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RECLASSIFICATION OF AGRO-ECOLOGICAL ZONES IN ZIMBABWE – THE RATIONALE, METHODS AND EXPECTED BENEFITS: THE CASE OF MASVINGO PROVINCE

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ABSTRACT

For agriculture to develop in a sustainable way in Zimbabwe, there a need to reclassify its agro-ecological zones. The current zones developed in the 60s have become redundant, outdated and cannot be used to plan sustainable agriculture. This is because of climate change and variability and which has shifted previously derived zones and the development of new tools and technology that are more effective in agro-ecological zonation. This paper was therefore aimed at making a critical review of the current agro-ecological zones and justifies the need for a reclassification of these zones using Masvingo province as a case in point. The paper examines the methods, the shortcomings of the current classification and the expected benefits of the reclassified agro-ecological zones. A holistic approach was recommended in the re-classification attempt and incorporated factors such as climate and bio-climatic features, physiographic features, edaphic characteristics, use of geospatial technologies and length of the growing season. Among the expected benefits of the new agro-ecological zones are improved land use planning and management, increase in agricultural productivity, development of appropriate agro-technologies transferrable across similar zones and accurate research, extension services and sustainable development of Zimbabwe's agricultural sector. This paper was meant to culminate in the derivation of new boundaries of agro-ecological zones in Masvingo Province, at a finer scale and it is hoped similar techniques could be applied at national scale and beyond.

Keywords: Agro-ecological, climate change, zonation, Masvingo, input parameters, Zimbabwe and sustainable development.

INTRODUCTION

The biophysical environment within which economic men operate often dictates the potentials as well as limits to the activities they may do. It is quite essential that environmental parameters like climate, soil types, natural vegetation, wildlife, water resources and other natural resources are closely studied and known. Knowledge of these parameters enables informed and sustainable long term planning particularly in the agricultural sector (Mudzengi *et al*, 2013). These diverse biophysical variables interact continuously to produce a dynamic platform on which a series of socio-economic activities unfold. A closer analysis of these factors would result in seemingly uniform observable geographical spaces. From an agro-ecological perspective, the uniform land units are termed agro-ecological zones (AEZs).

Agro-ecological zones are land areas representing unique combinations of homogenous agro-climate, ecology, soil units and agricultural activities (FAO, 1978). Climate is a prime factor that exerts major influence and control over vegetation, soil type, water resources and ultimately human activities. Earlier work by Vincent and Thomas, (1960) divided Zimbabwe into five agro-ecological zones, with best agricultural suitability being highest in Region 1 and least in Region 5. The spatial distribution of average rainfall was the basis of this classification. However, it is vital that spatial as well as temporal distributions and patterns of effective rainfall and other factors be considered too (Waugh, 1995). By taking a cue from their work, this paper reviews the current agro-ecological zones and justifies the need to come up with disaggregated agro-ecological zones in Masvingo Province by adopting a holistic approach. The methodology of creating these homogenous land use units is carefully described, paying special attention to the factors that need to be considered for a thorough classification.

Sustainable development is development that is equity led. It implies that the consumption levels of the current generation should not preclude future generations from enjoying a level of well being at least as great as that of the current generation (Anand and Sen, 2000). When the concept is applied to agricultural development, it implies the agricultural practices of current generations should not destroy or reduce the capacity of future generations to enjoy current or increased levels of agricultural production. This means that for agriculture to be sustainable now and in the future, it needs proper planning and agro-ecological zonation of areas of equal agricultural potential is one of the ways of enhancing this.

There have been efforts toward dividing the globe, continents and sub-continents, countries and regions within countries into ecological (natural) zones, and even more specifically, agro-ecological zones (FAO, 2004). An Agro-ecological Zone is a land resource mapping unit, defined in terms of climate, landform and soils, and/or land cover, and having a specific range of potentials and constraints for land use (FAO 1996). Several techniques have been employed to achieve that, but usually climate takes an overriding influence. The full knowledge of one’s ecological environment has been quite handy in weighing land use planning options as well as land and water resources management practices. However, it is appalling to note that such preceding work has been at a macro scale, thereby limiting accurate land use planning at micro scale. This means that the zones do not show local variations, transition zones or the influences of relief (Waugh, 1995). This study therefore seeks to assess the rationale of disaggregating Zimbabwe’s agro-ecological zones to emerge with new zones at a finer scale. It is the apparent absence of similar efforts elsewhere that has prompted the current study to enquire on the need, methods and expected benefits of reclassifying agro-ecological zones within a region of a country.

This paper therefore mainly addresses the need for coming up with agro-ecological zones at a finer scale, through the use of more input parameters, factoring in climate change and variability, new geospatial technologies and methods to enhance efficiency in sustainable land and water resources management and achieve improved agricultural productivity and sustainability.

JUSTIFICATION OF NEW AGRO-ECOLOGICAL ZONE CLASSIFICATION

In a survey carried out by Great Zimbabwe University on climate change and vulnerability around Masvingo province, most people perceived climate change to be taking place. They confirm that the onset of the rainfall season is now coming late and cessation time coming earlier than before with some severe midseason droughts in between (Simba, 2012b). This has made it difficult to reliably grow crops that in the past used to thrive on an area. This can be confirmed by the Zimbabwe Meteorological Services Department, (2002) on Figure.1

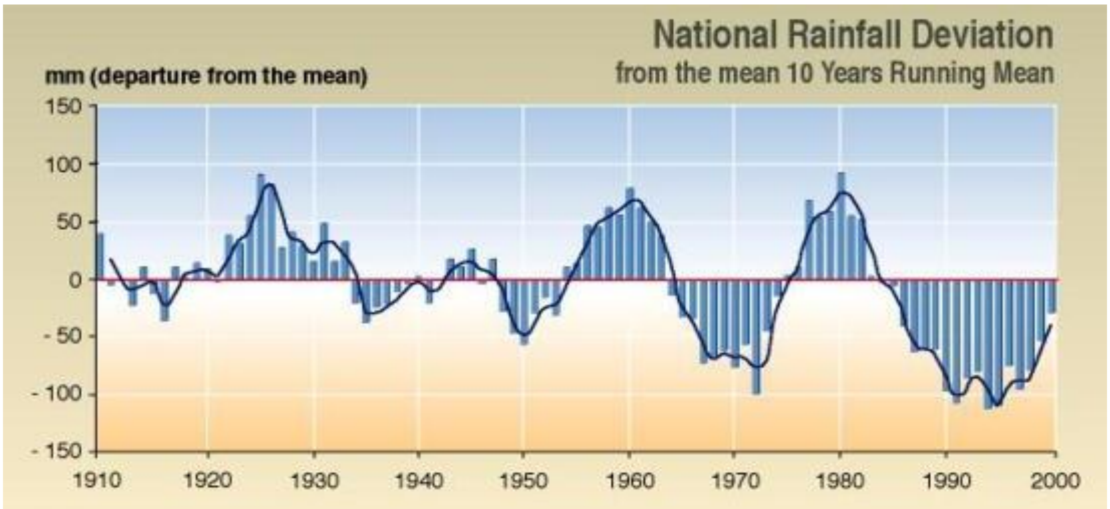

Figure 1: Zimbabwe rainfall deviation from Mean.(Source: Zimbabwe Meteorological Services Department, (2002))

Figure.1 shows that rainfall in Zimbabwe since 1980s has been deviating more from mean in a negative way with an increased magnitude. All this points towards climate change and the need to adjust farming systems practised for sustanable agriculture, hence the need for new agro-ecological zones as planning units.

It is important to classify land into agro-ecological zones because of the following reasons:

- Need to design appropriate agricultural programmes for specific areas
- Long term frost protection measures
- Land use planning

The above reasons attempt to answer the following questions according to FAO (1996):

- How is land with different potentials and constraints distributed within the country and in component provinces or districts?
- What uses can be recommended on different types of land in different locations?
- How do potential yields vary among locations, years and seasons?

This information can then support the development of land-use policies and enabling strategies in such specific areas such as:

- the provision of appropriate, area-specific, extension information and advice

- the provision of agricultural inputs, or of relief programmes
- the setting of agricultural research priorities, and the establishment of networks for agro-technology transfer
- establishment of environmental monitoring
- the formulation of legislation or guidelines to regulate and minimize environmental damage, and the
- The identification of particular development programmes or projects

Investment in agricultural production is being increasingly directed at agro-ecological zones where output benefits may be expected to be greatest. This first requires that the zones themselves be defined. This therefore means that agro-ecological zones are standard tools for prioritising agricultural research and investment because they offer relevant, available information about target environments (Corbett 1996, Fischer et al, 2006).

Study Area

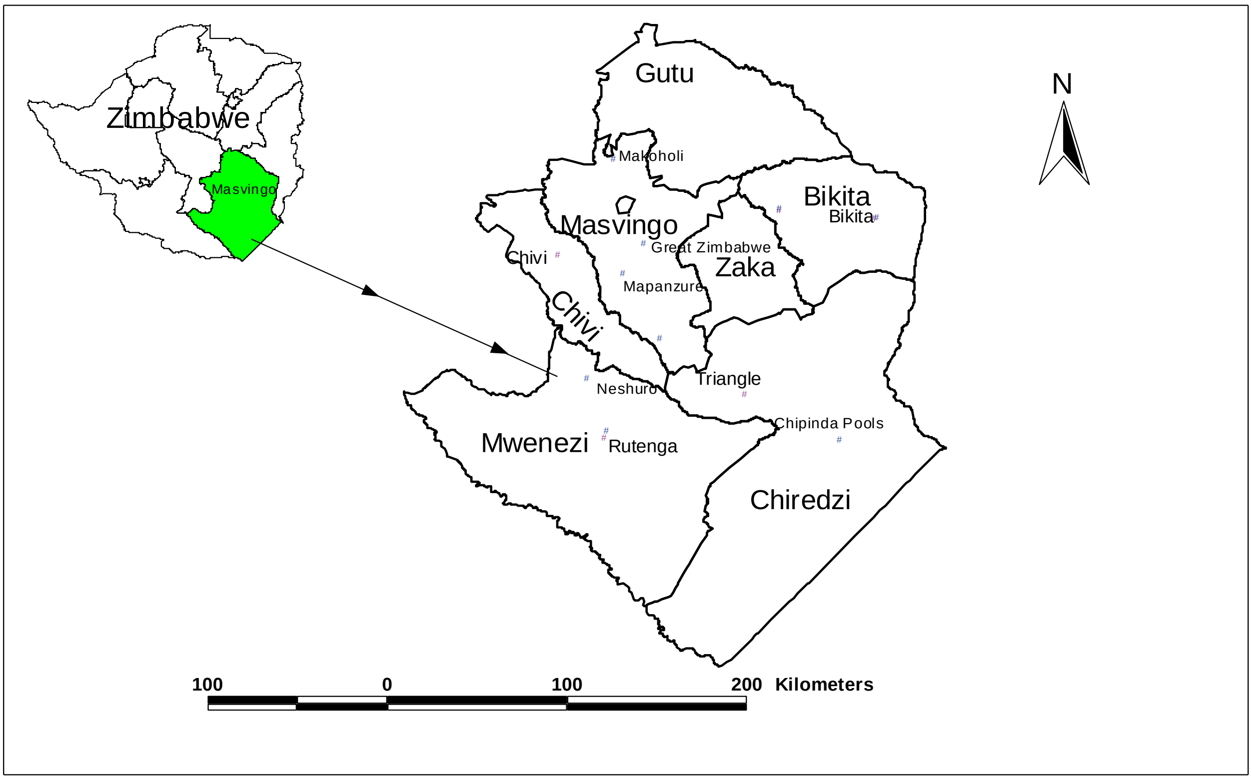

Figure 2: Masvingo Province

Masvingo is one of the ten provinces in Zimbabwe found in the drier south-eastern lowveld of the country (Figure 2). The province has an area of 56,566 km² and a population of approximately 1.3 million (CSO, 2002). There are seven administrative districts run by Rural District Councils (RDCs), namely Bikita, Chiredzi, Chivi, Gutu, Masvingo, Mwenezi and Zaka. The province is predominantly semi-arid, rainfall is minimal, highly variable/erratic and uncertain making the province prone to droughts. The bulk of the province is set as region 5 in the country's climatic agro-ecological regions. Though most of the province is generally dry, it does possess some of the most agriculturally fertile soils, inland water bodies and river systems (Save, Runde, Mwenezi, Mutirikwi and Limpopo river systems dominate the drainage system in the province), drought tolerant and sturdy vegetation like Mopani trees, and very rich natural pastures (Murwendo and Munthali, 2008). Kopjes, hills and mountain ranges dot the countryside. The dominant agricultural activities include subsistence cultivation of drought resistant cereal crops (sorghum, rapoko, millet, and some varieties of maize) and cattle rearing (and commercial cattle ranching) (Simba, 2012a; Wikipedia, 2012).

AGRO-ECOLOGICAL ZONES IN ZIMBABWE

Currently Zimbabwe is divided into five agro- ecological zones based on the work done by Vincent and Thomas (1960). These regions are shown on Figure 3.

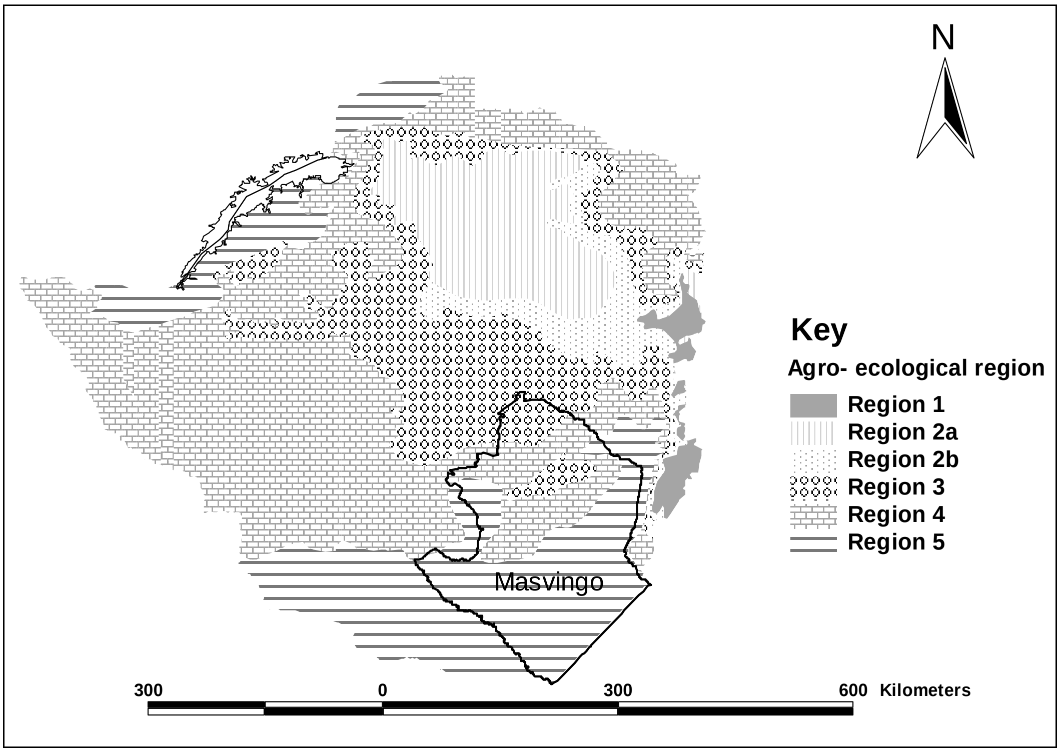

Figure 3: Zimbabwe’s Agro-ecological Zones

The properties of agro-ecological Zones shown in Figure 3 are described by Table.1.

Table 1: The attributes of Zimbabwe's current agro-ecological zones

AEZ	**Area covered**	**Agricultural production**	**Description**
1	7000km/ 2%	Specialised and diversified farming	<1000m rainfall, tea,coffee, plantation farming, macademia, fruits, intensive livestock production
2	58 600km2/ 15%	Intensive farming	750-100mm rainfall, Intensive crop and livestock production
3	72 900km^2 / 19%	Semi-intensive farming	650-800mm of rainfall. Severe mid-summer droughts but maize, tobacco, cotton and other cash crops grown
4	147 800km^2/ 38%	Semi extensive	650- 800mm of rainfall .Livestock and drought resistant crop production
5	104 400km^2 / 27%	Extensive	<450mm rainfall supports extensive cattle or game protection

The province lies within regions 3, 4 and 5. Northern parts of Gutu, Zaka; north-western Bikita, Chivi north and south and western Masvingo districts are categorised as region 3. Most portions of Gutu south, Zaka and Masvingo and Bikita central are in region 5. All of Chiredzi, most of Mwenezi and Chivi central are found in region 5 (figure.4).

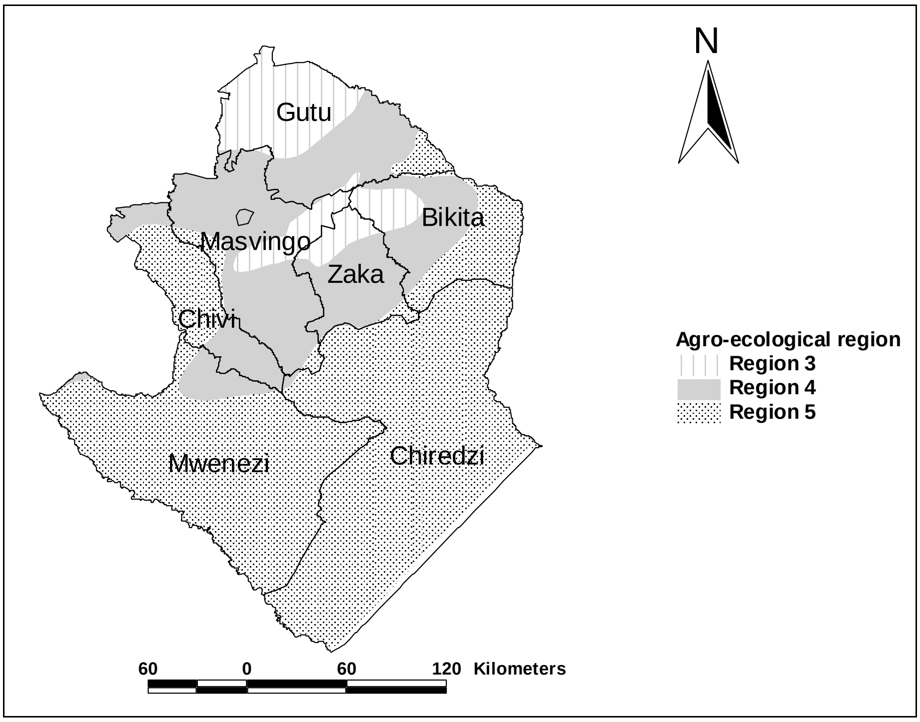

Figure.4: Masvingo Districts & Agro-ecological Regions

PREVIOUS WORK ON AEZS IN ZIMBABWE

1. Vincent and Thomas (1960) divided Zimbabwe into five AEZ (figure 3, table 1). They however did not consider effective rainfall, did not consider anomalies in length of growing season for individual stations in Zimbabwe, and used a database with very few data and less developed tools. Technological change has brought new methods and techniques, better updated and managed databases, hence there is need to reclassify these zones. Due to the effects of climate change and variability, Zimbabwe now has more hot days and fewer cold days as compared to the 1960s when Vincent and Thomas did their agro-ecological zonation of Zimbabwe.

   There has also been the expansion of arid conditions into regions that were previously semi arid, this has been exacerbated by serious and more frequent precipitation deviation from the mean that even makes it more difficult to schedule the best time for crop cultivation. This makes their agro- ecological zones less effective as a planning tool for viable and sustainable agricultural production.
2. Kainamura (2000) did a partial reclassification northern parts of Zimbabwe. He used long term average rainfall, soil type, length of growing season and temperature. The results showed that both sizes and position of regions had shifted as compared to Vincent and Thomas (1960) zones. The major shortcomings of this research were the scale which was used that was macro and also used less developed tools and parameters. Although Kainamura (2000) used more parameters and tools than Vincent and Thomas (1960) more parameters like physiographic features and bio-climatic features could have been used coupled with geographic information systems and remote sensing.

3. Mugandani (2009) reclassified agro-ecological regions of Zimbabwe at a scale of 1: 1 000 000. The new regions differed from the ones previously produced by Vincent and Thomas (1960). His work took a holistic approach in which most of the factors limiting land productivity were taken into account. The research however did not look at agricultural production trends and types in the new agro-ecological regions to compare them with the previous ones of Vincent and Thomas (1960). The scale he used was also very course and the derivation of suitability agricultural zones was based on only one crop which was maize. Study also has a limitation of using very few parameters which were rainfall and soil suitability, and the length of the growing season ignoring all other parameter like altitude, frost vulnerability and vegetation patterns.

NEW METHODS OF CLASSIFYING A.E.ZS

Most modern methods used in agro-ecological zonation demarcation use the following input parameters shown on Figure. 5.

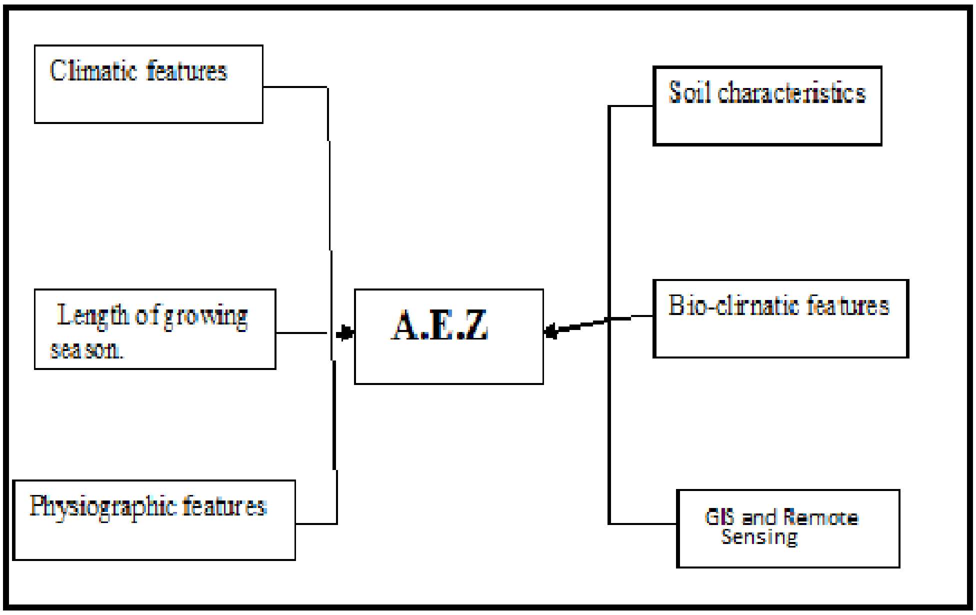

Figure.5: Input parameters used in Agro-ecological Zonations

The methods widely used today follow the guidelines given by FAO (1996). The parameters used during the demarcation of agro-ecological zones are highlighted below:

Bio-climatic Features

On the basis of the rainfall, temperature, potential evapo-transpiration, altitude and vegetation. Chandy (1997) prepared bio-climatic map of India using the water balance approach and Penman's Potential Evapo-Transpiration (PET) values. The water balance indicates the water surplus or water deficit, determining the moisture index with positive or negative values showing the moist or dry climate depending on the PET, which again indicates the radiation energy received and the summer intensity. If the rain fall is more than tile PET then the moisture index is positive and if less than PET then it is negative. Ultimately tile moisture index form the basis for the bioclimatic classification. (Thornthwhite and Mather, 1955; Chandy, 1997).

Temperature and Rainfall Sensitivity

Global warming will lead to higher temperatures and changes in rainfall, and this in turn will modify the extent, sustainability and productivity of land suitable for agriculture. The application of a set of temperature and rainfall sensitivity scenarios have revealed a modest increase of cultivable rain-fed land for temperature increases up to 2 °C on a global scale. If temperature increases further but precipitation patterns and amounts remain at current levels, the extent of cultivable rain-fed land starts to decrease. When both temperature and rainfall amounts increase, the extent of cultivable rain-fed land increases steadily (Le Houérou et al. 1993, Kannangara, 1998).

Growing period

The concept of the growing period is essential to AEZ, and provides a way of including seasonality in land resource appraisal. In many tropical areas, conditions are too dry during part of the year for crop growth to occur without irrigation, while in temperate climatic regimes crop production in winter is limited by cold temperatures. The growing period defines the period of the year when both moisture and temperature conditions are suitable for crop production (Mantel, 1995, White, 1998).

The growing period provides a framework for summarizing temporally variable elements of climate, which can then be compared with the requirements and estimated responses of the plant. Such parameters as temperature regime, total rainfall and evapotranspiration and the incidence of climatic hazards are more relevant when calculated for the growing period, when they may influence crop growth, rather than averaged over the whole year.

Thermal regime

The thermal regime is the other basic climatic parameter used to define the agro-ecological zones. The thermal regime refers to the amount of heat available for plant growth and development during the growing period. It is usually defined by the mean daily temperature during the growing period. In regional and national AEZ assessments, thermal zones may be defined based on temperature intervals of 5°C or 2.5°C. A more detailed treatment of thermal regimes is often required in temperate or subtropical areas.

Soil mapping unit

The soil mapping unit is the basic unit taken from the soil map. On small-scale maps, soil mapping units rarely comprise single soils, but usually consist of a combination of a dominant soil with minor associated soils. When the various soils of a soil mapping unit occur in a recognizable geographical pattern in defined proportions, they constitute a soil association. If such a pattern is absent, they form a soil complex.

Each soil type occurring in each soil mapping unit is characterized in terms of its land characteristics and qualities which relate to the edaphic requirements of plants or to land-use requirements for management or conservation (IUSS, FAO and ISRIC 2003).

Land resource inventory

The land resource inventory is essentially an overlay of climatic and soil information. The resulting units are the agro-ecological zones, which have a unique combination, or a specified range, of soil mapping units, growing period regimes, and thermal regimes; and agro-ecological cells, with unique combinations of growing period and thermal regimes and soil types. The relevant land characteristics of each AEZ are listed under headings related to agro-climatic constraints and soil or land constraints. Information on land administration, land tenure and present land use, related to potential land availability, may be incorporated in the land resource inventory (Corbett 1996, Fischer etal, 2006).

Land utilisation types and crop adaptability

Assessment of land suitability and potential productivity is made in relation to a specific type of land use under certain production conditions.

Geo-Spatial Technologies

All the data above should be spatially enabled and the combined together in a GIS, to create a land resources database, that can then be used to demarcate the agro-ecological region on a place. Each input parameter has to be analysed for its climatic/ biophysical limitations and potentials to agricultural production and then assigned a score. Each input parameter must not have the same role and weight in the modelling of the final AEZs. In order to designate the importance of each parameter multi-criteria decision making procedures will have to be implemented.

The success of zoning a particular region lies in adoption of new research tools available, particularly the vital inputs from space technologies such as remote sensing (RS) and geographic information systems (GIS) (Steven 1993). Remote sensing technology has been of great use to planners in planning for efficient use of natural resources at national, state and district levels.

EXPECTED BENEFITS FROM THE RECLASSIFIED AEZS IN MASVINGO PROVINCE.

Geographers find it quite convenient to utilise classification of phenomena (such as types of climate, soil, vegetation, landform, settlement, land use). Classes or groups create order, ease for comparisons, understanding and use planning (Waugh 1995). The classification of regional agro-ecological zones, if linked to the natural resource base of climate, vegetation, soil, topography, wildlife, water resources, the socio-economic and land use database, will obviously yield managerial efficiency and sustainable development. Since none of these parameters is constant, it is essential to revisit the current classification to ensure that it is in tandem with, not only these dynamic environmental factors, but even their complex interrelationships and sum influences.

It is quite a disservice on the part of researchers, scientists, extension technicians and other stakeholders to continue advising farmers on farming techniques basing on the land classification of the 1960s (The Herald, 2011). Environmental changes on the ground warranty that a new classification be availed that reflects on current environmental conditions. The following benefits are expected to accrue to the residents of Masvingo province, government planners, their partners (donors and developmental agencies) and any organisations interested in developmental issues in the region.

Efficient land use planning and soil conservation – the reclassified agro-ecological zones would be at micro-scale, paying attention to local variations in effective rainfall, altitude, water resources, soil and vegetation types. Previous classification lumps vast areas together as sharing similar characteristics, however the current effort would give due recognition to local variations. This approach ensures that there would be efficient land use planning and well coordinated soil conservation methods by relevant stakeholders. Land and land-based resources may be exploited in diverse ways, and combining the local knowledge systems with the technical and research skills of expects results in distinct participatory extension and research approaches to attain efficient land use patterns (SAFIRE, 2002). Each micro-zone is unique hence should be considered as such. It is for this reason that the reclassified agro-ecological zones would receive site-specific land use recommendations based on available resources, environmental dynamisms, local indigenous technical knowledge systems (ITKs), technical and research services. The setting up irrigation schemes, paddocks, crop fields, nature conservancy's, aquariums, agro-forestry, is all guided by a clear understanding of local conditions. A particular soil type requires specific new agricultural technologies and technical management practices to sustain its integrity and fertility. This can only be achieved through advocating for and promotion of appropriate land use activities, guided by a thorough and close knowledge of the prevailing, operating and interacting factors.

Promotion of appropriate and sustainable agricultural practices – a land classification based on many factors puts agricultural extension and research services in a better position to select the most appropriate and sustainable agricultural practices. Each farmer would be given sufficient and effective support for their activities. Generally Masvingo province is a dry region (receives an average of 500 mm rainfall per annum which is erratic, unreliable, unpredictable and unevenly distributed) but is endowed with fertile soils in the Lowveld, high temperatures, perennial rivers, vast water reservoirs and a very diverse terrain. Such endowments represent the region with quite a wide array of sustainable agricultural opportunities like irrigated arable farming, aquaculture, crocodile farming, cattle ranching, dairying, market gardening, horticulture, orchard plantation and others. Many agricultural production systems, technologies and practices are often associated with specific agro-ecological zones (Fisher, et al 2001).

Integrated land use options/sustainable land use management – agro-ecological zones provide consolidated information, a useful spatial framework for identifying the most appropriate land use options for an area. Since there are variations within regions at whatever scale, it's quite hard to come up with uniform zones, but creating small uniform zones is quite closer to achieving useful land use zones.

Land degradation prevention – the redefined agro-ecological zones would favour recommendations on the use of new appropriate agricultural technologies suiting prevailing conditions in an ever changing environment. Such zones can be devised to help estimate the varying, site-specific responses to new agricultural technologies. The use of inappropriate technologies is detrimental to environmental integrity, as that leads to nature degradation. A specifically defined agro-ecological zoning is vital for matching ecological conditions with socio-cultural production practices. The traditional strategies of improving land productivity, which are, intensification and rehabilitation, have important ecological dependencies (Wood and Pardey, 1997). Agro-technologies should be specific to each agro-ecological zone to ensure minimal disturbances to the ecological systems (Haward, 2008).

Adapting to environmental change - agro-ecological zones at small scale help highlight areas within a region where farmers may face greater challenges related to the adoption of new technologies, responding to adverse climate conditions and an ever changing environment. Disaggregated agro-ecological zones would allow research and extension services to prepare and implement climate resilient management plans to increase water retention, soil conservation and food security in the drought prone province. Also, this would facilitate the introduction of climate resilient agro-ecological farm practices to make effective use of available water (UNDP, 2011).

Conclusion

If the exercise of reclassification of AEZs is executed well and with minimum ambiguity, it holds a lot of potential and is key to sustainable development which is critical in developing countries to come out of the quagmire of underdeveloped agriculture. The proposed work should be done at a local scale such as the Provincial level and verified if the findings are feasible, accurate and sustainable enough as a guiding tool for extension of the work to other provinces in the country.

The paper asserted the rationale, methods and expected benefits of reclassifying AEZs in Zimbabwe in general and Masvingo province in particular. Creation of homogenous agro-ecological spatial units requires an in depth knowledge of the prevailing biophysical factors that interplay to shape the dynamic environment. Due to environmental dynamism and technological advancements, it is apt to continuously review the agro-ecological regions in existence to keep updated and abreast with the current situation. Agro-climatic conditions, physiographic and edaphic factors, as well as technological developments have been cited as the most compelling factors for classification of AEZs in a country or region within a specific country. The benefits of reclassification of AEZs are so vital to be ignored. Since the new classification yields disaggregated AEZs, this stands to greatly facilitate area-specific land use planning and recommendations, inform land use planning policies, and allow research and extension services as well as agro-technology transfer across similar zones. It is recommended by this paper for future research to have a map showing reclassified AEZs of the Masvingo province and later, following such a success case, transfer similar techniques to do this at a broader scale, that is, at country level and regions beyond.

REFERENCES

Anand, S and Sen, A (2000) 'Human Development and Economic Sustainability', *World Development,* vol 28, pp 2029-49.

Central Statistics Office (CSO) (2002) Census 2002- Provincial Profiles, Masvingo Province. CSO. Harare.

Chandy K. T(Ed)(1997) *Agro-ecological Regions on India* Booklet No. 534 Agricultural Meteorology: AMTS-3

Corbett, J.D (1996) *The changing face of agroecosystem characterization: Models and spatial data, the basis for robust agroecosystem characterization*. Proceedings of the Third International Conference on the Integration of GIS and Environmental Modeling, Santa Fe, New Mexico.

FAO and ISRIC (2003) Soil and Terrain Database for Southern Africa (1:2 million scale). Land and Water Digital Media Series 25, FAO, Rome

Fischer Günther, Shah Mahendra, Harrij (2006) *Agro-Ecological Zones Assessment* Reprinted van Velthuizen & Nachtergaele Freddy from *Encyclopedia of Life Support Systems. (EOLSS)*, EOLSS Publishers,Oxford, UK

Food and Agriculture Organization of the United (FAO) (1996). Agro-ecological Zoning Guidelines. FAO Soils Bulletin 73. Rom. www.fao.org

Food and Agriculture Organization of the United (FAO) (2004) http://www.fao.org *Annex I. Agro-ecological Zones Framework and Database for the Review of CGIAR Priorities and Strategies*

Food and Agriculture Organization of the United Nations (FAO) (1978) 1978-81. Report on the Agro-Ecological Zones Project. World Soil Resources Report No. 48 Vols. 1-4. FAO: Rome.

Haward, J., Jayne, T. and Weber, M.(Eds) (2008) *African perspectives on Progress and Challenges in Transforming Agriculture to help cut Hunger and Poverty*. http://geosis-naip-nbsslup.org

IUSS, ISRIC and FAO (2003) World Reference Base for Soil Resources. World Soil Resources Report 84, FAO, Rome.

Kainamura, B (2000) in Mugandani, R (2009) *Towards Food Sustenance: A revisit to the agro ecological zones of Zimbabwe*. Paper presented at the Land Use Workshop at the Bindura University of Science Education in Zimbabwe, November 2009.

Kannangara, Ratnaseeli (1998) An agro-climatic analysis of Sri Lanka. PhD thesis, Australian National University, Canberra.

Le Houérou, H.N.; Popov, G.F. (1993) Agro-bioclimatic classification of Africa, FAO Meteorology Series No. 6; 1993: 227 pp.

Mantel S. (1995) The automated land evaluation system applied to SOTER, with an example from West Kenya. Working Paperand Preprint 95/03, ISRIC, Wageningen.

Mudzengi, B.K, Simba F.M, Murwendo, T, Mdlongwa T. (2013) *Perspectives in climate change and gender issues: a case study of Masvingo Province in Zimbabwe*. Sacha Journal of Environmental Studies, Vol 3, No. 1 pp. 1-10.

Mugandani,R (2009) *Towards Food Sustenance: A revisit to the agro ecological zones of Zimbabwe*. Paper presented at the Land Use Workshop at the Bindura University of Science Education in Zimbabwe, November 2009.

Murwendo, T and Munthali, A. (2008). The value of backyard trees to peoples lives in Masvingo City, Zimbabwe Journal of Geographical Research, Vol 2, No. 1, pp. 24-37.

SAFIRE (2002) *Chivi Food Security Project:A Process Approach.* http://ufh.netd.ac.zabitstreammushunjethesis.

Simba F.M , Murwendo T, Chikodzi, Mapurisa B, Munthali A, Seyitini L (2012a) Environmental changes and farm productivity: a case study of masvingo province in Zimbabwe. Sacha Journal of Environmental Studies,UK. Vol.2 No.1 pp114-129.

Simba F.M, Chikodzi D, Murwendo, T (2012b). Climate change scenarios, perceptions and crop production: a case study of Semi-arid Masvingo Province in Zimbabwe. J Earth Sci Climate Change (JESCC). Vol 3. No.3

Steven, M. D., (1993) Satellite remote Sensing for agricultural management: Opportunities and logistic constraints. Photogramm Remote Sensing 48(4): 29-34.

The Herald Thursday (2011) *Redraw boundaries of natural farming, Government urged.*www.herald.co.zw.

Thornthwaite, C.W., and J.R. Mather. The Water Balance. Laboratory of Climatology Publ. 8.Centerton, NJ (1955).

UNDP (2011) *Reduction of Risks and Vulnerability Based on Flooding and Droughts in the Estero Real River Watershed.* http://www.dev.adaption learning.net

Vincent, V. and Thomas, R. G. (1960).*An agricultural survey of Southern Rhodesia: Part I: agro-ecological survey*. Government Printer, Salisbury

Waugh, D (1995) *Geography: An Integrated Approach.* Nelson. London.

White, D. H. (1998) *A global agro-climatic analysis of the distribution and production of livestock commodities.* Economic Evaluation Unit Working Paper No.30, Australian Centre for International Agricultural Research.

Wikipedia, (2012) http//en.wikipedia.org *Masvingo Province*.

Wood, S. and Pardey P. G. (1997) *Agroecological Aspects Of Evaluating Agricultural R&D* Washington, D.C. 20036-3006 U.S.A. Environment and Production Technology Division.

Zimbabwe Meteorological Services Department, (2002) http://www.weather.co.zw

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