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CRITICAL NATURAL RESOURCES FACTORS THAT PROMOTE THE ADOPTION OF NEW IN-FIELD RAINWATER HARVESTING (*IRWH*) BY EXTENSIONIST IN LAMBANI, LIMPOPO PROVINCE

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ABSTRACT

This paper describes natural resource factors in order to assist extension service with decision making and planning purposes in Lambani, a rural farming community in the Limpopo Province. The natural resource factors (soil, climate and rangeland) were described for implementation of Rainwater Harvesting and Conservation (RWH&C) techniques in Lambani. The long-term climate data was used to characterize the climate in the study area. An intensive-grid soil survey was conducted and the soils were described and classified according to South African Classification System. Climate results indicate that the low rainfall should be utilized effectively by making use of RWH&C techniques. The soil survey results showed that the area comprise of eight different (8) soil forms of which three (3) are not recommended for crop production. A soil map showing soils in this community was created and it is recommended that it should be used for land-use planning.

2. INTRODUCTION

Like many other semi-arid areas in the world, South Africa's food production is limited due to its scarce water resources. There are various soil and water conservation techniques currently being practiced in semi-arid areas of South Africa, mainly in homestead gardens to improve food production (Joseph & Botha, 2011:36). Successful implementation and adoption of new RWH&C techniques such as in-field rainwater harvesting (*IRWH*) has been reported in homestead gardens in Thaba Nchu (Free State Province) and Alice (Eastern Cape Province) to be more than 260 and 1 000 households, respectively (Joseph & Botha, 2011:36). This success was achieved through partnership of researchers and extension service by working together with the farmers. Agricultural extension is the most important source of information to farmers in South Africa and can therefore bring new technology that can be adopted and improve production, incomes and standards of living. In this instance, agricultural extension can play a role in dissemination of new RWH&C techniques like *IRWH* to rural farming communities in the semi-arid areas of Limpopo Province. Extension service can also play a key role in agricultural decision-making and planning purposes in a particular area.

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The *IRWH* technique was proposed in South Africa as an alternative to conventional crop production in semi-arid areas (Hensley, Botha, Anderson, Van Staden, & Du Toit, 2000:92). It was designed to minimize unproductive losses due to ex-field runoff and evaporation from the soil surface. By combining the advantages of water harvesting, no-till, basin tillage and mulching on high drought-risk clay soils, the *IRWH* technique reduces runoff to zero and evaporation from the soil surface considerably. *IRWH* promotes rainfall runoff on a 2-m wide strip between crop rows, storing the runoff water in 1-m wide basins where it infiltrates deep into the soil below the surface layer from which evaporation losses occur (Botha, Van Rensburg, Anderson, Hensley, Macheli, Van Staden, Kundhlande, Groenewald, & Baiphethi, 2003:2).

The soil is the link between the atmosphere (climate) and production (plants or crops). Proper land use is part of successful farming and relies on proper matching of land qualities with land use requirements (Tekle, 2004:2). Most of the land reform projects of land allocated to resource poor farmers are failing. The study in the south-eastern Free State revealed that most of the projects failed due to unsatisfactory land evaluation prior to allocation of land to beneficiaries (Gaetsewe, 2001:40). Food production is fundamentally a product of the atmosphere-plant-soil (APS) system and how it is being utilized by the human beings. This system is the nucleus of nature's factory for the production of all the land-grown food, natural fibre, wood, and paper used by mankind (Hensley, Anderson, Botha, van Staden, Singels, Prinsloo & du Toit, 1997:1). Optimal management of the APS system to the benefit of mankind requires that its' functioning is well understood and therefore proper integration of the three disciplines (climate, plants/crops and soil) and the socio-environment with its human resources are very important. The characteristics, productivity and stability of the APS system and the socio-environment depend on the natural resource factors (climate, topography, crop and soil) and the human resources in a particular area. Therefore it is very important to describe and understand the natural and socio-economic conditions in a particular area, especially when that information is going to be used for planning, or as baseline information.

2. OBJECTIVE OF THE STUDY

The main goals of the study were:
(1) To identify the different natural resource factors in the study area that affect crop production and rangelands.
(2) To identify ideal soils and climatic range needed for crop production in water stressed environments in Limpopo, specifically in Lambani.
(3) To recommend appropriate rainwater harvesting and conservation techniques in the study area.
(4) To present the data of the area in such a way that Extension can use it in farm planning and project planning.

3. MATERIAL AND METHODS

The study area (Lambani) with coordinates; $22^0$42'59.78"S and $30^0$50'00.01"E is about 60 km north of Thohoyandou and approximately 8 km south-west of Punda Maria Gate (Kruger National Park) in the Limpopo Province.

To analyze the climate, a databank from Punda Maria Gate weather station which represents the study area was used in order to identify climatic range needed for crop production in the study area. Description of the climate entailed the analysis of rainfall and temperature for the purpose of this study. In order to morphologically describe and classify the soils a hand auger was used to drill 80 holes on the crop and rangelands. The soils were classified according to South Africa Classification System (Soil Classification Working Group, 1991). The soil colour in the moist and dry state was read by using a Munsell Soil Colour Chart (Munsell Soil Colour Chart, 1990). A soil map was then created showing the distribution of various soil forms. The topsoil and subsoil samples were taken and analyzed following standard procedures for particle size distribution, exchangeable cations, pH (H_2O), total nitrogen, P (Bray 1) and organic carbon (Non-Affiliated Soil Analysis Work Committee, 1991).

In order to describe and assess the rangeland condition of the study area, species composition was determined using the step point method and the nearest species to the point were identified. Each transect consisted of 100 points and the data was analyzed by a simplified technique while bush component was also calculated (Berckerling, Trollope, Mbelu, & Scogings, 1995). The condition of the rangeland was determined to assess the livestock production potential and the potential for rehabilitation if needed.

4. RESULTS

4.1 Climate description

Knowledge of the climate in this study area would enable decision makers (including extensionist) to make more informed decisions, have a better base to plan and structure, be able to identify the risks and opportunities that the climate holds for farming and the intended implementation of RWH&C techniques. Implementation and adoption of RWH&C techniques should be done in semi-arid areas with average annual rainfall between 500 and 700 mm (Botha, Magingxa, Joseph, Smith, Fraenkel & Fouche, 2008: 30). Long-term climate data of 44 years indicates that the study area is semi-arid due to low annual rainfall and high evaporative demand. The long-term climate data results indicate that the area receives 587 mm of rain with 1395 mm of evaporative demand. The area is classified as semi-arid when aridity index (AI) is between 0.2 and 0.5 (Reij, Mulder, & Begemann, 1988: 25). The aridity index of 0.39 is in agreement with the semi-arid conditions of the study area. Figure 1 indicates that the highest average rainfall (115 mm) occurs in January while the lowest (6 mm) occurs in June and August.

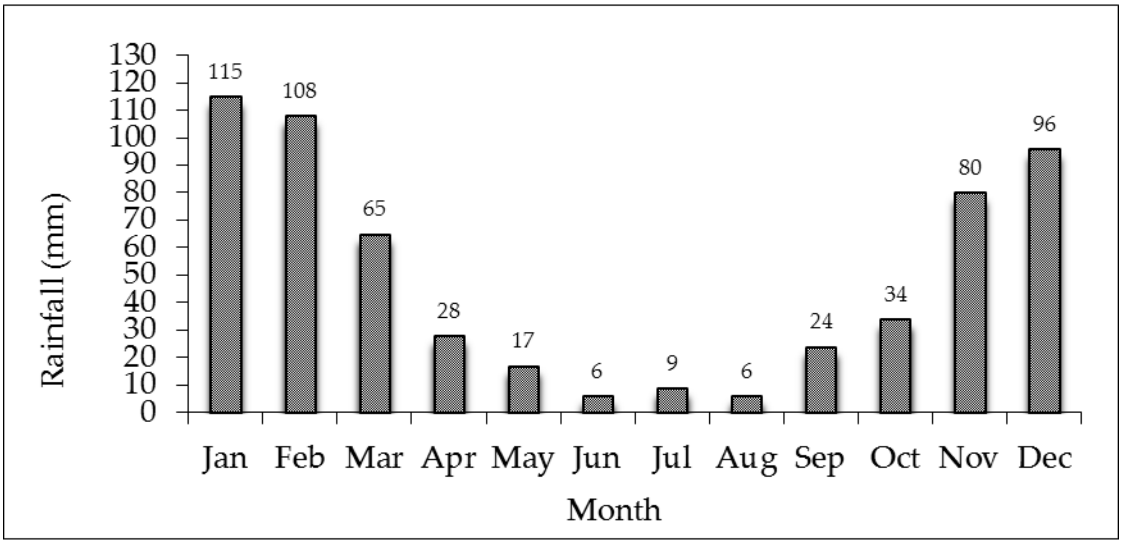

Figure 1 Average monthly rainfall in Lambani.

The study area receives 86% of its annual rainfall between October and March. December, January and February are the warmest months with an average temperature of 27°C and July the coldest month with an average temperature of 19°C.

4.2 Soil description

A soil survey is used as an aid for decision-making and it is therefore used in land planning and management. The soils differ spatially and soil survey results facilitate the matching of the land use requirements with the soil resource. The range of soil forms suitable for rainwater harvesting is very wide and includes soils generally considered to be of marginal potential for crop production in semi-arid areas, e.g. vertic, margalitic and duplex soils (excluding Estcourt form). To ensure minimal losses from deep drainage, soils with a low water-holding capacity in the root zone should be avoided, like sandy soils with a coarse texture. The minimum rooting depth for a soil to be considered depends mainly on two factors: a) capacity of the root zone to store available water for crop production; and b) degree of aridity of the climate. Taking the above-mentioned aspects into consideration, the recommended minimum rooting depth should be at least 500 mm (Botha, Magingxa, Joseph, Smith, Fraenkel & Fouche, 2008: 30).

4.2.1 Soils units
4.2.1.1 Physical state of the soil units

The distribution of the various soil mapping units is shown on the soil map in Figure 2. The symbols in the soil map represent the dominant soils found in Lambani as well as giving a depth indication which is indicated by a prefix **d** (deep; >1000 mm), **m** (moderately deep; 500 – 1000 mm) and **v** (shallow; <500 mm). Terrain plays an important part in the distribution of the soils. The majority of soils on the crest morphological terrain unit are shallow while the ones occurring on the valley bottom morphological terrain unit are moderate to deep. The mainly shallow and stoney soils which are indicated by *Ms* on the map occur mostly on the plateau of the study area. The plateau is used for communal grazing purposes. The soil depth varies between 160 and 2200 mm.

The most dominant soil form in the valley bottom terrain morphological unit is the Hutton which is indicated by the symbol *Hu.* These red structureless soils with clay content of 10 - 20% and 20 - 30% in the topsoil and subsoil, respectively are mostly used as croplands. Soil forms with similar characteristics like Clovelly (*Cv*), Pinedene (*Pn*) and Avalon (*Av*) were also found. These soils have similar properties; soil colour and clay content. The topsoil colour is dark yellowish-brown while the subsoil is brownish-yellow. The clay content in the topsoil ranges between 8 and 15% while the subsoil clay content is about 40%. The main difference between these three soil forms is the third diagnostic horizon. The *Cv* form has a non-diagnostic horizon while the *Pn* and *Av* forms have unspecified material with signs of wetness and soft plinthic horizon, respectively. The latter diagnostic horizons have implication on crop production especially in the semi-arid areas, because of the potential of storing water for crop uptake.

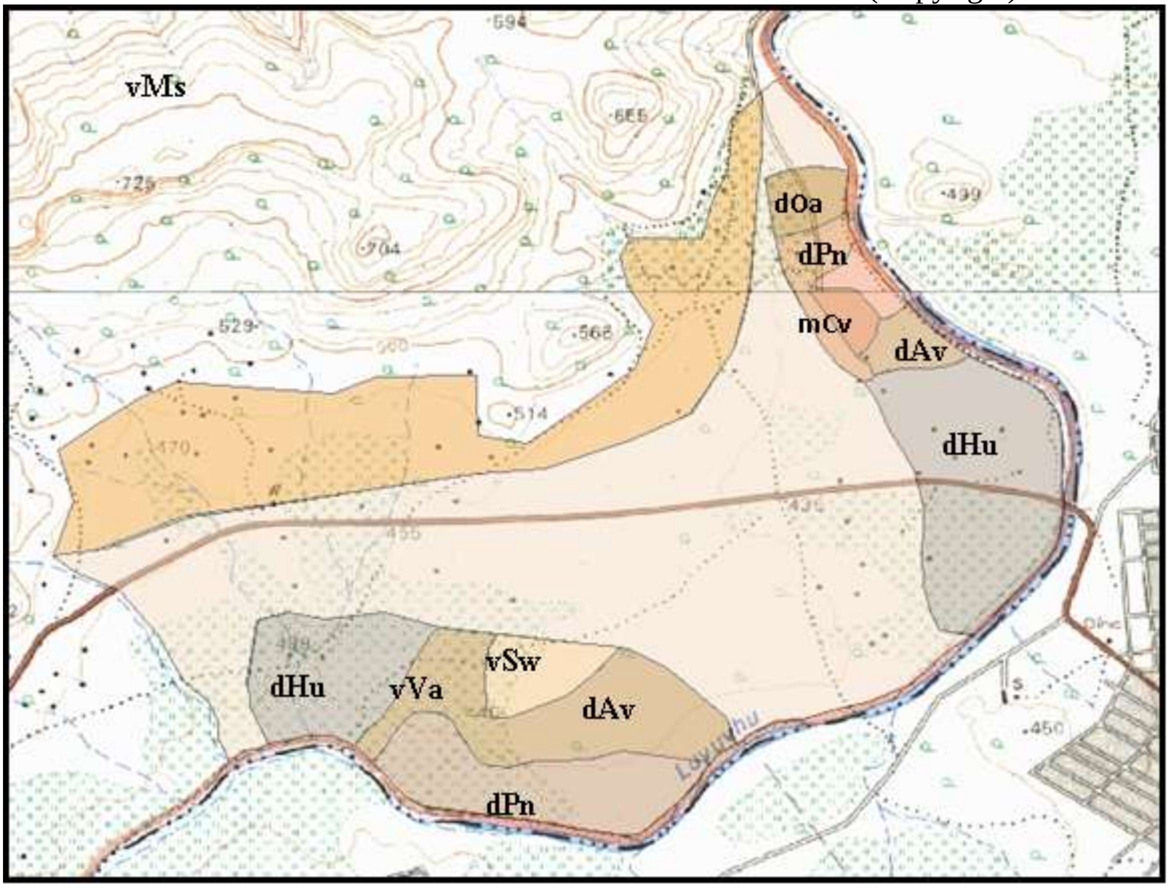

Figure 2 Soil map showing various soil forms in Lambani.

Two similar duplex soil forms are also found; *i.e.* Swartland (*Sw*) and Valsrivier (*Va*). These are clearly typical duplex soils with sandy topsoil and very clayey subsoil. The clay content in the topsoil is between 15 and 20%, and more than 40% in the subsoil. The difference between these soil forms is that the third diagnostic horizon is saprolite and unconsolidated material without signs of wetness for *Sw* and *Va* forms, respectively. The Oakleaf (*Oa*) soil form which is well-drained is also found. This *Oa* form has dark brown to dark yellow brown colour and clay content ranging between 15 and 20% in the topsoil; and to up to more than 30% in the subsoil.

4.2.1.2 Chemical state of the soil units

Soil chemical analysis is used as a tool to determine nutrient availability in the soil. Generally, the soils in the study area fall under EA group, these are red, yellow and greyish soils with low to medium base status (Soil Survey Staff, 2002). The results of *Hu, Cv, Pn, Av* and *Oa* units indicate that these soils' reaction is moderately acid to mildly alkaline. The $pH_{(H2O)}$ values range between 5.4 and 7.5. These results are in agreement with EA group soils. The pH range recommended for most grain crops and vegetables is between 5.5 and 7.5 (Fertilizer Society of South Africa, 2007:162). The phosphorus (P) values for these soils are very low and range between 1.17 and 3.55 mg kg^{-1}. The P (Bray 1) values for grain crop and vegetable production should be 15 – 30 and 30 – 60 mg kg^{-1}, respectively (Fertilizer Society of South Africa, 2007:163). The recommended values for exchangeable cations (Ca, Mg and K) for grain production are 300 – 2000, 80 – 300 and 80 – 160 mg kg^{-1} while the values for vegetable production are 400 – 2500, 100 – 400 and 120 – 240 mg kg^{-1}, respectively

(Fertilizer Society of South Africa, 2007:164). The results of this study area indicate that the exchangeable cations values range between 384 and 2611, 104 and 814 and 25 and 66 mg kg^{-1} for Ca, Mg and K, respectively. The low K-content of the study area is sub-optimal for both grain and vegetable production.

Sw and *Va* units have high pH $_{(H2O)}$ values of between 7.1 and 9.7 making them to be mildly to strong alkaline. These soils also exhibit a low P value of 1.95 mg kg^{-1} which is sub-optimal for grain crop and vegetable production. This justifies the application of P in order to increase the P-status of these soils. The Sw and Va soils have low K-values (62 – 84 mg kg^{-1}) like *Hu, Cv, Pn, Av* and *Oa* units. However, they have high Mg-values of between 440 and 1289 mg kg^{-1}. The organic carbon in the topsoil ranges between 0.44 and 1.8% while total nitrogen ranges between 0.02 and 0.09%.

4.3 Soils suitability for crop and rangeland production under RWH&C techniques

A literature review on rainwater harvesting techniques showed that RWH&C techniques could be implemented on soils with clay content up to 60%, slopes up to 50% and at least 500 mm soil depth for rangeland, crop and vegetable production (Joseph, 2007:26). Soil depth is a very important attribute for RWH&C techniques since depth is needed for adequate water holding capacity. Slope is also important for runoff collection, however it depends on the type of technique being applied since some techniques induce soil erosion rather than rainwater harvesting on steep slopes. The results indicate that 77% of these soils will be suitable for implementation of RWH&C techniques for rangeland, crop and vegetable production. The results have also indicated that climate in Lambani is suitable for implementation and adoption of RWH&C.

4.4 Rangeland description

4.4.1 Vegetation

In the latest classification of veld types this vegetation type is described as the Soutpansberg Mountain Bushveld (Mucina & Rutherford, 2006: 475). This veld type typically consists of a dense tree layer with a canopy cover of 60-70%, and a poorly developed grassy layer. At the top of the mountain there is a plateau with relatively open savanna sandveld on both deep and shallow quarzitic sands. It is this plateau that is mainly used as communal grazing area by the people of Lambani, as well as neighbouring communities. The survey results reveal that most of the perennial grasses were replaced by pioneer grasses due to overgrazing of the area over a long period of time.

There is also a concern about a woody dwarf shrub, *Helichrysum kraussii*, which tends to encroach on the plateau, probably due to overgrazing and a lack of strong perennial grasses to compete with it. This dwarf shrub is known for its ability to form dense stands, especially on overgrazed mountain summits and rocky outcrops (Van Wyk & Malan, 1988:112). From the herbaceous layer it is also clear that most of the forbs (herbaceous flowering plants) are typically of disturbed or overgrazed areas. Some of these forbs which are also an exotic from India are; *Vinca rosea*, *Tephrosia lupinifolia*, *Blepharis spp.*, *Chamaecrista spp.*, *Dicerocaryum eriocarpum*, *Merremia tridentate* and *Sida spp.*, (Pooley, 1998:416).

5. SUMMARY AND RECOMMENDATIONS

The natural resource factors that affect crop production and rangelands were successfully identified in Lambani. Majority of soils in Lambani were identified as suitable or ideal for crop production. According to soil survey results, the average soil depth in the study area is 1035 mm with clay content up to 40%. The soils in the study area are slightly acidic to more alkaline. Due to low phosphorus and potassium content of the soils, it is recommended that these two nutrient elements be applied for optimal crop production. Generally, the soils in the study area are relatively good (*Hutton*, *Pinedene*, *Clovelly*, *Avalon* and *Oakleaf*) and should be utilized for crop production. It is recommended that shallow and poor soils (*Mispah*, *Valsrivier* and *Swartland*) be utilized for the rangeland. Considering soil and average annual rainfall of 587 mm, adoption of *IRWH* is recommended for sustainable crop production in water stressed environment like Lambani. *IRWH* can be combined with mulching to minimize evaporation from the soil surface. Since it would a huge challenge to implement *IRWH* in the rangeland it is recommended that veld management practices be adopted.

It is recommended that extension use similar approaches in their respective areas to describe and analyse the natural resources in detail. If extension does not have capacity to describe and analyse the natural resource in detail, it is recommended that they link up with scientists who are capacitated to do the task. This information will assist them to: (i) better understand the natural resources factors in their areas; (b) plan land use activities far better in order to optimize production and economic viability of the farmers (small-scale and commercial) in their areas; (c) have a data base of the natural resources in their respective areas which will assist them with continuation and expert advice to farmers even when extension staff leave their respective areas.

Land use planning is critical especially during this time of climate change with additional pressure of producing enough food. This includes activities like: recommendation of appropriate cultivation practices, e.g. rainwater harvesting and conservation techniques; recommending appropriate or suitable crops in specific areas; utilizing only high potential soils for crop production and use low potential soils exclusively as veld or planted pastures. Following similar approaches will result in increased productivity and sustainable agricultural production.

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