The Detection of Forest Health Level as an Effort to Protecting Main Ecosystem in the term of Watershed Management in Maros Watershed, South Sulawesi

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Abstract. Forests have an important role in the balance of watershed systems, mainly as water management regulators by providing sustainable water resources for humans and the environment. The changing of forest conditions could give a huge impact to the balance of the watershed. The effect of this imbalance has caused flooding problems in the rainy season and drought in the dry season as it’s happened in the Maros watershed. These problems occur because of the lack of optimal carrying capacity of forest ecosystems due to changes in forest conditions. Healthy forest conditions have a very different response compared to unhealthy forests, particularly in regulating watershed management. Based on these problems, this research was conducted to identify the condition of forests in the Maros watershed by detecting the level of forest health in forest types in Maros watershed through forest health analysis using Landsat 8 recording image of 2013 and to identify the impact of forest conditions on water availability (blue water and green water) by using SWAT model on the scenario of changing forest conditions and to make optimum forest condition direction which supported to become a sufficient Maros watershed management and to identify the condition of the forest related to air (blue water and green water) by using the SWAT model as much as possible and sustainable through reforestation or afforestation activities. The forest types in Maro's watershed consists of primary and secondary dryland forests, plantations forest and mangrove forests, with an area of 162.07 km2. The results of forest health analysis obtained a good level of forest health (very healthy and healthy) covering an area of 128.54 km2 and a poor (unhealthy and dead) forest health covering an area of 33.53 km2. The presence of unhealthy forests condition in Maros Watershed influenced the optimal proportion of the forest area in providing water yields. A good forest area in the Maros watershed produces 3,289,440 m3 of blue water. This value is very far from the water needs of the people around Maros watershed (3,308,977 m3/year). Therefore, it is necessary to optimize forest land through reforestation (improvement of forest conditions) and afforestation (forest addition). From the SWAT modeling results, it was found that the addition of forest area would increase the value of blue water, but to the optimum extent of forest addition with an area of 33.44% of Maro's watershed. The addition of forest area that exceeds this capacity will reduce the value of the blue water of the Maros watershed due to the increasing of green water through the evapotranspiration process.
1. Introduction

Forests have an important role in the balance of water-shed ecosystems, as it’s greatly affected the natural processes that occur in the watershed. Without the existence of the forests, with proportional distribution in a water-shed (according to the government regulation No. 41 of 1999 [1], 30% minimal forest area of watershed), it is possible that damage and disasters will occur in a watershed as well as lead to the conflict [2]. However, along with the development of forests management, the importance of the forest is degraded along with the number of forest degradation. The data from the Ministry of Forestry in 2011, showed that the number of deforestations in Indonesia has reached 610,375.92 ha per year and was recorded as the world’s three most significant [3].

Based on these impacts, showed that it is necessary to protecting and monitoring the existing forests as a parameter in restoring forests in Indonesia. These protecting and monitoring of forest conditions are an effort to assess the presence of existing forest ecosystems regarding both the potential value of the forest and the level of forest health. The creation of a healthy forest condition is much related to the creation of healthy ecosystem such as a watershed. Both have integrated relation which has the same characteristics. The Achievement of healthy forest conditions will support increasing forest productivity, including forest services in creating forest balance as an important ecosystem in the watershed.

Forest health is based on the assessment and design of forest management directions [4]. One of the criteria to achieve sustainable tropical forest management by the International Tropical Timber Organization/ITTO (1998) [5] is the health and condition of forest ecosystems. One of the approaches that can be used to explain forest health conditions is the FHM (Forest Health Monitoring) method or forest health monitoring.

Healthy forests are capable of performing their functions optimally, at least it is approaching to predetermined primary functions [6]. On the other hand, sick or stress forests are not capable of function optimally by the land used that has been set. Protected forests well known as a healthy forest if it can fulfill its role as a water regulator, when the water system during the dry season in a region is running out and in the rainy season is very abundant and creates a disaster, so that the protected forest does not work according to its function or unhealthy. How severe the pain of the forest can be being measured from its declining capacity [7].

The role of forests has long been related to its ability as a sponge, which absorbs rainwater during the rainy season and releases it slowly in the dry season [8]. Forests also play a role in preventing floods, so that if deforestation happens, it will cause flooding in the area beneath it. Land-use activities that change the type of land cover in a watershed through activities such as deforestation, shifting cultivation, or forest land use changes into agricultural, grassland or settlement areas are also de-crease water yields[9]. From that point of view, present and future forest management require information about the forest condition focusing on forest health. It is because healthy forests can perform its functions well in contrast to the unhealthy forests. The protection and monitoring of forests are particularly important in creating integrated and sustainable watershed management of sustainable forest management aspects. However, nowadays, forest protection and monitoring related to forest health is still lack, and it is only limited to the studies in small areas.

In the term of watershed management, the study about the protection and monitoring of forest conditions has an extensive study of the different types of forests which is located within a watershed. Therefore, a method that is appropriate to the condition of Indonesia's forests in detecting the forest health level and to determine the role of forest conditions in regulating the availability of water in a watershed are necessary. It is done to create a strategy of sustainable Indonesian forest management which is based on watershed management.

2. Material and Method

This research is focusing on the detection of forests health level with watershed management-based, in this case, forest ecosystems are the most important ecosystems and influence toward the balance of
watershed ecosystems in the term of regulating water availability in the watershed. This research including.

2.1. Determining the Boundary of Research Location
Forest ecosystems with different types of forests. The watershed boundary used is Maros watershed which is located in South Sulawesi Province (presented in Figure 1).

![Figure 1. Location Research Map](image)

2.2. Collecting Research Data
This research combines survey methods and Geographic Information System (GIS) analysis to describe the condition of forests in the term of Maros watershed management. The data which was collected in this research consist of primary data and secondary data. The primary data including Landsat 8 OLI recording images 17-08-2013, 30-meter DEM Aster, river network maps, land type maps, weather and hydrological data and discharge data. The secondary data including the result of the assessment of forest health status in the field and data of physical and chemical properties of soil.

2.3. The Processing and analyzing research Data

Land Cover Interpretation
This activity was aimed to get information about land-cover forms especially the types of forests and its area distribution in Maros watershed by using Landsat 8 OLI satellite image with a combination of band vegetation analysis that is 654 (Shortwave Infrared 1 - Near Infrared - RED). The classification of land cover in this interpretation using land cover classification of Indonesian National Standard Number 7645: 2010.

Detection of Forest Health Rate
Detection of forest health level in this research was done by using a GIS approach and remote sensing. The forest health level parameters used were the result of spatial vegetation analysis of forest health
tools in ENVI 4.5 software. The analysis uses Landsat 8 satellite imagery with analysis boundaries in forest types which located in Maros watershed. The steps of Landsat 8 image analysis in detecting forest health levels in forest types in Maros watershed use four categories of vegetation index [9] which including:

a. Greenness, by using Normalized Difference Vegetation Index (NDVI = (βNIR-βRed) / (βNIR + βRed)). Index to determine the amount of green bio-mass (chlorophyll content).

b. Leaf Pigments, by using the Carotenoid Reflectance Index (CRI = (1 / β510) - (1 / β550)) and Anthocyanin Reflectance Index (ARI = (1 / β550) - (1 / β700)) which shown the carotenoid pigment concentration (yellow-orange pigment) that is able to protect the plant from the over light ray. Anthocyanin pigments (red, purple and blue pigments) by showing changes in vegetation canopy through new leaf growth and leaf death (fall).

c. Canopy Water Content, by using the Water Band Index (WBI = β900 / β970), to show the water concentration on the tree canopy.

d. Light Use Efficiency, by using the Photochemical Reflectance Index (PRI = (β531 - β570) / (β531 + β570)) which show the growth rate of the forest.

From the analysis results, we can detect forests health level, which is shown by index 0 to 9, then it will be clarified based on Forests health level clarification (presented in Table 1).

| **Table 1. Forest Health Level Classification** [9,10] |
|------------------|------------------|------------------|
| Index | Class | Color Map |
| 0-1 | Died | ![Red] |
| 2-3 | Unhealthy | ![Yellow] |
| 4-5 | Stress | ![Yellow] |
| 6-7 | Healthy | ![Gray] |
| 8-9 | Very Healthy | ![Green] |

To validate the detection result data of forests health level in various types of forests in Maros Watershed, it requires to conduct field crosscheck and assessment regarding the population of the health of that forest. The determining of the distribution of plot observation by using proportionately stratified technic with random sampling. This technique was conducted by collecting the data from heterogeneous data and stratified proportionally.

This technique was selected to determine the sample at the level of forest health class obtained in forest types in the Maros watershed by 50 observation points. The observation activities using the method of Forest Health Monitoring developed USDA, using the parameters of information needs on the tally sheet observations to detect ecological factors that affect the level of forest plant health in the field, which includes the extent of tree damage, crown condition and site quality (where it is grown).

2.4 Analysis of the influence of forests on watershed balance

The influences of forest on watershed balance are asses regarding the role of forests in maintaining the availability of water yield that regulates discharge fluctuations, control runoff, increase base flow and reduce erosion and sedimentation. Forests influence maintaining watershed balance regarding green water and blue water. Green water can be defined as the amount of rainfall that returns to the atmosphere due to the role of vegetation through the process of evapotranspiration [11]. Bluewater can be defined as rainfall that accumulates into surface runoff, lateral flow, and base flow that enter lakes, rivers, and aquifers [11] and flow into the ocean [12].

Optimal forest area in a watershed is the most rational approach to balancing and managing vegetative-based water. So that a forest cover management scenario is needed to maintain the balance of green water and blue water in the watershed. The green water values studied consist of evapotranspiration values and blue water values consisting of runoff, lateral flow, and base flow values. This scenario is carried out using a model called the SWAT (Soil Water Assessment Tools) Model. This model was developed by the USDA (United State Department of Agricultural) in software called ArcSWAT which is an extension of ArcGIS 10.1.

SWAT is a physically based hydrology model that requires specific information about the climate, physical and chemical properties of the soil, topography, vegetation, and land management practices that occur in the watershed. The forest cover scenario is used as input data to apply the model (Shown
in Table 2).

| Scenario | % of the forest coverage area | Remarks |
|----------|-----------------------------|---------|
| S1       | 25.80                       | Existing forest area in 2013 |
| S2       | 20.46                       | Forest area with forest quality is very healthy and healthy after forest health analysis. Forest area decreases, remaining primary forest (8.29%) and secondary forest (5.69%). Plantation forests become agricultural land while some secondary forests and mangrove forests become shrubs. |
| S3       | 13.98                       | Forest area decreases, remaining primary forest. Forest area decreases, remaining primary forest. Plantation forests become agricultural land while secondary forests and mangrove forests become shrubs. |
| S4       | 8.29                        | There is no forest, the area of the existing forest become a bush. |
| S5       | 0                           | Forest area increases, land with slopes > 40% and river border (a distance of 100 meters) becomes a forest. |
| S6       | 33.44                       | Forest area increases, land with slopes of 25-40% and > 40% and river border (100 meters distance) become a forest. |
| S7       | 44.08                       | Forest area increases, existing forest area in 2013 is overlain with a forest area of Minister of Forestry's regulation No. 434 the Year 2009 [13] regarding the Appointment of Forest Areas and Aquatic Conservation in the South Sulawesi Province with a forest cover area by the Maros watershed boundary. |
| S8       | 57                          | Forest area increases, land with slopes of 15-25%, 25-40%, and > 40% and river borders (distance of 100 meters) become forests. |
| S9       | 66.39                       | The area of forest is increasing, a cover of scrub land, grasslands and some agricultural turning into forests. |
| S10      | 74.17                       | Forest area increases, land with slopes of 15-25%, 25-40% and > 40% and river borders (distance of 100 meters) become forests. |

2.5. The strategy of Drafting the Optimal Forest Management Directives in the term to support Watershed Management

The direction of optimizing forest management is the optimal stage in developing a strategy for forest management in the Maros watershed to support watershed management based on information on the forest from the results of analysis and field observations as well as forest cover scenarios to maintain watershed balance. The forest management plan that will be applied to forest areas in the Maros watershed includes the drafting of activities for the protection and preservation of forests whose health is very healthy and...
healthy; carry out reforestation efforts (optimizing forest conditions) with silvicultural measures in the form of land control to improve forest quality at stressful, unhealthy and dead plant health levels to meet ecological and economic and make afforestation efforts in the form of additional forest area by planning community-based forms of forest management on forest areas that are not in accordance with their regional functions.

3. Results and discussion

3.1. Land Cover in Maros Watershed

The interpretation process of Landsat 8 OLI satellite imagery recording 17-08-2013 obtained 11 land cover classifications, with details in Table 3 and the distribution of land cover in Figure 2.

| No | Land Cover                | Area | %  |
|----|--------------------------|------|----|
| 1  | Primary Dryland Forest   | 52.10| 8.29|
| 2  | Secondary Dryland Forest | 87.84| 13.98|
| 3  | Mangrove forest          | 1.70 | 0.27|
| 4  | Plantations forest       | 20.44| 3.25|
| 5  | Settlement               | 8.12 | 1.29|
| 6  | Dryland Agriculture      | 276.70| 44.04|
| 7  | Pasture                  | 2.23 | 0.36|
| 8  | Padi Field               | 116.21| 18.50|
| 9  | Shrubs                   | 24.96| 3.97|
| 10 | Ponds                    | 29.48| 4.69|
| 11 | Water Body               | 8.48 | 1.35|
|    | Total                    | 628.25| 100.00|

Source: Results of the 2013 Land Cover Interpretation.

Figure 2. Land Cover Map in the Maros Watershed
From the results of the land cover classification in the Maros watershed, it can be seen that the land cover in the form of forest vegetation is only 25.80% of the Maros watershed area which is consist of as type of primary dryland forest with an area of 52.10 km² (8.29%), secondary dryland forest with an area of 87.84 km² (13.98%), mangrove forest with an area of 1.70 km² (0.27%) and plantation forest with an area of 20.44 km² (3.25%). The type of forest in the Maros watershed has characteristics and features that are very different from each other. The types of forest plants or trees found in forest types in the Maros watershed vary widely. The type of tree that constitutes the structure of forest stands has a very large influence on the function of the forest. Characteristics of individual trees such as crown shape, crown height, crown width, number of branches, horizontal and vertical root directions have a significant influence on soil hydrological function.

![Figure 3. Primary Dryland Forest Conditions (a), Secondary Dryland Forest (b), Plantations forest (c) and Mangrove forest (d) in Maros Watershed](image)

The type of tree that constitutes the structure of forest stands has a very large influence on the function of the forest. Primary and secondary dryland forests in the Maros watershed are heterogeneous forest types, some of which are tree species that grow in karst hills with very diverse species. Plantation forests in the Maros watershed are forests that are mostly managed by forest farmer groups and several companies that have forest exploitation permits in production forest areas in the Maros watershed. The types of forestry plants developed in the plantations in the Maros watershed consist of *Tectona grandis*, *Swietenia macrophylla*, *Pinus merkusii*, *Acacia mangium* and *Paraserianthes falcataria*. Mangrove forests found in the lower stream of the Maros watershed are natural mangrove forests and local community cultivation. Mangrove types that can be found are generally dominated by *Rhizophora apiculata*, *Rhizophora mucronata*, and *Avicennia lanata*.

3.2. Detection Forest Health Level

The importance of forests in a watershed is inseparable from its function as a regulator of the water system, in addition to the value of other functions such as the protection of biological ecosystems and as a source of economic community in the vicinity of the forest area. In watershed management, the goal of forest management is to regulate the hydrological system in the upstream (upland forest) and balance the ecosystem in the downstream (mangrove forest).

Healthy forests are characterized by the presence of trees that thrive and productive, the nutrient cycle is good, and there is no significant damage by plant disturbing organisms and able to form a unique ecosystem such as microclimate regulators or germplasm sources. In healthy forest conditions, the leaves of the forest constituent stand will look green due to chlorophyll content and have a high level of canopy density.
This is a forest condition that can reduce rainfall that falls within the watershed to reduce the rate of runoff from upstream. While unhealthy forests can be detected on the dried leaf components, this is because the leaves are dry, the water content which is the main ingredient of photosynthesis is very lacking (deficit) so that the growth process of the forest constituent stands is inhibited.

Forest health in the Maros watershed is obtained from the results of vegetation index analysis which is an optical measurement of the spectral greenness level captured by the remote sensing sensor on Landsat 8 satellite imagery. Based on the vegetation index used, the NDVI index is the index that most influences the level of forest health in the Maros watershed with a value of R² 0.81 which illustrates the greenness level of forest stands and also illustrates the level of stand density as in Figure 4 below.

![Figure 4. Difference between Greenish Level of Secondary Dryland Forest and Plantation Forest in Maros Watershed](image)

Then the ARI index with a value of R² 0.75, WBI index with an R² value of 0.74, CRI index with a value of R² 0.73 and a PRI index with a value of R² 0.54. The relationship of the five-vegetation index is used to determine the level of forest health in the Maros watershed. This relationship produces a healthy level of forest which consists of very healthy, healthy, stressed, unhealthy and died based on forest types in the Maros watershed as in Figure 5 and Table 4.

![Figure 5. Forest Health Level Map in Maros Watershed](image)
Table 4. The proportion of Forest Health Levels in Forest Types in the Maros Watershed

| Forest Health Level | Primary Dryland Forest | Secondary Dryland Forest | Plantations forests | Mangrove forest | Total     |
|---------------------|------------------------|--------------------------|---------------------|----------------|-----------|
| Very healthy        | 34.48                  | 67.2                     | 6.08                | 0.34           | 108.094   |
| Healthy             | 11.04                  | 5.57                     | 3.49                | 0.36           | 20.453    |
| Stress              | 3.07                   | 7.02                     | 4.52                | 0.03           | 14.645    |
| Unhealthy           | 1.84                   | 5.31                     | 3.99                | 0.48           | 11.616    |
| Died                | 1.67                   | 2.74                     | 2.36                | 0.5            | 7.27      |
| Total               | 52.1                   | 87.84                    | 20.44               | 1.7            | 162.08    |

Source: Results of Forest Health Watershed Analysis Maros, 2014.

The description of the level of forest health in the Maros watershed provides information that in the type of secondary dryland forest and plantation forest has a large enough forest area in unfavorable conditions. Many factors influence the level of forest health in the Maros watershed, so it is necessary to know the things that caused the level of health of the forest in the field through observation activities.

Many factors of forest health in the Maros watershed, so it is necessary to know the level of health of the forest in the field through observation activities and also to determine the accuracy of forest health level from the results of forest health analysis using Landsat 8 satellite imagery. Field observation activities used a sampling technique of 50 observation points (FH1-FH50) with a distribution of 28 points at the health level of very healthy forests, 7 points in healthy forests, 6 points in stressed forests, 5 points in unhealthy forests and 4 points in forests with health conditions die.

From the results of field observations, 7 observation points are not by the results of forest health analysis. This difference of the results is influenced by many factors between the effect of the level of accuracy of the analysis of vegetation index and the effect of time of field observation on the time of image recording used is one of the constraints that affect the results of field analysis and observation.

However, based on the results of the overall accuracy test, the accuracy of the observations of the health level of the forest in the Maros watershed is based on producer's accuracy (the level of confidence of the data obtained from field data) and user's accuracy (the level of trust obtained from the analysis of Landsat 8 images) obtained the overall accuracy of the test results value of 86% which is a comparison of the number of observation points that correspond to the total number of observation points.

The accuracy value obtained was 86%, included in the category of quite a high accuracy [14]. So that the results of the analysis of the level of forest health in the Maros watershed using forest health analysis can be used for further study. The results of this analysis can be used to find out the description of the forest condition in a watershed both regarding the quantity of the forest and regarding the quality of the forest. Figure. 6 provides an overview of the condition of poor forest constituent stands in the Maros watershed thus affecting forest quality and reducing the number of forests that function optimally.
3.3. Effect of Forest Conditions on Blue Water and Green Water in the Maros Watershed

The impact of land cover change through a scenario of changes in forest area in the Maros watershed is very real in influencing the value of blue water and green water. The availability of blue water is the accumulation of surface runoff, lateral flow, and base flow or ground flow to the total loss of water to the deep aquifer (Transmission losses the level of forest evapotranspiration strongly influences the value of green water in a concept of watershed management. SWAT modeling results show that the relationship between forest area in a watershed to surface runoff is linearly negative, namely increased forest area, it will significantly reduce the total surface runoff with a value of $R^2 = 0.9626$. Decreasing of surface runoff from the scenario of addition forest area has an impact on increasing lateral flow and base flow or groundwater flow. The relationship of the addition of forest area to lateral flow and groundwater flow is positive linear with $R^2$ values 0.9521 and 0.9939. Every additional 1 km$^2$ of forest area can reduce surface runoff by 9.93 mm or 9,925.08 m$^3$ and increase lateral flow by 0.93 mm or 934.46 m$^3$ and also increase groundwater flow by 4.31 mm or 4,309.52 m$^3$. The increasing of groundwater flow from the scenario of the addition of forest area in the Maros watershed illustrates conditions of increasing the water springs alternatives because the base flow is formed from vertical drainage of water into the soil through a percolation process to groundwater. Thus, the forest can be said to be the main part of the river that can maintain the availability of springs water in a watershed by reducing the maximum discharge and maintaining the minimum discharge in the dry season.

The accumulation of surface runoff, lateral flow, and groundwater flow in the Maros Watershed in SWAT modeling, describe the influence of changes in a forest area on the availability of blue water in the Maros watershed. However, the proportion of additional forest area in the Maros watershed is very important. Because of the addition of the proportion of vegetation will increase the process of evaporation of water through evapotranspiration (the value of green water). From the SWAT modeling results, the addition of forest area will increase the value of green water with a positive linear relationship and $R^2$ value 0.9733 as in Figure 7.
The increasing of the green water value through evapotranspiration process based on the scenario of addition the forest area causes the availability of blue water in the Maros watershed to have an optimum limit of the addition of forest area to 33.44% with a value of 3312.93 mm of blue water or 3,312,930 m$^3$. The relations between changes in forest area and blue water availability in the Maros watershed forms a quadratic polynomial relationship with a significant R$^2$ of 0.8465 as shown in Figure 8.

The value of the availability of blue water is a water limit that can be used by the community every year because the Maros watershed capacity is only able to supply by these optimum limits.

3.4. **Direction for Forest Optimization as Maros Watershed Management Efforts**

From the results of forest health analysis on forest area in 2013 in the Maros watershed, it was found that the forest area with good conditions with a very healthy and healthy health level was only 128,547 km$^2$. The data shows that around 33.53 km$^2$ or about 3,352.6 ha in unfavorable conditions. The decline in forest quality on the quantity of forest in the Maros watershed in 2013 resulted in a decrease in the amount of water supplied by the Maros watershed. Based on the results of the analysis of the availability of water according to the good quality of the forest covering an area of 128,547 km$^2$ in the Maros watershed, it was found that the area was only able to provide 3,289,440 m$^3$ of water yield. The value of the availability of water yield, if it linked to the water needs of the community in the Maros watershed per year based on the results of [11] research of 3,308,977 m$^3$/year is very far from the adequacy rate.
even this is what has caused the effects of drought and lack of water so far in the Maros watershed. To balance the need and availability of water in the Maros watershed, it is now necessary to optimize forest areas (reforestation), which even requires additional forest area (afforestation) by the carrying capacity and capacity of the Maros watershed. The results of modeling the availability of water in the Maros watershed using alternative land cover scenarios, it turns out the carrying capacity and capacity of the Maros watershed to the optimal forest area only reaches 33.44%. Where the forest area can produce 3,312,930 m$^3$ of water, the water yield can meet the community’s water needs in the Maros watershed. However, to get the value of water availability, it is necessary to increase the forest area, where to produce the water yield, it requires an area of 210.12 km$^2$. The direction of Forest management is to achieve the optimal forest area on land cover in the Maros watershed which is including direction to maintain forest conditions in good condition covering an area of 128.55 km$^2$, efforts to reforestation or optimization of unfavorable forest conditions cover 33.53 km$^2$. And afforestation efforts or additional forest area of 48.04 km$^2$. The direction of optimization of forest land in the Maros watershed is detailed in Table 5 and with the distribution in Figure 9.

**Table 5. Direction for Optimizing Forest and Land Coverage in Maros Watershed**

| Land Cover in 2013     | Direction         | Area (km$^2$) |
|------------------------|-------------------|---------------|
| Forest Direction       |                   |               |
| Primary Dryland Forest | Forest conditions are maintained | 45.51 |
| Secondary Dryland Forest | Forest conditions are maintained | 72.77 |
| Plantations forest     | Forest conditions are maintained | 9.57 |
| Mangrove forest        | Forest conditions are maintained | 0.70 |
| Primary Dryland Forest | Reforestation      | 6.58 |
| Secondary Dryland Forest | Reforestation     | 15.06 |
| Plantations forest     | Reforestation      | 10.88 |
| Mangrove forest        | Reforestation      | 1.00 |
| Pastures               | Afforestation      | 2.23 |
| Dryland Agriculture    | Afforestation      | 33.54 |
| Shrubs                 | Afforestation      | 12.39 |
| Non-Forest Direction (Other Land) |       |               |
| Dryland Agriculture    | Dryland Agriculture | 243.16 |
| Shrubs                 | Shrubs             | 12.58 |
| Settlement             | Settlement         | 8.12 |
| Paddy field            | Paddy field        | 116.21 |
| Ponds                  | Ponds              | 29.48 |
| Waterbody              | Waterbody          | 8.48 |
| Total                  |                   | 628.25 |

Source: Results of Maros Watershed Land Cover Analysis, 2014.
From the results of the direction of forest and land cover in the Maros watershed, it is known that the forest condition that is maintained is a good forest condition based on the results of the analysis of the health level of the forest in very healthy and healthy conditions. Efforts to maintain these forest conditions are carried out through the protection and preservation of forest areas in the upstream and downstream (coastal) watersheds such as making it as a protected area and conserving and improving the quality of stands in plantations that support forest hydrological processes such as developing agroforestry systems. This is because the development of agroforestry in a watershed has several benefits, such as having an ecological sustainability concept, economic benefits and socio-cultural adaptation.

The direction of forest optimization in unfavorable conditions (stress, unhealthy and dead forest health level) is carried out through refraction activities by optimizing the function of existing forests through reforestation in areas that are severely damaged (dead) and increased intensive silvicultural efforts in the area stressful and unhealthy. Intensive silviculture is a greening system that guarantees the return or even improvement of forest function in improving environmental quality.

For efforts to increase forest area, it is carried out through afforestation directives, namely the forestation of lands whose conditions should be protected areas (forested) such as lands that are on slopes above 40% (very steep) and river border areas. Afforestation directives in the Maros watershed are carried out on land cover that previously was pasture, shrubs and dry land agriculture which is included in the status of protected and conservation forest areas based on the Decree of the Minister of Forestry No. 434 of 2009 concerning the Appointment of Forest Areas and Aquatic Conservation in the Region of South Sulawesi Province. The directives for land cover reforestation in the Maros watershed are carried out by considering the ownership status of the land cover, such as not belonging to the community, such as paddy fields, ponds and dryland farming that do not have the state of the government so that the direction of forest optimization in the Maros watershed can be applied.
4. Conclusion
a. The results of the detection of the level of forest health in the Maros watershed using forest health analysis describe the quality conditions of the quantity of forest in the Maros watershed in 2013 with an area of 162.08 km². Of this quantity, there are forests in good condition (very healthy and healthy forest health level) of 128,547 km² and poor forest conditions (stress, unhealthy and dead forest health level) of 33.53 km². Accuracy test between forest health analysis on observation of health level in the field obtained 86% accuracy value, this value shows that forest health level detection method using forest health analysis on Landsat 8 imagery can describe the condition of forest in Maros watershed in the future and can also be applied to forest types that are similar to forests in the Maros watershed.

b. The condition of the forests in the Maros watershed both regarding quality and quantity significantly affect the hydrological balance. Decreasing forest area based on scenario results will increase the rate of surface runoff and reduce groundwater supply (decrease in blue water value). With the addition of forest area, the rate of surface runoff in the Maros watershed will decrease and increase ground water supply (increase in the value of blue water), but the increase in the value of blue water will reach the optimum point due to increased evapotranspiration (green water value) from the addition of forest area to area of 33.44% of Maros watershed area. The increase in forest area beyond the optimum capacity will reduce the value of blue water (water yield).

c. The direction of Maros watershed ecosystem balancing is done through optimization of forest land. This directive is carried out as a step for vegetative integrated watershed management efforts to overcome hydrological problems in the Maros watershed by regulating the availability of green water and blue water. The forest optimization strategy direction in the Maros Watershed includes efforts to protect and preserve good forest conditions by maintaining the quantity and quality and efforts of reforestation and afforestation.

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