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LEARNING FROM THE GRASSROOTS: THE CASE FOR THE CONSIDERATION OF COMMUNITY-BASED AGRARIAN AND FOOD SECURITY REFORMS IN SOUTH AFRICA

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ABSTRACT

Studies of projected agro-climatic variability on the productivity of smallholding farming livelihoods have been evaluated by indirect methods using simulation models on country or regional basis but few have been done at the community level. This study explores direct observation of the impact of soil and climate factors on crop and livestock livelihood systems in the three major agro-ecological zones of the Eastern Cape Province of South Africa. It also analyzed their influence on small farmers' choices of agrarian livelihood activities and the lessons learned for the suitability of agro-ecologically integrated agriculture as part of agrarian and food security reforms needed among small farming households in rural communities of South Africa. The impact of soil and rainfall on the crop and livestock livelihood choices of smallholders in the three major agro-ecological zones were explored. A cross-sectional survey was carried out among 223 smallholding farming households during the harvesting period of rain-fed farming season. Data on household livelihood activities were processed in monetary terms and subjected to gross margin and cost/benefit analysis. Geographic information system (GIS) mapping and statistical analysis were used to determine the association of smallholder maize revenue with agro-climatic variation. The results indicated that crop-based activities performed better in the Grassland zone, while livestock activities performed better in the Savanna zone. Small farms in the Karoo can only productively engage in livestock production. The results also showed that farming activities that combined more vegetable crops yielded greater profits than other field crops. Furthermore, the results indicate that the mixed cropping method remains one of the strategies for breaking-even and risk-bearing effort used by the smallholder farmers considering its cost-sharing benefits. Geographical information system (GIS) mapping further indicates that smallholders' farming activity was not only affected by soil-climatic factors but by their management skills as well. We recommend agro-ecologically adapted policies and incentives for agriculture-based livelihood activities and intensified mixing of cropping systems among the smallholder farming households in the study area.

Key words: agrarian reform, agri-systems, agro-ecology, rural livelihood, rural small farms

INTRODUCTION

Global food security has become increasingly fragile due to a series of crises including high and volatile food prices and economic recession that have worsened further due to the unprecedented effects of global warming on shifting weather patterns [1]. Effects of global warming have pushed millions of vulnerable people deeper into poverty and hunger all over the world [1]. Climate change is predicted to adversely affect food and water security in significant ways in the coming decades. There are also strong indications that low- and middle-income countries (LMIC) will bear the brunt of these adverse consequences because of high poverty rates, high vulnerability levels, and low adaptation capacities in the developing world [2,3].

Assessment reports from different authors state that any attempt to feed nine billion people in 2050 must be developed around the urgent need to adopt the most efficient farming systems [4,5]. This has increased the need for a well-coordinated and functioning agricultural extension systems, which are able to link research, training and policy [6]. The expected future population growth has increased concerns and resulted in recommendations for a fundamental shift towards agro-ecology-based farming systems to boost food production and improve the situation of the poor and vulnerable. This shift implies that agricultural activity should be appropriately adapted to local agro-ecological conditions and that the associated methods should respect and incorporate agro-ecological processes and principles [7].

The operation of one-size agricultural information and innovation supports to farmers have not yielded an improvement in the status of smallholder farmers as they are exposed to extreme events beyond their control [8]. Smallholder farming systems in African sub-regions are characterised by various climatic and soil differences, such that mainstream agricultural development programmes may fall short of achieving the expected food security among poor households. Previous studies state that the adoption of technology among farming households in Kenya was influenced by location and socio-ecological conditions [9]. A similar study emphasised the usefulness of agro-environmental indicators to determine the sustainability of family farms in Brazil [10]. In consideration of the present and predicted future climate, energy and economic scenarios, another study recommended that agro-ecologically tailored policies would be a good instrument towards improving sustainable food production and food security among the rural poor [7]. Smallholder farming systems in various agro-ecological zones have led to the domestication of crops and livestock species that are maintained and enhanced by indigenous soil, water, and biodiversity management regimes and nourished by complex traditional knowledge systems. The recognition of this fact in policy formulation, development programme planning and services provisioning will go a long way to improve food systems among the poor, since such systems have fed much of the region's population for centuries [10].

Studies on the impact of climate on the activities of smallholders in South Africa have presented the adaptation strategies that are adopted by farmers [11]. Other studies have also considered the influencing factors such as the decision to adapt, the response of mono-crops (large-scale maize production) to climate change, and the production efficiency of small farms [12, 13, 14]. However, studies on the performance of smallholder farming households, their choice of activities, livelihood combinations based on agro-ecology and how agricultural extension can utilise such information have not been conducted in agrarian communities in South Africa. This paper was aimed at filling that knowledge gap. This study was designed to explore whether there is an association of success in a type of livelihood or livelihood combination based on their agro-ecological background and how that can inform change in agricultural reform and support system for agricultural development and food security.

Livelihood analysis provides a useful starting point for an integrated analysis of complex, diverse and dynamic rural livelihoods and their contexts [15, 16, 17]. In the past decade, this method has been incorporated into the theory and practice of rural development as improvement on a half century of cross-disciplinary work that includes village studies, farming systems research, agro-ecosystem analysis, and rapid and participatory appraisals [17,18]. However, the livelihood analysis concept is not without its criticisms. These include the lack of appropriate measurement schemes for practical applications, which is partly due to the complexity of identifying and quantifying the contributing elements [18]. A lack of emphasis on markets as the weakness of the livelihood analysis has also been identified [20]. It is identified that there is relative neglect of questions related to knowledge, politics, scale and dynamics in livelihood analysis [17]. However, this paper assumes that farming households are conscious of their environment and the economic factors driving their livelihood decisions.

The objectives of this paper were to:

- Examine the impact of agro-ecological conditions (soil and rainfall) on the choice of livelihood and the combination of farming activities among smallholder farming households in the major agro-ecological zones of the Eastern Cape Province of South Africa;
- Explore the potential of applying the principles of cost/benefit analysis, to show the comparative feasibility and profitability of household farming activities and food security systems:
- Give pointers to enhance policy formulation and agricultural development programmes.

MATERIALS AND METHODS

Study Area

A cross-sectional survey was conducted in three major agro-ecological zones in the Eastern Cape Province of South Africa which represent different climatic and soil conditions. The Eastern Cape is the only province in South Africa with eight of the nine South African biomes, and includes twenty-eight of the classified vegetation types [21]. Among the nine major biomes found in South Africa, seven occur in the Eastern Cape with grassland being the dominant biome [22]. The grassland biome covers 39.8 % of the Eastern Cape followed by the Nama Karoo (25.4%), thicket (16.4%), savanna (10.2%), Fynbos (6.0%), forest (2.2%) and succulent Karoo (<0.1%) biomes. Although agro-ecological zones in South Africa have been established based on the rainfall pattern, the study employed exploratory survey with no pre-determined farming types, but the type of farming activities engaged in by the farmers. Fifteen communities representing the three major agro-ecological zones (biomes) were randomly selected in two district municipalities (Amatole and Chris Hani), covering seven local municipalities. The villages surveyed in the grassland zones were Elliot, Engcobo, Seymour, Tsomo, Roxeni and Elliotdale, while the villages surveyed in the savanna zone were Lady Frere, Qamata, Cala, Melani, Gqumashe and Middledrift. The surveyed villages under the Karoo (Nama) were Zola, Tarkastad and Hofmeyr. The surveyed areas are illustrated in Figure 1. The study focused on how the livelihood activities of smallholder and emerging farming households are influenced by the biome in which they live, which is conceptualised as the environment conditioned by abiotic factors, such as climate (rainfall) and soil in this paper.

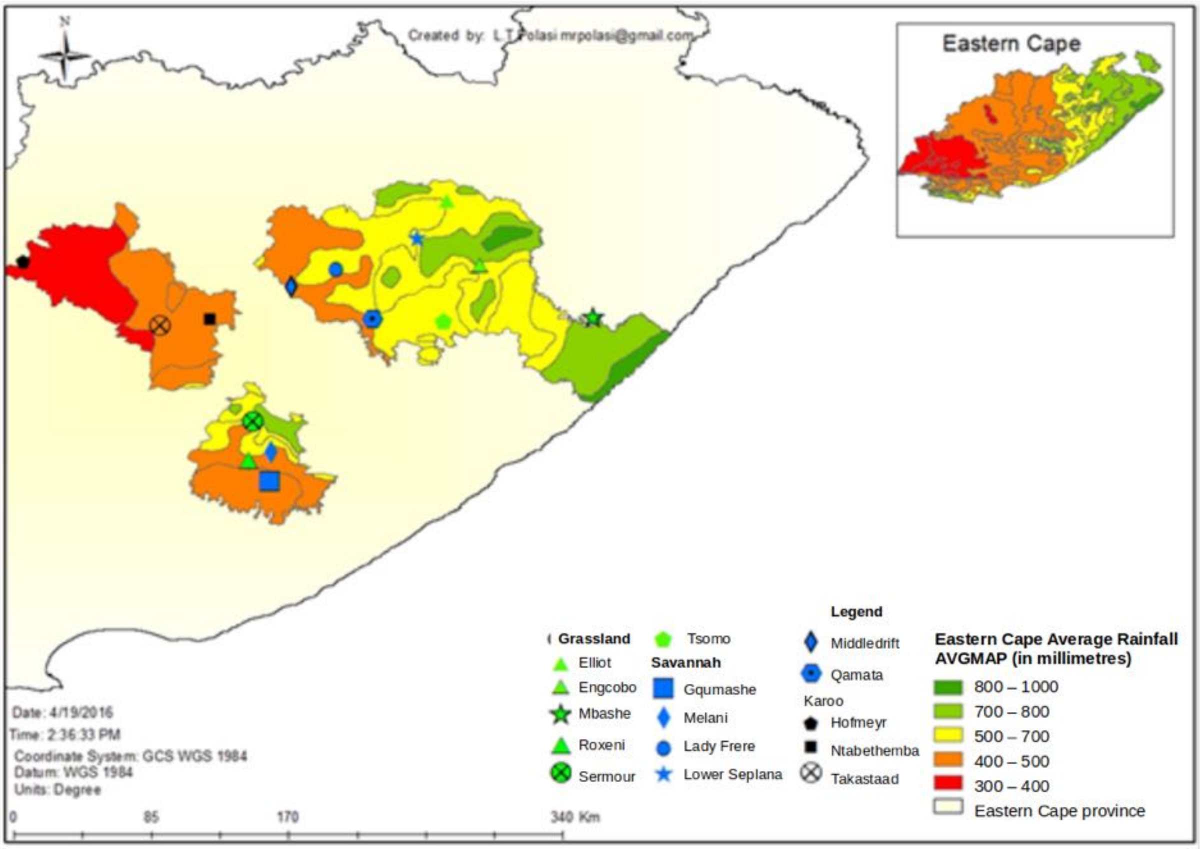

Figure 1: Geographic information system (GIS)-generated map of the study area according to the major agro-ecological zones

Smallholder farming households were interviewed through semi-structured questionnaires. In this paper, a small farming household is conceptualised as an individual farmer or a farming household that cultivates less than 5 hectares of land, keeps livestock, and uses minimal improved agricultural inputs such as agrochemicals, hybrid seeds and some level of mechanical power especially during land preparation. Although, agricultural activity is primarily aimed at satisfying the food security concerns of the household, selling to the market do occur when there is a surplus of

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output or a need for cash (liquidity). The farmers in this study engage in dryland farming, but within rural settlements, plots of land are near homes, providing the farmers the opportunity to water their vegetables from their homes.

With the support of extension officers, 223 farming households that engage in both cropping and livestock-keeping activities were interviewed using a systematic sampling technique. The consent of the household heads was sought and only the willing households in the selected area were interviewed on the basis of an anonymity. The consent included an agreement that personal information will be kept confidential and not shared and the summary of the consent agreement was added as the first paragraph of the questionnaire that was read to each respondent and agreed to. The survey was conducted within the months of March and May, which is the rain-fed agriculture harvesting period in South Africa. This timing further ensured the accuracy of the data since the farmers had just concluded a farming season and could easily recall what had occurred. The enumerators interviewed 77 farming households in the Grassland zone and 73 farming households each in both the Savanna and Karoo zones. Information on the types of crop or livestock enterprises in which the respondents engaged, and production data, including the use of inputs and output on the enterprise combinations were also collected.

Most of the interviewed households engaged in mixed cropping except for a few that engaged in monoculture, such as maize and potato during season that the survey was conducted. Production data on inputs used and the output produced in the livelihood activities were subsequently converted to monetary terms (in Rand) at the market price because the harvest was counted in bags, bunches and herds. Data on a climate indicator (average rainfall) and soil factors (soil types) of the areas were sourced from South African Agricultural Geo-Referenced Information Systems and the Agricultural Research Council (ARC) of the South Africa Soil Map [23,24].

Data Analysis

The average revenues from the crop combinations and livestock-rearing activities of the smallholder farmers in the three agro-ecological zones were estimated by adding cash sales and translating the quantity consumed in monetary terms (Rand), using gross margin analysis. The mathematical specification is stated as:

$$GM_i = TR_i - TVC_i$$

where

GM_i = ith livelihood/livelihood combination gross margin

TR_i = Total Revenue for *i*th livelihood/livelihood combination activities

TVC_i = Total variable cost from *i*th livelihood/livelihood combination production

The average gross margin analysis for all the identified farm crop combinations in which the respondents engaged in the three major agro-ecological zones is presented with details on the cost of the items used in agricultural production activities on a per hectare basis. The gross margin was calculated by deducting the total variable cost (TVC) from the total revenue generated (TR) by the identified crop and livestock

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activity combinations. In the crop combination analysis, the first crop was the main staple crop that contributed largely to farmer's revenues and other was represented in the magnitude of their contributions to revenue. In each of the agro-ecological zones, the cost of inputs was determined through cost/benefit analysis as a percentage of the total revenue generated by calculating the percentage of the variable (inputs) cost of the production activities compared to the gross margins. All these calculations were done on a per hectare basis for comparison purposes. Furthermore, GIS mapping was used to overlay the average revenue from maize production on the agro-ecological conditions (soil types and rainfall) to determine if there is any relationship between the average maize revenue and different agro-ecological zones. This was done by overlaying the average revenue generated by maize farmers on the agro-ecological conditions (soil and rainfall) of the surveyed areas.

T-test statistical analysis (paired samples t-test and correlation) was conducted to determine the relevance of agro-ecological zones on per hectare farm gross margins. The hypothesis of the statistic is stated as:

H_0: $\mu_1 - \mu_2 = 0$ (the difference between the paired means is equal to 0)

H_1: $\mu_1 - \mu_2 \neq 0$ (the difference between the paired means is not 0)

where μ_1 is mean per hectare farm gross margins of agro-ecological zone 1, and μ_2, is the mean per hectare farm gross margin of agro-ecological zone 2. The test was conducted in the order: Karoo and Savanna zones, Karoo and Grassland zones and Savanna and Grassland zones.

RESULTS AND DISCUSSION

Table 1 shows that the total gross earnings of the crop-based activities in the Grassland zone were higher (R 7,310.70) than those in the Savanna (R 6,198.44) and Karoo zones (R-2,416.19). Additionally, respondents in the Grassland zone did not rent land for their farming activities, and they used agro-chemicals minimally in their production activities. Furthermore, the results in Table 1 indicate that respondents in the Grassland zone had the highest cash sales and gross margin in the maize/pumpkin/cabbage/carrot crops combination (R 7,853.30), while the lowest cash sales (R 3,398.87) were recorded for sole maize production. The crop combinations with the highest cash sale shows the importance of fruit (pumpkin) and leafy (cabbage) vegetables in the area. The results also indicate that the farming households consumed or gave away more maize/potato/carrot crop combinations than other, which strongly suggests that the crops in this group were important staple foods among the smallholder farming households in the study area. The results in Table 1 also show that the respondents in the Grassland zone minimised costs (cost efficiency) more by combining different crop types than by producing single crops.

The gross margin analysis of crop-based activity in the Savanna zone is presented in Table 2. The results indicate that there were rents paid on land used for cultivation and greater use of agro-chemicals than in the Grassland zone. Most of the respondents in

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the Savanna zone preferred to use herbicides rather than hoes and cutlasses for weeding. Furthermore, Table 2 shows that the combination of maize/beans/cabbage/carrot made the highest contribution to farm earnings (R 7514.61), while the smallest contributor to farm earnings (R 2739.32) was sole maize production, as was also the case in the Grassland zone. Like in Grassland zone, fruit/seed vegetable (bean) and leafy (cabbage) vegetable were among crop combinations that recorded highest sale. The results show that smallholder farming households in the Savanna zone consumed a higher proportion of the maize/pumpkin/cabbage/carrot/spinach crops combination than the other zones, and this consumption bundle indicates a more balanced diet than in the Grassland zone. Additionally, Table 2 shows that more labour costs (hired labour) were incurred by respondents in the Savanna zone when producing single crops, such as maize and potato, than when combining crop activities. Overall, smallholder farmers in the Savanna zone also minimised costs by distributing input costs among a combination of crops which resulted in higher revenues than with mono-cropping.

The performance of crop-based activity as reported by the respondents in the Karoo zone is presented in Table 3, with the exception of the maize/bean/cabbage/carrot crops combination. Negative gross returns were reported for all other crop-based activities, which illustrates the impact of low rainfall on crop production in the Karoo zone. It also emphasises the importance of fruit vegetable (beans) and leafy (cabbage) among crop combinations that generated highest gross margins in the Karoo zone. Interestingly, the results in Table 3 indicate that many of the farmers interviewed in the Karoo zone did not consume much of their farm produce. They preferred selling most of it to purchase desired food items they could not locally produce. They were unable to produce the crops due to limited rainfall.

It was also observed (Table 3) that higher costs of agro-chemicals were incurred for maize in monoculture, while higher fertiliser costs were incurred in the production of the maize/potato/carrot crop combination. Crop-based activities in the Karoo zone involved use of relatively high quantities of fertilisers and agro-chemicals because most of the cultivated lands were degraded and there was a shortage of rainfall, so soil nutrient fertility supplements and inputs were needed to sustain crop production [25]. Drought was the main reason for the negative returns recorded by most of the crop-based activities in the Karoo zone compared to Grassland and Savanna zones.

A comparison of the variable cost (VC) ratios (VC/TR) for all the crop-based combinations in the three major agro-ecological zones of the Eastern Cape is presented in Table 4. The values were calculated by determining the ratio of the variable cost of all enterprise combinations to the total revenue generated. In the Grassland zone, the results showed that VC/TR for sole maize production was the highest among all crop enterprises followed by the maize/potato enterprise combination. The lowest VC/TR ratio was recorded for the production of the maize/cabbage/carrot/potato/spinach/butternut combination in the Grassland zone. The study deduced that the more the smallholders diversified their cropping activities, the more the input costs were equitably spread and the greater the profit margin.

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The VC/TR ratio for the Savanna zone showed a similar pattern of input cost structure. The results in Table 4 indicate that the highest ratio was recorded for the production of maize alone followed by the production of the maize/potato/carrot crop combination and the lowest ratio was recorded for the production of cabbage/carrot/potato/spinach. The patterns also indicate that diversified cropping activities gave greater cost advantage to smallholder farmers in the study area than sole cropping activities. However, the results in Table 4 also show that although production activities in the Savanna zone were more cost-intensive than in the Grassland zone, the average VC/TR ratio in the Savanna zone (57 %) was lower than that (60 %) obtained for cropping activities in the Grassland zone. These results were obtained because there were higher levels of shared input costs among the smallholder farming households in the Savanna zone as a result of a more diversified cropping systems.

The VC/TR ratios for the Karoo zone showed that negative ratios were recorded for both monoculture and crop combinations, but the comparative analysis indicates that the magnitude of the VC/TR ratio recorded for the production of the maize/potato/carrot crop combination was greater, suggesting greater profitability of maize/potato/carrot crop combination. The highest VC/TR ratio was recorded for the production of the maize/cabbage/carrot/potato/spinach/butternut crop enterprise combination. The VC/TR ratios for monoculture, such as potato and maize, were relatively high in the Karoo zone.

The performance of livestock production in the agro-ecological zones is presented in Table 5. The results show that the profit margin from livestock activity was the highest for the Savanna zone. It was also noted that the labour cost incurred in the production of livestock was minimal in the Savanna zone compared to the Grassland zone but the cost of livestock vaccination was highest in the Karoo zone followed by the Grassland zone. Overall, the production of livestock incurred the least total variable cost (TVC) in the Karoo zone, so the cost structure of both livestock and cropping activities in the Karoo zone indicates that the respondents are better-off engaging in livestock production.

The GIS mapping of the revenues from sole maize production in different communities is presented in Figure 2. The Figure depicts an interesting interaction between the effect of agro-ecological variation and the impact of management skills on smallholder farming systems in the Eastern Cape. The results show, as expected, that revenue was higher in the areas that received more rainfall and had good soil types than the areas that received less, However, there were communities in the Karoo zone with low soil fertility that also recorded improved revenues from sole maize production which could possibly have happened if the farmers in these marginal areas employed some sort of better management practices and skills. The study did not interrogate this occurrence.

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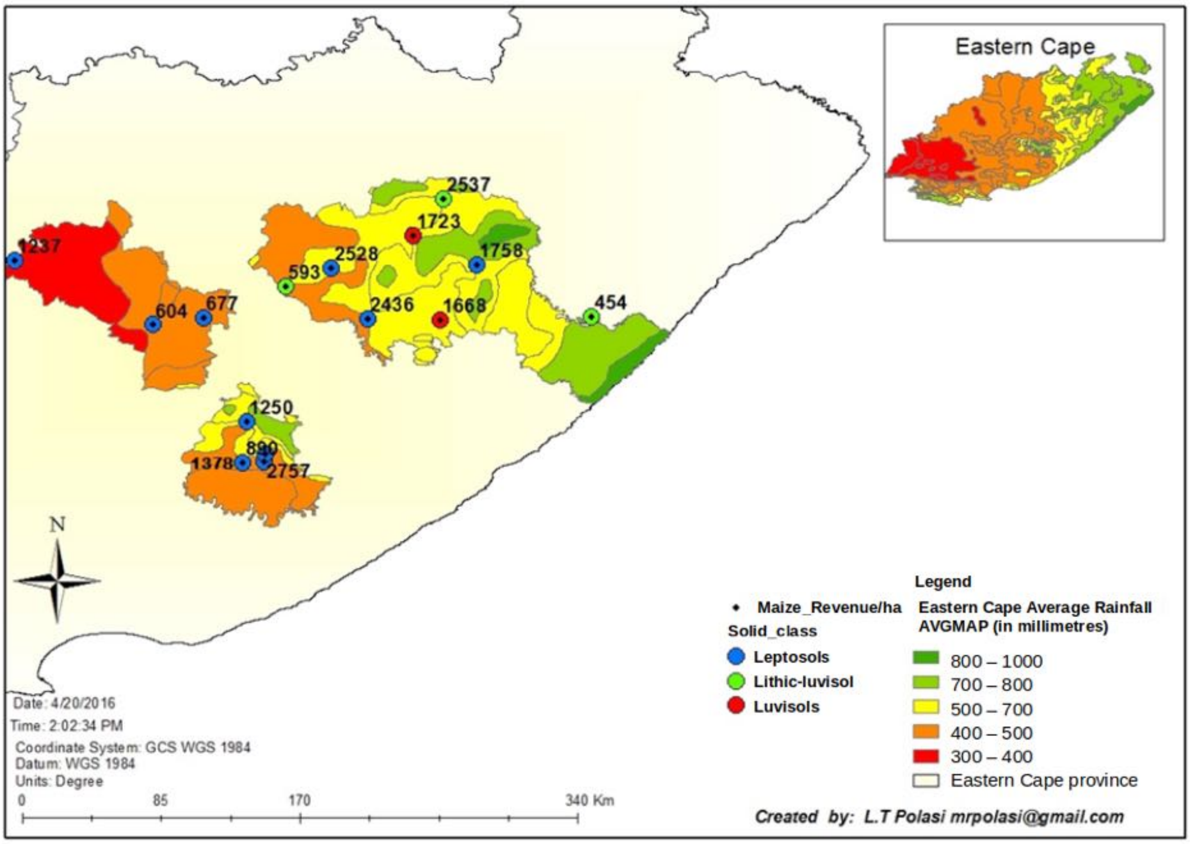

Figure 2: GIS-generated map showing smallholder farm maize revenue based on rainfall and soil types

The t-test statistical analysis was conducted using paired samples t-test and correction. The results of paired sample statistical analysis conducted on the mean farm (crops and livestock) gross margins of livelihood activities in the agro-ecological zones are presented in Table 6. The statistics indicate that the mean per hectare farm gross margin of livelihood activities in the Karoo zone showed a weak negative correlation with mean per hectare gross margin accrued in the Savanna biome ($r = -0.092$, $p < 0.004$). The results indicate a significant average difference between per hectare farm earnings by the interviewed farmers in the Karoo and Savanna zones. On the other hand, the results indicate a weak positive correlation between the mean per hectare of farm gross margins from the Karoo and Grassland ($r = 0.083$, $p > 0.001$). However, this result was not statistically significant, indicating that the differences in the average rainfall received by the zones did not have influence on gross margins. These results can be explained by the wide gap of average rainfall received by both biomes, Karoo being the driest and the Grassland being the zone with the highest rainfall in South Africa. This observation is coupled with the fact that respondents (farmers) in the Karoo zone augment their revenues with livestock production activities. Furthermore, the statistical results in Table 6 show that the mean per hectare gross margin of the livelihoods activities (crops & livestock) in Savanna biome is positively correlated with the mean per hectare gross margin earned by farmers in the Grassland zone ($r = 0.032$, $p <$

0.001). The results show that there was a significant average difference between the mean per hectare farm earnings in the livelihood activities (crops & livestock) in the Savanna and Grassland biomes.

The information generated in this study reveals vital dynamics of smallholder farming activities and validates the fact that pedo-climatic variation greatly influences production in the study area. Crop-based activities were observed to thrive better in the Grassland than the other two zones of the Eastern Cape Province. One of the proximate reasons for this difference was that the Grassland receives higher average annual rainfall (745 mm) than the Savanna (600 mm) and the Karoo (416 mm. A similar study found that regional variation in crop production systems over the last two decades positively affected the expansion of crop production in Bangladesh [26]. Another study reported that a disparity in rainfall and temperature influenced crop growth and yields in sub-Saharan Africa [3]. In response to this situation, a fundamental shift towards agro-ecologically influenced paradigm would be required to boost crop production to feed nine billion people by 2050 and improve the situation of the poorest people [5].

The analysis of livestock-based activities in different agro-ecological zones of the Eastern Cape Province showed that livestock farmers in the Savanna zone generated the highest gross returns, and they took advantage of available grazing resources to maximise profits and ensure sustainable livelihoods and food security. The dominant grasses in the Savanna zones are the most important production components for domestic livestock [27]. Because strong seasonal summer rainfall encourages the development of woody shrubs, the Savanna zone has become the region where a large portion of the national beef production occurs under extreme conditions.

The Karoo is an arid zone that also provides opportunity for the production of livestock rather than crops and this study showed that most of the respondents in the Karoo zone mitigated the negative impact of scarce rainfall by engaging in livestock husbandry. Furthermore, practising mono-cropping increases food insecurity risk at household level as the farm is prone to crop failure [28]. Farmer-training is one of the responsibilities of public agricultural extension agents. However, training can only be initiated if the extension agents are aware of the issue and the need for such [6]. Consequently, there is need to link agricultural extension agents with the current research findings to inform the formulation of farmer-training agenda.

The information generated through the analysis showed that the crop-based enterprise combinations of smallholder farming households were influenced by agro-ecological variation. Livelihood options decreased as agro-ecological conditions became marginal. This implies that farmers located in areas of marginal agro-ecological conditions have less diversified farming activities and thus, making them prone to climate related risks. Livelihood diversification provided risk aversion and hedging pathways for crop and livestock failure due to climate, disease and pest related risks [29]. The results from this study highlights the differences between mixed cropping systems and monoculture systems, revealing that farmers were able to reduce costs and increase their profit margins by incorporating crop combinations into their farming activities. In addition to existing farmer knowledge and production choices, agricultural extension agents can

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influence the farmers' choice at household level through dissemination of proven technologies, demonstrations and best practises vis-à-vis prevailing agro-ecological and climatic conditions.

Furthermore, the findings showed that farming activities that integrated more vegetable crops yielded greater profits than other field crops, which may be explained by the short cycle of production and the less amount of rainfall required by vegetable crops. This result was likely influenced by the ability of farmers to irrigate with water from their homes, which further justifies the need to strengthen home-gardening as a policy intervention. The use of grey water technology and adapting the water into drip irrigation should be promoted among the home- gardening farmers. Furthermore, the findings in this study showed that livestock production has a comparative advantage over crop production. Therefore, the promotion of livestock production could enhance the livelihoods and food security for the rural poor in the Savanna and Karoo zones.

CONCLUSION

This paper analysed the effect of agro-ecological variation on faming activities and choices of smallholder farming households in the Eastern Cape Province of South Africa.

The findings showed that farming activities and food systems (food grown and consumed) of a community are associated with the prevailing climatic conditions of the environment. This finding has an implication for the agricultural extension approach that can be deployed in the dissemination of technology and service delivery to smallholder farmers.

Secondly, gross margin analysis of the smallholder farm production systems indicates the need for a drive towards mixed cropping systems among farming households instead of the more popular monoculture system. Mixed cropping systems will not only serve to mitigate crop losses as a result of climatic stress but will also reduce shared costs and avail nutrition diversity within rural households.
Finally, the gross margin analysis and the GIS extrapolation of the livelihood activities of smallholder farmers indicated that when farming activities are managed as a business with the allocation of cost to inputs and revenue, even gifts and home consumption, smallholder farmers can transform a "hand-out" intervention into a productive farming household that can operate profitably and ensure food security. Such training can be facilitated cost-effectively by agricultural extension services in collaboration with agribusiness institutions. We recommend further studies on specific crop varieties, management practices and tailored financial literacy among smallholder farmers in these agro-ecological zones.

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Table 1: Average gross margin analysis of crop combinations in the Grassland zone (mean land area cultivated: 3 ha)

Crop combination	Total cash sales (R)	Gift & home consumption (R)	Total revenue/ ha	Planting materials	Labour cost	Chemicals	Fertiliser	Ploughing	TVC/ha (R)	GM/ha
Maize/cabbage/ /carrot/spinach	7024.86	2443.57	3156.14	413.95	2682.68	56.17	1126.08	233.14	1509.00	1647.13
Maize/beans/cabbage/ carrot	7853.30	1290.21	3047.84	227.50	3555.18	-	832.33	254.68	1623.23	1424.60
Maize/cabbage/carrot/ Butternut	5120.15	553.78	1925.01	341.74	1462.89	131.08	431.97	112.35	826.67	1098.33
Maize/pumpkin/cabbage/ carrot	7828.68	1259.513	3029.4	438.27	4372.28	86.89	980.89	187.26	2061.82	967.57
Maize/potato/carrot	5316.85	2924.195	2747.01	169.13	4288.00	-	506.87	374.53	1429.33	1317.68
Sole maize	3398.87	1006.554	1468.47	110.95	2249.53	-	847.67	266.85	1158.39	310.14
Maize/potato	5259.36	894.662	2051.34	577.71	2429.77	-	1049.04	458.80	1506.11	545.23

Source: Computation from field survey data

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Table 2: Average gross margin analysis of crop-based livelihood combinations in the Savanna zone (mean land area cultivated: 3 ha)

crop combination	Total cash sales (R)	Gift & home consumption (R)	Total revenue/ha (R)	Planting materials (R)	Labour cost (R)	Land rent (R)	Chemicals (R)	Fertiliser (R)	Ploughing	TVC/ha (R)	GM/ha (R)
Maize/cabbage/carrot/spinach	5191.262	519.77	1903.67	353.93	2733.04	0	84.05	462.85	189.34	1274.41	629.26
Maize/beans/cabbage/carrot	7514.607	606.74	2707.12	139.33	4107.11	0	97.37	0	416.47	1540.31	1166.80
Maize/cabbage/carrot /butternut	4911.27	773.55	1894.94	441.08	2029.67	0	63.38	236.23	144.059	971.48	923.46
Maize/pumpkin/cabbage/ carrot/spinach	2708.82	1310.94	1339.92	311.12	1100.32	0	0	558.97	65.27	678.56	661.35
Maize/potato/ carrot	2672.22	336.07	1002.76	312.35	1514.60	374.5	104.86	274.65	146.68	776.07	226.69
Sole potato	3887.64	642.32	1509.98	138.57	1455.05	0	0	0	18.72	537.45	972.53
Sole maize	2739.32	320.59	1020.28	93.25	1990.54	0	0	299.62	129.68	841.07	179.21
Cabbage/carrot /spinach	3774.71	380.149	1384.95	146.06	998.12	0	112.35	0	56.18	437.57	947.38
Maize/and potato	4771.20	675.32	1815.50	275.48	2984.187	0	29.13	249.69	432.79	1324.38	491.74

Source: Computation from field survey data

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Table 3: Average gross margin analysis of crop combinations in the Karoo zone (mean land area cultivated: 1.90 ha)

Crop combination	Total cash sales (R)	Gift & home consumption	Total revenue/ ha	Planting materials	Labour cost	Rent	Chemicals	Fertiliser	Ploughing	TVC/ha (R)	Gross Margin/ ha
Maize/cabbage /carrot/spinach	1525.18	153.76	883.65	134.26	1567.23	159.17	0	299.63	150.57	991.03	-107.37
Maize/beans/cabbage /carrot	2803.31	358.85	1664.30	65.17	1360.3	89.89	205.99	228.21	299.63	1183.94	480.32
Maize/cabbage/carrot butternut	522.09	88.76	321.50	67.41	1123.59	0	0	0	0	626.85	-305.34
Maize/potato/carrot	1152.93	98.50	658.65	80.73	2290.88	112.35	0	362.54	411.98	1773.94	-1056.35
Sole potato	1067.41	205.99	433.21	37.45	1037.45	0	0	69.28	168.54	690.89.	-6.90
Sole maize	2257.18	242.49	1320.94	121.72	1544.56	0	711.61	243.44	220.97	1495.91	-174.97
Maize and potato	1311.26	233.61	813.21	58.83	1391.69	187.26	0	139.06	107.67	991.85	-178.65
Total	13542.1	1603.12	7990.45	676.41	13015.6	754.68	1172.28	1696.49	1790.83	10524.47	-2416.19

Source: Computation from field survey data

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Table 4: Comparative Cost/Benefit analysis of crop combinations in the three agro-ecological zones

Enterprise combinations	Grassland Biome (N=77)			Savanna Biome GM (N=73)			Karoo Biome GM (N=73)		
	Total revenue/ha (R)	TVC / ha	TVC percent of TR	Total revenue/ ha (R)	VC/ ha	TVC percent of TR	Total revenue / ha (R)	TVC/ha (R)	TVC percent of TR
Maize/cabbage/carrot/spinach	3156	1509	47.81	1904	1274	66.94	884	991	-1.12
Maize/beans/cabbage/carrot	3048	1623	53.25	2707	1369	50.57	1664	1184	0.71
Maize/cabbage/carrot/butternut	1925	827	42.94	1895	971	51.26	322	627	-1.94
Maize/pumpkin/cabbage/carrot/	3029	2061	68.02	1340	679	50.64	-	-	-
Maize/potato/carrot	2747	1429	52.03	1003	776	77.39	1583	1774	-0.12
Sole potato				1510	537	35.59	433	691	-1.01
Sole maize	1468	1158	78.88	1020	841	82.43	1321	1496	-1.13
Cabbage/carrot/spinach	-	-		1385	438	31.59	-		
Maize and potato	205	1506	73.42	1816	1324	72.94	813	992	-1.21

Source: Computation from field survey data

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Table 5: Average Cost/Benefit analysis for livestock enterprises in the agro-ecological zones

Enterprise type		Cash sale (R)	Gift & home consumption (R)	Total revenue (R)	Cost of labour (R)	Cost of vaccination (R)	Total variable cost (R)	Gross margin (R)
Grassland zone								
	Cattle	13276.13	705.19	13981.32	4133.90	791.72	4925.62	9055.70
	Sheep	273.76	115.32	389.08	211.37	50.34	261.71	127.37
	Goat	702.03	142.28	844.31	130.19	46.21	176.40	667.91
Savanna zone								
	Cattle	31447.67	998.73	32446.40	2621.91	745.34	3367.25	29079.15
	Sheep	631.12	212.27	843.39	165.52	52.05	217.57	625.82
	Goat	900.46	154.90	1055.36	23.48	60.25	83.73	971.63
Karoo zone								
	Cattle	11134.79	1575.01	12709.80	1115.83	970.25	2086.08	10623.7
	Sheep	448.00	248.33	696.33	68.34	47.68	116.02	580.31
	Goat	448.86	191.27	640.13	10.57	44.49	55.01	585.12

Source: Computation from field survey data

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Table 6: Statistical analysis (paired samples t-test) of per hectare total farm gross margins of the agro-ecological zones

	Mean	Std. dev	Std. error mean	95% confidence interval of difference		t	df	r	Sig (2-tailed)
				lower	upper				
Karoo and Savanna	21028.46	59309.63	6989.63	7091.52	34965.39	3.009	71	-0.092	0.004***
Karoo and Grassland	10577.52	59334.93	6944.63	-3266.34	24421.38	1.535	72	0.083	0.132
Savanna and Grassland	-10482.65	14317.33	1687.31	-13847.08	-7118.25	-6.213	71	0.032	0.000***

***** is 1% significance level, ** is 5% significance level and * is 10% significance level**

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