III. METHODOLOGY

3.1 Location and Time

This research was done in Lembang Sub-district, West Java province. The research spent for 4 months, since November 2011- February 2012. The location of study area seen on Figure 2.

Figure 2. Location of study area

3.2 Materials

Tools requirements on the research were computer, questioner sheets, stationeries and software. Software used was Powersim Studio 2005 for building the dynamic model. The spatial analysis was carried out for determining the ecological suitability for forage. This analysis was used software Arc View 3.2. The questioner sheets, measurement equipments for productivity of forage, scale and measurement band were used for validation method. The secondary data collected; biophysics data, economy and social data from was gotten from
stakeholder-North Dairy Cooperative (KPSBU) : Central of Bureau (BPS), Perum Perhutani and Animal Livestock Services of West Bandung District

3.3 Methods

The method used to collect information was as follows: 1) Desk study from the previous information and research, 2) survey to collect the quantitative and qualitative data, 3) interview, 4) Focus Group Discussion (FGD) with the stakeholder. The respondents (the dairy farmers) were divided into four groups, they were Owned Land For Forage Farmers (FOL), Renting Land Forage Farmers (FRA), Sharing Land Area Farmers With Perhutani (FSL), and The Non Land-Forage Farmers (FNL). The amounts of respondents were counted by the proportion estimation by using this equation:

\[ n = \frac{Z_{\alpha/2}^2 \hat{p} \hat{q}}{\alpha^2} \]

- \( n \) = sample
- \( \hat{p} \) = estimated value for \( p \)
- \( \hat{q} \) = (1 - estimated value for \( p \))
- \( e \) = error
- \( Z_{\alpha/2}^2 \) = normal distribution

3.4 Technique for Collecting Data and Data Used

The primary and secondary data were collected for this research. The primary data was collected from farmer’s field using interview, questioner sheets and survey. The primary data were taken such as the productivity of forage, feed consumption and productivity of dairy farming. The secondary data were conducted to literature view and desk studies from the previous research. The secondary data were gotten from the KPSBU, Animal Livestock Services of West Bandung District (Table 1).
Table 1  Data type and sources

<table>
<thead>
<tr>
<th>No</th>
<th>Data</th>
<th>Unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Base map of Lembang</td>
<td>-</td>
<td>BPN KBB</td>
</tr>
<tr>
<td>2.</td>
<td>Rainfall map of Lembang</td>
<td>-</td>
<td>BPN KBB</td>
</tr>
<tr>
<td>3.</td>
<td>The effective depth soil map of Lembang</td>
<td>-</td>
<td>BPN KBB</td>
</tr>
<tr>
<td>4.</td>
<td>The elevation map of Lembang</td>
<td>-</td>
<td>BPN KBB</td>
</tr>
<tr>
<td>5.</td>
<td>Land use map of Lembang</td>
<td>-</td>
<td>BPN KBB</td>
</tr>
<tr>
<td>6.</td>
<td>Annual rainfall data</td>
<td>mm/year</td>
<td>BMKG</td>
</tr>
<tr>
<td>7.</td>
<td>Temperature data</td>
<td>°C</td>
<td>BMKG</td>
</tr>
<tr>
<td>8.</td>
<td>Dairy cattle population</td>
<td>heads</td>
<td>KPSBU</td>
</tr>
<tr>
<td>9.</td>
<td>Milk Production</td>
<td>litter</td>
<td>KPSBU</td>
</tr>
<tr>
<td>10.</td>
<td>Death, birth, emigration and immigration data of dairy cattle</td>
<td>heads</td>
<td>Animal Livestock Services of West Bandung District.</td>
</tr>
</tbody>
</table>

Social Data

<table>
<thead>
<tr>
<th></th>
<th>People</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>People</td>
<td>BPS</td>
</tr>
<tr>
<td>The amount of farmers</td>
<td>People</td>
<td>BPS</td>
</tr>
<tr>
<td>Immigration</td>
<td>%/ Year</td>
<td>BPS</td>
</tr>
<tr>
<td>Emigration</td>
<td>%/ Year</td>
<td>BPS</td>
</tr>
<tr>
<td>Average of life time</td>
<td>Year</td>
<td>BPS</td>
</tr>
<tr>
<td>Fertility</td>
<td>%/Year</td>
<td>BPS</td>
</tr>
</tbody>
</table>

Economic Data

<table>
<thead>
<tr>
<th></th>
<th>Rupiah</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Price</td>
<td></td>
<td>KPSBU</td>
</tr>
<tr>
<td>Milk Revenue</td>
<td></td>
<td>KPSBU</td>
</tr>
</tbody>
</table>

3.5 Data Analysis

3.5.1 How the Model is built for Forage Sustainability

There are three mainly reasons why the model is considering to be built. First, the model is very useful to make some predictions in the future. Second, it can be known how the system is working. Third, a model shows the complexity and the relationship in each variable (Thornley 1998). Model is simplification of the complexity in the real time. The model will be able to solve some complicated problems with many variables involved. The step on how to build model by using system approach was shown in figure 3.
Figure 3. The step on how the model is built by using system approach (Manetsch and Park 1977 in Hartisari 2007).

3.5.1.1 Need Assessment

The first step on how to build the model was doing the need assessment. It was the method to know what the primary needs from the stakeholder. It was conducted by using the depth interview and Focus Group Discussion (FGD) to specific stakeholder.

3.5.1.2 Problems Formulation

The problems occur as the impact of contradictory basic need, conflict of interest and lack of resources among each stakeholder. Thus, the disclosed points on these problem statements were:

a. Reference pattern
   On dynamic system, the problem formulation was done to identify historical pattern or hypothetic pattern from problems behavior. The aim of this step was to describe the independent of each object in the system, and subsequently the pattern will be formed.

b. Dynamic hypothetic
   The initial hypothetic related to the behavior interaction of the stakeholder as the base form of reference pattern. Some iteration, formulation, and the
comparison with the empirical proofed and reformation problem was considered as the goal of logic hypothetical.

c. Model Boundary

Model boundary of forage sustainability was desired to tell how extent to be wished on the model. It was separated process caused by the internal interactions in the reference pattern and the process influenced from the external interaction.

3.5.1.3 System Identification

The model for forage sustainability was divided into four submodels. The first submodel was population that shown the dynamic changes of population in Lembang. The second was dairy cattle population submodel that described the dynamic population on dairy farming. The third was economic submodel. The last was forage availability submodel that described demand and supply of forage for dairy cattle. System identification was done by using input-output diagram.

Input-Output Diagram

System identification also illustrated by using input-output diagram. It was seen as the relation both the output resulted and input based on the problem identification and formulation (Figure 4)
Output was the intend goal of the system. It was classified into desired output and undesired output. Undesired output could not be avoided and somehow identified as the negative impact in the system. Feedback was very important to push back the undesired output. Based on this problem, input was highly needed to be modified in order to result desirable output. Input was the factor that influenced how the system worked. Input be classified into direct input and indirect input. Direct input was the factor that affected the system directly working. There were two kinds of direct input; controlled input which directly affecting the system, while uncontrolled input was indirectly affecting the system. Indirect input contained some elements beyond the scope of system called environment input.

3.5.1.4 Model Formulation

Model formulation is defined as the process to change the conceptual system or the model’s structure into the form of equation on software/computer. This process changes a transformation from the conceptual informal to conceptual formal. Model formulation will able to simulate or to determine the dynamic. Model of forage sustainability on dairy farm divided into four sub model (1) population, (2) dairy cattle population, (3) economic, (4) forage supply. As generally, the form equations were used:

1. Population submodel

\[ Y_1(t=T) = Y_1(t=0) + \int_0^t X_1 \text{ population in.dt} - X_1 \text{ population out.dt} \]

- \( Y_1(t=T) \) = Amount of population in \( T \)
- \( Y_1(t=0) \) = Initial amount of population \( (t=0) \)
- \( X_1 \text{ population in.dt} \) = Additional amount of population
- \( X_1 \text{ population out.dt} \) = Reduction amount of population

2. Dairy population submodel

\[ Y_2(t=T) = Y_2(t=0) + \int_0^t X_2 \text{ dairy population in.dt} - X_2 \text{ dairy population out.dt} \]

- \( Y_2(t=T) \) = Amount of dairy cattle population in \( T \)
- \( Y_2(t=0) \) = Initial amount of dairy cattle population \( (t=0) \)
- \( X_2 \text{ dairy population in.dt} \) = Additional amount of dairy cattle population
- \( X_2 \text{ dairy population out dt} \) = Reduction amount of dairy cattle population
3. Economic submodel

\[ Y_3(t=T) = Y_1(t=0) + \int_0^T X_1 \text{ milk production}.dt - X_2 \text{ milk reduction}.dt \]

- \( Y_3(t=T) \) = Amount milk in T
- \( Y_3(t=0) \) = Initial amount of milk (t=0)
- \( X_3 \text{ milk production}.dt \) = Additional amount of milk
- \( X_3 \text{ population out}.dt \) = Reduction amount of milk

Forage availability submodel

\[ Y_4(t=T) = Y_4(t=0) + \int_0^T X_4 \text{ forage production}.dt - X_4 \text{ forage consumption}.dt \]

- \( Y_4(t=T) \) = Amount of forage in T
- \( Y_4(t=0) \) = Initial amount of forage (t=0)
- \( X_4 \text{ forage production in}.dt \) = Addition amount of forage production
- \( X_4 \text{ forage consumption}.dt \) = Reduction amount of forage consumption

Model formulation was built by using the dynamic model software-\textit{Powersim Studio 2005}. The submodels were integrated into flow diagram of forage sustainability for dairy farming in Lembang. The next step was entering these fourth submodels into software that able to running the model. Powersim was the tool that used to build, to analyze, and to simulate the dynamic system.

There were some variables in dynamic system as follows "level", "rate", "auxiliary", and "constant" (Figure 5).

![Flow diagram by using Powersim Studio 2005.](image-url)
1. Level

Current state or condition in the system was level in the dynamics system terminology. Level expressing the accumulation, stock, or state variable from nouns such as people, money, inventory etc, due to the time. Level was the accumulated flow and showed the existing condition. Level deeply influencing by rate. The symbol of level was box and beyond the level denoted as the name of variable (Figure 6).

Powersim equation for level:

Init LEV = Initial condition
Flow LEV = -dt*(RK) + dt*(RM)
LEV = level (unit)
RM = rate (rate) input
RK = rate (laju) output
dt = interval simulation (time)
Init = initial value
Flow = Flow for variable

2. Rate

Rate defined as the activity, movement, or rate that contributed to the change of time in variable level. Rate was the only variable which influenced the level (Tasrif 2004). Rate also gave addition effect or reduction effect of level. There were two kinds of rate; input rate and output rate. Input rate gave the additional impact of level, while output rate reduced the accumulation in level. The symbol of rate was depicted as the combination of flow and auxiliary. This symbol must be connected to the level symbol (Figure 7).
3. Auxiliary

Auxiliary defined as the additional information inserted to the equation in rate. It raised when formulation of a level influenced by the rate that involved one or more intermediate calculations. Auxiliary affected the simplification of information among level and rate. It was often useful to formulate complex rate equations (Figure 8).

![Auxiliary](image)

Figure 8. Symbol of auxiliary

4. Constanta

Constanta was the input for the rate equation. It was directly influencing to rate or indirectly-influenced auxiliary. Constanta was showing the parameter value from the real system. The symbol of constanta was depicted by rectangular form (Figure 9).

![Constanta](image)

Figure 9. Symbol of constanta

5. Source and Sink

Source showed the level of system and rates outside the boundary of the model. Sink was flows terminated outside the system (Figure 10).

![Source and Sink](image)

Figure 10. Symbol of source and sink

6. Link

Link was connected from one variable to another, or from variable and constanta. The symbol of link was illustrated by the arrow (Figure 11).
3.6 Verification and Validation

The next step was simulation and validation due to the model. The aim of simulation is to understand the process in a system, to analyze and to forecast from the process in the future (Muhammadi 2001). Validation was done to understand how proper the model. Validation was very important to recognize the suitability among the simulation and the process in the real time. The implementation of the model is started from the validation of the model structures and the responses from the model Sushil (1993). Validation of model structures divided into suitability test to answer general question “Does the model structure is proper enough with the fact?”. Another validation was dimension test, that very important to answer “How the dimension does used in every equations?”. Validation was done by quantitative behavior pattern comparison. The model of forage sustainability for dairy farm was validated by using MAPE test (Mean Absolute Percentage Error).

\[
\text{MAPE} = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|
\]

Information:
At = Simulate data
Ft = Actual data
n = period (time)

The accuracy of MAPE:

- MAPE < 5% : Highly correct
- 5% < MAPE < 10% : Correct
- MAPE > 10% : Incorrect

3.7 Policy Analysis due to the Forage Sustainability on Dairy Farming

Policy analysis was accessed from the model. Sensitivity’s test was the real form intervention from model structures. It showed how sensitive the model as the change of output and how the effect resulted. The policy analysis was
considering the carrying capacity in Lembang. The method for counting carrying capacity was using ICPRC (Increasing Capacity Population of Ruminant Cattle).

The potential distribution and dairy farming area was the capacity of the territory in accommodating the additional population of dairy cattle. ICPRC was highly useful in observing how large the area due to its potency to increase population of ruminants based on the ability of forage in the specific region. The calculation of ICPRC was indicated the tendency of relevant areas that allowed additional dairy cattle population of existing number of animal unit (AU).

Department of animal livestock services (1994) stated the model of ICPRC used the maximum the ability of land resources (LR) potency and the labor resources (LR) potency. The equation was used:

a. Maximum potency based on the ability of land resources (MPLR)

\[ MPLR = a \cdot AL + b \cdot GL + c \cdot SL \]

- \( a \) = Carrying capacity coefficient of arable land; 
  \( a = 0.082 \) AU/Ha for plantation area; \( a = 1.52 \) for rice field area.
- \( AL \) = Arable land area (Ha)
- \( b \) = Carrying capacity coefficient of grass land (0.5 AU/Ha)
- \( GL \) = Grass land area (Ha)
- \( c \) = Carrying capacity coefficient of field area (2.86 AU/Ha)
- \( SL \) = field area (Ha)

b. Maximum potency based on the ability of labor resources (MPRR)

\[ MPRR = d \times KK \]

- \( a \) = The average coefficient of dairy farm can be kept on by farmer householders (3 AU/HH)
- \( KK \) = Maximum potency (AU) based on householder

ICPRC based on MPLR

\[ ICPRC (LR) = MPLR - POPRILL \]

- ICPRC (LR) = Increasing Capacity Population of Ruminant Cattle (AU) Based on land resources
- MPLR = Maximum potency based on the ability of land resources (AU)
- POPRILL = Real population of dairy cattle
d. ICPRC based on MPRR

\[
\text{ICPRC (RR)} = \text{MPRR} - \text{Real Population}
\]

ICPRC (RR) = Increasing Capacity Population of Ruminant Cattle (AU) based on the ability of labor resources

MPRR = Maximum potency based on the ability of labor resources (AU)

Real Population = Real population of dairy cattle

The effectiveness of ICPRC could be seen by using the most influence constraints:

- The effectiveness of ICPRC (RR) if ICPRC (RR) < ICPRC (LR) and
- The effectiveness of ICPRC (LR) if ICPRC (LR) < ICPRC (RRR) and

3.8 The spatial Analysis of Ecology Suitability for Forage Management

The spatial analysis of ecology suitability for forage in Lembang was done by considering suitability of forage management to determine the pathway of policy analysis. The ecological suitability was built by classified the land suitability that has been appointed (Table 3). Land suitability was physically divided into 4 classes, namely: highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N).

**Table 2. General criteria of ecological suitability for forage** (*pennisetum purpureum* SCHUM)

<table>
<thead>
<tr>
<th>Quality/land characteristic</th>
<th>Critical Limits For</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1</td>
</tr>
<tr>
<td>Annual Rainfall (mm)</td>
<td>1.700-2.000</td>
</tr>
<tr>
<td>Effective depth soil (cm)</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Slope elevation(%)</td>
<td>&lt;8</td>
</tr>
</tbody>
</table>


The spatial analysis showed the suitability class for forage management. The stage of working with GIS was overlaying two polygon layers combined into a single layer analysis on every single digital mapping to obtain the suitability area for forage (Figure 12).
The assessment on suitability of forage was determined by using spatial analysis with Geographical Information System (GIS). The using of GIS was giving us probability in obtained the geographical data/geospatial data for policy analysis.