 doi:10.20944/preprints201908.0277.v1

Article

Forest Revegetation to Preventive Springs Degradation in Arjuna Mount East Java, Indonesia

Matheus Nugroho[1], Soemarno Soemarno[2], Harsuko Riniwati[3], Aminudin Afandhi[4]
[1]Student of Environmental Science Doctoral Program of Brawijaya University, Postgraduate Program in Malang, East Java, Indonesia; mtnugroho@gmail.com
[2]Faculty of Agriculture Brawijaya University in Malang, East Java, Indonesia; smno@ub.ac.id
[3]Faculty of Fisheries and Marine Science Brawijaya University in Malang, East Java; Indonesia; riniwatisepk@gmail.com
[4]Faculty of Agriculture Brawijaya University in Malang, East Java, Indonesia; a.afandhi@gmail.com
Correspondence: mtnugroho@gmail.com ; Tel.: +62-81-3338-67954

Abstract. The objective of the study was to examine the effect of forest revegetation to preventive springs degradation in Arjuna mount East Java, Indonesia. The research method was quantitative descriptive, by conducting a survey of measurements in the area around the springs. The survey method covers: (1) the measurement of the number and type of plants, the results of their growth (number of plants that live and die), as well as measuring the water discharge of springs; (2) interviews of people living in the vicinity of springs; (3) direct observation of vegetation conditions around Lajer, Dawuhan, Sumber Kuning and Watupereng springs in Arjuna Mount. Data were analyzed quantitatively spatially using GIS, ArcView 3.3 programs and Google Earth. The results of the study explain the profile of forest revegetation, namely plant species, nursery, fertilization, planting, plant care had a significant effect to the springs preservation in Arjuna mount. The forest revegetation has a positive and significant effect on the preservation of springs. The better the revegetation of the forest, the better the preservation of springs, and vice versa. Vegetation cover plays an important role in regulating the hydrological system, especially the effect of sponges that can trap rainwater and drainage so as to reduce the tendency of flooding and maintain the flow of water in the dry season. The results showed that (1) forest revegetation in Lajer's springs area, the water debit of the springs were 10.35 liters/second; (2) forest revegetation in the Dawuan springs, the water debit of the springs were 25.47 liters/second; (3) forest revegetation in the Sumber Kuning springs area, the water debit of the springs were 10.25 liters/second; (4) forest revegetation in the Watu Pereng springs, the water debit of the springs were 0.80 liters/second.

Keywords: revegetation; forest, springs preservation; Arjuna mount; plant species; nursery; fertilization; planting; plant care

---

1. Introduction

The closure of vegetation plays an important role in forest management for the functioning of the hydrological system, especially the effect of sponges capable of holding rainwater and regulating its drainage, thereby reducing the occurrence of flooding and maintaining water flow in the dry season. The hydrological function of the forest will be lost, when vegetation in the higher watersheds was damaged. In tropical forest areas, 90% of farmers in the lowlands depend on the activities of 10% of the people living in the upper reaches of the river. For example, the Ganges river basin, 40 million people living in the Himalayas affect 500 million people in the lowlands (Mac Kinnon, K. 1992). Tropical forest vegetation cover can

 doi:10.20944/preprints201908.0277.v1

reduce water flow rates by 10-40%, and increase deposit water through litter by more than 4% (Soemarwoto, 1991).

In the area of Indonesia's tropical forests and specifically Arjuna mount, awareness of the importance of vegetation cover and revegetation of forests in achieving sustainable forests was still lacking, so that flooding problems in the rainy season, and no water drought in the dry season always occur every year (Soemarwoto, 1991). There were four key ecological indicators of damage to tropical rainforests, namely: (1) vitality (tree damage and canopy conditions); (2) decreasing forest productivity; (3) low biodiversity; and (4) low site quality. The four ecological indicators have a close relationship with each other, both separately and together can describe the level of forest destruction (Supriyanto *et al.*, 2001).

The results of monitoring (USAID, 2008), show that during the last 20 years there has been a rate of forest degradation on Arjuna mount, some areas of the watershed sub-watershed have decreased springs, this was allegedly related to forest destruction in the recharge area continues to increase. Recharge area damage was caused by land use change, illegal logging, fire and wild sand mining which results in soil damage and increased erosion and sedimentation. The number of dry or dead springs is 30 springs, out of a total of 41 springs. The main cause of dry springs was damage to protected forests and production on Arjuna Mount. Thousands of hectares of Arjuna mount forests were critical, due to fire and illegal logging. The forest area of Arjuna mount in the Pasuruan Regency area reaches 12,000 hectares. About 1,500 hectares of them were damaged by fires in 2012. Of the 1,500 hectares burned, only 300 hectares have been rehabilitated. According to the study from the Clinton Foundation, USA in 2011-2012, the rate of forest destruction on Arjuna mount reached 0.24%, equivalent to 68 ha/year. If this condition continues, it will threaten the supply of clean water for almost 2 million people in Pasuruan Regency, 4.7 thousand hectares of irrigated rice fields and around 500 industries in Pasuruan Regency (Wiyono, 2008).

Based on some of the facts and problems mentioned above, it was necessary to implement the forest revegetation to preventive springs degradation in Arjuna mount East Java, Indonesia.

2. Materials and Methods

Data material was taken from the growth of plant species that exist in each area around the spring by recording and photographing parts that characterize the tree species. The next step was to measure water discharge in the dry and rainy seasons, water quality data. The results of plant species growth data will then be analyzed for plant density, relative density, frequency, relative frequency, importance value, and diversity index (Indriyanto, 2006).

This research was an associative problem, which was a research question that connects two or more variables. The relationship variable in research was a causal relationship, that was a causal relationship. There were independent or exogenous variables, and dependent or endogenous variables. Exogenous variables are selected according to consideration based on empirical conditions, forest revegetation activities and community empowerment around the year forest, the ability of researchers, the availability of supporting theories, and the characteristics of the study area (Supranto, 2004).

Exogenous variables in this research plan were:

- Community empowerment (PM), including: human resources (PM1); economics (PM2); social (PM3); local institutions (PM4); facilities and infrastructure (PM5)
- Geography and land (GT), including: land slope (GT1); effective soil depth (GT2)

There were 3 endogenous variables in this study, namely:

- RH, was a symbol of the Arjuna mount forest revegetation variable in the area of the Lajer, Dawuan, Sumberkuning and Watupereng springs, Prigen, Pasuruan, East Java, Indonesia, with indicators including: plant species (RH1); nurseries (RH2); fertilization (RH3); planting (RH4); care (RH5). Forest revegetation was determined by measuring the fulfillment of community empowerment; geography and land.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 August 2019 doi:10.20944/preprints201908.0277.v1

- PVH, was a symbol of Arjuna mount vegetation and fauna profile variable, with indicators: vegetation stratification (PVH1); bird wealth (PVH2); taxonomy wealth (PVH3); plant density (PVH4). The profile of vegetation and fauna of Arjuna mount was determined by measuring the fulfillment of forest revegetation, geography and soil conditions and empowerment of communities around the forest.
- PSA, was a symbol for variable conservation of spring water, with indicators: water discharge in the rainy season (PSA1); water discharge in the dry season (PSA2); erosion (PSA3); economic value of water (PSA4). Conservation of springs is determined by measuring the fulfillment of forest vegetation and fauna profiles, revegetation of forests, geography and soil as well as the empowerment of communities around the forest.

The method used was descriptive method. While based on the techniques and tools used to research, the author uses the survey method to obtain facts that occur in the research area, namely in the area around the spring of the Kedunglarangan and Gumandar Prigen watersheds, Pasuruan Regency. Data obtained in the field are then processed and analyzed using GIS, ArcView 3.3 and Google Earth programs. The study population covering the community around the forest and springs, who lived in three villages, namely Leduk, Jatiarjo and Dayurejo Village, Pasuruan, East Java-Indonesia. Data obtained from respondents with questionnaires and analyzed using SEM (structural equation modeling), to find out a general description of respondents' responses about community participation in the preservation of Arjuna mount forest.

3. Result

3.1 Plant species

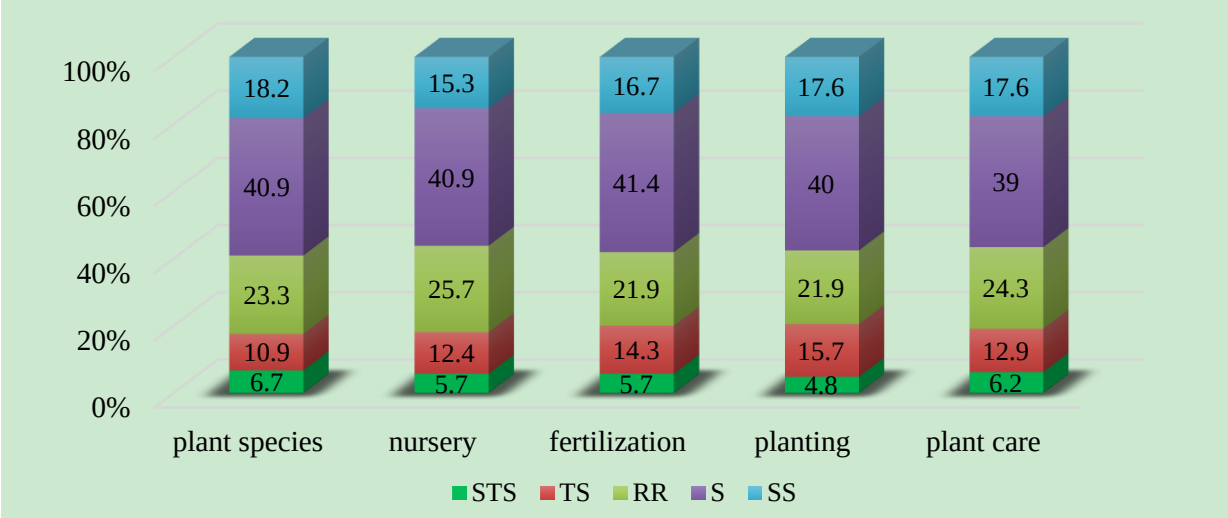

Figure 1. Respondent's perception of revegetation of Arjuna's mount forest

Note:

STS	:	explain the perceptions of respondents strongly disagree about community empowerment
TS	:	explain the perceptions of respondents disagree about community empowerment
RR	:	explain the perceptions of respondents hesitant about community empowerment
S	:	explain the perceptions of respondents agreeing about community empowerment
SS	:	explain the perceptions of respondents strongly agree about community empowerment programs

 doi:10.20944/preprints201908.0277.v1

The profile of Arjuna mount forest plant species, namely: (1) the current vegetation condition of Arjuna mount forest plants, was better compared to 10 years ago; (2) the amount of vegetation of Arjuna's mount forest plants was currently increasing, and the source of the spring continues to flow; (3) the variety of plant species in the forests of Arjuna mount was currently increasing; (4) tree species planted in the forests of Arjuna mount were native plants of the forest; (5) what names of tree species planted in the forests of Arjuna mount include bamboo, kaliandra tree, rattan, banyan, sono tree, mahogany, rengas tree, kesambi tee, trengguli, tamarind trees.

The perception of 210 respondents towards the profile of Arjuna mount forest plant species towards the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, in Figure 1. shows that 18.2% of respondents expressed strongly agree, 40.9% of respondents stated agree, 23.3% of respondents expressed doubt, 10.9% of respondents stated disagree and 6.7% of respondents stated strongly disagree. Based on these data the revegetation plant species of Arjuna mount forest influence the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 59.1% of respondents stated strongly agree and agree. Figure 1. explain the responses of respondents about the revegetation plant species of Arjuna mount forest.

3.2 Plant Nursery

Profile of forest nursery plants in Arjuna mount, namely: (1) community members around the forest were involved and provide plant seeds for the preservation of Arjuna mount forest; (2) tree seedlings planted in the forests of Arjuna mount, originating from certified nurseries; (3) the height of the initial tree seedlings planted in the Arjuna mount forest was a minimum of 2 meters; (4) seed nursery function, before planting in Arjuna mount forest was quality and uniform seedlings and (5) the estimated price of seedlings for each tree with a height of 2 meters was around IDR 20,000 to IDR 25,000.

The perception of 210 respondents to the profile of the Arjuna mount forest plant nursery towards the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, in Figure 1. shows that 15.3% of respondents expressed strongly agree, 40.9% of respondents stated agree, 25.7% of respondents expressed doubt, 12.4% of respondents stated disagree and 5.7% of respondents stated strongly disagree. Based on these data, revealing that the nursery of Arjuna mount forest revegetation affects the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 56.2% of respondents stated strongly agree and agree. Figure 1. explain the responses of respondents about the nursery of the Arjuna mount revegetation plant.

3.3 Fertilizing

The profile of Arjuna mount forest plant fertilization includes: (1) plant fertilization was carried out by community farmers from the villages of Leduk, Jatiarjo and Dayurejo; (2) the purpose of fertilizing plants was to meet the adequacy of soil nutrients, and plant growth could be optimally optimized; (3) fertilizing the plants was done at the beginning of planting, and continuously every 3 months, until the age of the plants was 3 years; (4) the type of fertilizer given to fertilizing plants was inorganic fertilizer (NPK) and organic (manure); (5) NPK fertilization method for each plant was fertilizing by circling around the plant.

The perception of 210 respondents towards the profile of Arjuna mount forest plant fertilization towards the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, in Figure 1. shows that 16.7% of respondents expressed strongly agree, 41.4% of respondents stated agree, 21.9% of respondents expressed doubt, 15.7% of respondents stated disagree and 4.8% of respondents stated strongly disagree. Based on these data, revealing the fertilization of Arjuna mount forest vegetation affects the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 58.1% of respondents agreed and strongly agreed. Figure 1. explain the responses of respondents about the fertilization of Arjuna mount forest revegetation plants.

 doi:10.20944/preprints201908.0277.v1

3.4 Planting

Profile of Arjuna mount forest tree planting includes: (1) managing the forest together with the government, applying strict regulations to the lawbreakers of forest destruction and actively involved in tree planting activities and caring for them were a number of forest management activities, so that they could continue to benefit humans and their environment; (2) The Village Government makes village regulations for forest management; (3) tree planting, width and distance between trees, greatly affect plant growth; (4) spacing and number of trees planted in forest revegetation was 3 meters x 3 meters (300 trees/ha); (5) a simple procedure for planting trees was to make holes and plant tree seeds in an upright position, as deep as 3 cm from the neck of the root, and cover the soil again.

The perception of 210 respondents to the profile of Arjuna mount forest planting on the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, in Figure 1. shows that 17.6% of respondents expressed strongly agree, 40% of respondents stated agree, 21.9% of respondents expressed doubt, 15.7% of respondents stated disagree and 4.8% of respondents stated strongly disagree. Based on these data stated the planting of Arjuna mount forest trees influence the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 57.6% of respondents agreed and strongly agreed. Figure 1. explain the responses of respondents about the planting of Arjuna mount forest trees.

3.5 Plant care

The profile of Arjuna's mount forest care includes: (1) care was needed to maintain the plants so they were not damaged after planting; (2) maintenance activities include: cleaning plants from grass, weeding plants, making firebreaks during the dry season, reporting treatment results to LMDH once every 1 month, and then evaluating them; (3) the duration of plant maintenance was carried out once a week, for 3 years after planting; (4) the plant maintenance process was also carried out monitoring activities, which include direct growth checking, which is done every 3 months; (5) caring for plants includes prevention of plant diseases, fertilizing and administering drugs, weeding from weeds, providing water during the dry season and protecting plants from natural and human damage.

The perception of 210 respondents towards the care profile of Arjuna mount forest plants towards the preservation of the spring water source of Lajer, Dawuan, Sumberkuning and Watupereng, in Figure 1. shows that 17.6% of respondents stated strongly agree, 39% of respondents agreed, 24.3% respondents expressed doubt, 12.9% of respondents expressed disagreement and 6.2% of respondents stated strongly disagree. Based on these data, revealing the maintenance of Arjuna mount forest vegetation affects the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 56.5% of respondents said they agree and strongly agree. Figure 1. explains the respondent's response to the maintenance of Arjuna mount forest revegetation plants.

3.6 Structural model the effect of forest revegetation to preventive springs degradation

Structural model testing was used to test the research hypothesis. Stages in structural model testing include structural model formation stage, structural model feasibility test and test the significance of the influence of endogenous variables on endogenous variables.

3.6.1 Structural model specifications

By referring to the hypotheses and framework of the model constructed in this study, the specification of the structural model of SEM (structural equation modeling) analysis built in this study was figure 2.

3.6.2 Structural model suitability test

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 August 2019 doi:10.20944/preprints201908.0277.v1

The suitability test of the structural model in SEM (structural equation modeling) analysis was done by looking at some criteria of goodness of fit model such as chi square value, probability, df (degrees of freedom), GFI (goodness of fit indices), AGFI (adjust goodness of fit), TLI (trucker lewis index), CFI (comparative fit index), RMSEA (root mean square error of approximation) and SRMR (standardized root mean squared). In this test, the structural model was stated to have fulfilled the goodness of fit model criteria if the model meets one of the assumptions contained in the table above. Solimun (2002) states that if there were one or two goodness of fit criteria that have been fulfilled, then it can be said that the model built was good. Based on the estimation results of the structural measurement shows that the structural model has not been so good in meeting the criteria of goodness of fit model, the probability of the model was still below 0.05, which means that with the model, 210 samples have not had the same covariance matrix with the actual population covariance matrix, so it was necessary to modify the model. Modification indices to increase the goodness of fit model, then add paths between error e1 and e2, e4 and e5, e7 and e9, e9 and e10, e17 and e20, and in the path between e14 and e15. The results of the goodness of fit model test after the three lines were added presented in figure 2. shows that after the modification of the model, the model has a probability above 0.05, thus, the model has been used to test the hypothesis in this study.

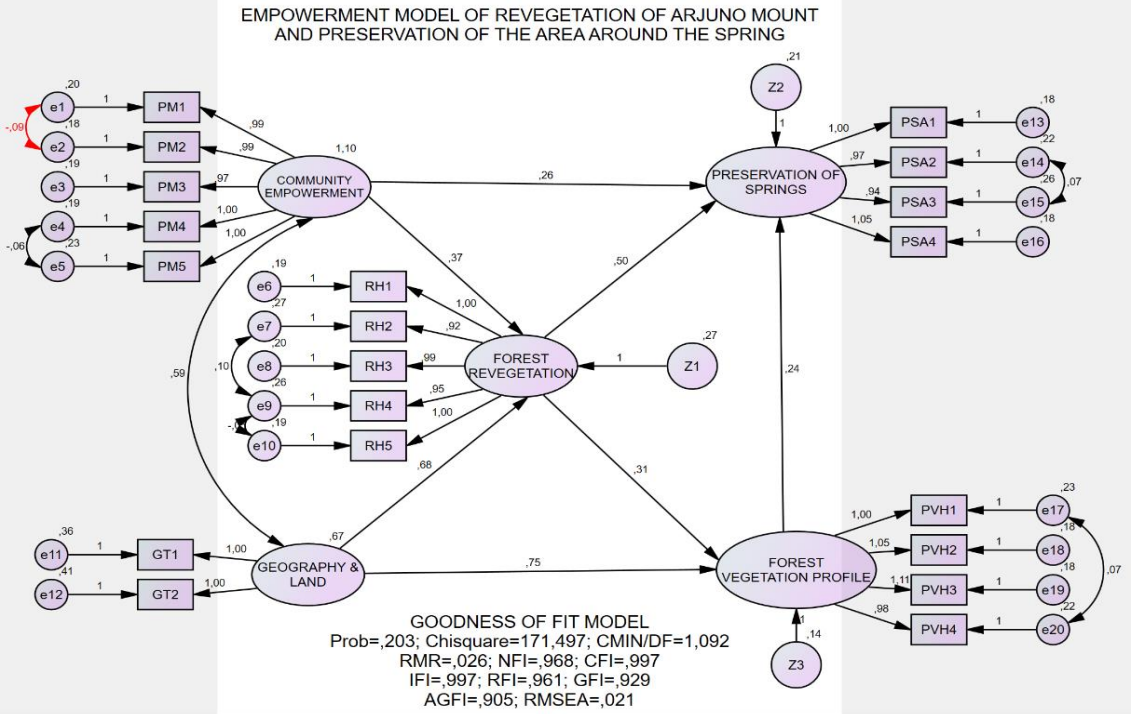

Figure 2. Results of estimation of structural model modifications

3.6.3 Significance test

The significance test aims to examine whether there was a significant influence of exogenous variables on endogenous variables. The hypothesis built in this test was as:

H0: There was no significant effect of exogenous variables on endogenous variables

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 August 2019 doi:10.20944/preprints201908.0277.v1

H1: There was a significant effect of exogenous variables on endogenous variables, with a significant level of 0.05, H0 will be rejected if significant values P (probability) < 0.05 and CR (critical ratio) > 1.96, while if the significant value P (probability) > 0.05 and CR (critical ratio) < 1.96 then H0 was not rejected.

Table 1. *Test results of signifikansi regression weights*

			Estimate	S.E.	C.R.	P	Label
forest revegetation	<---	community empowerment	0.374	0.075	5.005	***	par_15
forest revegetation	<---	geography and land	0.679	0.108	6.273	***	par_16
forest vegetation profile	<---	forest revegetation	0.312	0.101	3.084	0.002	par_18
forest vegetation profile	<---	geography and land	0.750	0.141	5.299	***	par_20
preservation of spring water	<---	forest revegetation	0.503	0.087	5.760	***	par_17
preservation of spring water	<---	community empowerment	0.256	0.059	4.344	***	par_19
preservation of spring water	<---	forest vegetation profile	0.241	0.083	2.914	0.004	par_21

Based on the results of the regression weights SEM analysis (structural equation model), in Figure 2., it shows that the forest revegetation variable has a significant effect on the preservation of spring water sources on Arjuna mount. The better the revegetation of the forest, the preservation of the spring will take place well. The estimated regression weights SEM (structural equation model), in Figure 2., for each forest revegetation indicator shows plant species 1.00, nursery 0.92, fertilization 0.99, planting 0.95 and plant care 1.00. This condition shows that according to respondents forest revegetation had a significant influence on the preservation of the Arjuna mount springs

3.7 Results of springs preservation

The spring protection method that can be applied one of them was by revegetation technique. One of the protection of springs with revegetation techniques was by planting various types of trees. Protection of springs by revegetation could be done in 2 ways, namely (1) planting around the point of spring (radius 10-15) as spring protection; and (2) planting in the recharge area as spring shed protection. The purpose of planting around the spring was more to protect spring points from all pollutants and damage due to human activities. Whereas planting in the groundwater recharge area was expected to help absorb rainwater into the soil which in the long run can fill aquifers, and not become surface runoff. It was expected that the tree planting will protect springs from pollutants, bacteria and harmful chemicals. Thus the sustainability of the spring will be maintained, so that the quality, quantity and continuity of the water flow were met. The results of measurements of water debit from each springs as an indicator that of the springs were still sustainable because the condition of the vegetation of the plant was still able to absorb rainwater presented in table 2.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 August 2019 doi:10.20944/preprints201908.0277.v1

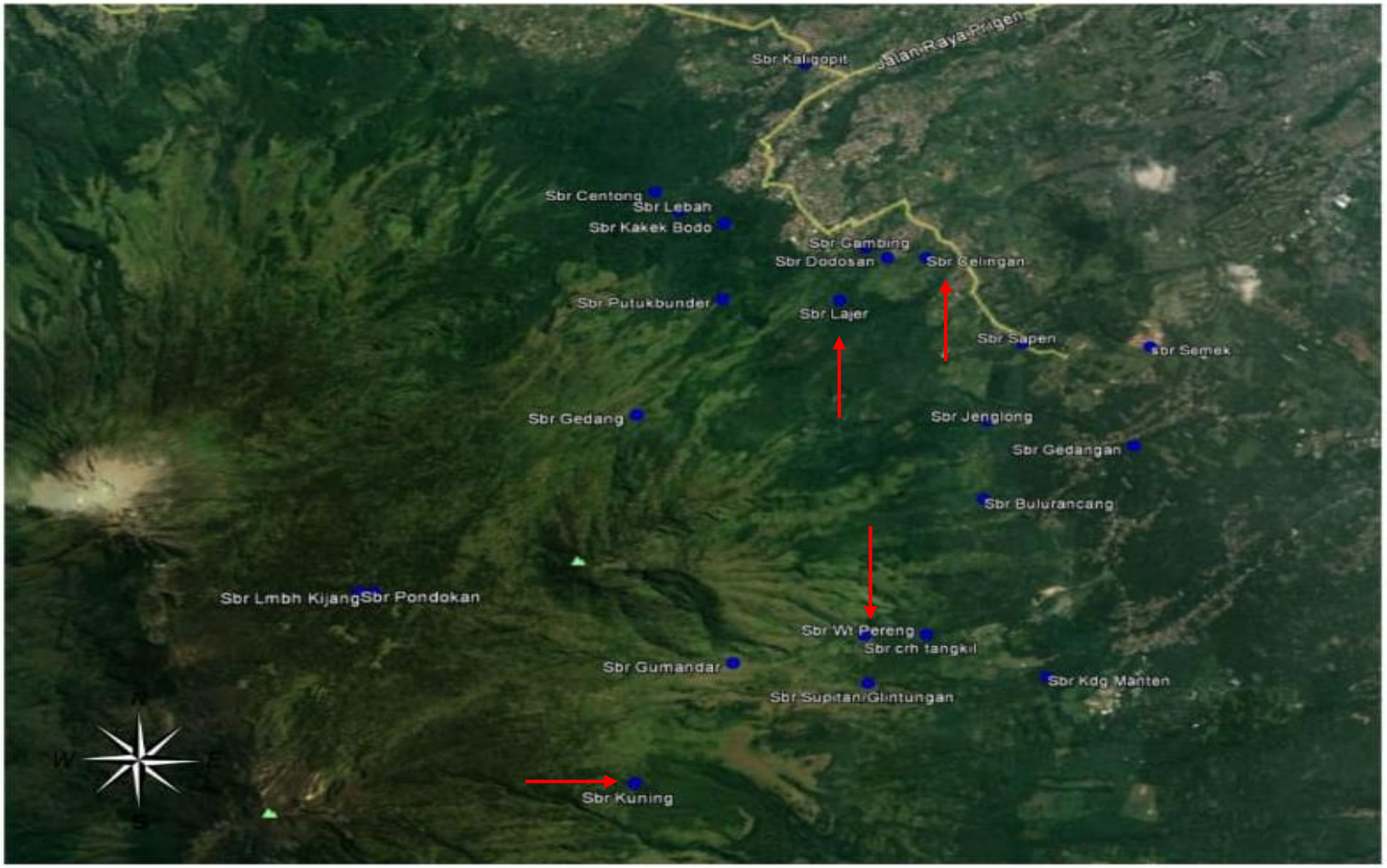

Figure 3. Map of the location of springs in the forest area of Arjuna Mount

Note → : Springs location in Lajer, Dawuan, Celingan, Sumberkuning and Watupereng

 doi:10.20944/preprints201908.0277.v1

Table 2. *Condition of springs in conservation and forestry areas of Arjuna mount, Pasuruan East Java*

NO	Springs name	Location	Village	Elevation (meters above sea level)	Coordinate	Water discharge (liter/second)
1	Lembah Kijang	Pecalukan	Pecalukan	2484	07˚44' 36,8" LS 112˚35'46" BT	2,08
2	Gumandar	Gumandar	Dayurejo	2100	07˚42' 30,3" LS 112˚36' 35,8" BT	21,05
3	Sumber Kuning	Sumber kuning	Jatiarjo	1960	07˚45' 54" LS 112˚ 37'07,6" BT	10,25
4	Putu Bunder	Putuk bunder	Dayurejo	1119	07˚42' 36,7" LS 112˚37' 30,6" BT	14,16
5	Sumber Gedang	Pecalukan	Pecalukan	1900	112˚37' 04,1" BT 07˚43'26,1" LS	4,70
6	Pondokan	Pecalukan	Pecalukan	1700	112˚35" 41,8' BT 07˚44' 36,8" LS	2,08
7	Bulurancang	plot 42C	Dayurejo	832	07˚44'00,1″ LS 112˚ 39'03,1” BT	1,37
8	Jenglong	plot 43	Dayurejo	792	07°43'26.56"LS 112° 39'4.19" BT	3,27
9	Supitan	plot 31	Jatiarjo	1172	07˚45'17,7″ LS 112˚ 38'23,8″ BT	1,50
10	Kedungmanten	plot 35	Jatiarjo	837	07˚45'16,0″ LS 112˚ 39'26,9″ BT	no water
11	Curah Tangkil	plot 36	Dayurejo	1026	07˚44'57,6″ LS 112˚ 38'43,7″ BT	dry
12	Watu Pereng	plot 35	Dayurejo	1159	07˚44'57,6″ LS 112˚ 38'22,1″ BT	0,80
13	Gumer/Semek	Taman Dayu area	Dayurejo	550	07°42'52.95" LS 112°40'2.70" BT	0,19
14	Sapen	plot 43a	Ledug	648	7°42'52.68" LS 112° 39'16.17" BT	0,49
15	Lajer	plot 51g	Ledug	925	07˚42'35,7″ LS112˚ 38'11,0″ BT	10,35
16	Sumber Gambing	Plot 50a	Ledug	652	07˚42'12,7″ LS 112˚ 38'19,7″ BT	28,86
17	Centong	plot 54b	Pecalukan	948	07°41'50.83"LS 112° 37'5.57"BT	no water
18	Kakek Bodo	plot 53e	Tretes	1100	7°42'3.64" LS112° 37'29.83" BT	1,89
19	Sumber Lebah	plot 53a	Pecalukan	946	07˚41'59,0″ LS 112˚ 37'14,0″ BT	0,54
20	Sumber Kali Gopit	plot 3f	Lumbang	572	07˚40'51,7″ LS112˚ 37'56,7″ BT	36,58
21	Celingan	plot 43d	Ledug	596	07˚42'16,1″ LS 112˚ 38'41,3″ BT	4,03
22	Dodosan	plot 42	Ledug	639	07˚42'16,7″ LS 112˚ 38'27,5″ BT	3,67
23	Dawuhan	plot 51	Ledug	652	07˚42'11,3″ LS 112˚ 38'20,3″ BT	25,47
24	Sumber Gedangan	Tegal Gamoh	Dayurejo	600	7°43'36.47" LS 112° 39'57.15" BT	dry

Source: [13]

 doi:10.20944/preprints201908.0277.v1

4. Discussion

4.1 Plant species

Constraints of plant species conditions for revegetation of Arjuna mount forest were endemic plant species and spring water vegetation. [6], explained that the main indicator of forest revegetation through the restoration of degraded ecosystems was plant species. Selection of tree species to be planted was determined by three factors, namely: (1) the importance of natural species for revegetation, (2) the availability of seedlings and propagation, and (3) the location of revegetation to be carried out (Basyuni, 2002).

Some of the successes that have been carried out in relation to Arjuna mount forest revegetation plant species preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs were the first stage revegetation activities at the Lajer spring with an area of 10 hectares, the number of plants 3000 trees, with a breakdown of plant species: 1000 bamboo (*Dendrocalamus asper*), 600 candlenut (*Aleurites moluccana*), 400 kluwek (*Pangium edule*), 300 kluweh (*Artocarpus communis*), 100 banyan (*Ficus benyamina*), 500 durian (*Durio* sp) and 100 elo (*Ficus glomerata*).

The second stage of revegetation of Arjuna mount forest in the area around the Dawuan spring was 15 hectares, the number of plants was 1500 trees, with details of plant species including petung bamboo (*Dendroca-lamus asper*) 300 trees, candlenut (*Aleurities mollucana*) 500 trees, banyan (*Ficus benyamina*) 50 trees, bendo (*Artocarpus elasticus*) 450 and ivory 200 trees.

The third stage of revegetation of Arjuna mount forest in the area around the Sumberkuning springs, the area of revegetation area of 25 hectares, the number of plants of 5000 trees, with the details of the types of plants including mountain spruce (*Casuarina junghuniana*) 2000 trees, 300 trees kesek 300 trees, petung bamboo (*Dendrocalamus asper*) 500 trees, tutup (*Mallocus moluccana*) 200 trees, mlandingan (*Leucaena glauca*) 500 trees, kaliandra (*Calliandra calothyrsus*) 1000 trees and gmelina (*Gmelina arbora*) 500 trees.

Revegetation of the fourth stage of Arjuna mount forest in the area around the Watupereng springs, the area of revegetation area of 46 hectares, the number of plants 8000 trees, with details of the types of plants including bamboo petung (*Dendrocalamus asper*) 1300 trees, banyan (*Ficus* sp) 500 trees, kluweh (*Artocarpus communis*) 180 trees, candlenut (*Aleurities mollucana*) 450 trees, matoa (*Pometia pinnata*) 820 trees, cloves (*Syzygium aromaticum*) 850 trees, soursop (*Annona muricata*) 800 trees, avocado (*Persea americana*) 1000 trees, durian (*Durio* sp)) 1200 trees and coffee (*Coffea* sp) 900 trees.

Based on the results of surveys and socialization in group discussions, the targets to be carried out related to the revegetation plant species of Arjuna mount forest preservation in 3 springs are springs that were Curahtangkil Dayurejo village), Puthukbunder Jatiarjo village) and Talangwatu Leduk village, with a total revegetation area of 90 hectares, the number of plants 18000 trees, with details of the types of plants include:

1) Endemic plant species, namely: bendo (*Artocarpus elasticus*) 1000 trees, kluwek (*Pangium edule*) 1000 trees, breadfruit (*Artocarpus altilis*) 1000 trees, candlenut (*Aleurites mollucanus*) 1000 trees, gondang (*Ficus variegate*) 1000 trees
2) Species of spring water plants, namely: petung bamboo (*Dendrocalamus sp*) 2000 trees, aren (*Arenga pinnata*) 1000 trees, banyan (*Ficus benyamina*) 2000 trees, epek (*Ficus elastica*) 1000 trees
3) Fruit plant species, namely: avocado (*Persea americana*) 1500 trees, oranges (*Citrus* sp) 1000 trees, coffee (*Coffea* sp) 1000 trees, soursop (*Annona muricata*) 1500 trees, durian (*Durio* sp) 1000 trees and guava (Psidium guajava) 1000 trees

4.2 Plant Nursery

The obstacle of plant nursery conditions for revegetation of Arjuna mount forest was that the quality of seedlings was not the same, so plants die in the first month of planting, plant seeds were unable to adapt to the environmental conditions in which they grow. In the first phase revegetation at the Lajer spring with an

 doi:10.20944/preprints201908.0277.v1

area of 10 hectares, the number of plants was 3000 trees, for 3 years the number of dead trees was 801 trees. In the second phase revegetation in the area around the Dawuan spring area of 15 hectares, the number of plants was 1500 trees, the number of trees that died over 3 years was 325 trees. In the third stage revegetation in the area around the Sumberkuning spring, the area of the revegetation area was 25 hectares, the number of plants was 5,000 trees, the number of trees that have died for 3 years was 697. In the fourth stage revegetation of Arjuna mount forest in the area around the Watupereng spring, revegetation area of 46 hectares, the number of plants 8000 trees, the number of trees that die during 1 year was 42 trees.

Provision of quality plant seedlings could be done through seedbed, nursery first in the nursery before planting in the field intended to get good seedlings in terms of quantity and quality and could be planted at the right time too (Onrizal, 2005). High-quality plant seeds could only be obtained from seed sources that were built from the best selected individuals. It was expected that with the use of quality seeds, crop productivity will increase. The seed source of forest plants was an influential factor in improving the appearance of forest stands (Danu, 2004).

Some of the successes that have been carried out related to plant nurseries for revegetation of Arjuna mount forest were the availability of plant seeds for revegetation in the area around the Lajer, Dawuan, Sumberkuning and Watupereng springs with an area of 90 hectares, and the number of plants of 17500 trees. The height of the initial tree seedlings planted was at least 2 meters. The price of seeds per tree with a height of 2 meters was IDR 18,000. Plant seeds that die due to disease pests or damaged by porcupine pests, then immediately replaced with other plants that were able to live with the environmental conditions in which they grow. Good quality disease-resistant seeds were affected by a variety of factors including: tree age, tree size, crowns, genetic factors, climate, soil fertility, stand density, pests and diseases, fruit maturity and handling processes ranging from downloading in the field to storage and distribution (Nath, 2013).

Based on the results of the survey and socialization in the group discussion, the targets to be carried out in relation to the nursery of Arjuna mount forest revegetation were (1) providing quality seedlings from 18,000 trees; (2) tree seedlings consist of endemic plants, springs and fruit plants; (3) height of tree seedlings planted at least 2 meters.

4.3 Fertilizing

The obstacle of fertilizing plants for revegetation of Arjuna mount forest was the type of fertilizer that was given to plants that was not in accordance with the changing soil nutrient content, this was due to the loss of nutrients from forest damage or erosion. Fertilization was done if there was a lack of nutrients or growth was slow (Budiawan *et al*., 2012).

Fertilizers given to plants were organic fertilizer and inorganic fertilizer. Provision of organic fertilizer can improve soil structure, increase soil absorption of water, improve living conditions of soil microbes and as a food source for plants. Application of inorganic fertilizers could stimulate overall plant growth and important assistance in the formation of green leaves (Dewanto *et al.,* 2013).

Some of the successes that had been carried out related to plant fertilization for revegetation of Arjuna mount forest are providing NPK organic fertilizer and inorganic manure for 17500 trees 3 times in 1 year for 3 years of care by smallholder farmers. According to (Nath, T.N. 2013), fertilization was a very important way to improve crop productivity and soil quality. The use of organic fertilizers and inorganic fertilizers was the right way, not only to produce crop productivity but can maintain intensive plant production stability.

Based on the results of surveys and socialization in group discussions, the target to be carried out by plant fertilization in the advanced forest revegetation program was to provide NPK organic fertilizer and inorganic manure for 18000 trees 3 times in 1 year for 3 years of care by the cultivating farmers.

 doi:10.20944/preprints201908.0277.v1

4.4 Planting

The obstacle of planting trees for revegetation of Arjuna mount forest was the size and the distance between plants was a factor that must be considered for plant growth, because the success of forest revegetation technically according to [8] was the regulation of light (light control) and selection of plant species. The width and distance between revegetation plants of Arjuna mount forest towards the preservation of Lajer, Dawuan, Sumberkuning and Watupereng springs were 10 meters x 10 meters (200 trees/ha).

According to the Minister of Forestry Regulation Number P. 70/Forester Minister-II/2008 about Technical Guidelines for Forest and Land Rehabilitation, explained in Chapter IV. point 2. In general the number and distance of planting that was often used for revegetation was divided into several groups, namely: (1) spacing of 5 meters x 5 meters (400 trees/ha); (2) spacing of 5 meters x 2.5 meters (800 trees/ ha); (3) spacing of 3 meters x 3 meters (1,110 trees/ha); (4) spacing of 3 meters x 2 meters (1,666 trees/ha); plant spacing of 3 meters x 1 meter (3,333 trees/ha).

Some of the successes that had been carried out related to planting for revegetation of Arjuna's mount forests were the implementation of revegetation around the area of the Lajer, Dawuan, Sumberkuning and Watupereng springs, a total area of 93 hectares and a total of 19,500 trees. This revegetation program was carried out by PT. Sorini Agro Asia Corporindo (Cargill) in collaboration with the Kaliandra Foundation, Cempaka and the people of the villages of Leduk, Jatiarjo and Dayurejo.

Table 1. Arjuna mount forest revegetation to the springs preservation period 2014-2018

No	Springs location	Number of trees	Area (hectares)	the percentage of trees living
1	Lajer – Arjuna mount	3000	10	94%
2	Dawuan – Arjuna mount	1500	5	92%
3	Sumber Kuning – Arjuna mount	5000	25	86%
4	Watu Pereng – Arjuna mount	6000	34	99%
5	Watu Pereng – Arjuna mount	4000	19	99%
		19500	93	

Source: PT. Sorini Agro Asia Corporindo (2017)

4.4.1 Revegetation of forests I in 2014 Lajer springs area

The first year of forest revegetation program began planting on February 27, 2014, with the purpose of improving the vegetation of around area of Lajer springs, by planting and maintaining plants for 3 years to keep the volume of water flowing and increasing, and preventing landslides and floods. Guidelines for revegetation of the Lajer spring water source area were PP No. 43 of 2008, that revegetation was carried out thoroughly in groundwater basins which include recharge areas and groundwater discharge areas, through (1) protection and preservation of groundwater; (2) preservation of ground water; and (3) quality management and control of groundwater pollution. The decrease in spring discharge was caused by a reduction in protected areas or water catchment areas due to illegal deforestation and land conversion that results in critical land occurrence and a decline in the quality of water catchment areas (Tjakrawarsa and Handoko, 2013). The result of revegetation phase I was to increase the vegetation cover of 10 hectares of land in the area around Lajer springs, with a total of 3000 trees. 3000 species of plants include: 1000 Bamboo (*Dendrocalamus asper*), 600 Pecan (*Aleurites moluccana*), 400 Kluwek (*Pangium edule*), 300 Kluweh (*Artocarpus communis*), 100 Banyan (*Ficus benyamina*), 500 Durian (*Durio zibethinus*) and 100 Elo (*Ficus glomerata*). Intensive plant maintenance was carried out for 3 years, with 5 nurse farmers from the community around the forest.

 doi:10.20944/preprints201908.0277.v1

Based on verification results in each year shows that in the first year period of 2014 the percentage of living trees was 98%, in the second year of 2015 the percentage of living trees was 96% and in the third year 2016 the percentage of trees the life was 94%. Some factors that influence the percentage of the number of trees that live relatively stable are nurse farmers who directly replace dead plants with other plants, even though the plant species are different, so the number of trees was relatively close to a percentage. While other technical factors that affect the percentage of living trees are relatively stable, among others: (1) treatment of grass cleansing on plants, (2) weeding plants, (3) giving water to plants in the dry season, (3) making bulkhead burn, during the dry season, (4) routine evaluation of plant maintenance from farmers to NGOs, forest village community institutions, companies and the government every month, (5) corporate social responsibility programs for economic empowerment for nurse farmers. The results of verification for 3 years showed that the highest number of plant deaths occurred in durian plants reaching 98.8% (the initial number of plants 500 trees, which lived were 6 trees), the cause of death of durian trees (*Durio zibethius*) was eating animal Porcupines especially new stems who sprouted, so that the corrective action was to replace the types of plants that are resistant to porcupine pests such as Jackfruit, Mahogany, Sengon Buto, Srampang Balong and Segawe plants. The dry season factor during August-November 2014, with temperatures above normal temperature (temperature 37-39^{O}C), has the potential to cause forest fires.

4.4.2 Forest revegetation II year 2015 Dawuan springs source area

Based on the results of verification on February 23, 2015 shows that the area of forest rehabilitation in the second period in the area around the Dawuan spring was 15 hectares, with the number of plants was 1500 trees, data on types of plants include petung bamboo Petung (*Dendroca-lamus asper*) 300 trees, candlenut (*Aleurities mollucana*) 500 trees, banyan (*Ficus benyamina*) 50 trees, bendo (*Artocarpus elasticus*) 450 trees and Ivory tree 200 trees. The number of nurse farmers who directly carry out and care for plants was 3 people, each of whom receives 6 goats breeding assistance. Plant maintenance was scheduled every 1 week with the main goal of caring for and maintaining plant growth. 3 months after the initial planting, in April 2015 the nurse farmers carried out fertilization and planting dead plants.

Based on the results of verification at the planting location around the Dawuan spring, it showed that up to May 30, 2015 the number of dead plants was 103 plants, and the nurse farmers immediately replaced with 140 new plants for planting. The total number of plants from verification in December 2016 was 1537 trees. Some types of plant replacement for revegetation include: Spathodea (*Spathodea campanulata*) 20 trees, mahogany (*Sweetenia mahagoni*) 8 trees, Srikaya (*Annona squamosa*) and jackfruit (*Artocarpus heterophyllus*) 5 trees. [5], states that plant growth was influenced by soil factors, climate, microorganisms, competition by other organisms, and is also influenced by available organic substances, humidity and sunlight. Based on the results of the implementation of this second rehabilitation program, researchers measured and verified that Petung bamboo plants were very strong and resistant to be planted in critical areas and with little water, and able to hold water when the rainy season occurs.

Based on the results of observations and measurements show that the number of plant deaths in the second stage rehabilitation program in the Dawuan springs, verification during the first year of 2015 the number of living trees was 1442 trees (96%), in the second year 2016 the number of living trees was 1404 trees (94%), and in the third year verification in April 2017 the number of trees that lived to be 1380 trees or 92% of the initial number of trees planted as many as 1500 trees.

4.4.3 Forest revegetation III year 2016 Sumber Kuning springs area

The third stage of the forest revegetation program was held on March 29, 2016 with a location in the Sumber Kuning springs area. The revegetation area was 25 hectares with a total of 5000 trees, with plants including mountain cypress (*Casuarina junghuniana*) 2000 trees, Kesek 300 trees, Petung Bamboo (*Dendrocalamus asper*) 500 trees, tutup tree (*Mallocus moluccana*) 200 trees, Mlandingan (*Leucaena*

 doi:10.20944/preprints201908.0277.v1

glauca) 500 trees, Calliandra (*Calliandra calothyrsus*) 1000 trees and Gmelina (*Gmelina arbora*) 500 trees. Sumber Kuning spring was included in the area of Jatiarjo Village, Prigen Subdistrict, Pasuruan Regency, with different conditions compared to phase 1 and 2 revegetation activities (Lajer and Dawuan springs). The Sumber Kuning spring was located at an altitude of 2,427 meters above sea level, and the forest area was under the management of the East Java Province Forestry Service. Community forest park of Raden Soerjo. The area was included in the conservation forest status, where there was a community allowed to do forest conservation but cannot take anything inside the forest area. The selection of forest rehabilitation sites in the Sumber Kuning area was to protect upstream springs, which have been damaged by forest fires in November 2015, so that these forests need to be treated and protected from forest fires. If the water discharge in the area of the spring was reduced, then it has an impact on a number of springs under it.

Based on the results of verification on March 29, 2016, the third period of forest revegetation area in Sumber Kuning springs area were 25 hectares, with a total of 5000 trees. The results of planting verification for 2 years showed that in the first year the number of living plants was 4485 trees (90%) and 515 trees died. In the second year of verification in April 2017, the number of living plants was 4303 trees (86%) and the number of plants that died from 2017 to April 2017 was 697. The number of nurse farmers who were directly involved in the management of Sumber Kuning springs forest rehabilitation in the program community empowerment was 5 people.

4.4.4 Forest revegetation IV year 2017 Watu Pereng springs area

The fourth stage of the forest rehabilitation program was carried out in the springs area of Watupereng, the Gumandar Sub-watershed (watershed) in Jatiarjo Village, Prigen District, Pasuruan Regency on February 21, 2017, with the theme "Caring for the Forest". The area of the forest rehabilitation area was 46 hectares, with the number of trees as many as 8,000 trees, this rehabilitation area was included in the protected forest of the Indonesian state forest company of west Lawang in plot 35. The types of trees planted include petung (*Dendrocalamus asper*), banyan (*Ficus sp*), kluweh (*Artocarpus communis*), pecan (*Ale mollucana*), matoa (*Pometia pinnata*), clove (*Syzygium aromaticum*), soursop (*Annona muricata*), avocado (*Persea americana*), durian (*Durio Zibethinus*) and coffee (*Coffea canephora Pierre*). By implementing this revegation program, Sorini Cargill has been conserving 4 springs (Lajer, Dawuan, Sumberkuning and Watupereng), with a total area of 83 hectares, and 17,500 trees planted and involving 28 forest nurse farmers in the form of a program to empower communities around the forest Through this sustainable forest rehabilitation program, the company was committed to carrying out the obligation to improve the rainwater catchment area that was upstream for water needs for all communities in Pasuruan Regency. The results of tree planting verification show that up to April 2017 the number of living trees was 7958 trees (99%).

Based on survey results and socialization in group discussions, the target to be carried out with planting for the forest revegetation program was to carry out a revegetation program for the second period of 2019-2020 in the area around of springs the Dayurejo Sumbertangkil, Jatiarjo Puthukbunder and Leduk Talangwatu. The extent of revegetation was 90 hectares, the number of plants was 18000 trees. This revegetation program was carried out by PT. Sorini Agro Asia Corporindo, in collaboration with the Cempaka foundation, Indonesia state forest company, the Pasuruan Regency Environmental Service and the villagers of Dayurejo, Jatiarjo and Leduk.

Some tree species planted include: (1) endemic plant species, namely: bendo (*Artocarpus elasticus*) 1000 trees, kluwek (*Pangium edule*) 1000 trees, breadfruit (*Artocarpus altilis*) 1000 trees, candlenut (*Aleurites mollucanus*) 1000 trees, gondang (*Ficus variegate*) 1000 trees; (2) springs plant species, namely: petung bamboo (*Dendrocalamus* sp) 2000 trees, sugar palm (*Arenga pinnata*) 1000 trees, banyan (*Ficus benyamina*) 2000 trees, epek (*Ficus elastica*) 1000 trees; (3) fruit plant species, namely: avocado (*Persea americana*) 1500 trees, orange (*Citrus* sp) 1000 trees, coffee (*Coffea* sp) 1000 trees, soursop (*Annona muricata*) 1500 trees, durian (*Durio* sp) 1000 trees and guava (*Psidium guajava*) 1000 trees.

The purpose of this revegetation program was to improve the condition of forest cover in the area around 3 springs, covering 90 hectares on the slopes of Arjuna and Welirang mount through the concept of enrichment of productive plants that can be utilized by the community to improve the welfare of forest farmers. The location of the planting was in the area around the Dayurejo Sumbertangkil springs, Jatiarjo Puthukbunder and Leduk Talangwatu, all three villages are included in the Kedunglarangan Sub-watershed, which was part of the catchment area as an underground water source of PT. Sorini Agro Asia Corporindo.

4.5 Plant care

The obstacle of tree care for revegetation of Arjuna's mount forest was the growth of weeds or weeds around the plants, replacing and replacing dead plants, due to pests and plant diseases and damaged by animals. According to (Nurhasybi and Sudradjat, 2002), care plays an important role in achieving successful planting. Maintenance activities include weeding from weeds, pests or the like that were wrapped around the plant, and from pioneers that rival the plants, and replanting if any plants die. In the treatment of plants, monitoring activities could also be carried out which includes verification of growth (plant survival), growth performance (growth performance), increment (growth increments) including height, diameter, volume and attack of pests and diseases.

Some of the successes of plant maintenance that had been carried out for revegetation of Arjuna mount forest were funding of plant care for 5 nurse farmers for 3 years on 10 hectares of land vegetation in the area around the Lajer spring, the number of plants 3000 trees, with plant species including 1000 bamboo (*Dendrocalamus asper*), 600 candlenut (*Aleurites moluccana*), 400 kluwek (*Pangium edule*), 300 kluweh (*Artocarpus communis*), 100 banyan (*Ficus benyamina*), 500 durian (*Durio* sp) and 100 elo (*Ficus glomerata*).

Plant care financing for 3 nurse farmers for 3 years in a 5 hectare vegetation area around the Dawuan springs, the number of plants was 1500 trees, plant species data including petung bamboo (*Dendroca-lamus asper*) 300 trees, candlenut (*Aleurities mollucana*) 500 trees, banyan (*Ficus benyamina*) 50 trees, bendo (*Artocarpus elasticus*) 450 and ivory 200 trees.

Funding for plant maintenance in the Sumberkuning springs area. Revegetation area was 25 hectares with a total of 5000 trees, with types of plants including mountain spruce (*Casuarina junghuniana*) 2000 trees, 300 trees squared, petung bamboo (*Dendrocalamus asper*) 500 trees, cover (*Mallocus moluccana*) 200 trees, mlandingan (*Leucaena glauca*) 500 trees, kaliandra (*Calliandra calothyrsus*) 1000 trees and gmelina (*Gmelina arbora*) 500 trees.

Plant care funding for 28 nurse farmers for 3 years in a 46 hectare vegetation area around the Watupereng springs, a total of 8000 trees, with types of plants including bamboo petung (*Dendrocalamus asper*) 1300 trees, banyan (*Ficus* sp) 500 trees, kluweh (*Artocarpus communis*) 180 trees, candlenut (*Aleurities mollucana*) 450 trees, matoa (*Pometia pinnata*) 820 trees, tutup plant (*Syzygium aromaticum*) 850 trees, soursop (*Annona muricata*) 800 trees, avocado (*Persea americana*) 1000 trees, durian (*Durio* sp) 1200 trees and coffee (*Coffea* sp) 900 trees.

Based on survey results and socialization in group discussion, the target to be carried out with plant care in the revegetation of Arjuna mount forest in the second period of 2019-2020 was plant care financing for 32 nurse farmers for 3 years on vegetation in an area of 90 hectares in the area around the source of the Dayurejo Curahtangkil springs, Jatiarjo Puthukbunder springs and Ledug Talangwatu springs, the number of plants was 18000 trees. Cempaka foundation and nurse farmers are responsible for maintaining crop growth rates up to 3 years by 90% of the trees planted are still alive and growing.

4.6 *Structural model testing*

The relationship of the effect of forest revegetation variables on the preservation of springs was very significant (Table 1.), with C.R. positive at 5.760. Therefore the value of p value obtained > 0.05 and C.R.

 doi:10.20944/preprints201908.0277.v1

positive sign and > 1.96, it could be concluded that revegetation of the forest has a positive and significant effect on the preservation of springs. The better the revegetation of the forest, the better the preservation of springs, and vice versa. Vegetation cover plays an important role in regulating the hydrological system, especially the effect of sponges that can trap rainwater and drainage so as to reduce the tendency of flooding and maintain the flow of water in the dry season. This function will be lost if vegetation in the higher watersheds was lost or damaged. Across the tropics, 90% of farmers in the lowlands depend on the activities of 10% of the people living in the headwaters (MacKinnon *et al.*, 1992). In the effort to conserve springs, one method that can be used was the vegetation method, through programmatic rehabilitation in watersheds, to support the hydrological balance in the area of springs (Davis and De Wiest, 1966). Riastika (2012) explained that one of the efforts to protect and preserve recharge areas includes: (1) carrying out conservation activities in an agronomic manner, (2) carrying out conservation activities mechanically and (3) regulating the water source border area.

5. Conclusion

Arjuna mount forest revegetation to the springs preservation in around area of Lajer, Dawuan, Sumberkuning and Watupereng springs, Pasuruan of East Java, Indonesia with the following results:

- The revegetation plant species of Arjuna mount forest influence the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 59.1% of respondents stated strongly agree and agree
- The nursery of Arjuna mount forest revegetation affects the preservation of the Lajer spring, Dawuan, Sumberkuning and Watupereng springs, because almost 56.2% of respondents stated strongly agree and agree
- The fertilization of Arjuna mount forest vegetation affects the preservation of the Lajer spring, Dawuan, Sumberkuning and Watupereng springs, because almost 58.1% of respondents agreed and strongly agreed
- The planting of Arjuna mount forest trees influence the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 57.6% of respondents agreed and strongly agreed
- The plant care of Arjuna mount forest vegetation influence the preservation of the Lajer, Dawuan, Sumberkuning and Watupereng springs, because almost 56.5% of respondents said they agree and strongly agree

The forest revegetation has a positive and significant effect on the preservation of springs. The better the revegetation of the forest, the better the preservation of springs, and vice versa. Vegetation cover plays an important role in regulating the hydrological system, especially the effect of sponges that can trap rainwater and drainage so as to reduce the tendency of flooding and maintain the flow of water in the dry season. The forest revegetation to the springs preservation in around area Lajer, Dawuan, Sumberkuning and Watupereng with results showing that revegetation forests have a significant effect on the springs preservation

- Forest revegetation in Lajer's springs area, the number of trees 3000, with an area of 10 hectares, the percentage of trees living 94%, and the water debit of the springs were 10.35 liters/second
- Forest revegetation in Dawuan springs are, the number of trees 1500, with an area of 15 hectares, the percentage of trees living 92%, and the water debit of the springs were 25.47 liters/second
- Forest revegetation in Sumber Kuning springs area, the number of trees 5000, with an area of 25 hectares, the percentage of living trees 86%, and the water debit of the springs were 10.25 liters/second
- Forest revegetation in Watu Pereng springs area, the number of trees was 8000, with an area of 46 hectares, the percentage of trees living was 99%, and the water debit of the springs were 0.80 liters/second

References

[1] Basyuni, M. 2002. Guide to restoration of damage mangrove forests. University of North Sumatra digital library

[2] Budiawan, Arifin H. and K. Suprayogi. 2012. Training manual: Nursery techniques and silviculture, plant planting and maintenance, financial management and management. Technical report - volume 3. Ministry of forestry Republic of Indonesia. directorate general of forestry business development and international tropical timber organization (ITTO). Jakarta

[3] Danu. 2004. Potensi Produksi Benih di Jawa. Potential seed production in Java. Proceedings of the integrated expose of research results. Forestry research and development agency. Ministry of forestry. Pages 10-25

[4] Davis S.N and De Wiest RJM. 1966. Hydrogeology. John Willey & Sons. New York

[5] Dewanto, F.G., J.J.M.F. Londok, R.A.F. Tuturoong, and W.B. Kaunang, 2013. Effect of inorganic and organic feed on corn production as feed sources. Zootek Journal. 32 (5): 1-8. ISSN. 0852-2626

[6] Dolezal, J. and M. Srutek. 2002. Altitudinal changes in composition and structure of mountain-temperate vegetation: A case study from western carpathians. *Journal of plant ecology* 158 (16):201-221

[7] Hakim L. and H. Miyakawa, 2013. Plant trees species for restoration program in Ranupani, Bromo Tengger Semeru National Park Indonesia. Biodiversity journal, 2013, 4 (3): p. 387-394. Department of biology, faculty of mathematics and natural sciences, Brawijaya University, Malang 65145, Indonesia

[8] Mac Kinnon, K. 1992. Nature's treasurehouse-the wildlife of Indonesia. Jakarta: PT. Gramedia pustaka utama.

[9] Mori, T., 2001. Rehabilitation of degraded forest in Lowland Kutai, East Kalimantan Indonesia. Center for International forestry research, Bogor Indonesia. Page 17-26

[10] Nath, T.N. 2013. The macronutrients status of long term tea cultivated soils in Dibugrah and Sivasgar districts of Assam, India international journal of scientific research. 2(5):273-275

[11] Nurhasybi and Dede J. Sudradjat. 2002. Relationship between tree age and production potential and seed quality of several forest plant types. Seed techno. Vol. 7 No. 2. 2002. Research and development center for biotechnology and forest plant breeding. seed technology research and development center. Bogor

[12] Onrizal, 2005. Enrichment planting for rehabilitation of former felling forests using line planting techniques. E-USU repository. University of Northern Sumatra

[13] Permadi P., Lelana N.E, Anggraeni I., and W. Darwiati, 2012. Seminar formulation. Inside: national seminar on forest health and forest utilization for forest productivity. June 14, 2012. Bogor. Indonesia. R and D center for increasing forest production. Page 1-2

[14] PT. Sorini Agro Asia Corporindo, 2017. Forest rehabilitation program for Arjuna mount forest. Prigen Pasuruan

[15] Riastika, 2012. Conservation-based groundwater management in the Boyolali Recharge Area (Case Study of the Cepogo Recharge Area, Boyolali, Central Java): Journal of Environmental Science Vol. 9, issue 2: 86-97 (2012). Environmental Study Program Postgraduate Program

[16] Soemarwoto, O. 1991. Indonesia in the arena of global environmental issues. PT. Gramedia pustaka utama. Jakarta

[17] Solimun, 2002. *Structural Equation Modelling* (SEM). Prints I. Publisher of state university of Malang. Malang, Indonesia

[18] Supriyanto, Stolte K.W., Soekotjo and A.N. Ginting, 2001. Forest health monitoring plot establishment. In: Forest health monitoring to monitor the sustainability of Indonesian tropical rain forest. Volume I, Japan (JP): ITTO and Bogor ID: SEAMEO-BIOTROP

[19] Tjakrawarsa G. and C. Handoko, 2013. Study of springs protection techniques on Lombok Island: a case study in KHDTK Rarung (study of technique protection of springs at Lombok Island case study at the

 doi:10.20944/preprints201908.0277.v1

Rarung research forest). *Indonesian center for forestry technology research institute for forest rehabilitation Journal* Vol. 1 No. 1, September 2013: 1-15
[20] USAID. 2008. Nanggroe Aceh Darussalam Environmental services program. Aceh. In. http://www.esp.or.id/wp-content/uploads/pdf/fs/nad-id.pdf. Retrieved 11 August 2009
[21] Wiyono, A. 2008. Preservation of the R. Soerjo grand forest park to maintain water supply and biodiversity. Kaliandra sejati foundation, Gamoh village, Dayurejo village, Prigen, Pasuruan. USAID