Vegetative engineering as landslide reduction and handling alternative

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Abstract. This paper is prepared as the results of review study approach of landslide-affected location a week after the event and analysis of literature study. The landslide event on April 1st, 2017 that caused the death of 26 people in Banaran village on the slopes of Mount Wilis, Ponorogo, East Java, as an example of events occurred due to loss of natural elements in the form of perennials. Vegetative engineering effort is one of alternatives in reducing or preventing landslides, by utilizing hardwoods with strong roots in order to withstand landslide scours. The Center for Volcanology and Geological Disaster Mitigation estimated that landslide on Mount Wilis slopes was initiated by the absence of plant species as water absorber and land cover disappearance that led to increased critical land and environmental degradation. The purpose of vegetative engineering research was to select plants with function to prevent landslides. Type of this research was descriptive qualitative analysis through method of vegetative engineering in selecting right kind of plant species to be cultivated on the land with altitude 0-2000 MASL (Meter Above Sea Level).

1. Introduction
According to the data from the National Board for Disaster Management in [1], during 2016 landslide disasters had occurred 612 times. Landslide is a process of mass transfer of soil or rock with a sloping direction from its original position, so that it is separated from the steady mass, due to the influence of gravity, with the type of rotational and translational movement. Landslide may occur due to unstable slope, so that the materials/rocks above the slope eventually move down, causing an unacceptable water flow. In general, landslides happen after loose soil conditions plus the loss of natural elements in the form of hard plants that have strong roots, where the plant is able to withstand the scouring of rain water.

The landslide disaster is predicted to be prevented by vegetative engineering efforts, in the form of planting trees on the slopes. The plant will absorb water and its roots bind the soil. Vegetative engineering is a method of preventing and mitigating landslide risk through tree planting efforts based on plant typology and hill elevation [2]. The bare land on the slopes should be greened, as a landslide in Banaran village on the slopes of Mount Wilis, Ponorogo, East Java is in a deforested condition. The occurrence of landslides might as well be due to the lack of knowledge of residents about the condition of the land for farming. They generally grow short-lived crops and are rooted in short-rooted fibers, such as ginger and other types of plant fibers that are fast-selling in the market rather than unproductive or slow-growing perennials that provide financial benefits. This situation should have been anticipated, before the landslide disastrous case happened in Banaran Village, Pulung districts,
Ponorogo district, East Java on April 1st, 2017 that left 28 dead victims buried in the 14-meter-thick land and dozens of casualties have not been found, while about 300 people fled to safe area. The occurrence was observed by Center for Volcanology and Geological Disaster Mitigation [2,3], where it was estimated to be the beginning of increasing critical land, the disappearance of land cover, environmental degradation, and decreased water absorption ability [4]. According to Daniel (1987), the other potential trigger was land-processing patterns that ignored environmental conservation [5]. Therefore, vegetative engineering by planting tall trees of certain species on steep and long slopes needs to be done to withstand rainfall, as well as maintaining land conditions while improving land function [6,7]. Planting trees should be taken into consideration in order to infiltrate larger rainwater flowing into the inner layer of soil. Characteristics of plants that are eligible to be planted in the landslide prone lands should take into account, such as the ability to grow on the slope of the earth 0-2000 meters above sea level at its root state, stem density, crown density and certain plant height [2].

In relation to prevent an erosion, the selection of tree crops should pay attention to other specific properties, such as extensive roots, strong and deep, the ability to cover the soil quickly, dense and deep, horizontal propagation [3]. So the selection of large trees must be done and can be expected as an alternative to soil cover and preservative of ground water. So that in the rainy season the rainwater will be accommodated and stored in the soil, then the danger of landslides and erosion is reduced. While in the dry season it is expected the water reserves shall remain available. The scope to be discussed in this discussion is vegetative engineering, particularly how to choose trees that have functions that can reduce and prevent landslides. The root is then referred to as a taillar root (Radix primaria) [6]. Fiber roots are generally found in monocot and dicot plants propagated vegetatively. The formation of fibrous roots is when the root of the institution grows from seed germination dies and is replaced with a root that is more or less the same and out of the base of the stem.

2. Purpose
The objective of this research was vegetative engineering research in selecting examples of plants that has the function of reducing and preventing landslides.

3. Research methods
The research method used was Descriptive Qualitative, with method of vegetative engineering and subject of choice of plant type with cultivation area at slope of land at 0-2000 MASL (Meter Above Sea Level) by using secondary data from national media news, relevant references on landslides, and proper selection of perennial crops, as an effort to reduce and inhibit landslide disaster. Crop characteristics to be taken into account were roots, stem density, certain crown density and height, which as well supplemented by criteria such as: broad, strong and deep rooting; the ability to cover the soil quickly, thickly and deeply; and whether the breed is horizontal.

4. Discussion
One effort in relation to the prevention of landslides is the cultivation elements choice of a type of plant that enters the chronically large tree strata as well as the way of soil conservation [8]. For that purpose, the special nature of trees and the right soil conditions must be thoroughly considered.

For example, the roots should be very broad, strong and deep, with the ability to cover the ground quickly and the progress of hybrid breeding is dense [3]. In addition, if grown in areas that have a lot of rain, the crop should have a water-volatile property and can be utilized in the future [8]. Examples of plant options are as followed: kemiri (Aleurites mollucana) [2], jengkol (Archidendron pauciflorum) [2], mahoni berdaun besar (Swietenia macrphylla) [9], sono keling (Dalaeia soides) [9], asam jawa (Tamarindus indica) [2,9], kayu manis (Cinnamomum zeylancium) [9], bambu tali (Asparagus cochinchnensis) [9,10], durian (Durio zibethinus) [9], pinus (Cupressus lusitanica) [9], damar (Agathis dammara) [9], kluwak (Pangiumedule Reinw) [9]. Moreover, regarding the type with high tree strata, it is also necessary to select plants with bush strata, to cover the soil surface, for examples are babadotan (Ageratum conizoides L) [9,10] and the types of ground cover strata such as
grasses like akarwangi (Chrysopogon zizanioides) [9], rumput gajah (Pennisetum purpureum) [9] and rumput benggala (Megathyrsus maximus) [9,10]. As mentioned by [3] this covering crop besides can be considered as additional conducts in preventing or controlling landslide hazards, it can also function to improve soil structure, increase soil organic matter, prevent nutrient leaching process, reduce soil temperature fluctuations and can obviously add material organic soil.

Table 1. Table of examples of plants that can prevent landslides

| No | Types of Plants | Plant Structure | Tolerant To Grow (MASL) | Height of tree (M) | Ø header of tree (M) | Root Type | Leaf Density | Root Density |
|----|----------------|----------------|-------------------------|-------------------|---------------------|-----------|--------------|--------------|
| 1. | Kemiri (Aleurites Moluccana) | Tree | 500-1200 | 40 | 1.5 | 30 | — | √ | — | √ | — |
| 2. | Jengkol (Archidendron Pusillum) | Tree | 1000 | 26 | 3 | 14 | — | √ | — | √ | — |
| 3. | Mahoni berdaun besar (Swietenia macrophylla) | Tree | <1500 | 25 | 1.2 | 8 | — | √ | — | √ | — |
| 4. | Sono Keling (Dalbergia Soides) | Tree | <600 | 30 | 1.5 | 7 | — | √ | — | √ | — |
| 5. | Asam Jawa (Tamarindus indica) | Tree | <1500 | 30 | 2 | 15 | — | √ | — | √ | — |
| 6. | Kayu Manis (Cinnamomum zeylanicum) | Tree | 500-1500 | 15 | 2 | 15 | — | √ | — | √ | — |
| 7. | Bambu Tali (Asparagus Cochinchinensis) | Tree | 800-1000 | 22 | 0.6 | — | — | √ | — | √ | — |
| 8. | Durian (Durio zibethinus) | Tree | <800 | 35 | 4 | 12 | — | √ | — | √ | — |
| 9. | Panus (Cupressus lasianica) | Tree | 200-2000 | 40 | 2 | 6 | √ | — | — | √ | — |
| 10. | Damar (Agathis dammara) | Tree | 300-1200 | 35 | 1.6 | 15 | — | √ | — | √ | — |
| 11. | Klawanuk (Pangium edule Reinw) | Tree | <1275 | 60 | 1.2 | 18 | — | √ | — | √ | — |
| 12. | Babadotan (Ageratum conyzoides L) | Shrubs | 1-2100 | 0.6 | — | √ | — | — | √ | — |
| 13. | Akar Wangi (Chrysopogon zizanioides) | Shrubs | 500-1500 | 2.5 | — | √ | — | √ | — | — |
| 14. | Rumput Gajah (Pennisetum purpureum) | Ground Cover | 0-3000 | — | √ | — | — | √ | — |
| 15. | Rumput Benggala (Megathyrsus maximus) | Ground Cover | <1950 | — | √ | — | — | √ | — |

Source: reference analysis no. [2,3,4,8,9]

Tree including those that can be older than 20 years old—and sometimes more than 100 years-can be the choice of natural plants to be cultivated in accordance with unstable areas. Slopes of more than 20 degrees should not be used for agricultural land [3], however it should be pursued with permanent natural plants. The selected plant species in addition to covering the soil also shall serve to prevent and improve soil structure, prevent the process of nutrient loss, and adding soil organic matter. The cultivation is expected to reduce the kinetic energy caused by rain water droplets and ground surface flows.
Based on the analysis, plants that can withstand avalanches are indicated possessing strong stems and roots that can bind water. The table above enlisted plants that can withstand landslides, one of which is due to the desired root density, either the fiber root (Radix adventicia) or the tail root (R. primaria).

Tap roots are generally found in dicoty plants that are propagated by seed. Root riding is the root that grows continuously into the root then to branches into smaller roots. Because these roots are not from the original root candidates, they are called wild roots. Furthermore, because of its irregular shape and fibers, it is called fiber roots (R. adventicia). And grass is a fibrous rooted monocoty plant that has narrow-shaped tapered leaves that grow from the base of the stem. With the structure and function of fibrous fiber network that has the function of absorbing water and can hold the soil erosion, it is useful in preventing erosion and landslides.

The plants included in the table above are considered to have met the criteria, as entire list of 15 plants are able to grow in altitude between 0-2000 Meter Above Sea Level set by slope in vegetative engineering. In addition to the 15 plants with tree strata, shrubs and ground covering plant criteria also are classified to which able to reduce and prevent landslides. As the 15 plants have been tested with typology of crown and rooting, they have been evidenced to exhibit important role in preventing or eliminating landslide events [2,9,10].

5. Conclusion
One of the most frequent disasters in Indonesia during the rainy season is landslide. The case that occurred in Mount Wilis, Ponorogo, East Java, Indonesia is an example of landslides that happened during rainy season due to the absence of certain types of perennials that could hold the soil of the hillside. One effort to reduce the risk of landslides is through vegetative engineering, by cultivating the right type of plant selection, such as strata of tree, shrubs and ground covering plants. This study took into account the characteristics and criteria of plants such as their broad, strong and deep roots, tree stem density, horizontal cultivation of plants, plants intercropping between trees with shrubs and cover crops, so the intercropping can cover and protect unstable slopes. Finally, the local government and local communities of areas with potential landslides occurrence should implement alternative handling landslides as described above.

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