Abstract - Land use patterns in various forms and ways will have an impact on the environment. Indications of a decrease in the carrying capacity of the environment in a region can be seen from various disasters that occur such as floods, landslides, and droughts. Therefore, changes in land use from non-built land to build land will stimulate the amount of runoff water. This study aims to determine the effect of changes in land use, evapotranspiration, and rain on total runoff. This research was carried out in the Gumbasa Watershed. Data is needed in the form of primary data (soil characteristics) and secondary data (rain, climatology, a map of the earth, a map of land use). The rainfall data used are Bora, Palolo, Wuasa, Kulawi and Bangga Bawah stations with observations for 14 years (2002-2015). Climatology data was used by Bora Station with observations for 14 years (2002-2015). The analysis was carried out namely: regional rainfall, evapotranspiration, MockWyn-UB model and linear regression. The linear line equation obtained: \( Y = 97.325 - 0.747X_1 + 0.697X_2 + 0.442X_4 + 0.447X_5 \). This equation has been tested statistically and fulfilled the linear regression requirements. Based on the above equation, it can be said that: 1) Forest land is an excluded variable so that it is not in the equation. 2) The smaller the evapotranspiration and the greater the rainfall and the area of mixed gardens and open land, the greater the runoff, and vice versa.

Keywords - Gumbasa Watershed, MockWyn-UB Model, Linear Regression

I. INTRODUCTION

The phenomenon of climate change is a very serious challenge facing the world. Climate change is increasingly evident and affects various aspects of life, whether individual or domestic, even to the global development sector. On the other hand, it is increasingly recognized that accelerating the occurrence of climate change begins with human decisions and behavior which then accumulate massively and change the weather elements, especially the temperature that causes the phenomenon of global warming.

Edi Nurrohcman (2018) [1] stated that the hydrological cycle is the rotation of water that never stops from the atmosphere to the earth and returns to the atmosphere through condensation, precipitation, evaporation, and transpiration. The hydrological system is a series of soil type elements, land use, topography and interrelated slope lengths between one component and the other components so as to form a mutually influencing unit towards the balance of the water system. Changes in the hydrological cycle are changes in behavior and function of surface water, namely decreasing the base flow and increasing surface flow which causes an imbalance in water management and the occurrence of flooding and inundation in the downstream area.

Indonesia is one of the developing countries that is carrying out development in various sectors. As is known so far, development provides many benefits, especially the provision of employment for the community, but in addition, the development also requires environmental sacrifices such as changes in land use, from the original green space to high-rise buildings or settlements, agriculture, and industry. Changes in land use that have the greatest influence on increasing the value of surface runoff coefficients that have an impact on increasing discharge are the use of forest areas into other uses such as agriculture, settlements, and industry. Industrial activities, livestock, agriculture and settlements along the river flow (river banks) produce various wastes, both solid and liquid, into the river. This condition occurs even worse when the river reaches large cities in Indonesia.
Fuad Halim (2014) [2] suggests that watersheds are natural ecosystems that are bounded by ridges. Rainwater that falls in the area will flow to rivers which eventually lead to the sea or to the lake. In the Watershed, two regions are known, namely the water supply area (upstream) and the water receiving area (downstream area). These two regions are interconnected and affect the watershed ecosystem units. The function of the Watershed is as a catchment area, water storage, and distribution water.

Land use patterns in various forms and ways will have an impact on the environment. Indications of a decrease in the carrying capacity of the environment in a region can be seen from various disasters that occur such as floods, landslides, and droughts. The occurrence of flooding is basically triggered by two main things, namely (1) the less land that functions as water absorption. (2) land subsidence due to groundwater exploitation and physical development that exceeds carrying capacity [3]. Therefore changes in land use from non-built land to built land will stimulate the amount of runaway water [4].

Wahyunto (2004) [5] suggested that the impact of changes in land use from green space to built-up areas would affect the ability of water absorption by the land, and the quality of water along the watershed to cause flooding.

II. LITERATURE STUDY

A. Rainfall Watershed

The rain that occurs in an area called regional rainfall is calculated by the Polygon Thiessen equation [6-18]:

\[ R = \frac{A_1 \cdot R_1 + A_2 \cdot R_2 + \ldots + A_n \cdot R_n}{A_1 + A_2 + \ldots + A_n} \] (1)

B. Evapotranspiration

Potential evapotranspiration is calculated using the equation of Penman Montieth [6,15-17,19-24]:

\[ ETo = \frac{\Delta (R - G) + \rho \cdot c \cdot p \cdot (es - ea) \cdot ra}{\Delta + \gamma (1 + \frac{Rn}{ra})} \] (2)

C. Model MockWyn-UB

Total river water runoff is calculated by the MockWyn-UB equation model [6, 22, 24], which is the sum of the base flow with direct runoff.

\[ \text{Base Flow (BF)} = I + \Delta Vn \] (3)

\[ \text{Direct Run Off (DR)} = WS - I \] (4)

\[ \text{Total Runoff (TRO)} = BF + DR \] (5)

D. Model Regression

To get the constant and correlation coefficient value of land use, evapotranspiration, rain and total runoff, multiple regression equations are used, namely:

\[ Y = a + b \cdot X_1 + c \cdot X_2 + d \cdot X_3 + e \cdot X_4 + f \cdot X_5 \] (6)

Where:

- \( a \) = Constant
- \( b-f \) = Coefficient value for each variable
- \( Y \) = Total runoff, mm / year
- \( X_1 \) = Evapotranspiration, mm / year
- \( X_2 \) = Annual rainfall, mm / year
- \( X_3 \) = Forest area, Ha
- \( X_4 \) = Mixed garden area, Ha
- \( X_5 \) = Open land area, Ha

III. METHODOLOGY

A. Location of Research

The research location is located in the Gumbasa River Basin (Sigi Regency and Poso District, Central Sulawesi Province, Indonesia). Geographically located at 01°01’- 01°21’ South Latitude and 119°56’- 120°19’ East Longitude. Research locations can be seen in the following map.
B. Stage of Research

The stages of research can be explained as follows:

1. **Data collection**
   
The data used in this study are primary data (soil characteristics in the form of open land vegetation, mixed gardens, and forests) and secondary (rainfall data, climatological data, maps of the earth and maps of land use). The rainfall data used are Bora, Palolo, Wuasa, Kulawi and Bangga Bawah stations with observations for 14 years (2002-2015). Climatology data was used by Bora Station with observations for 14 years (2002-2015). All data were obtained from the Office of the Sulawesi III River Regional Office, Central Sulawesi, Indonesia. The map of the earth was obtained from the Office of the National Survey and Mapping Coordination Agency (Bakosurtanal) in 1991. The vegetation of land cover was obtained from the Government of Sigi Regency, Central Sulawesi Province, Indonesia in 2015 as well as modifications from satellite image data to obtain 2002, 2005, 2008 land use data and 2012. The data are presented in Table I.

| Year | Forest (Ha) | Mix Garden (Ha) | Open Field (Ha) | TOTAL (Ha) |
|------|-------------|-----------------|-----------------|------------|
| 2002 | 1022.76     | 79.83           | 126.84          | 1229.43    |
| 2005 | 1013.2      | 96.07           | 120.16          | 1229.43    |
| 2008 | 974.97      | 97.99           | 156.47          | 1229.43    |
| 2012 | 965.41      | 110.41          | 153.61          | 1229.43    |
| 2015 | 955.85      | 113.28          | 160.3           | 1229.43    |

2. **Rainfall Area**

Rainfall areas are analyzed by the Thiessen equation, where the area of influence of each rain station can be explained as follows: Kulawi Station (0.27); Palolo Station (0.30); Bora Station (0.06); Bangga Bawah Station (0.20) and Wuasa Station (0.17). The input is in the form of monthly rainfall every year from each rainfall station.

3. **Evapotranspiration**

Evapotranspiration is calculated by the Penman Montieth equation, where the input is in the form of monthly climatology data (air humidity, air temperature, solar radiation time and wind speed) while the output is in the form of monthly evapotranspiration data.

4. **Land Use**

The input of the MockWyn-UB model is in the form of land use every year, while the available data is insufficient. Therefore, a regression analysis was conducted based on existing land use data so that land use data were obtained as follows:
5. Total Run-Off
Total river water runoff was analyzed by the MockWyn-UB model. Data input in the form of monthly rainfall data, monthly evapotranspiration, and land area based on vegetation land cover. The output is a monthly total runoff (TRO) every year.

IV. RESULT AND DISCUSSION

A. Model MockWyn-UB
Based on the MockWyn-UB model, the total runoff per month (mm/month) and total annual runoff (mm/year) are as follows:

| Year | Forest (Ha) | Mix Garden (Ha) | Open Field (Ha) | TOTAL (Ha) |
|------|-------------|-----------------|-----------------|------------|
| 2002 | 1022.76     | 79.83           | 126.84          | 1229.43    |
| 2003 | 1004.58     | 86.27           | 138.58          | 1229.43    |
| 2004 | 986.42      | 88.73           | 154.28          | 1229.43    |
| 2005 | 1013.20     | 96.07           | 120.16          | 1229.43    |
| 2006 | 950.10      | 93.65           | 185.69          | 1229.43    |
| 2007 | 931.93      | 96.10           | 201.39          | 1229.43    |
| 2008 | 974.97      | 97.99           | 156.47          | 1229.43    |
| 2009 | 895.61      | 101.02          | 232.80          | 1229.43    |
| 2010 | 877.45      | 103.48          | 248.50          | 1229.43    |
| 2011 | 859.29      | 105.93          | 264.21          | 1229.43    |
| 2012 | 965.41      | 110.41          | 153.61          | 1229.43    |
| 2013 | 842.87      | 110.85          | 295.61          | 1229.43    |
| 2014 | 804.81      | 113.31          | 311.32          | 1229.43    |
| 2015 | 955.85      | 113.28          | 160.30          | 1229.43    |

B. Statistic Analysis
Statistical analysis uses the variables in Table IV below:
TABLE IV. Total Runoff Data, Land Use, Evapotranspiration and Rainfall

| Year | Total Runoff, TRO (mm/year), Y | Evapotranspiration ETo (mm/year), X1 | Rainfall, R (mm/year), X2 | Forest (Ha) (X3) | Mix Garden (Ha) (X4) | Open Field (Ha) (X5) |
|------|--------------------------------|-------------------------------------|--------------------------|------------------|-------------------|-------------------|
| 2002 | 536.27                         | 1330.30                             | 1878.73                  | 1022.76          | 79.83             | 126.84            |
| 2003 | 949.43                         | 1090.83                             | 2335.31                  | 1004.58          | 86.27             | 138.58            |
| 2004 | 516.04                         | 1332.30                             | 1616.6                   | 986.42           | 88.73             | 154.28            |
| 2005 | 524.50                         | 1276.62                             | 2035.98                  | 1013.20          | 96.07             | 120.16            |
| 2006 | 416.76                         | 1297.20                             | 1722.07                  | 950.10           | 93.65             | 185.69            |
| 2007 | 1269.41                        | 1035.54                             | 2653.81                  | 931.93           | 96.10             | 201.39            |
| 2008 | 1454.19                        | 696.09                              | 2339.13                  | 974.97           | 97.99             | 156.47            |
| 2009 | 516.94                         | 959.18                              | 1476.25                  | 895.61           | 101.02            | 232.80            |
| 2010 | 756.45                         | 1231.69                             | 2162.49                  | 877.45           | 103.48            | 248.50            |
| 2011 | 549.40                         | 1186.35                             | 1874.8                   | 859.29           | 105.93            | 264.21            |
| 2012 | 784.25                         | 1420.09                             | 2359.54                  | 965.41           | 110.41            | 153.61            |
| 2013 | 1407.73                        | 1378.98                             | 2989.57                  | 822.97           | 110.85            | 295.61            |
| 2014 | 578.89                         | 1435.82                             | 1840.74                  | 804.81           | 113.31            | 311.32            |
| 2015 | 477.10                         | 1239.79                             | 1639.97                  | 955.85           | 113.28            | 160.30            |

With the help of SPSS 16.0 software the following results are obtained:

a. Model Summary

TABLE V. Model Summary

| Model | R   | R Square | Adjusted R Square | Std. An error of the Estimate | Durbin-Watson |
|-------|-----|----------|-------------------|------------------------------|---------------|
| 1     | .965\(^a\) | .931    | .901      | 113.64009                     |
| 2     | .965\(^b\) | .931    | .911      | 107.88530                     |
| 3     | .961\(^c\) | .924    | .911      | 107.98218                     |

a. Predictors: (Constant), Open field, Rainfall, Evapotranspiration, Mix Garden
b. Predictors: (Constant), Open field, Rainfall, Evapotranspiration
c. Predictors: (Constant), Rainfall, Evapotranspiration
d. Dependent Variable: TRO

To find out the good equation obtained can be known from the reflected coefficient. The closer to 100%, the better the equation will be. The coefficient of determination is shown in the adjusted R square column, which is equal to 91.1%, meaning that the equation obtained is able to predict total runoff by 91.1%, while the remaining 8.9% is obtained from other variables not examined.

The independence requirement is that the independent variable has a strong correlation with the residue that can be known by looking at the value of Durbin-Watson (DW). Independence requirements are met if the DW value is close to two. In the model summary, the DW value is 2.179 meaning that the independence requirements are met.

b. Output Coefficient

In the output coefficient (Table VI) information is obtained about variables related to total runoff, the equations obtained as well as testing the requirements for multicollinearity. Multicollinearity requirements can be tested with collinearity statistics. The tolerance value that approaches 1 indicates the absence of multicollinearity between independent variables.
TABLE VI. Output Coefficient

| Model       | Unstandardized Coefficients | Standardized Coefficients | Collinearity Statistics |
|-------------|----------------------------|---------------------------|-------------------------|
|             | B       | Std. Error | Beta | t    | Sig. | Tolerance | VIF |
| 1 (Constant)| 97.325  | 376.516    | .258 | .802 | .965 | 1.036 |
| Rainfall    | .697    | .074       | .832 | 9.362| .000 | .942     | 1.062 |
| Evapotranspiration | -.747  | .160       | -.421| -4.683| .001 | .596     | 1.677 |
| Mix Garden  | .442    | 3.898      | .013 | .113 | .912 | .601     | 1.665 |
| Open field  | .447    | .641       | .079 | .698 | .503 | .601     | 1.665 |
| 2 (Constant)| 128.867 | 240.646    | .536 | .604 | .968 | 1.033 |
| Rainfall    | .698    | .071       | .832 | 9.886| .000 | .959     | 1.043 |
| Evapotranspiration | -.745  | .150       | -.420| -4.962| .001 | .941     | 1.062 |
| Open field  | .491    | .486       | .086 | 1.010| .336 | .941     | 1.062 |
| 3 (Constant)| 165.815 | 238.061    | .697 | .501 | .996 | 1.004 |
| Rainfall    | .709    | .070       | .846 | 10.184| .000 | .935     | 1.070 |
| Evapotranspiration | -.716  | .147       | -.403| -4.854| .001 | .941     | 1.070 |

a. Dependent Variable: TRO

c. Excluded variables

In the excluded variables (Table VII), it is found that the variable coefficient of forest land is very large (8.951E2) but has a tolerance value of almost zero (2.782E-9) so that the total runoff equation is ignored.

TABLE 7. Excluded variables

| Model       | Beta In | t    | Sig. | Partial Correlation | Tolerance | VIF | Minimum Tolerance |
|-------------|---------|------|------|---------------------|-----------|-----|------------------|
| 1 Forest    | 8.951E2 | .519 | .618 | .180                | 2.782E-9  | 3.595E8 | 2.782E-9         |
| 2 Forest    | -.086   | -.113| .912 | -.038               | .013      | 75.964 | .013             |
| Mix Garden  | .013    | .113 | .912 | .038                | .596      | 1.677 | .596             |
| 3 Forest    | -.087   | -1.018| .333 | -.306               | .935      | 1.070 | .935             |
| Mix Garden  | .060    | .685 | .509 | .212                | .935      | 1.070 | .935             |
| Opened field| .086    | 1.010| .336 | .304                | .941      | 1.062 | .941             |

a. Predictors in the Model: (Constant), Open field, Rainfall, Evapotranspiration, Mix Garden

b. Predictors in the Model: (Constant), Open field, Rainfall, Evapotranspiration

c. Predictors in the Model: (Constant), Rainfall, Evapotranspiration

d. Dependent Variable TRO

d. Output Residual Statistics

In the Residual Statistics output (Table VIII), information about the residual requirement can be obtained as zero.

Based on Table VIII, the mean of the residue is equal to zero, meaning that the residue does not play a role in the equation obtained.
TABLE VIII. Output Residual Statistics

|                      | Minimum   | Maximum   | Mean       | Std. Deviation | N      |
|----------------------|-----------|-----------|------------|----------------|--------|
| Predicted Value      | 359.0840  | 1.3270E3  | 7.6695E2   | 347.25378      | 14     |
| Std. Predicted Value | -1.175    | 1.613     | 0.000      | 1.000          | 14     |
| Standard Error of Predicted Value | 29.890 | 81.851 | 47.421 | 16.404         | 14     |
| Adjusted Predicted Value | 325.1434 | 1.3205E3 | 7.4755E2 | 323.68074      | 14     |
| Residual             | -1.71935E2| 1.56956E2| 0.00000    | 99.32916       | 14     |
| Std. Residual        | -1.592    | 1.454     | 0.000      | 0.920          | 14     |
| Stud. Residual       | -1.660    | 1.806     | 0.072      | 1.080          | 14     |
| Deleted Residual     | -1.86960E2| 2.99043E2| 1.94057E1 | 142.99702      | 14     |
| Stud. Deleted Residual | -1.829 | 2.054 | 0.103 | 1.158          | 14     |
| Mahal. Distance      | 0.067     | 6.541     | 1.857      | 2.029          | 14     |
| Cook's Distance      | 0.000     | 1.469     | 0.191      | 0.407          | 14     |
| Centered Leverage Value | 0.005 | 0.503 | 0.143 | 0.156          | 14     |

a. Dependent Variable: TRO

e. Output Histogram

At the histogram output (Figure 2), normality conditions can be known, namely, the residue is normally distributed. Figure 2 shows that the residual has a normal distribution

![Histogram Total Runoff]

Fig. 2. Histogram Total Runoff

f. Scatter Output Linearity Plots

In the scatter plot output (Figure 3), linearity requirements can be known. Based on Figure 3 it appears that linearity requirements are met, meaning that the correlation between the dependent variables and free variables is linear.
g. Homogeneity Scatter Plot Output

On the scatter plot output homogeneity (Figure 4) shows a homogeneous nature where scatter does not have a certain pattern, meaning that the variant of residual is homogeneous.

h. Statistical Test Recapitulation

Based on the results of the statistical tests above, it can be recapitulated as follows
C. The relationship between Land Use, Evapotranspiration, Rainfall, and Total Runoff

Based on the results of the statistical analysis with SPSS, the correlation between the total runoff and land use, evapotranspiration and rainfall are:

\[ Y = 97.325 - 0.747X_1 + 0.697X_2 + 0.442X_4 + 0.447X_5 \]  

(6)

From equation (6) some conclusions can be drawn, namely: 1). Forest land \( (X_3) \), the variable coefficient is very large but the correlation value is almost zero so it is an excluded variable. 2). Evapotranspiration \( (X_1) \) as a deduction, meaning that the greater the evapotranspiration, the lower the total runoff. 3). Rain \( (X_2) \) as the increasing variable of total runoff, meaning that the greater the rain, the greater the total runoff. 4). Variables of mixed garden land \( (X_4) \) and open land \( (X_5) \) as increasing variables, meaning that the wider the mixed garden and open land, the greater the total runoff.

V. CONCLUSION

The equation model resulting from multiple regression analysis between variables of land use, rainfall, and evapotranspiration with total runoff is: \[ Y = 97.325 - 0.747X_1 + 0.697X_2 + 0.442X_4 + 0.447X_5 \]

This equation has been tested statistically and fulfills linear regression requirements such as independent and dependent variables must be linear, Scatter must be around the diagonal line, Histograms are normally distributed, Value DW = 2.179, The variant is constant because scatter doesn't have a certain pattern, Tolerance value = 1.

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