sources of Information for Farmers

One way of understanding why farmers adopt certain management practices is to identify sources of information farmers use when making farm-related decisions. This knowledge could be helpful in developing alternative agricultural land management policies that promote sustainable intensification efforts. Several authors have argued that the concept of ecosystem services is not perceived by practitioners such as farmers [35,36] while the literature on farmers' sources of information when making agricultural land management decisions is limited [34]. However, a study by Schuler [37] found that farmers had learned about the concept of ecosystem services during interactions with agricultural extension officers and conservation specialists. The study, therefore, focuses on farmers' sources of information when making farm management-related decisions.

2.3. Consideration of Management Practices and Ecosystem Services

Schuler [37] explains that provisioning ecosystem services are viewed as the most important ecosystem services for farmers as they form the basis of farmers' livelihoods and income sources. However, studies show that ecosystem services are interrelated [38] and maximizing the provision of a single ecosystem service may lead to a decline in other ecosystem services and ultimately the degradation of the ecosystem as a whole. This study focuses on management practices related to irrigation and fertiliser management as they are directly related to increasing food production through additional inputs of nutrients and water. Inorganic fertilisers combined with irrigation can maximise crop yields but, if not well-managed, they can have negative impacts on scarce water resources especially water quality [39]. On the other hand, organic fertilisers can increase the carbon content of the soil, improve soil structure thereby promoting the creation and conservation of soil organic matter [40].

Sustainable agricultural land management is important to reverse land degradation and to maintain the integrity of agroecosystems that generate ecosystem services [41]. In the Eastern Cape, farmers are mostly affected by soils with declining nutrient availability, low rainfall, and frequent droughts [42]. To increase soil productivity, farmers often use fertilisers combined with irrigation water. Hence, the focus of this study is on irrigation and fertiliser management practices

2.4. Ecosystem Services Flow in Agroecosystems

In response to current debates on how ecosystem services flow from natural systems until society realises benefits, Potschin and Haines-Young [43], developed the "ecosystem services cascade model" to explain the flow of ecosystem services from natural ecosystems to humans. The model was developed to explain how the idea of ecosystem services can be used to understand the relationships between people and nature [44]. Briefly, the cascade model denotes ecosystem services as part of a production chain that links the biophysical components of an ecosystem to socio-economic and cultural gains in human well-being [45]. In the model, the service is placed between the ecosystem and human well-being implying that no service is provided without ecosystems and no service is used without humans [43,46]. However, the model has been criticised for neglecting societal influence by under-representing societal feedback mechanisms and the influence of agricultural land use and management on ecosystem services provision [46,47].

To overcome this shortcoming, this study adapts the cascade model to include the role of farmers in ecosystems management and ecosystem services provision. This study focuses on commercial and conventional farmers in the Eastern Cape as they are key decision-makers responsible for managing agricultural land and food production in the area. Conventional farmers are defined as farmers who regularly use inputs such as synthetic fertilisers and irrigation water in their day to day farming. Commercial farmers are defined as farmers who produce crops and livestock for sale, usually with the use of modern technology such as sprinkler and drip irrigation systems. In this study, 'farmers' refers to both conventional and commercial farmers.

In the adapted framework of this study (Figure 1), it is assumed that farmers' land management decisions are influenced by both the knowledge and values they have regarding ecosystem services and external drivers such as climate, government policies and the political context within which such decisions are made. Knowledge in the framework refers to farmers' understanding of how ecosystems provide benefits to society and the effects of their land management practices on such ecosystem services. Values here refer to the importance farmers assign to different ecosystem services within an agroecosystem context, while external drivers could be biophysical, e.g. climate, soils; and socio-economic, e.g. government policies, desired income, and profit from farming. There are also feedback loops between biophysical drivers and socio-economic drivers, for example, prolonged droughts can influence the development of policies on water usage which in turn, can significantly affect the way farmers manage their farms. Decisions refer to the desired action chosen among alternatives after taking into consideration the knowledge and values about ecosystem services in addition to the influence of external driving influences [48].

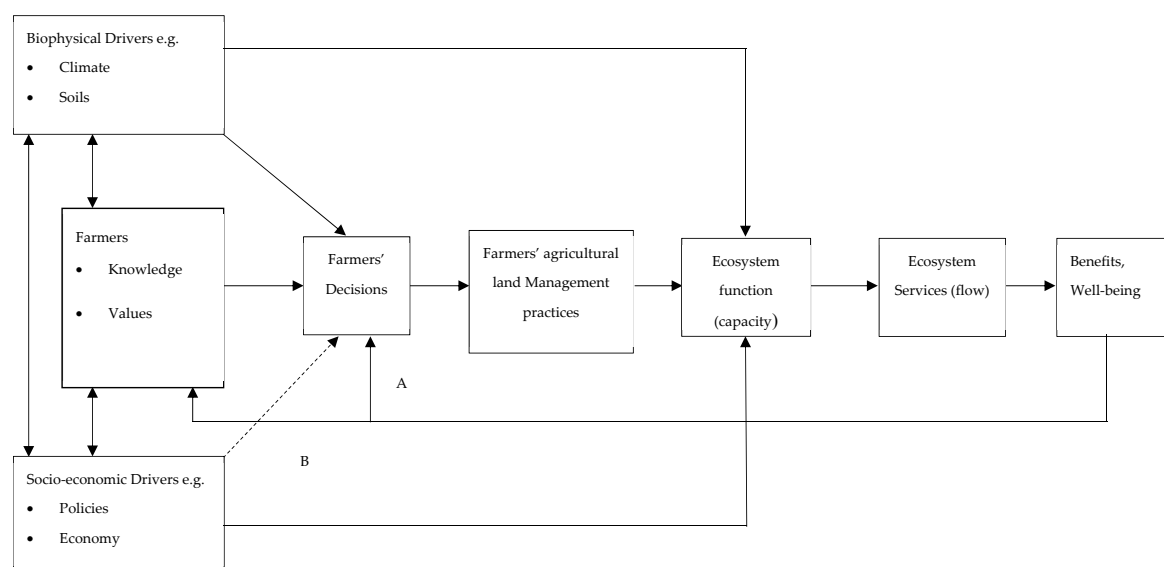


Figure 1. Adapted 'ecosystem services cascade' to show how farmers' agricultural land management practices affect the flow of ecosystem services. The framework shows the links and feedback between farmers' values and knowledge, management practices, and ecosystem services. Benefits and values from ecosystem services can have direct effects (A) and indirect effects (B) on farmers' decisions. The model is inspired by Potschin and Haines-Young [43] and Lamarque et al. [48].

3. Methods

3.1. Study Area

The study was carried out in the Eastern Cape (Figure 2). Rainfall follows a bimodal pattern with winter rainfall generally in the west of the province and summer rainfall in the east. Agriculture remains an important economic activity in the Eastern Cape for both subsistence and commercial farming. Most subsistence farming occurs in rural areas while commercial crop farming is mostly concentrated around 'farming' towns (towns in which agriculture is the major economic activity). The majority of these farming towns are situated along rivers where river water is used for irrigation purposes. Somerset produces beetroot, carrots, and most vegetables while the Cradock area has maize, pasture, dairy, and beef producing farmers [49]. In the inland areas of the Karoo, the harsh climate limits agriculture to livestock farming. Declining soil productivity and increasing water scarcity due to low rainfall and frequent droughts have led to an increase in irrigation water and fertiliser use to maintain agricultural productivity. Consequently, the increased use of fertiliser and irrigation water has led to a general deterioration of environmental water quality in commercial farming areas [42].

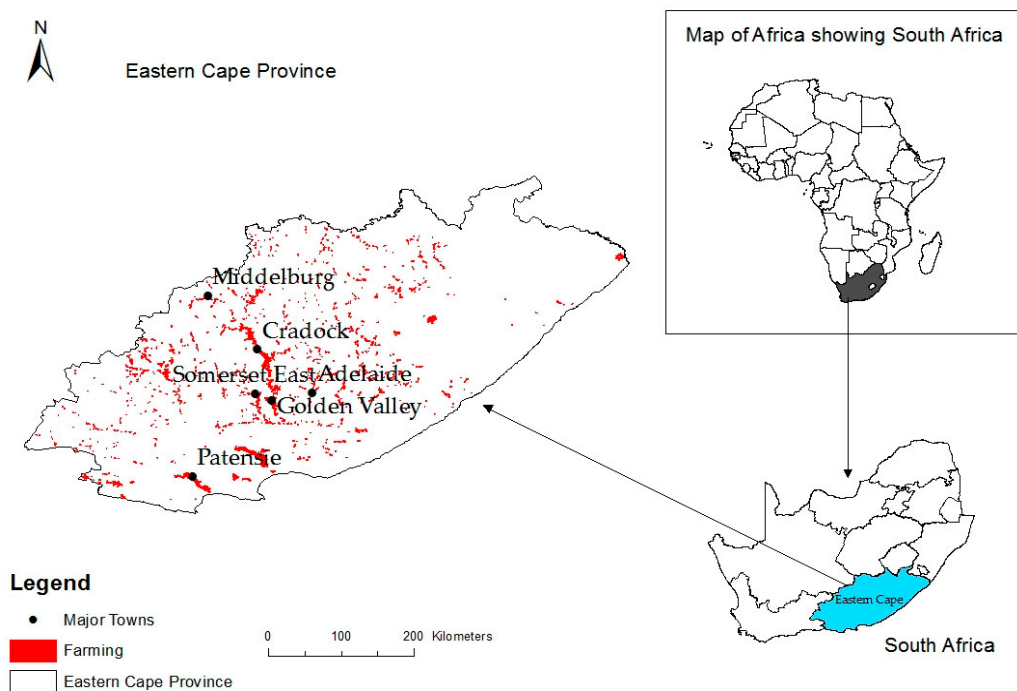


Figure 2. Map of Africa showing South Africa and the locations of the major farming towns in the Eastern Cape.

3.2. Farmers Selection

The study targeted farmers in the major farming towns in the Eastern Cape (Cradock, Somerset East, Middleburg, Golden Valley, and Adelaide). The targeted farmers were either the farm owners or farm managers who managed the farm on behalf of the farm owner. The Eastern Cape provincial government has recently embarked on plans to boost agricultural production in the Eastern Cape, an area which has been predominantly a livestock production area. The government launched the Agricultural Economic Transformation Strategy in an effort to maximise agricultural land uses, especially in the communal areas where land has been underutilised. Increasing agricultural production in this area can contribute to job creation and increased food security in the Eastern Cape area, however, this increase in production must not be at the expense of the environment.

Purposive sampling [50–52] was used in this study to select farmers that used inputs such as fertilisers and irrigation water regularly. Although random sampling procedures are considered more rigorous and accurate than non-probabilistic sampling methods, there may be instances where it is not feasible or practical to apply a random sampling method [53]. At the time of carrying out this research, there were—and still are—ongoing political debates in South Africa on issues of land reform and land redistribution. As a result, many farmers that were contacted were not willing to participate in studies that involved them giving out information concerning details of their farm enterprises.

To overcome this challenge, farmers' organisations in the Eastern Cape (Agri Eastern Cape and Eastern Cape Farmers Group) were approached to identify farmers that would be willing to participate in the study. Ten farmers were initially identified and then contacted via email and also asked to identify other farmers that would be willing to participate in the survey. Through this snowballing sampling process [54], an additional 21 farmers were identified. An online version of the survey questionnaire was developed and the link attached to a request letter, which was shared via email with the identified farmers. Additionally, the survey link was shared on the online social networking platform of the Eastern Cape Farmers Group, after approval from the farmers' platform administrators, inviting farmers to complete the survey following [13]. This was done to accommodate farmers who

were not identified beforehand but would be agreeable to participating in the survey. This meant that farmers also had the option to self-select and participate in the study.

The research was conducted from January to April 2019. A period of two months after April was given to allow feedback from online/e-mail participants. During this two-month period, regular follow-ups were carried out to encourage participation. According to [54], the longer a respondent delays replying, the less likely he or she will be to do so. Therefore, at the end of the two-month period, it was assumed that no more responses would be received. The study was conducted in accordance with the Declaration of Helsinki, and the questionnaire and research design approved by the Rhodes University Research Ethics Committee (ethics approval no. SCI2018/007).

3.3. Questionnaire Development and Survey

The survey questionnaire, adapted from [55] and [56] (see questionnaire in Supplementary Materials), consisted of both open and closed-ended questions to elicit responses that could be analysed qualitatively and quantitatively. For closed-ended questions, respondents were allowed to add to the existing categories [57,58]. The questions were formulated and presented in sections according to the following aspects: (1) agricultural management practices; (2) the values assigned to different agroecosystem services by farmers; and (3) demographic information. For the sections on ecosystem services and payments for ecosystem services (PES), a brief description and explanation of the terms were given at the beginning of the section (see questionnaire in Supplementary Materials). At the end of the questionnaire, participants were given the room to express any comments they had regarding agricultural land management practices and agroecosystem services.

For quality assurance, the questionnaire was pre-tested in focus groups with postgraduate students at Rhodes University, who had a background in agriculture and survey research methods. Only students who had gone for internships for more than a year in farms in the Eastern Cape were chosen for the test group. These students were deemed knowledgeable about the type of farming practiced in the Eastern Cape. Feedback from the group was incorporated to improve unclear and misleading/confusing wording.

3.4. Data Analysis

Thematic Analysis

Open-ended questions such as reasons for the type of fertilisers and irrigation methods were analysed using a thematic analysis. The questions were developed with the intention of getting insights into why farmers used particular management practices and the values they assigned to ecosystem services. Thematic analysis is a technique for classifying recurrent and emerging themes [59] and establishing a framework for presenting the meaning of collected data. The method is flexible and can be modified according to the needs of the study. The method can also be used for both explorative and deductive studies. Thematic analysis was chosen because the method can be used to produce an insightful analysis that answers the research question based on the data collected from key informants, in this case, farmers.

The data were compiled in Microsoft Excel 2016 and each question and response coded, grouped, and ranked. The thematic analysis method used in this study was based on a 6-step framework developed by Braun and Clarke [60]. The six steps were as follows; Step 1 involved becoming familiar with the data by reading and re-reading the transcripts and writing down ideas and early impressions from the data. Step 2 involved generating initial codes relevant to the research objectives. Codes could also be modified during the coding process. In this research open coding was used, meaning that there were no pre-set codes but codes were developed during the coding process. New codes were created while some codes were also modified. Step 3 involved searching for themes and combining codes into prospective or potential themes and collecting all data relevant to each prospective theme. Step 4 comprised of reviewing codes, modifying and developing codes from the preliminary themes

generated in Step 2. All data relevant to each theme was gathered. Step 4 also included checking whether the themes made sense with respect to the research context and if the data supported the themes. Step 5 involved defining themes by generating names of the themes and clear definitions. The final step, Step 6, involved producing the report for analysis.

4. Results

4.1. Profile of Farmers

The basic characteristics of farmers who participated in the survey are summarised in Table 1. The average farming experience was 12 years and the average age of respondents was 46 years. Of the 48 farmers who participated, 56% had a university degree, 40% had completed a diploma or technical vocation training and 4% had a high school education only. The farmed area managed ranged between 2 hectares to 2000 hectares with an average of 246 hectares per farm. Most farms greater than 300 hectares were skewed towards beef and dairy cattle production. The majority of farmers were mixed farmers (70%) having both crops and livestock whilst 24% were ‘crops only’ farmers and 6% ‘livestock only’ farmers. There were 75% of farmers who engaged in cereal farming, mostly wheat, and maize, 31% who grew legumes on their land and 23% who engaged in fruit and citrus farming.

Table 1. Demographic information of farmers showing the age, gender, education, and type of farming (n = 48).

Summary of farmers' demographic information		Total (n = 48)
Age (mean)		46
Gender (%)	Male	70
	Female	30
Education (%)	University degree	56
	Diploma and Technical college	40
	High school and lower	4
Crop type (%)	Cereals	75
	Fruits and citrus	23
	Vegetables	58
	Legumes	31
Livestock (%)	Beef cattle	38
	Dairy cattle	17
	Poultry	52
	Sheep and goats	54
Farm size (%)	Small < 5 hectares	25
	Medium 5–100 hectares	52
	Large > 100 hectares	23
Farm type (%)	Crop only	24
	Livestock only	6
	Mixed	70

4.2. Sources of Information when Making Farm Management Decisions

The survey results show that the majority of farmers consulted other farmers when making farm decisions. Other noteworthy sources of information were the Internet, Farmer Organisations and Agricultural magazines. The least cited source of information was self-teaching (6%). Figure 3 shows a summary of the sources of information farmers used when making farm decisions.

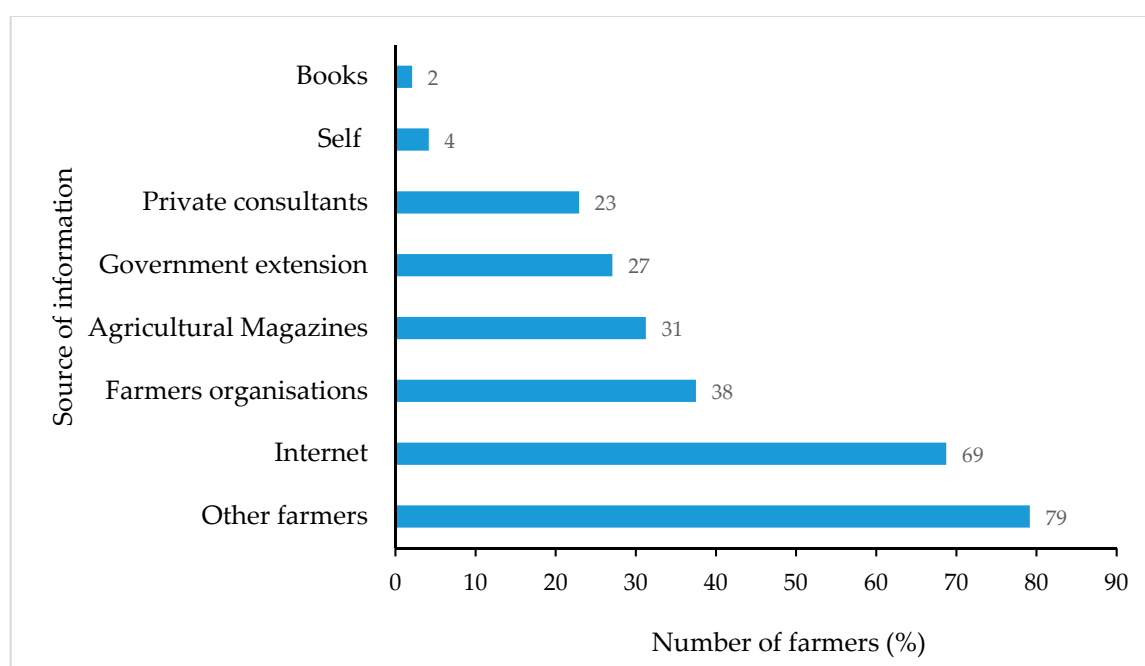


Figure 3. Sources of information used by farmers when making farm management-related decisions.

4.3. Irrigation and Fertiliser Management Practices

4.3.1. Irrigation Management

A total of 83% of farmers irrigated their land with the rest relying on rainfall. Irrigation scheduling was primarily determined by farmer experience (58%) and plant appearance or need (47%) (Table 2). Regarding irrigation methods, farmers applied irrigation via overhead sprinklers (58%), drip (33%), or surface irrigation (20%). Thematic analysis identified four main themes farmers cited as reasons for their choice of irrigation method, which included available irrigation equipment, water-saving, saving money, and crop type (Table 2). For example, farmers responded:

“I use Sprinklers for better germination on direct-seeded crops, drip to avoid disease on some crops.”

“Cannot afford drip system.”

Table 2. Survey of irrigation scheduling and reasons for the use of particular irrigation methods by farmers (n = 40). Respondents were asked open-ended questions about how they scheduled irrigation and the reasons they used specific irrigation methods.

How do you schedule irrigation? (n = 40)	Respondents (%) ¹
Past experience	58
Plant need	47
Set schedule	10
Sensors	2
Reasons for type of irrigation method used (n = 40)	Respondents (%) ¹
Crop type	43
Saves money	30
Saves water	23
Available irrigation equipment	20
Environmental considerations	10

¹ Farmers could choose more than one option, hence percentages do not add up to 100.

With regard to income and irrigation type, farms with higher income mainly used sprinkler irrigation systems (Figure 4). there were more farms with smaller incomes using drip irrigation compared to farms with higher income. The highest number of farmers using surface irrigation was recorded in the category in which farm income was less than 50,000 Rands per annum.

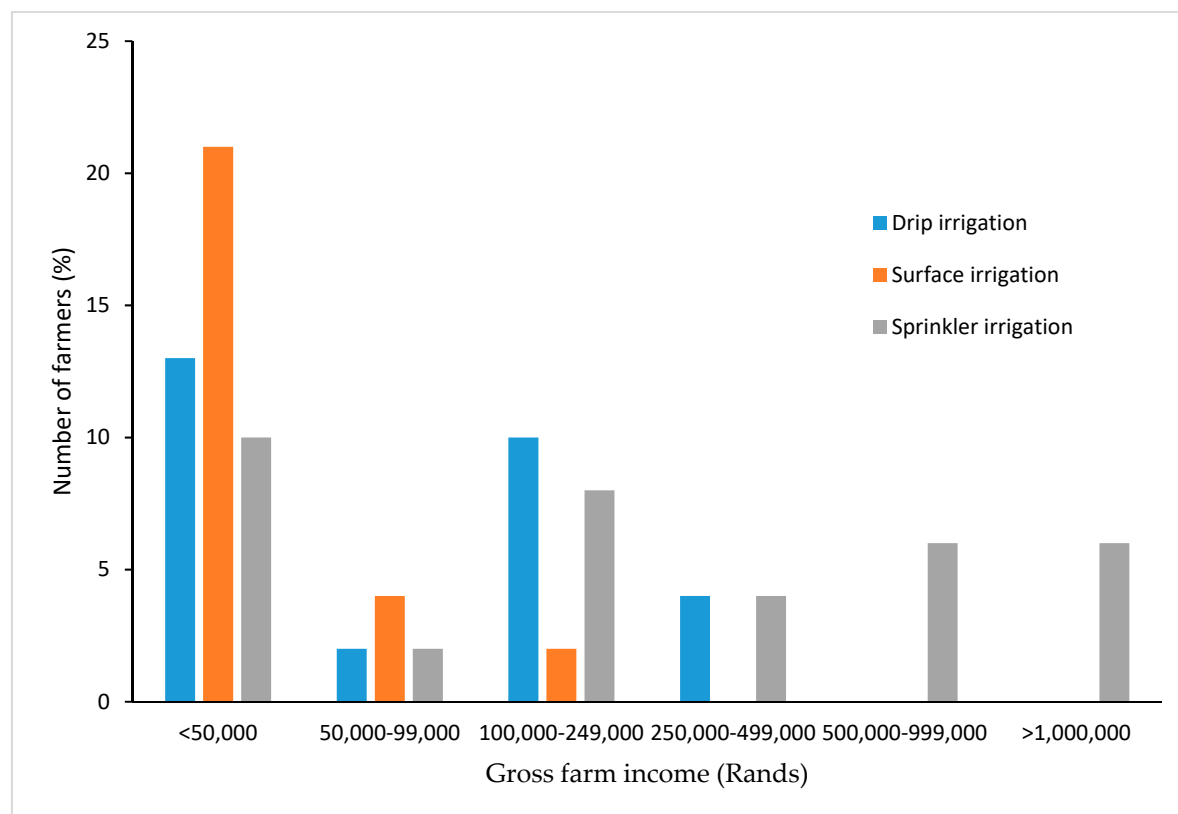


Figure 4. Graph showing the type of irrigation used by farmers in a particular income group.

4.3.2. Fertiliser Management

Concerning fertiliser type, 44% of farmers used a combination of both inorganic and organic fertilisers, while 26% used inorganic fertilisers only, and 30% used organic fertilisers only. The most common method of fertiliser application was broadcast (60%). Fertiliser application in liquid form was reported by 26% of respondents while controlled release accounted for 11%. Only one farmer cited that they used aerial spraying. Fertiliser application timing was based mostly on farmers' experience, plant appearance, and soil testing (Table 3).

The most recurrent themes cited for the type of fertiliser used were crop yield or crop quality (53%) and the cost of fertiliser (47%). Other reasons for using a particular fertiliser included environmental considerations and recommendations from soil tests (Table 3). Farmers' responses included:

"Organic fertiliser is good for the environment, but I don't get it in sufficient amounts so I also use chemical fertilisers which I can readily buy."

"Inorganic fertilisers are easy to apply and increase yields."

Table 3. Survey of fertiliser management strategies given to farmers (n = 47). Respondents were asked open-ended questions on how they scheduled fertiliser application timing and the reasons they used particular methods of fertiliser application.

How do you schedule fertiliser application timing? (n = 47)	Respondents (%) ¹
Past experience	70
Plant appearance need	60
Soil testing	45
Supplier recommendations	38
Consultant/extension	21
Other farmers	6
Reasons for type of fertiliser used (n = 47)	Respondents (%) ¹
Crop yield/crop quality	53
Cost/cheap/save money	47
Environmental considerations	23
Soil test recommendations	2

¹ Farmers could choose more than one option, hence percentages do not add up to 100.

4.4. Ecosystem Services

4.4.1. Knowledge of Agroecosystem Services

After a brief explanation of what ecosystem services were, farmers were asked if they had ever come across the term ecosystem services before the present study. A total of 77% of farmers indicated that they had never heard of the term before, and 23% reported they had heard the term before. Farmers were then asked to indicate how frequently they thought croplands provided eleven selected ecosystem services or benefits to society. The selected ecosystem services included provisioning, regulatory, supporting, and cultural services (Table 4). The provision of food was ranked highest as the benefit that croplands always provided followed by ‘farmlands are pleasing to look at’. Provision of fuel was cited as the least frequent ecosystem service farmlands provided.

Table 4. Farmers’ responses to the question, how frequently do you think farmlands provide the following ecosystem services to society

Ecosystem service	Number of farmers (%)		
	Always provided	Sometimes provided	Never provided
Provide food	75	25	0
Provide recreation	65	23	13
Provide medicine	60	15	25
Provide clean air	48	46	6
Are pleasing to look at	44	56	0
Reduce soil erosion	25	58	17
Maintain species diversity	17	58	25
Provide fuel	13	69	19
Regulate local climate	10	73	17
Provide fresh water	8	60	31
Reduce flooding	8	73	19

4.4.2. Value of Ecosystem Services from Agriculture

Farmers were then asked to rank how valuable to them the benefits croplands provided were. Table 5 shows the results of how farmers ranked ecosystem services according to value. Food provisioning was valued higher than all the other ecosystem services followed by the provision of clean air. The provision of fuel was cited as the least valuable ecosystem service coming from agricultural lands.

Table 5. Values assigned to different ecosystem services by farmers

Ecosystem service	Number of farmers (%)		
	Very valuable	Medium value	Not valuable
Provide food	88	10	2
Provide clean air	83	17	0
Reduce soil erosion	67	31	2
Provide fresh water	58	35	6
Are pleasing to look at	54	42	4
Reduce flooding	54	38	8
Maintain species diversity	50	31	19
Provide recreation	42	29	29
Regulate local climate	42	48	10
Provide medicine	38	42	4
Provide fuel	21	48	31

4.4.3. Payments for Ecosystem Services

86% of the farmers specified that they would be prepared to participate in a conservation program that offered payments for improving ecosystem services on their farmlands, whilst 4% said that they would not be willing to participate and 10% were not sure if they would be willing to participate in a PES scheme at the time of the survey. Concerning who should be responsible for maintaining the benefits from farmlands, 50% of the farmers indicated that society should be responsible, while 50% thought it was the responsibility of farmers.

5. Discussion

5.1. Profile of Farmers

A total of 48 farmers participated in the study and completed the questionnaire, the number having been limited by project resources and a generally low willingness to participate in the survey by commercial farmers. From the 31 farmers identified through the snowballing process, 14 farmers filled out and returned the questionnaire through email representing a 45% response rate. For the online questionnaire, 34 complete responses were returned.

An examination of the participants showed that participants were mostly crop farmers, livestock farmers, and mixed farmers, which was judged to be representative of the range of farmers in the Eastern Cape. A spatial analysis of the responses also revealed that responses came from the majority of towns in the Eastern Cape where farming was the major activity, with each town receiving at least one response. The proportion of crop and livestock farmers in the study reflects the type of farming in the Eastern Cape area. While the most recent published agricultural census at the time of writing was in 2007, expert opinion [61] revealed that the type of farming is mostly mixed farming of crops and livestock. The area has been predominantly a livestock producing region due to the semi-arid climate that prevails in the region. These conditions are generally not ideal for cereal production compared to the warmer and traditional cereal producing areas such as Kwa-Zulu Natal. However, the production of cereals such as maize has gained interest in recent years due to government efforts to increase grain production in the Eastern Cape [49]. This explains why there are more farmers engaged in both livestock and crop farming compared to single enterprises.

The choice of fertiliser was mainly based on crop type. Farmers' comments revealed that organic fertilisers were used mostly for vegetables whilst inorganic fertilisers were used primarily for cereal crops. A common reason for using organic fertilisers on vegetables was to improve the quality of vegetables whilst inorganic fertilisers were preferred for cereals to ensure maximum grain yields. Studies have shown that consumers have a higher preference for organically produced vegetables as they perceive them to be healthier than conventionally produced vegetables [62–64]. This may explain

why farmers used organic fertilisers for vegetables, to improve the quality of vegetables, and inorganic fertiliser for cereals, where quality may be less important compared to yield.

Also, there were fewer 'organic-only' farmers compared to farmers who used a mixture of both fertilisers. Several studies have shown that while organic farming systems are more environmentally sustainable, they produce lower yields compared to conventional systems [65,66]. This difference in yield between conventional and organic systems may discourage farmers who are 'maximum yield-oriented' from converting to organic farming systems. However, studies by Sandhu et al. [67], have shown that the total economic value of ecosystem services may be higher in organic farms compared to conventional farms. In addition, studies by Cavigelli et al. [66] and Pergola et al. [68], found that the production costs for conventional agriculture were higher compared to organic-based agriculture over the long term period. Thus, farmers may not have complete knowledge of the economic performance of organic farming versus conventional farming when total ecosystem services are considered and require further education on the disadvantages and advantages of both farming systems.

5.2. Fertiliser Management

In this study, results show that although the cost of fertiliser was a factor in the choice of fertiliser applied, farmers mainly considered fertilisers that enhanced crop appearance or crop quality, or led to increased yields when choosing fertilisers. Few farmers cited environmental considerations as a driving factor when choosing the type of fertiliser. This is likely to be a response for farmers to produce maximum yields and good quality crops within the growing season period and make a profit, even though it might be at the expense of the environment. This suggests that farmers may need more education on how ecosystem services are interlinked and how maximizing the provision of one ecosystem service may, in the long run, lead to a general decline of all ecosystem services from a given parcel of land. However, since farmers consider profits, farmers may need incentives for them to seriously consider the environmental implications of fertiliser choices and not focus only on economic goals.

The broadcast method was a common fertiliser application method as it provides an easy and convenient way of applying solid fertilisers such as nitrogen compounds and manure. However, in a study by Khan et al. [69], comparing fertiliser application methods, the broadcast method was found to be less efficient than other methods such as ring application and fertigation, with fertiliser being easily washed away and lost in runoff. The use of this method indicates that farmers are losing part of their fertilisers through this application method and this affects crop yields and has implications for sustainable intensification.

5.3. Irrigation Management

Concerning irrigation management, the most cited method of irrigation—overhead sprinklers—has been shown to be less efficient compared to drip irrigation when it concerns water-saving [70,71]. While drip irrigation might be the logical choice because of its higher efficiency in saving water, results show that the reasons why farmers use one irrigation system over another are varied, complex, and not always about the efficiency of the irrigation system. Farmers' responses showed that besides efficiency, the choice of irrigation method was also dependent on what irrigation equipment was available to the farmer, the cost of maintaining the irrigation system and what irrigation system the farmer could afford. This information is important when making recommendations to farmers on irrigation systems as an emphasis on the most efficient irrigation system only, might not be helpful or even possible for all farmers. Hence, it is important, from an agricultural extension perspective, to consider local constraints to the adoption of 'best' irrigation management practices before suggesting alternative irrigation methods to farmers. For example, the efficiency of surface irrigation systems can be improved by leveling fields and collecting and re-using runoff. Demonstrating this information to farmers through farmer field schools might be useful to farmers who cannot afford the most efficient irrigation system and encourage them to manage their existing irrigation systems more efficiently.

5.4. Simultaneous Management of Irrigation and Fertiliser Inputs

Although the irrigation and fertiliser methods being used by farmers in this study vary in their efficiency of use, none of the fertiliser and irrigation application and scheduling methods are 100% efficient and all result in fertiliser and water loss from the growing area. Results also indicate that most farmers manage fertiliser and irrigation separately using methods such as past experience and plant observation which may not be entirely accurate in determining crop irrigation and fertiliser. However, fertiliser and irrigation management closely interact in determining crop yields [55]. Farmers must manage both inputs carefully to achieve high yields and make a profit on their investments while reducing the impact of water and nutrients use on ecosystems and ecosystem services. Using the appropriate amounts of fertiliser and water at the right time is key to improving yields and minimizing negative environmental impacts. However, the results of this study show that farmers may not be practicing this balanced application of fertiliser and water due to financial capacity, logistic constraints or lack of appropriate knowledge. Developing innovative irrigation systems designed to suit local farmers and farmer education on appropriate fertiliser and irrigation management practices through Farmers' Organisations and Farmers' online social media groups may help farmers choose the best irrigation and fertiliser management practices that can achieve both economic and environmental objectives.

In this study, farmers mentioned experience as an important knowledge source for scheduling irrigation and fertiliser management practices. A literature review by Ritter et al. [72], came to the conclusion that farmers often used knowledge from their farming experience more than knowledge from education. The review went further to suggest that this experience included information learned from exchanges and discussions between farmers themselves. This is also in agreement with the results of this study as the major source of information for farmers was from other farmers. Events such as farmer field school or farm tours organised by Farmers' Organisations or government agencies such as the Eastern Cape Rural Development could provide a platform for researchers and government officials to introduce and discuss the concepts of sustainable intensification and ecosystem services with farmers. These discussions could help fill the gap between scientific information and farming practices by bringing together theory and practice in a practical and all-inclusive manner for all stakeholders. Ground-level support from extension officers and dialogue between farmers and scientists are conducive for the implementation of effective and sustainable fertiliser and irrigation management practices.

5.5. Sources of Information for Farmers

With regard to sources of information, results show that most farmers obtain their information for making farm-related decisions from other farmers. The results of other studies with farmers have shown that the majority of farmers also get their information when making farming decisions from other farmers [53,73]. The Internet and Farmer's Organisations were also important sources of information in this study. Research shows that internet use in South Africa is on the rise, especially through mobile phones, with more people being able to access a variety of information on their mobile smartphones [74]. Studies by Lu and Chang [75] and Phillips et al. [76], have demonstrated that farmers are increasingly using social media platforms including Facebook for knowledge exchange to support on-farm decisions. This is in agreement with the results of this study in which the majority of farmers indicated the use of the internet as a source of information for making decisions. This suggests that potential for engaging farmers in policy and agricultural land management discussions may entail outreach through internet platforms such as online farmer groups and electronic agricultural magazines or through Farmers' Organisations which have online platforms as these sources seem to be popular with farmers.

Interestingly, government extension accounted for less than half of the farmers as a source of information. Several studies in South Africa have highlighted challenges currently being faced by government extension services such as lack of skilled manpower and financial support in extension

and conservation [53,77]. Studies by Mnkeni et al. [78], at the Zanyokwe and Tugela Irrigation Schemes in the Eastern Cape, highlighted that extension officers lacked basic technical skills in crop husbandry and irrigation management and could not fully support farmers. There is, therefore, an opportunity for the government to work with farmers to increase awareness of the ecosystem services concept. Efforts to work with farmers and invest more resources in building capacity of extension services should be prioritised so that government extension specialists are able to fully support farmers in developing and adopting strategies that improve crop yields while protecting the environment at the same time.

5.6. Concept of Ecosystem Services in Practice

Researchers and policymakers are increasingly using the ecosystem services concept to deal with natural resources management however this does not seem to be the case at the farming community level. In this study, 77% of farmers were not familiar with the term ecosystem services. This is in agreement with studies by Bernues et al. [79] in which more than 70% of the survey respondents were not familiar with the term. Although farmers were not familiar with the term ecosystem services, the results of this study show that farmers were knowledgeable about ecosystem services without calling them ecosystem services. By ranking (always, sometimes, or never) the selected ecosystem services that agriculture provided, farmers demonstrated knowledge and understanding of what ecosystem services were, even if they did not specifically use the term ecosystem services. This is similar to studies by Lamarque et al. [48] and Koschke et al. [36], in which farmers were knowledgeable about ecosystem services without calling them ecosystem services. In a similar study, Smith and Sullivan [56], highlighted that poor familiarity with the term ecosystem services is a reflection of different exposure levels towards the concept of ecosystem services with a low awareness at the farming community level while there is a high level of awareness at the research level. Another reason for farmers being less familiar with the term ecosystem services may be that currently there is no agreed definition of the term ecosystem services [80] and several terms such as ‘nature’s benefits to people’ or ‘nature’s contribution to people’ are used to refer to ecosystems services. Dietze et al. [34] further explain that the term is still very much theoretical and more comprehensive terms would contribute much to enable the implementation in practice.

5.7. Consideration of Ecosystem Services in Agricultural Farming Practices

Food provisioning was considered as the most important ecosystem services for farmers because it is the source of livelihoods and income for farmers. This is supported by studies by Logsdon et al. [81], who found that farmers placed a higher value on the provision of food compared to other ecosystem services such as climate regulation. This shows that farmers typically manage agricultural lands for food provision and economic reasons and not necessarily for the provision of other ecosystem services. This management of ecosystems for single services based on economic considerations only could reflect a lack of complete knowledge by farmers on how ecosystem services are interconnected and influence each other. For example, climate regulation was not valued as highly as the provision of food. However, climate regulation and agricultural production are highly interlinked [34] with the majority of greenhouse gas emissions coming from agricultural land uses such as deforestation and the application of chemical fertilisers and manure [82].

From a sustainable intensification and ecosystem services point of view, farmers are critical stakeholders responsible for agroecosystems management and ecosystem services supply. While farmers may manage agroecosystems for the sole purpose of food provision, food provision is just one of a variety of interconnected ecosystem services supplied by agroecosystems. Swinton et al. [83] explain that agriculture supplies and receives ecosystem services that range well beyond the provision of food. Previous research has demonstrated that when farmlands are managed for maximum food production, other ecosystem services may decline and ultimately lead to a decline in overall agricultural productivity [84]. This highlights an urgent need to adopt an ecosystem services approach to managing agroecosystems that advocates for the management of multiple ecosystem services rather

than single services based on economic considerations only. Increasing farmers' knowledge on the interconnectedness of ecosystem services and how supporting services underpin food provisioning may encourage farmers to manage their farms in a more sustainable way and move away from managing ecosystems for single services, such as food provisioning to managing ecosystems for multiple ecosystem services.

5.8. Research Needs and Recommendations for Policy Implementation

Studies that quantify ecosystem services provision in agricultural ecosystems are important to identify trade-offs and make decisions involving trade-offs. However, studies that assess stakeholder perceptions in agricultural land management are also important to complement quantification studies and give a holistic view of ecosystem services provision in agricultural landscapes. Both types of studies are important as they offer complementary information on the biophysical factors and socio-economic factors that drive the provision of ecosystem services in agricultural landscapes. The results of this study show the importance of case studies in investigating local preferences in terms of ecosystem services. This can help policymakers to develop policies that respond to local stakeholder needs and are context-specific. Further research should focus more on interrelationships between multiple ecosystem services provision and stakeholders' awareness of the relationships between different ecosystem services.

Understanding the reasons why farmers adopt certain management practices and the values they assign to different ecosystem services is important if society is to achieve sustainable food production. Individual differences between farmers exist and farmers may have different goals, be in different stages of the farming life cycle and have different values and perceptions which may all influence decision making processes on the farm. Hence, there is no 'one correct way' of farm management that will suit all farmers. However, considering these factors in developing land management policies and recommending 'best management practices' is critical if farm businesses are to progress in a sustainable way. Failure to take into consideration these factors will likely result in a mismatch between policy and practice and lead to conflicts between stakeholders and low adoption of ecosystem-oriented management practices. An understanding of the human element and farmers' decision-making process in ecosystem services provision will help researchers provide farmers with more accurate information, improve communication between farmers and policymakers, and increase the adoption of good agricultural land management practices which will result in better outcomes for both farmers, society, and the environment.

In this study, the majority of farmers indicated a willingness to participate in conservation programs that would offer payments to improve ecosystem services management. The implication for sustainable intensification and land management policy development is that farmers may require ongoing financial payments 'on behalf of society' to manage ecosystems in a more sustainable way for present and future generations. Other studies such as those by Hanslip et al. [85] and Xiong and Kong [86] have demonstrated that farmers are generally willing to receive payments to manage ecosystems more efficiently. Payments for ecosystem services (PES), while beyond the scope of this study, have been the focus of several studies [87–89]. Although not a cure-it-all solution to address ecological problems in agriculture, PES can be a useful policy tool to enhance ecosystem services management in agricultural landscapes. The results of this study provide further evidence to motivate the implementation of such policies in South Africa. Farmers' willingness to participate in PES programs is an indication to policymakers to develop PES programs and incentives for farmers to manage their farms in a more efficient and sustainable manner. However, it is important to involve farmers and other stakeholders early on in any PES development programs, for example, on which ecosystem services should PES be prioritised. This is in order to minimise the likelihood of mismatches between policy and implementation which might lead to unintended outcomes and further ecosystem degradation.

Few conservation agriculture initiatives that are farmer-led have been implemented in the key commercial farming areas in the Eastern Cape. Much of the work being done in the area of PES is being carried out by Working for Water and focuses on invasive alien species such as Black Wattle [90]. Programs that specifically target conventional farmers to improve agroecosystem services at the farm scale may increase the likelihood of achieving sustainable intensification in the Eastern Cape. Policies aimed at enhancing and strengthening conservation agriculture innovation systems and programs that are farmer-centered and farmer-driven could be an important platform to increase the wider adoption of ecosystem-oriented agricultural management practices that contribute to sustainable intensification of crop production. To increase wider use and adoption of agricultural BMPs, government outreach workshops and farmer field schools could be conducted to educate farmers on the range of BMPs available and how they relate to the ecosystem services found on their farmlands.

6. Conclusions

Farmers are critical stakeholders in the management and provision of ecosystem services in agricultural ecosystems. Farmers have a variety of reasons—such as costs, equipment available, crop yield, and crop quality—when choosing agricultural land management practices. Farmers recognise that croplands provide a variety of ecosystem services such as food, clean air, and aesthetic beauty. Farmers assign different values to ecosystem services with food provision being valued the highest. Although farmers acknowledge the range of ecosystem services provided by farmlands, most farmers in the Eastern Cape are not familiar with the term ecosystem services yet. To develop effective policies and agricultural land management practices that promote sustainable intensification in agricultural systems, it is important to know the reasons behind farmers' management decisions and have a good understanding of farmers' perceptions of ecosystem services. This is because farmers' reasons for adopting certain agricultural management practices and their perceptions towards different ecosystem services are linked to their attitudes towards ecosystems management and hence affect the way farmers manage agricultural ecosystems.

Ecosystem services-based agricultural land management is a promising way of safeguarding the sustainability of agricultural systems. However, efforts to educate farmers on BMPs and complementary approaches, such as climate-smart agriculture, should be increased in the Eastern Cape. This can be achieved through the strengthening of extension services and farmer field schools, where sharing and exchange of information between farmers, researchers, and policymakers can be encouraged. While financial measures such as PES can play an important role in encouraging farmers to adopt sustainable agricultural land management practices, it is equally important for farmers to realise that managing their farms for single ecosystem services may be unsustainable in the long-term and eventually lead to a decline in the total ecosystem services provided by farmlands, including food provisioning.

The results of the study suggest that to achieve sustainable management of croplands in South Africa and increase the adoption of sustainable agricultural land management practices in farming requires: (1) a common language between researchers, policymakers and farmers, (2) a knowledge of the factors that drive farmers when making farm management decisions, and (3) the values and importance different stakeholders in agriculture assign to different ecosystem services. The study presents a preliminary study that offers insights into some of the important factors related to farmers' decision making and how this affects the provision of agroecosystem services. Future studies should investigate the amount or types of PES that would be attractive to farmers as well as test farmers' knowledge on the interrelationships between multiple ecosystem services.

Supplementary Materials: Questionnaire for Eastern Cape conventional farmers are available at <http://www.mdpi.com/2071-1050/11/23/6567/s1>.

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