III. METHODOLOGY

3.1. Time and Location

The research was conducted from February to May 2011. The area concerns in Kupang District, East Nusa Tenggara. It is bounded between longitude 9°19’10.57” longitude – 10°22’-12.44”S and 121°15’-124°11” longitude, with an area of approximately 5,431.23 km². The administrative boundaries of Kupang District are as follows:

- **North**: Savu Sea and the Strait of Ombai
- **East**: Timor Tengah Selatan (TTS) District, Timor Tengah Utara (TTU) District and District Ambenu (Timor Leste)
- **South**: Timor Sea
- **West**: Rote Ndao District and Savu Sea

![Figure 3 Location of the study area](image-url)
The topographical conditions of Kupang District are almost dominated by the elevation between 0-100 meters above sea level covering almost half the area of Kupang District (24 sub districts). Some sub districts are at an elevation of 100 to 1000 m above sea level (asl). Several sub districts in the area of Amfoang for example be between 500 - 1000 above sea level, and some areas such as Semau, West Kupang and Nekamese had altitude 0-100m asl. Based on the state of rock, in Kupang District the dominant soil type alluvial, regosol, andosol, glei humus, mediterranean red yellow, latosol, podzolic red yellow and rendzina. This soil texture are from fine to coarse.

This district has dry climates and according to Oldemam divide to type D4, and E4, this climatic conditions has very short wet season of 3-5 months, while the dry season of 7-8 months. Short wet season occurs only in December to March. These climatic conditions are certainly affects the pattern of cultivation and farming communities in Kupang District where 3% of the area is a dry rice field soil and 97% is dry soil in the yard or swidden cropping (Piggin, 2003).

3.2. Data Sources

The data Mainly has been used for this research acquired from government institution, as in the table below

<table>
<thead>
<tr>
<th>No</th>
<th>Data and Information</th>
<th>Type</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base map of Kupang</td>
<td>Vector</td>
<td>BAKOSURTANAL</td>
</tr>
<tr>
<td>2</td>
<td>Geology Database</td>
<td>Vector</td>
<td>BPDAS N-B Kupang</td>
</tr>
<tr>
<td>3</td>
<td>Climate data</td>
<td>Vector, Tabular</td>
<td>BMG Kupang, NOAA</td>
</tr>
<tr>
<td>4</td>
<td>Supported data</td>
<td>Tabular</td>
<td>BPS Kupang</td>
</tr>
<tr>
<td>5</td>
<td>Spatial Plan and policy</td>
<td>Vector, Tabular</td>
<td>BAPPEDA Kupang</td>
</tr>
<tr>
<td>6</td>
<td>Forest and Protected area</td>
<td>Vector, Tabular</td>
<td>BPKH Kupang</td>
</tr>
<tr>
<td>7</td>
<td>Livestock Population</td>
<td>Tabular</td>
<td>Kupang Animal Services</td>
</tr>
<tr>
<td>8</td>
<td>Expert Interview</td>
<td>Tabular</td>
<td>BPTP Kupang</td>
</tr>
<tr>
<td>9</td>
<td>Validation of <em>L. leucocephala</em></td>
<td>Vector, Tabular</td>
<td>Ground Truth</td>
</tr>
</tbody>
</table>
3.3 Tools Requirements

The processing data of this research was done at laboratory of Master of Science in Information Technology for Natural Resources Management (MSc in IT for NRM) at SEAMEO BIOTROP. Supporting software were used in this research are listed below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Tools</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Microsoft Office</td>
<td>Documentation</td>
</tr>
<tr>
<td>2.</td>
<td>ArcGIS 9.3</td>
<td>Spatial Analysis Process</td>
</tr>
<tr>
<td>3.</td>
<td>Microsoft Visual Studio 2008</td>
<td>Model Simulation</td>
</tr>
<tr>
<td>4.</td>
<td>ArcGIS Engine 9.3</td>
<td>Model Simulation</td>
</tr>
</tbody>
</table>

3.4 Methodology

There are some important stages of working with our data: the first one is data preparation and entry in which data about the study area is collected and prepared to be entered and/or used into the system, data analysis and the last part is a model simulation (Figure 5). To build the model, different processes have been conducted. Figure 4 are the criteria to be fulfilled in order to reach the objective which is to identify the land suitability for growth of *L.leucocephala* in Kupang District and to determine the carrying capacity to support feed security.

3.4.1 Determine Goal and Objectives

Goals and objectives to be achieved is obtained through a method of interviewing and filling questionnaires by experts who are competent in the field of their own. The questions raised are expected to provide important input in determining land suitability class. In order to reach the goal, there are some sets of objective that also should be considered as stated follows:

- What are the more important factors between criteria (climate, soil and topography) and sub-criteria for obtaining the land suitability for growth of *L.Leucocephala*. 
What factors are a greater influence in determining the proper location for the development of *L. leucocephala*, such as how much influence the one driving force compare one to another driving force.

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**Figure 4 Flow Chart of Methodology**
3.4.2 Spatial Analysis and Analytical Hierarchy Process for Determining Potential Land Suitability

Assessment of land potential is often done with agro-ecological zone approach with the physical environment as a supporting and limiting factors for planting of a commodity plant at a specific region. If only this approach, then the only plant zoning based on land capability class is not consider other factors such as social, economic and cultural. It is therefore necessary developed a method that can include all the factors affect plant zoning. In this research used the stages modified from agro-ecological zoning method to include attractiveness elements (driving forces) and constraints.

Prior to conducting the analysis to every stage, were first carried out weighting based on expert judgment that is very competent in this field. Analysis of agro-ecological zones; this analysis was based on suitability to grow of *L. leucocephala* on the condition of the physical environment consisting of climate, soil, and topography of the region. Analysis of the attractiveness (driving force) of this space were analyzed the results of agro-ecological zoning by adding a factor of closure, roads, livestock market and the existing land use, like a folk forest, protected forest, protected area, produced forest, industry area, water body, and wetland farming.

Land suitability criteria used in this research based on the Second Land Resources Evaluation and Planning Project (LREP II) in 1994; where the system itself refers to the land suitability criteria issued by FAO (1976). According to the basic concept of Land Evaluation Framework (FAO, 1976) the land suitability was distinguished on the physical land suitability (qualitative) and land suitability in the economic (quantitative). Land suitability was physically divided into 4 classes, namely: highly suitable (S1), moderately suitable (S2), marginally suitable (S3), and is not suitable (N). While economically differentiated into 5 classes, namely: Class 1 is very suitable (S1), its use is very profitable; Class 2 moderately suitable (S2), its use is beneficial; Class 3 according to the marginal (S3) use the marginal benefit; Class 4 does not fit economically (N1), its use is possible but not profitable today,
and by improving the management to raise its class, Class 5 is not as permanent, economically (N2) usage is not possible, and this class is physically derived from the class N. Predicting the suitability of land for agricultural commodities are necessary criteria for land suitability class of the most suitable (S1) to inconsistent (N). The criteria for land suitability of *L. leucocephala* shows on Table 6.

Table 6 Criteria for Land Suitability of *L. leucocephala* (LREP II 1994; FAO, 1976)

<table>
<thead>
<tr>
<th>Quality/land characteristics</th>
<th>Unit</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>N1</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Temperature (°C)</td>
<td>21-30</td>
<td>&gt;30-34</td>
<td>-</td>
<td>-</td>
<td>&gt;34</td>
<td>&lt;19</td>
</tr>
<tr>
<td>Annual Rainfall (mm)</td>
<td>&gt;750-1000</td>
<td>&gt;1000-2000</td>
<td>-</td>
<td>-</td>
<td>&gt;2000</td>
<td>&lt;600</td>
</tr>
<tr>
<td>Texture</td>
<td>L, SCL, SiL, Si, CL, SC, SiCL</td>
<td>LS, SL, SiC, C</td>
<td>Massif</td>
<td>-</td>
<td>Gravel, Sand</td>
<td></td>
</tr>
<tr>
<td>Efficiency Depth (cm)</td>
<td>&gt;100</td>
<td>75 ≤ 100</td>
<td>-</td>
<td>&gt;50 ≤ 75</td>
<td>&lt;50</td>
<td></td>
</tr>
<tr>
<td>Soil Acidity (pH)</td>
<td>7.0-8.0</td>
<td>&gt;8.0-8.5</td>
<td>-</td>
<td>-</td>
<td>&gt;8.5</td>
<td>&lt;5.0</td>
</tr>
<tr>
<td>Slope (%)</td>
<td>&lt; 8</td>
<td>8-15</td>
<td>&gt;15-30</td>
<td>&gt;30-50</td>
<td>&gt;50</td>
<td>-</td>
</tr>
<tr>
<td>Elevation (* )</td>
<td>0-750</td>
<td>750 -1000</td>
<td>-</td>
<td>&gt;1000</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Description:
- S = Sandy
- L = Loam
- CL = Clay Loam
- SC = Sandy Clay
- LS = Loam Sandy
- SiL = Silt Loam
- SCL = Sandy Clay Loam
- SiC = Silt Clay
- SL = Sandy Loam
- Si = Silt
- SiCL = Silt Clay Loam
- C = Clay
- Str C = Structured Clay

*additional parameter

Analytic Hierarchy Process (AHP) is a decision analysis approach developed by Thomas L. Satty in 1971. As an easy-use and very practical tool based on a simple theory, AHP is capable to extract the comments of multiple experts and decision makers, and is mainly applicable to handling the problems arising in an uncertain environment in which multiple evaluation criteria exist. The AHP are used to systemize complicated problems and dissolve these factors into different levels from various directions. A comprehensive analysis is conducted via the process of quantification to assist decision makers in the selection of appropriate plans.

Many factors must be taken into consideration when operating the evaluation mechanism. The study uses AHP to establish a hierarchical structure for all affecting factors and acquires the weight of each factor by pair-wise comparison. The acquired
weight distribution is more objective than setting the weight for individual factors. The steps of the analysis are described as follows:

A. Establishment of the Hierarchical Structure.

After the final goal of establishing the hierarchical framework is achieved, a mutually independent hierarchical relationship is built by interviewing experts and doing surveys (secondary goal), and analyzing the elements that might affect the secondary goal. The elements of similar importance are collected on the same level in this step.

B. Weight between the Elements on Different Levels

The calculation of the weight between the elements on different levels is completed through the following four steps:

- Establishment of Pair-wise Comparison Matrix: The element comparison is conducted in this step. The parent element of an element on a lower level is used as an evaluation criterion for the pair-wise comparison.

- Calculation of Priority Vector. Divided each comparison value by the sum of the values in corresponding fields for the aggregation of the rows; namely, the sum of the percentage each comparison value occupies in its corresponding row.

- Calculation of the Maximum eigenvalue $\lambda_{\text{max}}$:

  Multiply the entire matrix with the acquired priority vector to produce $n \times 1$ matrix. Then divide this matrix by the priority vector to acquire unit vectors. Calculate sequentially the average of the unit vectors to acquire the maximum eigenvalue $\lambda_{\text{max}}$.

- Examination of Consistency: During the pair-wise comparison, discrepancies might occur between the results of the comparison and the decision. The consistence ratio of Satty's AHP is used to examine the consistency of the entire matrix.
3.4.3 Calculation of Increasing Capacity Population of Ruminant Cattle (ICPRC)

This analysis is used to determine cattle population cattle can be added in every sub-district in Kupang District by calculate the availability of potential forage using Rollinson and Nell, (1974) approach. Secondary data used is the data in year 2009 from BPS of Kupang District. Based on the results of data processing of livestock population analysis with ICPRC model obtained a values show a different trend for each region. ICPRC positive value indicates a tendency that relevant districts still allow the addition of ruminant livestock population of the existing number of livestock units, whereas negative values indicate a tendency ICPRC concerned that the region needs to be directed to the development of the area of land that is the carrying capacity of principal farm businesses, such as grassland and the agriculture area. The potential forage capacities predicted as follows:

\[
\text{Total Potential Forage} = \text{Forage Production} + \text{Straw Production (Total)}
\]

\[
= \frac{\text{(Total Potential Forage, DM Tons / Year)}}{\text{(DM consumption Ton / AU / Year)}}
\]

\[
\text{ICPRC} = \text{Carrying Capacity} - \text{Real Population}
\]

Potential forage availability is based on several sources namely: pasture, fallow fields, shipyards rice fields, plantations, forest type, secondary forest, roadside and moor. Total areas of all components were considered capable of providing dry material as much as 3.75 tons / hectare / year. To reach the numbers required for the calculation ICPRC accordance with the steps above, also required some other numbers that the converter capable of converting land to provide fodder, as well as converting straw value are available or can be used for livestock. Thus, the total forage production (tons DM / year) for each district was calculated by the following formula:
$$\text{TFP} = 3.75 \sum + \sum$$

Where:

\( \text{TFP} \) = Total forage production of a district in one year (ton DM / year).

\( \text{LE}_i \) = Effective forage area (ha) to \( i \); where \( i \) = field in Rollinson and Nell’s Table

\( \text{PJ}_i \) = Straw Production (tons DM / year) from the source \( J \), where \( J \) = field in Rollinson and Nell’s Table

Every single Animal Unit (AU) of ruminants requires 5.38 tons DM forage / year, Thus Ruminants Carrying Capacities (RCC) each region is calculated as follows:

$$= \frac{\text{(Total Potential forage, DM Tons / Year)}}{5.38 \text{ (DM consumption in ton / AU / Year)}}$$

Further analysis of location quotient is used to determine whether a location can be classed as a base region or not a base region.

$$= \frac{\sum_{\text{eir}}}{\sum_{\text{Ei}}}$$

Where:

\( e_{ir} \) = cattle population in sub-district \((r)\)

\( \times e_{ir} \) = total big size ruminant livestock in sub-district \((r)\)

\( E_i \) = cattle population in district

\( \times E_i \) = total big size ruminant livestock population in district

3.4.4 Model Simulation

After obtaining the results in the form of a map of potential land suitability and after overlaying with constraint factors, then obtained the actual land suitability maps. The model simulation will be dynamically with the determination of scenarios.
that can be set by the user using different assumptions or scenario. The simulation model of *L. leucocephala* development are very influenced by 2 main factors, namely driving force and constraint.

**Driving force and constraints are the key factor in the of *L. leucocephala* development context.** Driving force can be defined as causes or factors influence for *L. leucocephala* growth modeling. In this research, road network, animal market, and Neighborhood Effect were selected as a driving force input in modeling of *L. leucocephala* growth in Kupang District. Whereas, protected forest, folk forest, protected area, production forest, industry area, wet land farming, swamp, weir/water body, settlement and mining area were selected as a constraint factor in this study area.

Driving force of *L. leucocephala* can be simply defined as cause for factors influence for growth modeling and in the opposite, whereas constraint is a limitation imposed or by nature or by human being that do not permit certain action to be taken (Keeney, 1980). Definition for each driving force and constraints for *L. leucocephala* development in this study was explained below:

**A. Neighborhood Effect**

Location has very large influence on the growth development of *L. leucocephala*. at a small scale, *L. leucocephala* tends to growth in the areas nearby the development agriculture area. Neighborhood, in another word, transition from non-*L. leucocephala* to *L. leucocephala* was much affected by the adjacent area. if the vicinity of a cell is developed area, this cell has much higher potential to change to *L. leucocephala* form if it was non-*L. leucocephala* before.

**B. Distance to Road Network**

Road network has proved to be the key factors in many evolution processes, as well as the development plans of planting *L. leucocephala* as forage. Road, heavily impact the plan development priority (settlement, industry etc.) and also land price. While the relationship between road network and *L. leucocephala* growth development is far from clear. Closer the distance of
the location from main roads, the land has higher probability to becoming developed to other purposes then to growth *L. leucocephala*.

Transport is a very important role in the success of development especially in support of economic activities, no exception in rural areas. Existing transportation system intended to improve mobility services and other resources that can support the growth of economics of rural areas. With the hopes of transport can relieve isolation and provide a stimulant to the development in all areas of life, whether trade, industry and other sectors in rural areas.

C. Distance to Location of Livestock Market

The existence of animal market has a very important function in the development of a suitable location for the planting of *L. leucocephala*. For consumers, the market will make it easier to obtain a cattle for needs. As for the farmer, the market becomes a place to ease the process of distribution of livestock. In general, the market has three main functions namely as a means of distribution, price formation, and as a promotion. The closer a location to a livestock market will be even greater opportunities to develop the site into areas of planting *L. leucocephala*.

D. Probability of Preference Location

*L. leucocephala* development will begin from the existing field, and will develop on area belonging to the class S1 and S2 which are not included in constraint areas such as pastures, grassland, dry land farming or plantations. Each selected region has a different weight to be taken into account in certain scenarios when the model is run.

Constraints are limitation imposed by nature or by human being that do not permit certain action to be taken (Keeney, 1980). The specification of constraint is typically based on available resources and regulation and involves value or professional judgment. The constraint factors indicate those limitations posed on the *L. leucocephala* development such us water body, protected forest, protected area,
folk forest, produced forest, settlement, and wet land farming is not allowed to develop the *L. leucocephala* growth area.

There are two kinds of spatial default scenario that is designed to look at the distribution pattern of *L. leucocephala*. The default scenario is:

1. Business as usual, in this scenario, the state is considered normal running as it should.
2. Spatial plan as constraints, in this scenario mining site plans will be a constraint.

Both the two scenarios mentioned above have default values in accordance with the current state, but those values can be set in accordance with the needs to be achieved.

Microsoft Visual Studio 2008 and ArcGIS Engine 9.3 is used to build simulation models for prediction the feed security of *L. leucocephala* to support Bali cattle during a certain period. The scheme of simulation model chart can be seen in the Figure 5.
Figure 5 Flow Chart of Model Simulation