



# Timber-Based Mixed Farming/ Agroforestry Benefits: A Case Study of Smallholder Farmers in Limpopo Province, South Africa

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## Abstract

Agroforestry is considered as “a sustainable land use system that includes the use of woody perennial, agricultural crops and animals in combination to achieve beneficial ecological and economical interactions for food, fiber and livestock production”. However, limited understanding, incorrect information, insufficient awareness and a negative mindset could hinder the benefits of this practice. The survey was conducted in Limpopo Province by the Agricultural Research Council, University of Venda and Water Research Commission (WRC). The research is fully funded by the WRC. The aim of the survey was to identify and describe the farmer’s benefits from timber-based mixed farming/ agroforestry cultivation in Limpopo Province. A total of 65 smallholder farmers participated in the study and were spread in districts as follows: Vhembe (40), Capricorn (21) and Mopani (4). Sixty-five potential smallholder agroforestry farmers were selected through a “purposive sampling technique” from the list of farmers’ provided by the Department of Agriculture, Forestry and Fisheries (DAFF) and Forestry South Africa Limpopo. Quantitative and qualitative designs were adopted along with the use of questionnaire, stakeholder’s discussion and field observations. Data was coded, captured and analysed using SPSS. The results indicated that some farmers in Limpopo Province were generating income through renting of farms for grazing and selling trees to the communities to build

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shelter, kraals, medicinal purposes, fuelwood, etc. Those farmers with access to water were able to grow crops and sell their produce at local communities, local municipality and international market. The majority of farmers also indicated that they were also benefiting from nitrogen fixation, increased crop production, economic gain, soil conservation and improved soil quality and sequestration of atmospheric carbon as a result of timber-based mixed farming/agroforestry practice. The identified farmers' benefits were in line with some of the researchers' field observations. It is thus recommended that stakeholders should take note of the benefits identified by farmers in an attempt to increase agroforestry farmers' participation.

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**Keywords**

Agroforestry · Mixed farming · Limpopo Province

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## 9.1 Introduction

Results from several studies have indicated that agroforestry practices are perceived in different ways. According to Lundgren and Raintree (1982), agroforestry is viewed as the set of land-use practices, which involves the combination of trees, agricultural crops and/or animals on the same land management unit. Nair (1993) emphasised that although cultivating trees in combination with crops and livestock is considered an ancient practice, factors such as the deteriorating economic situation in many parts of the developing world, increased tropical deforestation, incorrect agricultural practices, degradation and scarcity of land because of population pressures and growing interest in farming systems, intercropping and the environment have contributed to a rising interest in agroforestry since the 1970s. Based on the above-mentioned factors, Mercer and Miller (1998) further acknowledged that most research on agroforestry has been conducted from the biophysical perspective, but socio-economic aspects in relation to perception of farmers should be given more attention.

Combe (1982) classified agroforestry systems into three broad groups, namely agrosilvicultural (mixing trees and crops), silvopastoralism (mixing trees, pastures and animals) and agrosilvopastoralism (mixing trees with crops and animals). According to Rethman et al. (2007) these groups can further be subdivided as either simultaneous (where trees and crops are grown simultaneously) or sequential (where trees and crops are grown separately, temporally, over a number of seasons, as with improved fallows). According to DAFF (2017), agroforestry is viewed as “a land use system that includes the use of woody perennial and agricultural crops and animals in combination to achieve beneficial ecological and economical interactions for food, fiber and livestock production”. Sustainable management of agroforestry system contributes immensely to the ecosystem health, and the agroforestry system greatly empowers and improves the livelihood of farmers and other stakeholders through revenue generation (DAFF 2017).

According to Hassan (2013), South Africa is a rain-starved country having semi-arid climatic conditions and is often vulnerable to water stress. As regards the Limpopo province, the mean precipitation for the province is about 600 mm. The threshold for rainfed agriculture is placed at 250 mm per annum (LDA 2010). Limpopo Province is characterised by extreme climatic events, high variability and change. From a forestry perspective, plantation forests in South Africa consume only 3% of total water resources available in the country, and so the rainfall requirement for sustaining plantation forests is more than 750 mm per year. In the previous 18 months, South Africa has experienced one of the worst droughts in history where some provinces were declared disaster areas, for example, Western, Eastern and North West Provinces. Poolman (2017) predicted an increased likelihood for the development of El Niño during the next summer, which is often associated with drought and water scarcity, a phenomenon that has been widely experienced in South Africa over the past 2 years.

It is against this background that a comprehensive survey was conducted in Limpopo Province to identify the following factors: (a) social factors (agroforestry potential benefits, perceptions of agroforestry, knowledge and skills in agroforestry management practices), (b) land-related factors (shortage of land, operations within communal areas, security on land tenure), (c) technical factors (management and integrating crops into forest systems, the ecology of the system, the need for common understanding of agroforestry, quality materials availability), (d) economic factors (return on investments, labour requirements, etc.) and (e) policy-related factors (agriculture and forestry production systems, coordination between sectors and regulation of forestry aspects, etc.). The potential benefits from properly designed and managed agroforestry practices include nitrogen fixation, increased crop production and economic gain, soil conservation and improved soil quality, sequestration of atmospheric carbon, etc.

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## 9.2 Objectives

The aim of the survey was to identify and describe the farmer's benefits from timber-based mixed farming/agroforestry cultivation in Limpopo Province, South Africa. The following objectives were established:

- To describe the situational analysis of timber-based mixed farming/agroforestry in Limpopo Province
- To describe the socio-economic characteristics of the farmers in Limpopo Province

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## 9.3 Methodology

All research done so far with partners is focused on achieving or working towards a participatory research approach since the researcher, collaborators, extension officers, farmers and funders were actively involved in all phases to achieve eight

deliverables. According to Backeberg and Sanewe (2010), the method of participatory action research is most appropriate since people, especially farmers, benefit while the research is ongoing. The participatory action approach was also recommended by various researchers who emphasised that the participatory action approach is a good alternative to the traditional “transfer of technology” or “top – down approach” to agricultural research and extension. The research used both quantitative and qualitative methods. A detailed questionnaire written in English was developed as a quantitative data collection method and data was collected from 04th to 15th September 2017 in Vhembe, Capricorn and Mopani districts. The questionnaire used both open- and closed-ended questions. Qualitative data collection method included focus group discussions and field observations. The two methods were also used to identify the smallholder farmers and agroforestry systems/farms in Limpopo Province. A purposive sampling technique was used to select 65 potential productive agroforestry systems/farms from the list provided by the DAFF and Forestry South Africa Limpopo. As indicated in Figs. 9.18, 9.19 and 9.20, Vhembe district is dominant as a location for smallholder farmers with interest in agroforestry systems establishment. The same trend is observed at a local municipality level where Thulamela local municipality in Vhembe district had the most agroforestry systems followed by Molemole Local Municipality in Capricorn District. Data collected was analysed quantitatively using the Statistical Package for Social Sciences (SPSS).

The average monthly rainfall was determined by adopting the approach given by Malherbe and Tackrah (2003). “Decadal (ten-day period) 1km ×1km surfaces were created from the rainfall data (1920–1999) that was downloaded from the AgroMet databank at the Agricultural Research Council -Institute for Soil, Climate and Water (ARC-ISCW) (South African Weather Service and ISCW weather stations) from stations with a recording period of 10 years or more” (Malherbe and Tackrah 2003). The surface was developed using topographic indices (altitude, slope, aspect, etc.) through regression analysis and spatial modelling. Similarly, average monthly temperature was determined by adopting the approach given by Malherbe and Tackrah (2003) using the temperature data (1920–1999). Soil types were determined using the method given by ARC-ISCW (2017). Digital land type information, viz. soil depth and the spatial component, were used (Table 9.1). Soil depth is recorded as a range for each soil entry. A weighted average was calculated for each land type unit (Land Type Survey Staff 1972–2006; Land types of South Africa: Digital map 1:250000 scale). Soil drainage was determined using the method given by ARC-ISCW (2017).

**Table 9.1** Digital land type information – soil type and the spatial component

Class	Soil drainage	Qualifying soil forms	Percentage qualifying soil in land type
1	Poor	Ch, Rg, Wo, Ka, Kd, Es	> 40
2	Impeded	Ch, Rg, Wo, Ka, Kd, Es, Lo, Wa, Cf, La	> 40
3	Somewhat impeded	Ch, Rg, Wo, Ka, Kd, Es, Lo, Wa, Cf, La, Bo Fw, Vf, We, Av, Gc, Pn, Bv, Ss, Va, Sw	> 40
4	Other		

## 9.4 Results and Discussion

### 9.4.1 Situational Analysis

#### 9.4.1.1 Rainfall

With respect to the mean precipitation for the month of September, in most parts of the Limpopo Province, the mean precipitation was remarkably low between 0 and 25 mm (Fig. 9.1). Nevertheless, the mean precipitation for the month of September in parts of Vhembe, Capricorn and Mopani districts was comparatively higher (20–50 mm and 51–75 mm) (Fig. 9.1). The most potential agroforestry systems are found in Vhembe, Mopani and some parts of Capricorn districts.

As shown in Fig. 9.2, the mean precipitation for the month of October was found to increase (75–100 mm; 101–125 mm and 126–145 mm) in the study areas (Vhembe, Mopani and some of Capricorn respectively) so much so that the Forestry South Africa and DAFF had identified these districts for establishment and expansion of agroforestry.

As shown in Figs. 9.3 and 9.4, the long-term rainfall for the months November and December in the study areas, viz. Vhembe, Mopani and some parts of Capricorn, was found to be 126–150 mm, 151–175 mm, 176–200 mm and 201–220 mm, respectively. The increased rainfall during the months November and December enable expansion of agroforestry in the study areas as the rainwater is no more a constraint. The results are also in line with Rethman et al. 2007 (WRC Report

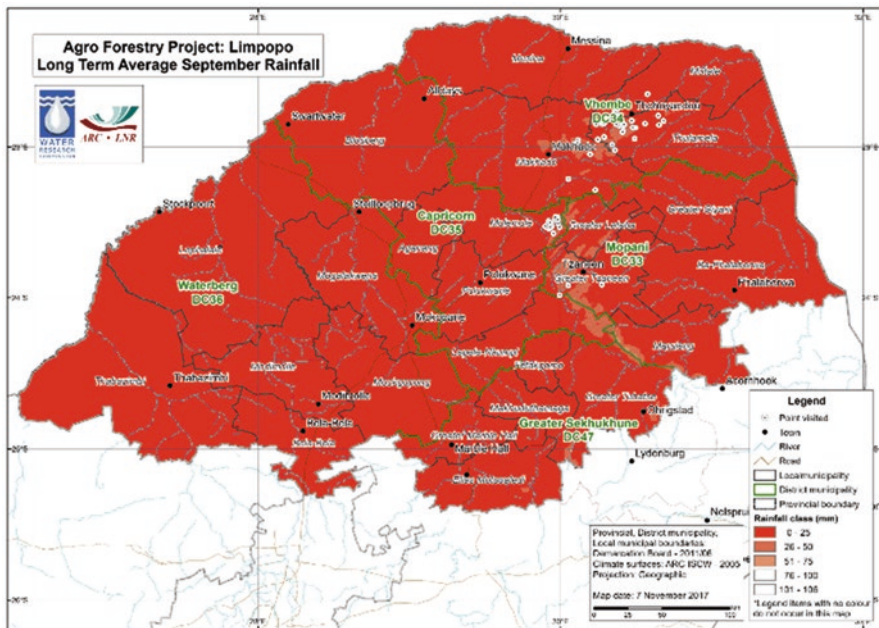


Fig. 9.1 Limpopo Province long-term average September rainfall. (ARC ISCW 2017)

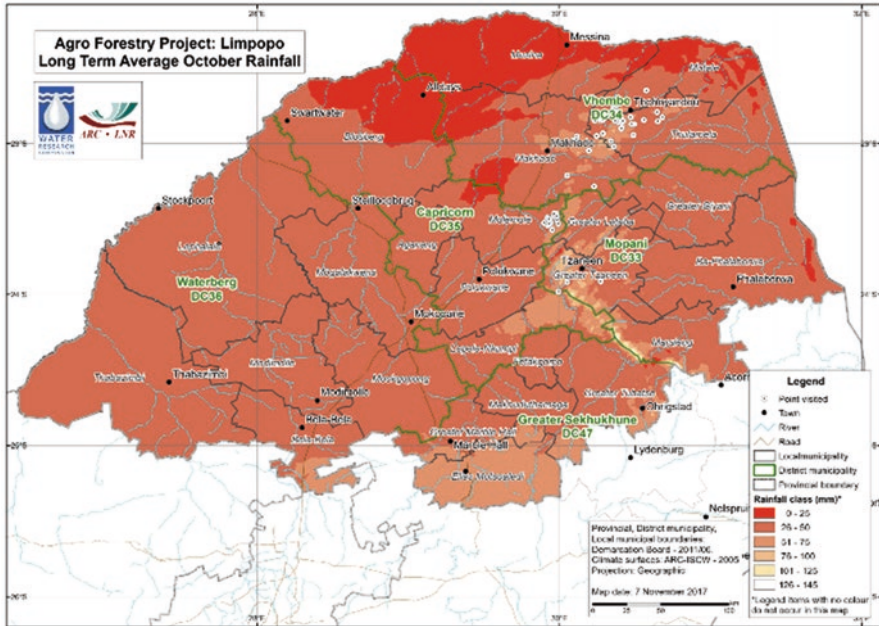


Fig. 9.2 Limpopo Province long-term average October rainfall. (ARC- ISCW 2017)

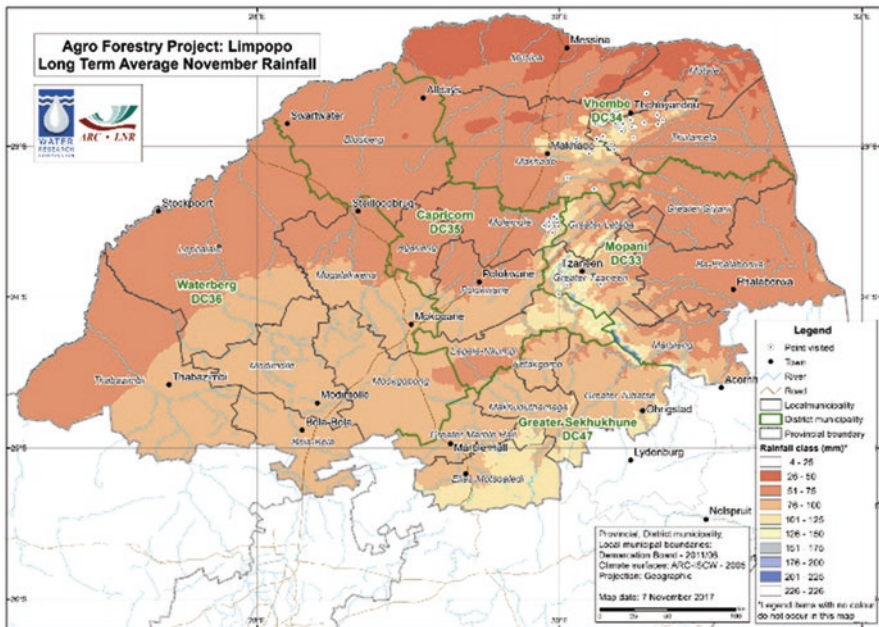
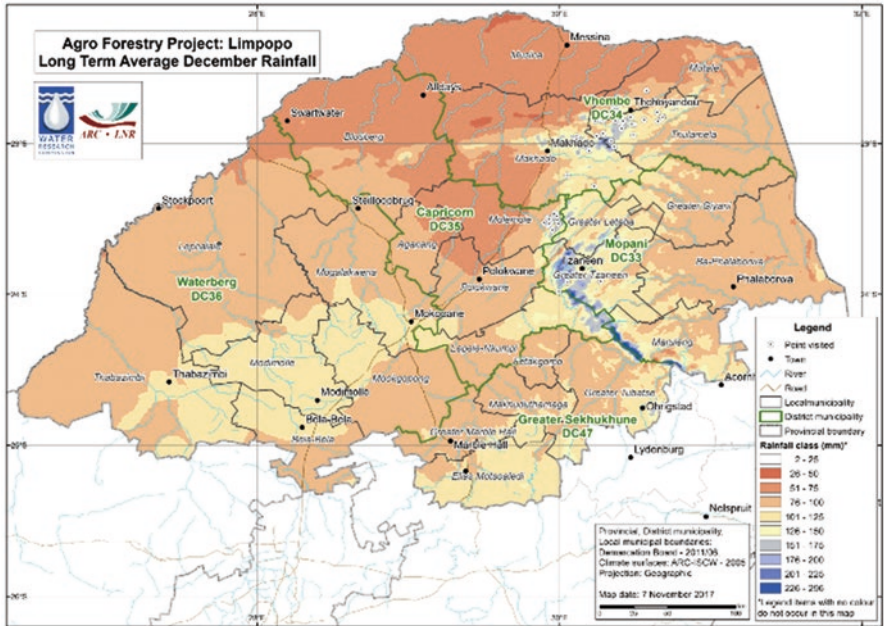


Fig. 9.3 Limpopo Province long-term average November rainfall. (ARC- ISCW 2017)



**Fig. 9.4** Limpopo Province long-term average December rainfall. (ARC- ISCW 2017)

1047/1/07) who found that water resource remains a serious key problem in the establishment of agroforestry in some parts of Limpopo province. The researchers found that in Sikhakhane village, almost 97% of rural communities recognised water resource as a key problem, while in Chuene Maja village, 71% of rural communities recognised water resource as a key problem. The participatory action approach of the research project helped to identify the potential constraints of water resource in agroforestry in Limpopo province.

The annual rainfalls were estimated for 33rd, 50th and 66th percentiles for the future years, and it was found to fall between 601–700 mm and 1001–2216 mm (Figs. 9.5, 9.6 and 9.7). The estimated rainfall trend was found to be higher than the annual mean rainfall (600 mm) for the Limpopo province, and the inference that can be drawn from this trend is that rainwater is not a constraint from the perspective of establishment of agroforestry production system in the Vhembe, Mopani and some parts of Capricorn.

According to ARC-ISCW (2017), the Vhembe District Municipality covers part of the Limpopo as well as parts of Luvuvhu and Letaba water management area. With respect to Luvuvhu and Letaba, it occupies the Luvuvhu/Mutale sub-area and parts of Shingwedzi and Klein Letaba sub-areas. In the Limpopo water management area, it occupies the Nwanedi and Nzhelele sub-areas. Apart from the Luvuvhu/Mutale area, the new Nandoni Dam resulted in a temporary water surplus. As indicated in Figs. 9.8 and 9.9, the visited potential agroforestry systems fall near the water bodies, and this offers a good opportunity for establishment and expansion of

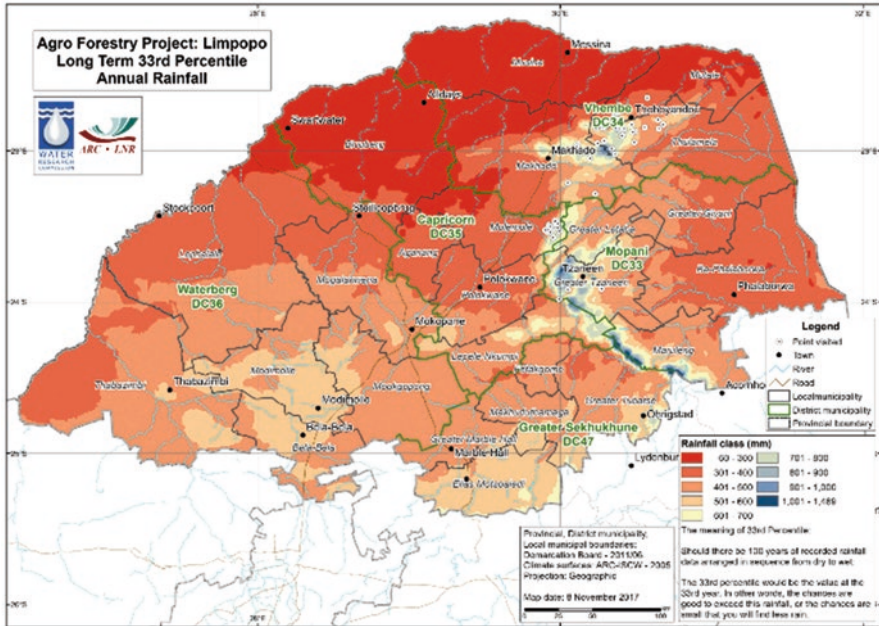


Fig. 9.5 Limpopo Province long-term 33rd percentile annual rainfall. (ARC- ISCW 2017)

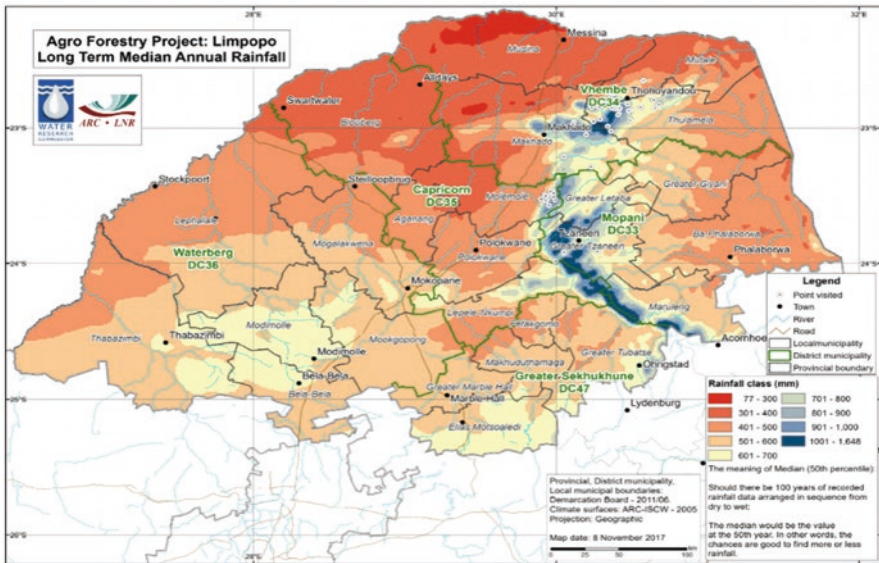


Fig. 9.6 Limpopo Province long-term median percentile annual rainfall. (ARC- ISCW 2017)



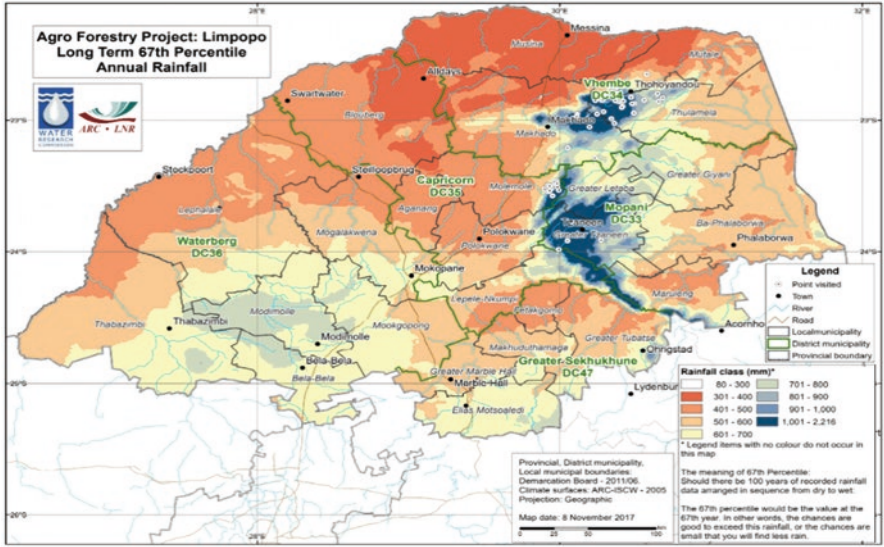


Fig. 9.7 Limpopo Province long-term 67th percentile annual rainfall. (ARC-ISCW 2017)

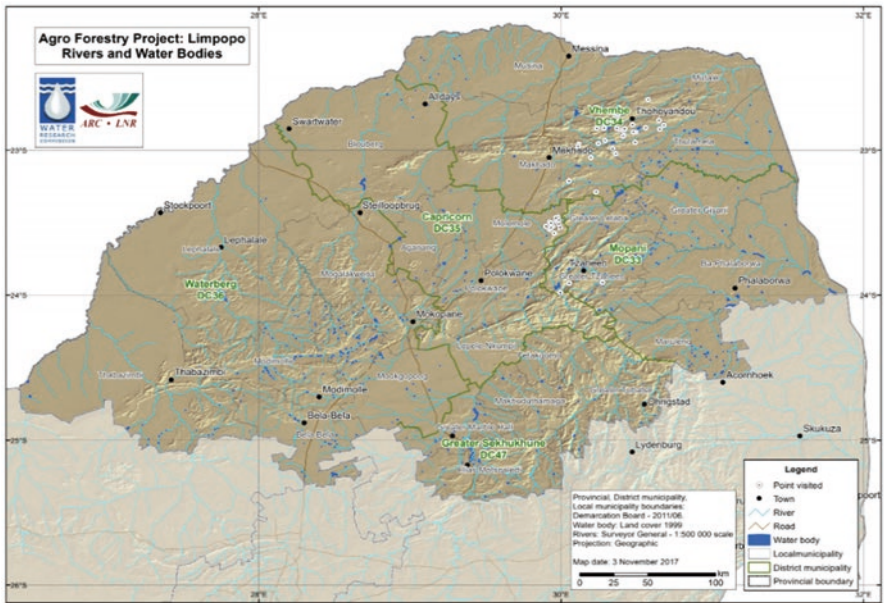
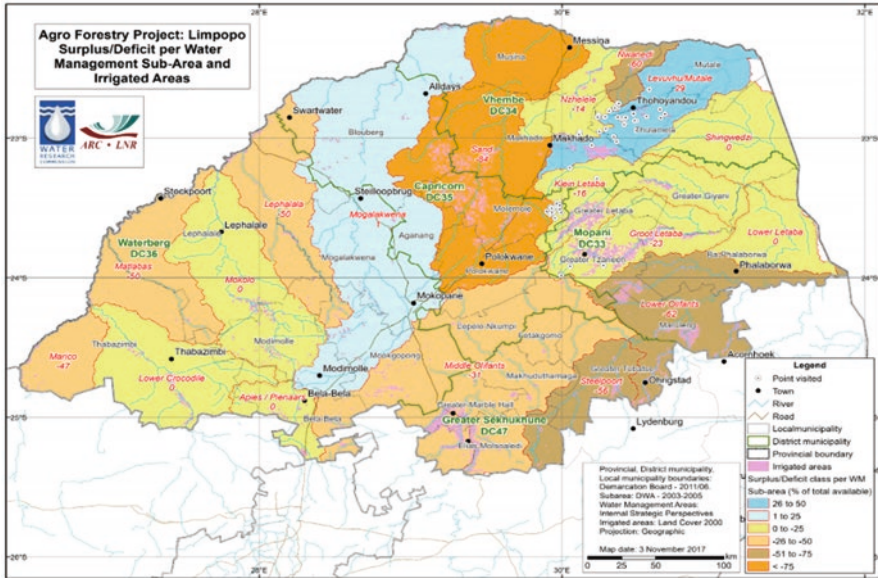


Fig. 9.8 Limpopo Province rivers and water bodies. (ARC-ISCW 2017)



**Fig. 9.9** Limpopo Province surplus/deficit. (ARC-ISCW 2017)

different agroforestry systems. The same trend is seen in Mopani district where the agroforestry systems fall within the Luvuvhu and Letaba water management areas. According to ARC-ISCW (2017), Luvuvhu/Mutale and Groot Letaba constitute important irrigation areas with high value crops. Apart from water from the new Nandoni Dam, the surface water resources are overextended, and water for irrigation is being augmented by groundwater. As indicated in Figs. 9.8 and 9.9, the water bodies with its surplus and deficit can be summarised as follows:

*Luvuvhu/Mutale:* 12400 ha irrigated; yield of Albasini Dam insufficient; high but un-monitored groundwater use; short term surplus available following the completion of the Nandoni Dam; allocations being made for domestic water use and to revitalise irrigation schemes which have fallen into disuse

*Klein Letaba:* Surface water overextended; 5100 ha irrigated; irrigation downstream of the Middle Letaba Dam in disuse due to decreasing assurance of water supply; targeted for revitalisation, despite insufficient water supply

*Nzhelele:* Surface water overexploited; water use dominated by irrigation; supplied by the Mutshedzi Dam, farm dams, run-of-river in the upper reaches of the catchment and the Nzhelele Dam in the lower reaches; much of the irrigation managed by smallholder farmers

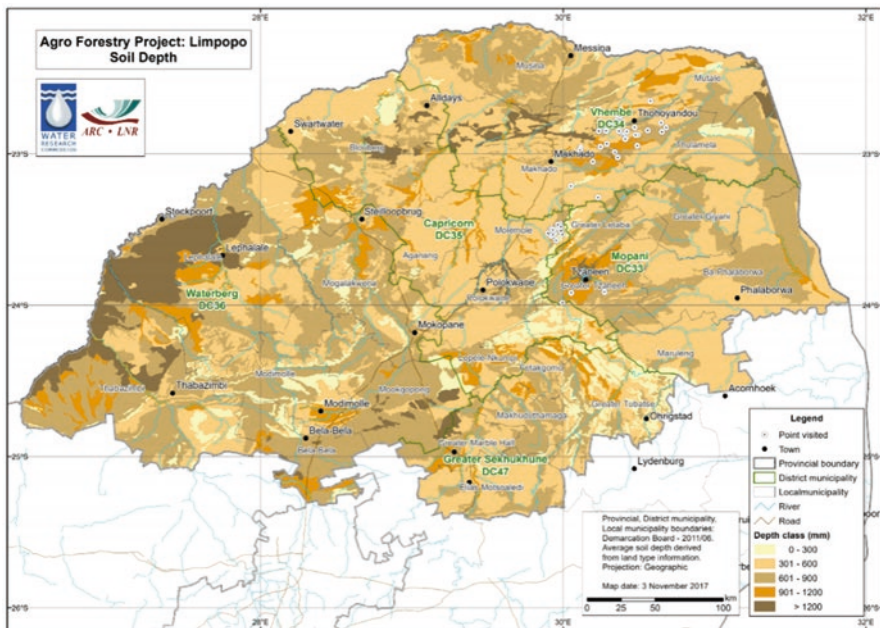
*Nwanedi:* Surface water overexploited; without major dams in the catchment, the surface water resource is limited; ample groundwater resources, although use of it is limited; substantial irrigation, much of it managed by smallholder farmers

*Groot Letaba*: Surface water over extended; 19,100 ha irrigated; groundwater supplementing irrigation supplies; irrigators upstream of Tzaneen Dam experience relatively high level of assurance; users downstream experience shortages; irrigation highly efficient and well managed; scope for further improvements limited

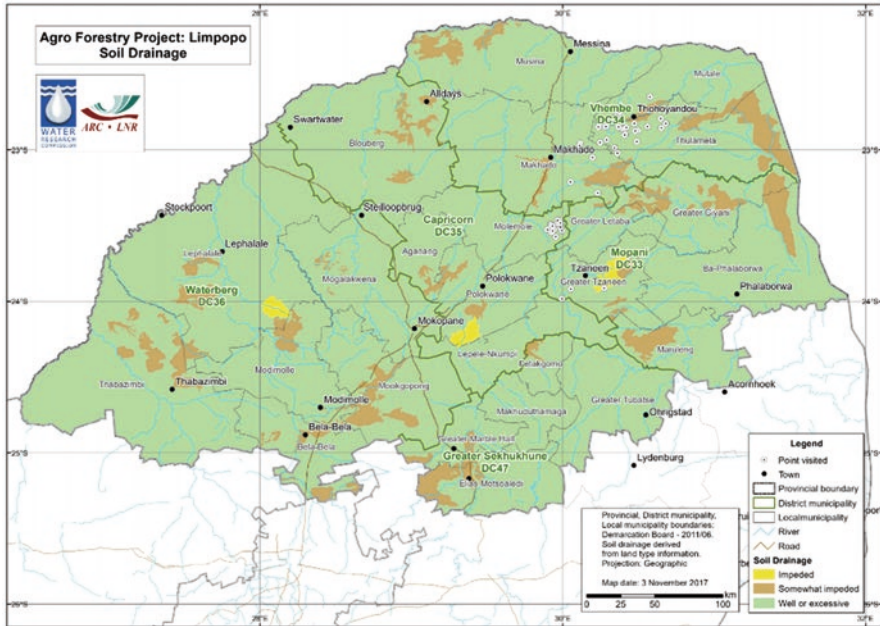
**9.4.1.2 Soil**

According to ARC-ISCW (2017), fairly large tracts of moderately deep to deep, well-drained loam or clay loam soils are found in the Tzaneen area, the alluvial valleys of the major rivers, a belt between Tzaneen and Phalaborwa and in areas between Phalaborwa and the Kruger National Park. Although the bulk of the lowveld area is dominated by shallow soils, sporadic occurrences of deeper soils occur. There is thus an overabundance of good soils in Mopani district. As indicated in Figs. 9.10 and 9.11, the potential agroforestry systems visited in Mopani district falls in well-drained soil with soil depth of 901–1200 mm. Moderately deep to deep, well-drained loamy or clay loam soils occur commonly in the escarpment and Soutpansberg areas as well as sporadically across the Vhembe district. Good soils are thus in overabundance. As seen in Figs. 9.10 and 9.11, the potential agroforestry systems falls in well-drained soils with soil depth of 601–900 mm and 901–1200 mm, respectively.

Moderately deep to deep, well-drained, sandy or loamy soils occur fairly widespread to the west and south of the Polokwane plateau, while good soils are rare on



**Fig. 9.10** Limpopo Province soil depth. (ARC- ISCW 2017)



**Fig. 9.11** Limpopo Province soil drainage. (ARC- ISCW 2017)

the Polokwane plateau itself. As is the case almost everywhere in the province, good soils are in over abundance. This statement is in line with agroforestry systems visited in some parts of Capricorn where potential systems were found in well-drained soils with soil depth of 601–900 mm (Figs. 9.10 and 9.11).

#### 9.4.1.3 Temperature

According to Luedeling et al. (2013), temperature is one of the climate variables that affects all organisms involved in an agroforestry system, possibly in very different ways. Exposure of livestock, crops, trees and bees to strong, direct sunlight or hot, humid conditions will definitely cause heat stress. As indicated in Figs. 9.12, 9.13, 9.14 and 9.15, the temperature condition in the identified potential agroforestry systems is mild to moderate (18–24 °C).

### 9.4.2 Socio-economic Characteristics and Agroforestry Benefits

The majority of farmers interviewed were men, and these men are involved in agroforestry activities. According to Table 9.2, 51 men were interviewed as compared to 14 females. As shown in Table 9.2, there is a huge difference between the number of female and male farmers, which implied that any developmental strategy for the farmers in the areas will benefit more males than females. All farmers interviewed were black South African citizens. In terms of educational attainment

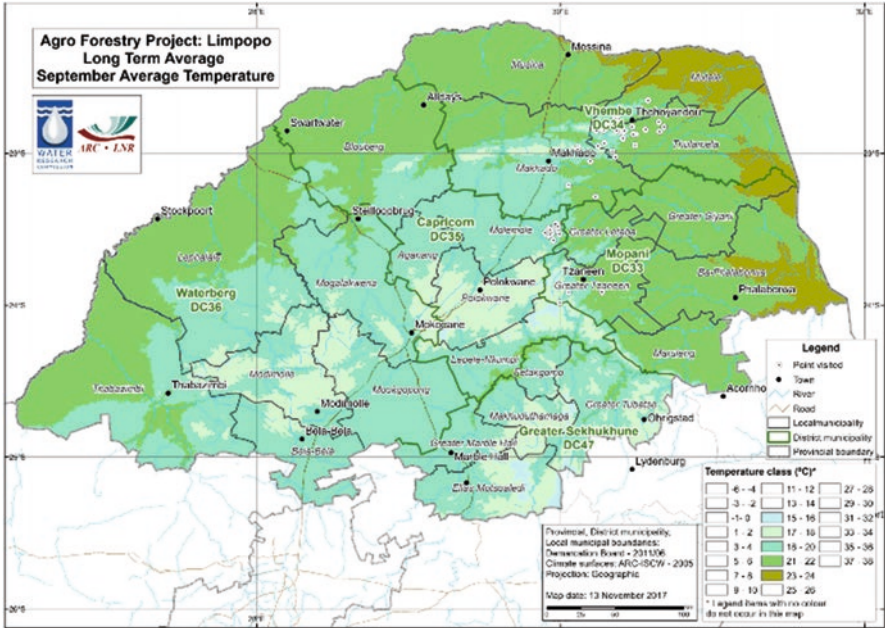


Fig. 9.12 Limpopo Province long-term average temperature in September. (ARC- ISCW 2017)

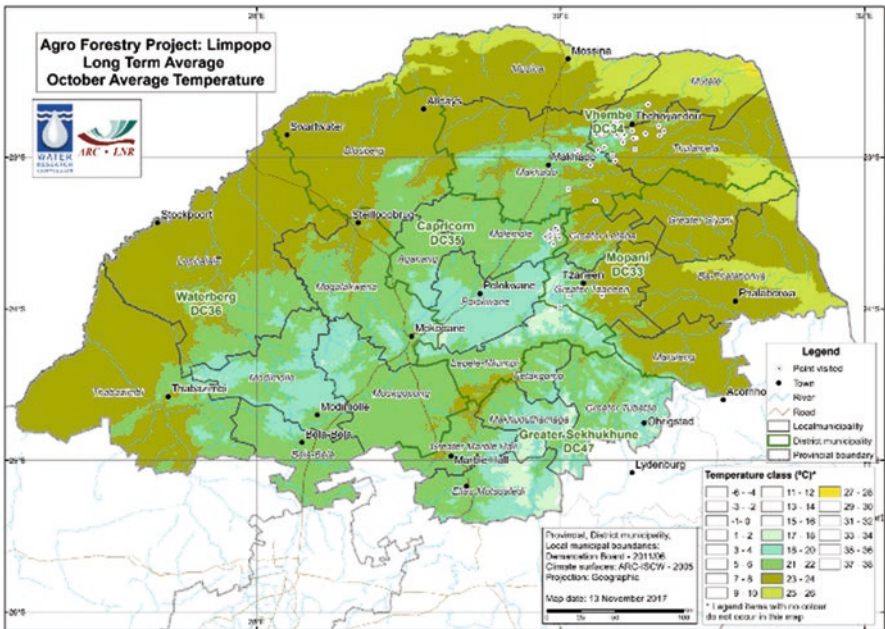


Fig. 9.13 Limpopo Province long-term average temperature in October. (ARC- ISCW 2017)

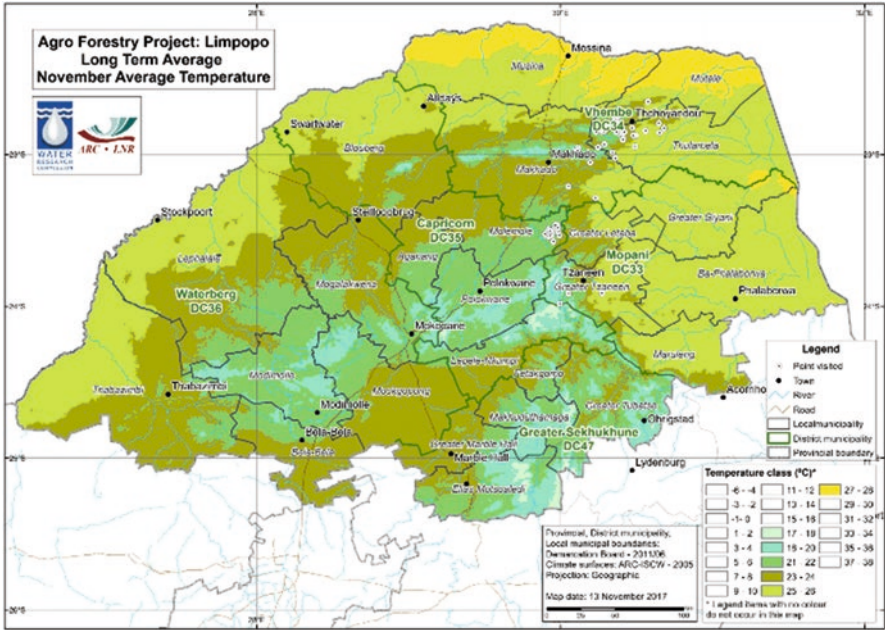


Fig. 9.14 Limpopo Province long-term average temperature in November. (ARC- ISCW 2017)

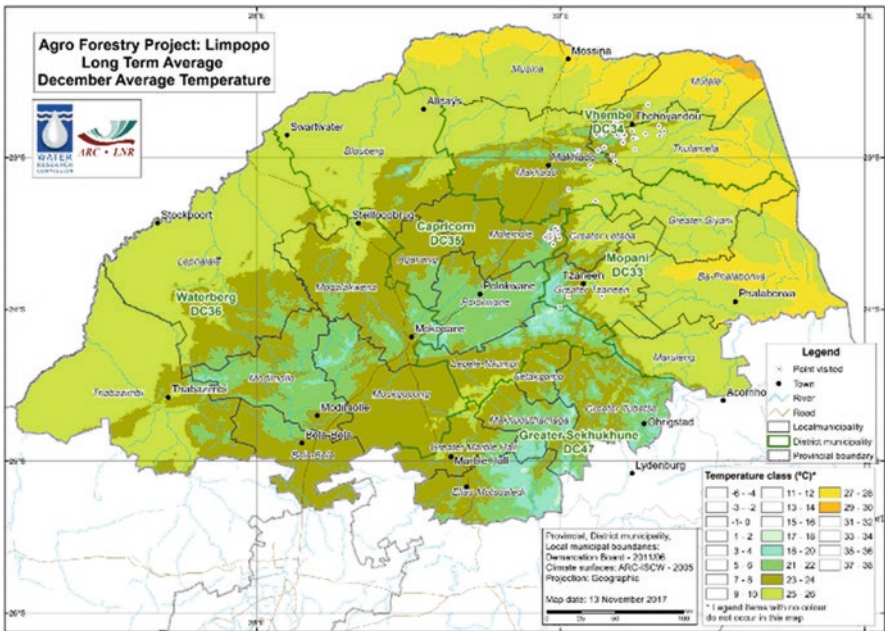


Fig. 9.15 Limpopo Province long-term average temperature in December. (ARC- ISCW 2017)

**Table 9.2** Limpopo Province farmers' demographics

Variables	Respondents	% of Respondents
<i>Gender</i>		
Female	14	78.5
Male	51	21.5
Total	65	100
<i>Level of education</i>		
No education	9	13.8
Primary education	20	30.8
Secondary education	27	41.5
Tertiary education	9	13.8
Total	65	100
<i>Training skills acquired</i>		
Yes	24	40
No	41	60
Total	65	100
<i>Agroforestry experience</i>		
Less than 5 Years	21	32
6–10 Years	14	22
More than 10 Years	30	46
Total	65	100
<i>Land acquisition</i>		
Bought	9	14
Leased	11	17
Inherited	2	3
Government	14	22
Permission to occupy	23	35
Renting	6	9
Total	65	100

(Table 9.2), 9 farmers had no education, 20 of the farmers completed primary education, 27 secondary education and 9 tertiary education. The educational levels of the farmers were generally good. Almost all farmers attended secondary and tertiary education levels. These results indicated that educational level of the selected farmers is generally adequate to enable interpretation and understanding of basic farming activities. It is expected of farmers with tertiary education to at least interpret and understand different farming principles to make informed decisions on general farming operations and to be able to negotiate contracts better than beneficiaries with lower education levels. The research done previously shows that farmers who have basic education are far better compared to farmers that do not have education at all. The farmers can be able to make strategic or informed decisions based on their understanding of agroforestry setups and also the situations that they find themselves in (Maponya and Mpandeli 2013). The lower educational levels among the farmers implied that written information might be of minimal benefit to such farmers, and alternatives will have to be developed.

According to Maponya et al. (2016), training and education plays an important role in smallholder farmer development. Failure to address some of the training needs has led to constrained agricultural growth in some districts in South Africa (Maponya et al. 2014, 2015). As indicated in Table 9.2, only 24 farmers received training, whereas the majority of farmers did not receive any training. The results showed farmers' variation in terms of agroforestry experience acquired over time (Table 9.2). The majority of farmers (30) had more than 10 years' experience, while 21 and 14 farmers had less than 5 years and 6–10 years' experience, respectively. Results on land acquisition (Table 9.2) indicated that the majority of farmers got land through Permission to Occupy (PTO) (25) while others received land through the following: government (14), leased (11), renting (6) and inheritance (2). The role of traditional leaders must be applauded as the majority of farmers had PTO.

As indicated in Figs. 9.16, 9.17 and 9.18, the following potential agroforestry systems were identified and visited in Limpopo province: (1) agrosilvoculture, (2) silvipasture, (3) agrosilvipasture, (4) apiculture and (5) combination of agrosilvipasture and apiculture. The most popular systems identified were silvipasture (32) and agrosilvipasture (23). The systems were popular because farmers were generating good income by allowing community livestock to graze in their forests throughout the year at a cost. As indicated in Figs. 9.16, 9.17 and 9.18, Vhembe district is dominant as a location for agroforestry systems establishment. The same trend is observed at a local municipality level where Thulamela local municipality in Vhembe had the most agroforestry systems followed by Molemole Local Municipality in Capricorn.

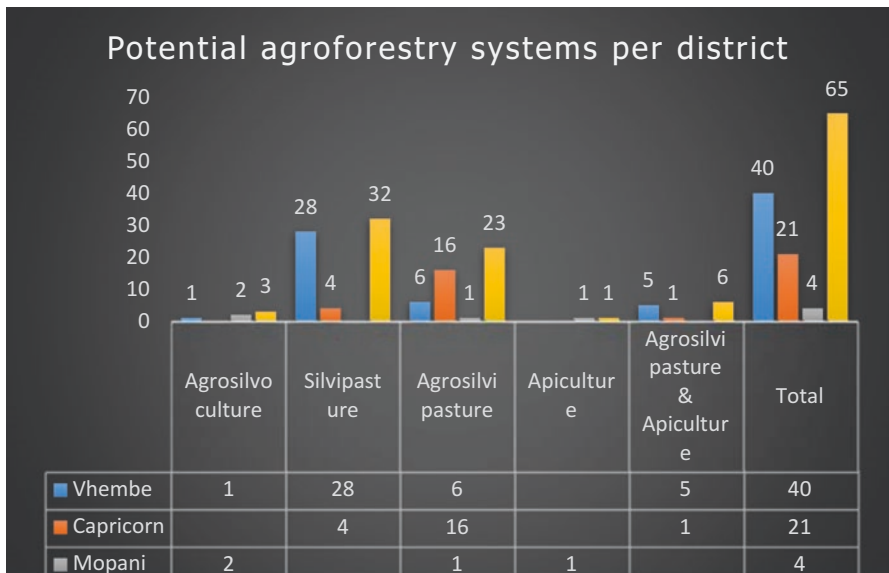


Fig. 9.16 Limpopo Province potential agroforestry systems per district



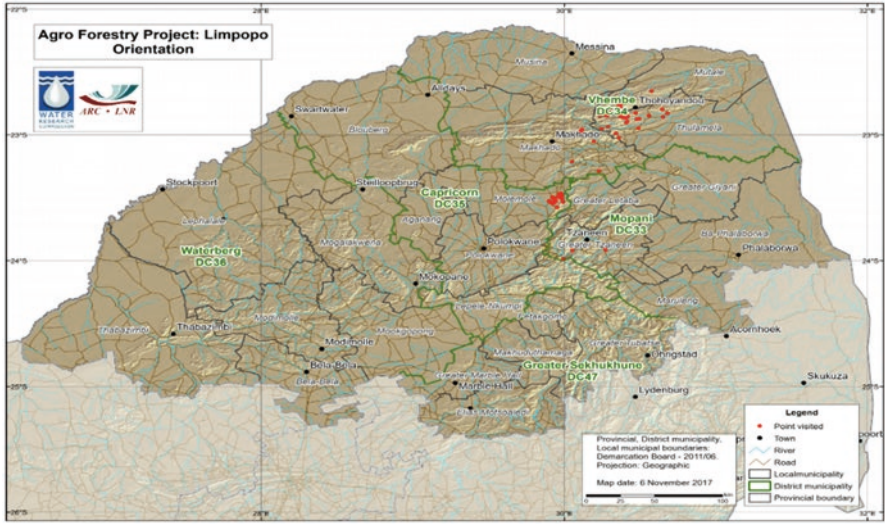


Fig. 9.17 Limpopo Province orientation. (ARC-ISCW 2017)

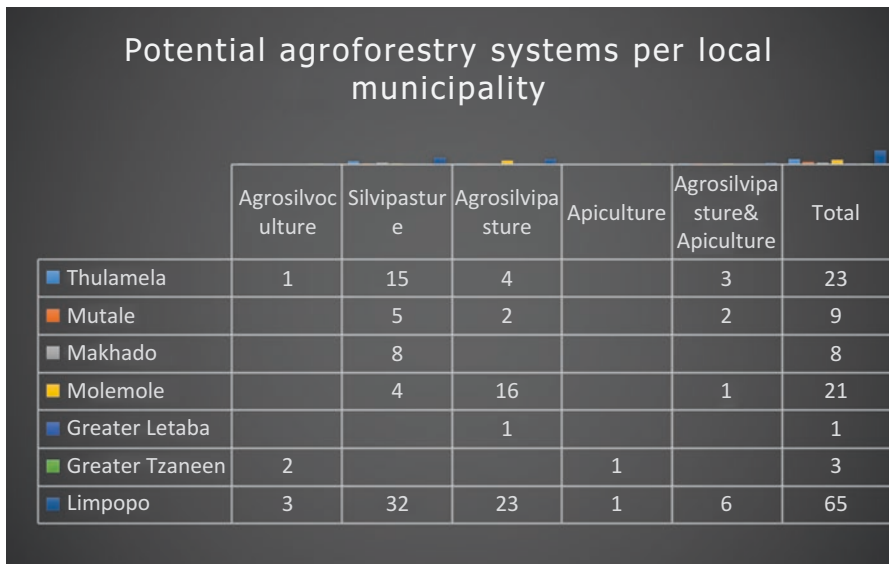


Fig. 9.18 Limpopo Province potential agroforestry systems per district

Table 9.3 shows the potential agroforestry systems, total land area and land used per enterprise. The results indicated that the total land available for agrosilvoculture system in the identified areas was 431 ha and the usage of land by other enterprises were as follows: (1) trees (230 ha) and crops (212 ha). The results also showed total

**Table 9.3** Potential agroforestry systems (AF), total land and land use per enterprise

AF systems	Total land (ha)	Trees (ha)	Crops (ha)	Livestock (ha)	Bees (ha)
Agrosilvipasture	7069	5552	208	5703	–
Agrosilvoculture	431	220	212	–	–
Silvipasture	3528	3512	–	3528	–
Apiculture	100	80	–	–	100
Agrosilvipasture and apiculture	165	128	44	165	165
Total	11,293	9492	464	9396	265

land and land usage per agrosilvoculture system. The results showed a balanced integration of crop and tree enterprises in the agrosilvoculture system.

The total land available for the apiculture system in the identified areas was 100 ha, and the usage of land by other enterprises were as follows: (1) bees (100 ha) and trees (100 ha). The results also showed a total land and land usage per apiculture system. The results indicated that the total land available for agrosilvipasture and apiculture system in the identified areas was 165 ha and the usage of land by other enterprises were as follows: (1) trees (128 ha), crops (44 ha), livestock (165 ha) and bees (165 ha). The results showed a balanced integration of enterprises except for crops. The total land available for the silvipasture system in the identified areas was 3528 ha and the usage of land by other enterprises were as follows: (1) trees (3512 ha) and livestock (3528 ha). The results also showed a total land and land usage per silvipasture system. The results showed a very good integration of enterprises in the silvipasture system.

According to DAFF (2017), centres of excellence should be identified and established as lead research agents in agroforestry systems. These may include universities, agricultural colleges, forestry colleges, research stations and state research agencies (e.g. ARC). The department of agriculture, forestry and fisheries further suggested that a number of centres be established and provided with funding for agroforestry research. The geographic location of these centres should reflect the different agro-ecological zones that occur in South Africa, and the research focus should be on systems best suited to the region in which the centre is located (DAFF 2017). The state should provide seed funding for research and assist the centres with securing funding from other sources (e.g. Water Research Commission, SADC funding mechanisms, etc.) (DAFF 2017). The centres of excellence should conduct technical, social, environmental and economic elements of agroforestry, with a particular focus on shared learning and participatory action research (DAFF 2017). The statements from the Department of Agriculture, Forestry and Fisheries are true as indicated in Fig. 9.19, whereby majority of farmers (46) in different potential agroforestry systems in identified areas in Limpopo province had no access to research. It is against this background that the current research is being conducted to enable full agroforestry benefits in Limpopo Province.

Figure 9.20 indicated that 29 beneficiaries received extension services, while only 36 did not. Most of the farmers were receiving extension services through

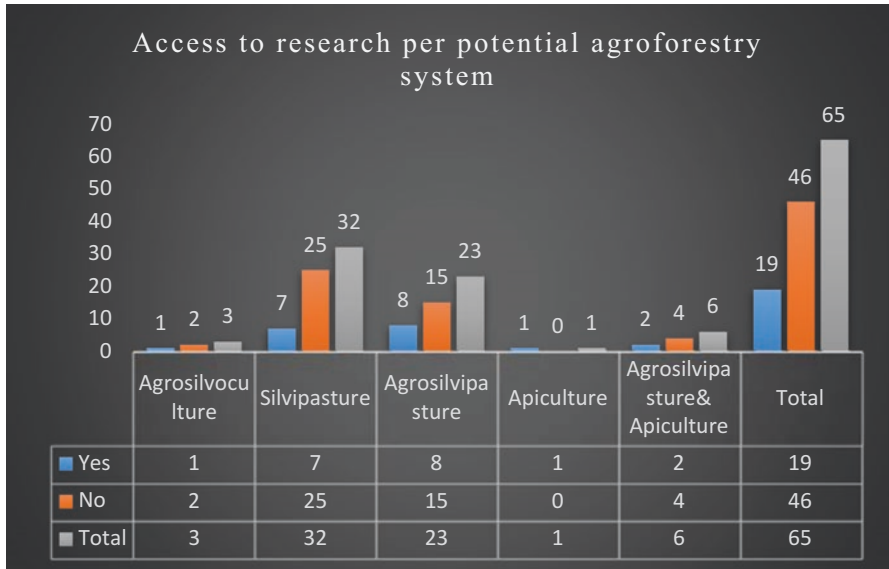


Fig. 9.19 Access to research per potential agroforestry system

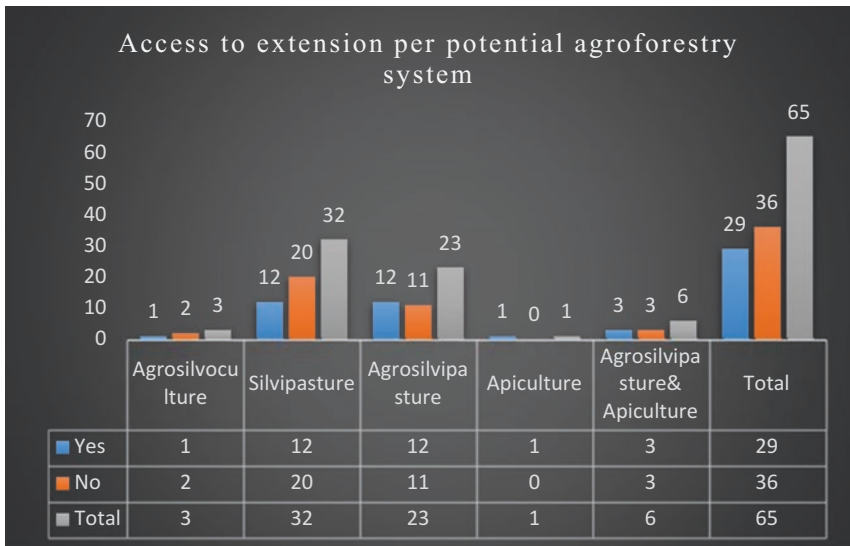
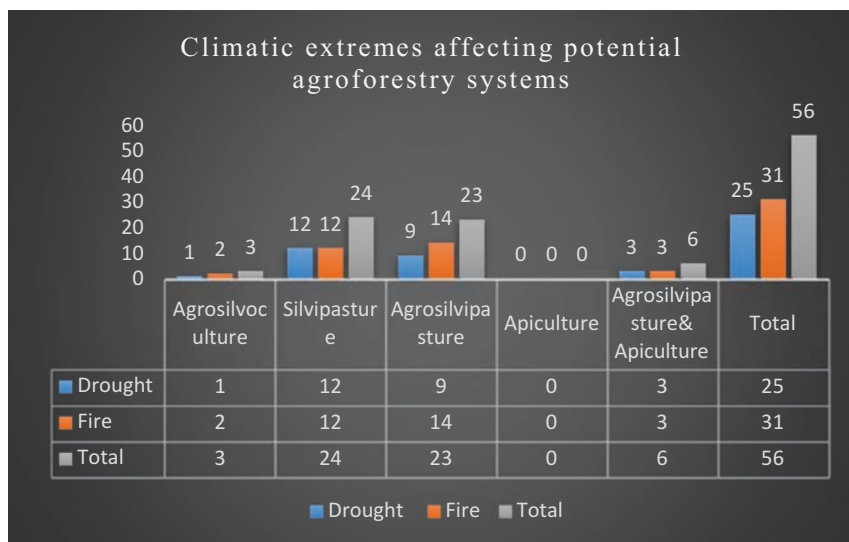


Fig. 9.20 Access to extension per potential agroforestry system

formal extension service, i.e., National, Provincial and Municipal Departments of Agriculture. This situation needs improvement especially for those who are not accessing extension service but encouraging as Mmbengwa (2009) and Maponya and Mpandeli (2013) emphasised that extension service has an important role in



**Fig. 9.21** Climatic extremes affecting potential agroforestry system

assisting farmers to acquire new technology, skills, innovation and production advice.

Climatic extremes have an adverse effect on food production and agroforestry systems as indicated in Fig. 9.21. The majority of potential agroforestry systems (56) in the identified areas has been affected by drought and fire, and this posed threats to the livelihoods of the majority of households in the province. The most affected systems were silviculture (24) and agrosilvipasture (23).

As indicated in Fig. 9.22, fire is one of the disasters that affected the agroforestry systems. The most fire happened in 2015 and affected silviculture (12) and agrosilvipasture (14) systems the most. Farmers explained that the fire burned trees and crops and destroyed infrastructure and livestock, and the damage ranked in millions of rands. It must also be emphasised that the support received was from N1 firefighters in stopping the fire. No preparedness plan and fire belts were available to the affected farmers as mandated by the National Disaster Management Act 57 of 2002.

According to the South African Weather Service, SAWS (2016), the 2015/2016 drought has been one of the worst in the history of Southern Africa with South Africa receiving the lowest rainfall since 1904. Eight South African provinces have been or have had some of their areas declared as disaster areas, except for Gauteng Province. The situation has thrown the country into pandemonium as the water scarcity debate has taken centre stage with every sector looking for ways of conserving water. As indicated in Fig. 9.23, drought had affected most potential agroforestry systems in 2016 and had affected silviculture (12) and agrosilvipasture (9) systems the most. These situations affected grazing and destroyed crops and plantations and resulted in low production in the affected areas. The farmers indicated that no/little support was received from the government, and they do not have any preparedness plan.

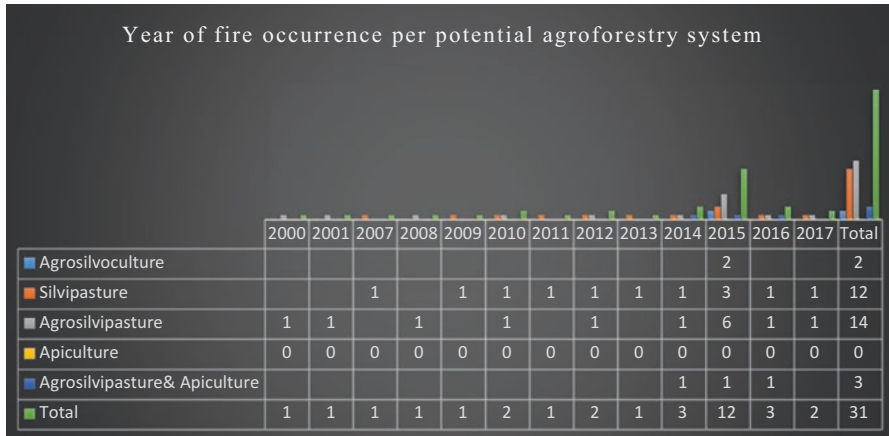


Fig. 9.22 Year of fire occurrence per potential agroforestry system

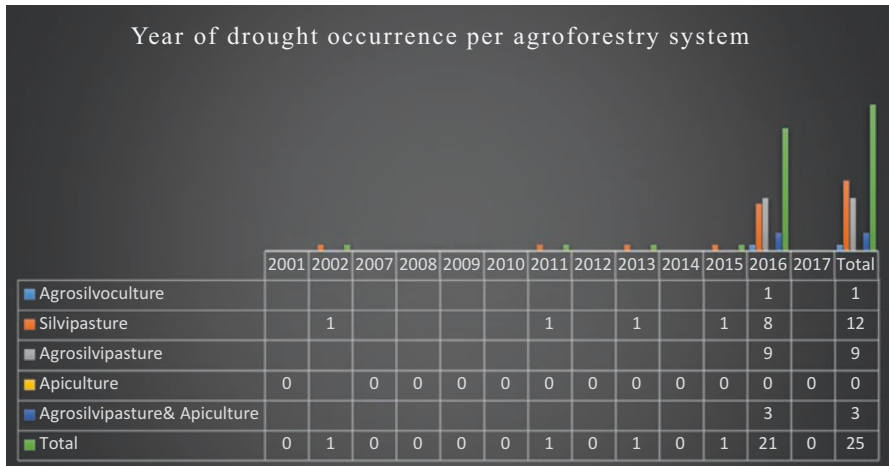


Fig. 9.23 Year of drought occurrence per potential agroforestry system

As indicated in Fig. 9.24, different prices per ton were received per agroforestry systems in Limpopo Province. The highest price per ton was R900 per ton (17), while the others were as follows: R300 per ton (1), R400 per ton (3), R500 per ton (9), R600 per ton (4), R700 per ton (6), R750 per ton (1), R800 per ton (12) and R850 per ton (1). This result indicated that trees serve as an important source of income and communities were using some of the trees to build shelter, kraals, medicinal purposes, fuelwood, etc. It must also be emphasised that few farmers were reluctant to disclose their farm income as they thought that it will jeopardise their chances of receiving support from the government.

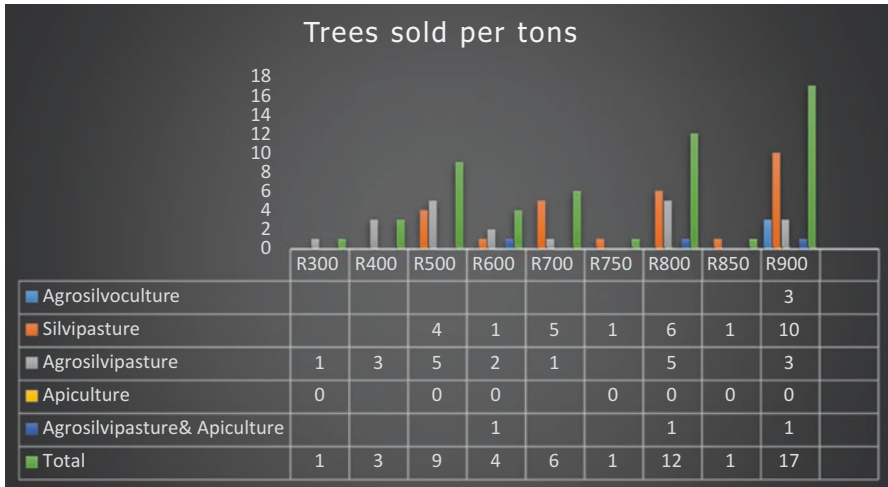


Fig. 9.24 Trees sold per tons

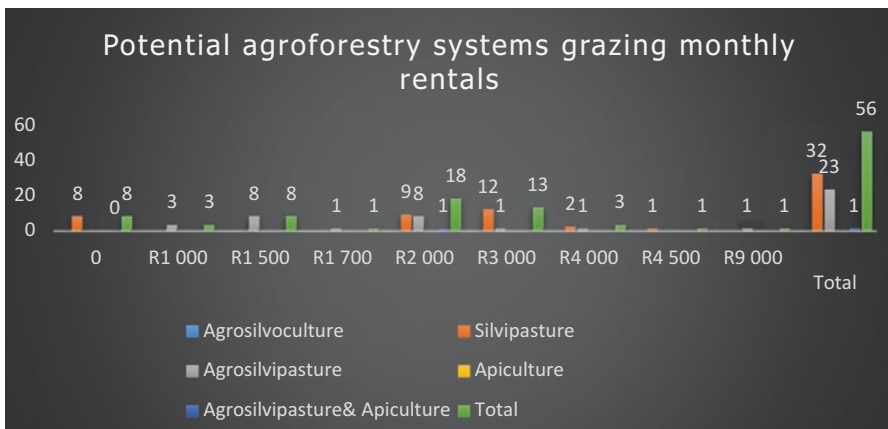
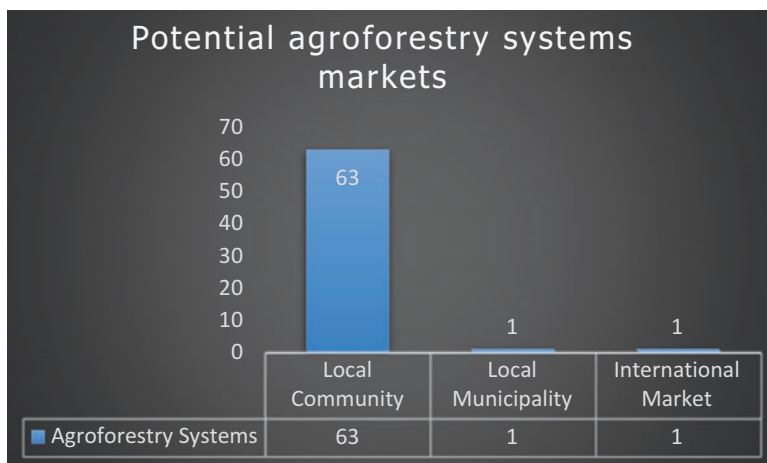


Fig. 9.25 Potential agroforestry systems grazing monthly rentals

As indicated in Fig. 9.25, it is very clear that silvipasture and agrosilvipasture remains the most popular systems in the identified areas in Limpopo Province. The reason is farmers were generating income through renting of farms for grazing. Quite a number of farmers were generating income ranging from R1000 to R9000 per month as indicated in Fig. 9.25.

Farmers used different marketing channels to market their produce for various reasons. For example, many smallholder farmers’ opt for informal markets for reasons such as inability to satisfy the quality standards in the formal markets. On the other hand, most commercial farmers prefer formal markets for reasons such as secured market with better returns. Figure 9.26 indicated that almost all farmers



**Fig. 9.26** Potential agroforestry systems' markets

were selling their produce at local communities (63), local (1) and international market (1). Due to poor record keeping of farmers, it was difficult to quantify their market information.

As indicated in Table 9.4, strength, weaknesses, opportunities and threats (SWOT) analysis was conducted to provide an accurate and relevant overview of what should be considered in taking agroforestry systems forward in the identified areas. Some of the SWOT analyses are in line with SWOT analysis conducted by the Department of Agriculture, Forestry and Fisheries.

### 9.4.3 Correlations and Univariate Analysis

Correlation is a bivariate analysis that measures the strengths of association between two variables and the direction of the relationship. In terms of the strength of relationship, the value of the correlation coefficient varies between +1 and - 1. When the value of the correlation coefficient lies around  $\pm 1$ , then it is said to be a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables will be weaker. The direction of the relationship is simply the + (indicating a positive relationship between the variables) or - (indicating a negative relationship between the variables) sign of the correlation. Usually, in statistics, four types of correlations are measured: Pearson correlation, Kendall rank correlation, Spearman correlation and the point-biserial correlation. In this example, Pearson and Spearman correlations were used, and the following variables were found to be significant: agroforestry systems, age and farming experience.

As indicated in Table 9.5 and Fig. 9.27, there is a positive correlation between agroforestry systems and age variables. The significant level is at 10% for Pearson

**Table 9.4** A strength, weaknesses, opportunities and threats (SWOT) analysis

<b>Strengths</b>	<b>Weaknesses</b>
Increased agriculture/forestry production	Management of projects is remote – many people on the ground needed and increased management costs
Availability of land	Lack of national coordination of agroforestry interventions
Diversification of income and risk reduction	Delayed benefits from agroforestry activities (long-term investment of 5–7 years) especially trees
Climate change adaptation and mitigation benefits	Lack of focussed and documented research
Monetary benefits – increased income from agroforestry adoption	Limited practical knowledge and applied research to address issues that affect agroforestry Lack of on-the-ground technical skills Skills shortage – management and administration of on-the-ground operations Lack of monitoring and evaluation of agroforestry efforts
<b>Opportunities</b>	<b>Threats</b>
Global carbon market (and other environmental service markets)	No formal government agroforestry policy/ programme to support agroforestry
Increased land value – preservation of land productivity and restoration of degraded land	Climate change and climate variability
Potential linkages with conservation and climate smart agriculture	Lack of markets or incentives for ecosystem services or non-carbon benefits
Co-benefits (socio-economic) such as honey production, tourism, increased wildlife viewing	Potential risks of fire and drought
Markets for diverse goods	

**Table 9.5** Correlation between potential agroforestry systems and age

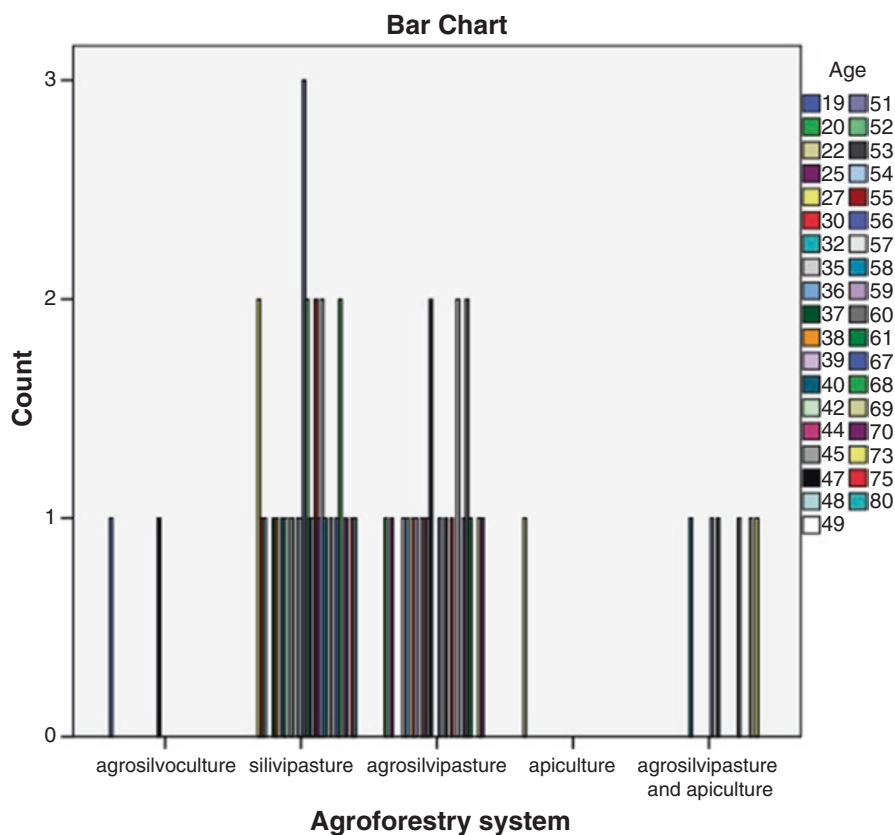
		Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Interval by interval	Pearson's R	0.098*	0.133	0.759	0.451
Ordinal by ordinal	Spearman correlation	0.053**	0.134	0.414	0.680
N of valid cases		65			

\*10% and \*\*5% significant levels

R and 5% for Spearman correlations. This is a clear indication that any age group can participate fully in any agroforestry system in the identified areas.

As indicated in Table 9.6 and Fig. 9.28, there is a positive correlation between agroforestry systems and farming experience variables. The significant level is at 10% and 5% for Pearson R and Spearman correlations, respectively. This is an





**Fig. 9.27** Correlation between potential agroforestry systems and age

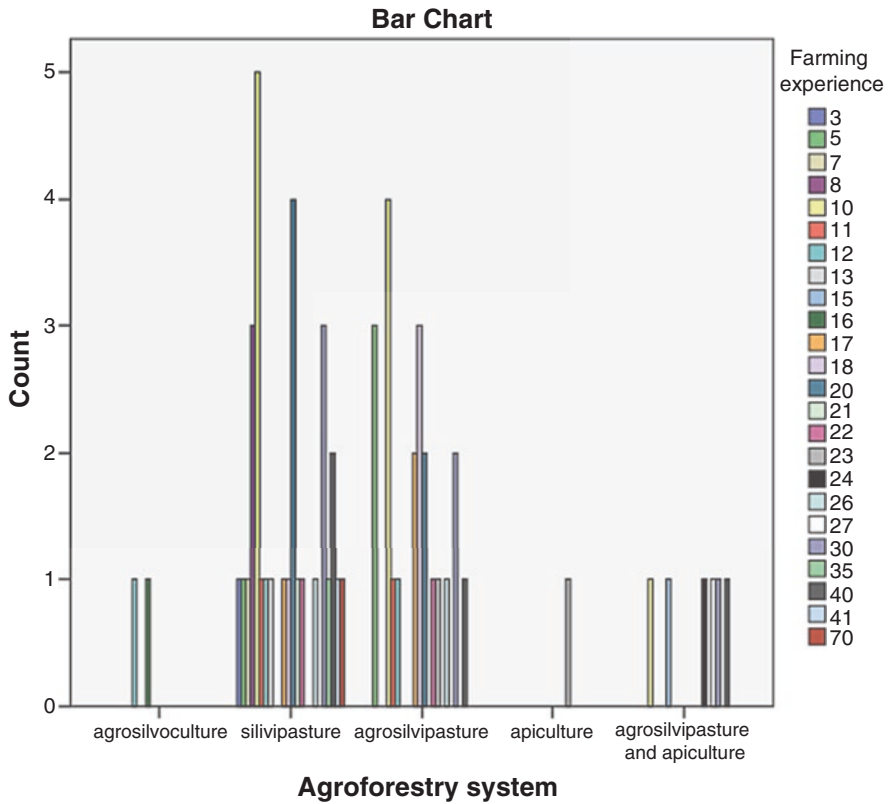
**Table 9.6** Correlation between agroforestry systems and farming experience

		Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Interval by interval	Pearson's R	0.085*	0.121	0.658	0.513
Ordinal by ordinal	Spearman correlation	0.095*	0.122	0.736	0.465
N of valid cases		65			

\*10% and \*\*5% significant levels

indication that farming experience plays an important role in integrating different farming enterprises (crops and livestock) in different agroforestry systems.

The sample data variables predicted 87% for Cox and Snell (measure for binary logistics regression); 91% for McFadden (measure for multinomial and ordered logit) variation in the dependent variable was explained by the independent variables. Prediction accuracy was assessed based on the coefficient of determination



**Fig. 9.28** Correlation between potential agroforestry systems and farming experience

( $R^2$ ). The coefficient of determination R- squared was used to explain the total proportion of variance in the dependent variable explained by the independent variable. The  $R^2$  removes the influence of the independent variable not accounted for in the constructs. R-squared is always between 0% and 100%. In general, the higher the R-squared, the better the model fits the data.

The following econometric model was used to determine association of variables (Greene 1993):

$$W_i = \beta_0 + \beta_1 X_i + \epsilon_i \tag{9.1}$$

$W_i$  is the dependent variable value for person  $i$  (9.2)

$X_i$  is the independent variable value for person  $i$  (9.3)

$\beta_0$  and  $\beta_1$  are parameter values (9.4)

$\epsilon_i$  is the random error term (9.5)

**Table 9.7** Univariate analysis determining factors enhancing participation in agroforestry

Variable	Total	(%)	OR [95%CI]
Selling	65	100	1.55[0.45–3.1]1
Land size	65	100	1.33[0.67–4.555]1
Market	65	100	1.44[0.276–2.4]1
Agricultural training	65	100	1.20[0.68–3.44]1
Production inputs	65	100	1.14[0.39–2.13]1

OR odds ratio, 95% CI 95% confidence intervals, 1< no association, 1> association

The parameter  $\beta_0$  is called the intercept or the value of  $W$  when  $X = 0$  (9.6)

The parameter  $\beta_1$  is called the slope or the change in  $W$  when  $X$  increases by one (9.7)

As indicated in Table 9.7, the odds of farmers' land size, selling, agricultural training, market and production inputs was more than 1. This clearly indicated a positive association with agroforestry systems. It was not surprising to realise a positive association among training, selling and market participation as a well-trained farmer is empowered to make informed decisions and to identify market opportunities where they exist. Moreover, farmers with large land sizes and production inputs could allocate their land partly for trees, livestock and bees, giving them a better position to participate in the market. These results are in line with smallholder surveys conducted by Maponya et al. (2014, 2015) in other South African districts.

## 9.5 Conclusion

Rainwater, temperature and soil were found to be constraints for promotion and establishment of agroforestry system in the districts of Limpopo province, viz. Waterberg, Sekhukhune and parts of Capricorn district. On the other hand, in Vhembe, Mopani and parts of Capricorn districts, factors like soil, precipitation and temperature were found to be a non-constraint for the establishment of the agroforestry system. The research indicated that potential agroforestry systems play a major role throughout human history in supporting livelihoods, assisting various communities to generate income and create job opportunities, as well as meeting food security and nutritional needs in Limpopo Province. The results further indicated an evidence of the importance of agroforestry systems especially silvipasture and agrosilvipasture for supporting food production and income generation in Limpopo Province. Some farmers in Limpopo Province highlighted that they are generating income through renting of farms for grazing, selling trees to the communities to build shelter, kraals, medicinal purposes, fuelwood, etc. Those farmers with access to water were able to grow crops and sell their produce at local communities, local municipality and international market. The farmers also indicated that they were also benefiting from nitrogen fixation, increased crop production, economic gain, soil conservation and improved soil quality and sequestration of

atmospheric carbon as a result of timber-based mixed farming/agroforestry practice. The identified farmers' benefits were in line with some of the researchers' field observations. It is thus recommended that stakeholders should take note of the benefits identified by farmers in an attempt to increase agroforestry farmers' participation.

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