

# The Potential Resources and the Utilization of Ngada Bamboo for Sustainability of Watershed Aesesa Flores

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**Abstract:** Bamboo is a sustainable commodity that has social, economic, and ecological benefits and has become a culture for the people in Aesesa Flores (AF) Watershed Area. However, bamboo has not provided more benefits; even information about its potential is very limited. In addition, the carrying capacity of AF watersheds that are currently in poor condition (degradation) can be overcome by expanding bamboo planting areas. The Information on the potential of resources and the use of bamboo in increasing social, economic and ecological benefits, especially for the conservation of the AF watershed, is important to research. This research was conducted in July-October 2019 in 12 sub-districts of Ngada Regency and used an exploratory descriptive method and literature review. The data used were primary data and secondary data obtained from various sources. The results showed that 1) Ngada Regency in 2018 had the potential of 75,570 clumps of betung bamboo, 10,68 clumps of pering type and 10,423 clumps of gurung/aur; and 2), Bamboo had an ecological function that can conserve soil and water in A F watershed. The recommendation was to improve the function of the AF watershed by expanding the planting area and utilizing bamboo by involving multi-stakeholders, especially the community on a large scale.

**Key words:** Bamboo Ngada, Aesesa Flores Watershed, critical land, soil and water conservation

## 1. Introduction

The development is declared sustainable if it is ecologically, economically, and socially sustainable. Sustainable development also requires harmony between the pace of development activities with the carrying capacity of the natural environment in ensuring the availability of natural resource assets and environmental services for future generations. Like other areas and ecosystems, a watershed is an area that requires a comprehensive management model to achieve sustainability. Watershed management basically aims to: 1) to conserve the soil on agricultural land; 2) to harvest/store excess water during the rainy season and use it during the dry season; 3) to promote sustainable farming and stabilize crop yields through improved management of agricultural systems; and 4)

to fix the ecological balance (the relationship between upstream and downstream water systems, water quality, land quality and capability, and biodiversity).

A half of Ngada Regency is the upstream area (43,053 Ha) of the AF watershed. Currently, the carrying capacity of the AF upstream region is very poor, so it needs to be restored. The limitation of carrying capacity in the AF Upstream Watershed is caused by the high percentage of critical land and the changing in vegetation cover, and the limitation of the flow regime coefficients, the occupational pressure on land availability, and the low level of land use for protected areas and cultivation [1].

The Aesesa Flores Land Rehabilitation is one of the three priority watersheds in East Nusa Tenggara Province, which is in the middle of Flores Island and has an important role, especially for the people of Ngada and Nagekeo Districts, both as a support for food barns and for Flores tourism objects. The AF watershed has an area of 129,005 Ha with a length of

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87 Km, which is divided into three parts, namely the upstream part in the Ngada Regency area, the Central part is in the Nagekeo Regency area and part of the Wolomeze Sub-district area, Ngada Regency, and the downstream part is in the Nagekeo Regency area. One of the recommendations so that the management of the AF watershed can function in a sustainable manner by carrying out one of the priority activities, namely expanding the planting area and improving bamboo cultivation and processing technology [2].

Bamboo is a type of plant that is very significant for Indonesia and other tropical countries because it is used to help people with their daily needs. For rural and urban communities, bamboo plays many roles in their lives. The people of Ngada Regency, Flores Island, East Nusa Tenggara Province; Bamboo becomes a part of their life and it is inherited by the ancestors. Almost every rural area of Ngada Regency has bamboo plants and it often used to support poles, house rooms, floors, fences, cages, artistic and cultural attributes, household utensils, foodstuffs, and so on. Until now, some houses use bamboo for entire buildings especially the roofs and walls. The closeness of bamboo in the daily life of rural communities in Ngada Regency shows a high dependence on bamboo. Bamboo is worth more than just a plant and makes it a source commodity for meeting household needs. Bamboo Ngada is known locally as *bheto*, *peri*, and *guru*.

Bamboo is a multipurpose plant, rich in benefits, and easy to grow. Ngada area is very suitable for bamboo growth and cultivation, supported by relatively fertile soil conditions and a suitable climate for bamboo growth. In general, bamboo has socio-cultural, economic, and ecological benefits. As a plant that has many benefits and is important for life, such as the roots of bamboo plants that can function as an erosion barrier to prevent the dangers of flooding and landslides, and play a role in dealing with toxic waste due to mercury poisoning, it is this part of the root that filters water exposed to waste through root fibers.

Bamboo can be able to accommodate springs so that it is useful as a supply of well water.

Even though bamboo has many advantages, its current utilization is still not optimum, because in general the cultivation and use of bamboo are still traditional. Currently, business entities or craftsmen have produced skewers and toothpicks mechanically, made other derivative products, and carried out other bamboo trading and industrial activities. So far the effort is still limited to buying or obtaining raw materials (bamboo) from society's yards or gardens that were traditionally planted by their ancestors. When this continues, it is frightened that in the next few years these bamboos will be exhausted and the production or industrial businesses will lose a very potential source of raw materials. The strategic and priority steps that must be taken are maximizing the social, ecological, and economic benefits of bamboo plants by undertaking a program to improve bamboo cultivation techniques and processing technology.

Bamboo cultivation does not require a large investment, after the plants have grown well, the results can be obtained continuously without having to plant again. Bamboo cultivation can be done by anyone, with simple equipment and does not require a high level of knowledge. Bamboo can grow on very dry land as well as inland that has lots of rainwater. Bamboo has a very fast growth rate, in contrast to forest timber trees that are only ready to cut with good quality after the age of 40-50 years, where bamboo with prime quality can be obtained only at 3-5 years of age. Bamboo plants have extraordinary resistance. Likewise, bamboo processing activities also do not require large technology and investment, with the aim of increasing the added value of bamboo [2].

The world's attention to bamboo has recently grown rapidly in line with the public's concern for sustainable natural resource management practices. Bamboo plants are one of the ideal types for sustainable use [3]. The potential of bamboo in supporting forests is considered economical in the future. Forests as the main source of

wood from time to time the conditions are very apprehensive. This situation is caused by exploitation in a very unwise manner, without paying attention to the sustainability and preservation of the forest itself [4]. There are around 1500 types of bamboo in the world with more than 140 species growing in Indonesia [5].

The bio-geophysical condition of Ngada Regency is a suitable agricultural area for bamboo cultivation. Ngada Regency also has a large area of bamboo plantations, with communities that have been cultured towards the practice of cultivating and utilizing bamboo. In addition, there is land potential, especially critical land in the upstream area of the AF watershed, covering an area of 42,986 hectares which can be used as conservation land by cultivating bamboo. The lack of information on the potential and cultivation technology and benefits of bamboo causes the function of bamboo for social, economic, and ecological benefits to be not optimal. For the purpose of developing and maximizing the function of bamboo, especially as a watershed conservation commodity, this study aims to present information on the potential availability of plants and types of bamboo in Ngada Regency and their use for the sustainability of the AF watershed function.

## 2. Method

This research uses a descriptive exploratory research method and also a literature review. The method used to determine resource potential bamboo is a direct survey method and literature study. The research was conducted in July-October 2019 in 12 districts of Ngada Regency which aims to obtain information on

the potential and types of bamboo plants. Types of bamboo plants found at the research location were recorded and described based on morphological characteristics and classification based on the Widjaja bamboo plant identification book (2001). Open interviews were also conducted with the community and craftsmen at the research location. The information collected includes: the number of bamboo clump ownership, the number of culms per clump, the name of the species (area/local), the part that is used, the form, the method of use, and the purpose of the use. Meanwhile, the study of the use of bamboo for the conservation of the AF watershed is guided by Noywuli (2020) [1] and Sutiyono (2014) [6].

## 3. Results and Discussion

### 3.1 Potential of Bamboo Ngada Resources

Ngada Regency is one of the districts in East Nusa Tenggara Province that has potential for bamboo plants and the data has not been widely published. Ngada Regency with Bajawa as its capital has an area of 1,620.90 Km<sup>2</sup> and administratively there are 12 districts [7], all of which have bamboo plants. Types of bamboo and the potential of Ngada bamboo resources are presented below.

#### 3.1.1 Types of Bamboo in Ngada Regency

Based on the roaming method by walking to explore places where bamboo is grown together with the local community and conducting interviews with people who know the types of bamboo and identification, the types of bamboo in Ngada Regency are obtained as described in Table 1.

Table 1 Types of Bamboo in Ngada.

| No | Local Name        | Common Name        | Family Name | Genus Name            | Scientific Name                   |
|----|-------------------|--------------------|-------------|-----------------------|-----------------------------------|
| 1  | Bheto             | Betung             | Gramineae   | <i>Dendrocalamus</i>  | <i>Dendrocalamus asper</i>        |
| 2  | Peri (ngura/sese) | ater/pering        |             | <i>Gigantochloa</i>   | <i>Gigantochloa atter</i>         |
| 3  | Guru (ngura/sese) | Ampel/gurung       |             | <i>Bambusa</i>        | <i>Bambusa vulgaris</i>           |
| 4  | To'e gaa          | Aur duri           |             |                       | <i>Bambusa blumeana</i>           |
| 5  | Peri kedhi        | bulu/talang        |             | <i>Schizostachyum</i> | <i>Schizostachyum brachyladum</i> |
| 6  | Yea, wulu         | Bulu tipis/ Suling |             |                       | <i>Schizostachyum blumei</i>      |

Ngada Regency has six types of bamboo plants that have existed since ancient times as presented in Table 1. However, there are three types of bamboo that are predominantly cultivated and used by the community since ancient times and are known as Ngada bamboo. The three types of bamboo are Betung Bamboo (*Dendrocalamus asper*) with the local designation Bheto, Pering Bamboo (*Gigantochloa atter*) as locally known as Peri, and Bambu Gurung/Aur (*Bambusa vulgaris*) with the local designation as Guru. The description of the types of bamboo presented is based on the results of research and is guided by Widjaya (2001) [8] as follows:

#### 1) Betung Bamboo

Betung bamboo (*Dendrocalamus asper*) is a type of bamboo that has a large trunk circumference and belongs to the grass family. This bamboo has the local name in Bajawa, called bheto or bamboo betung. It grows in almost all sub-districts, but there are mostly in Bajawa, West Golewa, and Golewa Districts. It grows clumps with characteristics such as black-purple bamboo shoots, covered with soft downy hairs (miang) such as brown to black. The trunk (reed) is large, internodes 40-50 cm long and 12-18 cm in diameter, overall the reed reaches a height of more than 20 m with a curved tip; the color varies from green, dark green, purplish green, whitish green, or spotted white due to lichen. The books are surrounded by aerial roots. The thick walls of the reeds are between 11 and 36 mm. Initial harvest at new planting at the age of 5-6 years. Bamboo shoots grow 15-20/clump, harvest 10-20 stems/clump/year.

Betung bamboo grows well on moist and fertile alluvial soils and is also be able to grow in dry places in the high and lowlands. It grows best at an altitude of 400-500 m up in areas with an average annual rainfall of about 2,400 mm. Betung bamboo also grows well in a variety of soils but will grow better on heavy well-drained soils. It has many uses and is mainly used as building materials and structural timber for the construction of various buildings and laminate

products. Its thick reeds are generally considered strong and durable; at 8% moisture content the density of the wood is between 0.7-0.8 g/cm<sup>3</sup>. Other uses include gutters or sap, water channels, musical instruments, furniture, household and handicraft equipment, plaques, paper pulp, chopsticks, toothpicks, as well as various other uses. The large and sweet birds are liked by the community, for pickles or other dishes. The quality of these bamboo shoots is considered the best compared to other types of bamboo shoots, and also when canned.

#### 2) Atter/Pering Bamboo

Pering/ater bamboo (*Gigantochloa atter*) is a type of bamboo that is also scattered in all districts, but in less number than Betung bamboo, which is locally called Peri or Pering bamboo. The pering bamboo that grows in clumps is dense and upright. The bamboo shoots are green to purplish, covered with black soft hairs (miang). Stems or reeds are straight, reaching a height of 22 m; 5-10 cm in diameter and sections along 40-50 cm, thick wall reeds 8 mm; green, dark green to bluish-green, with pale-colored rings on the books; knuckles near the ground with a few aerial roots.

Ater bamboo is widely used as a building material and household appliances, especially as a building material: house frames, walls, fences; and also for making household items such as halls, furniture, and cooking utensils. Ater bamboo is also good for making traditional musical instruments such as clung and angklung. Other uses include drying poles, broomsticks, and also supporting banana bunches. The reeds are also used as a material for plaiting (for baskets, etc.), as well as for making chopsticks, skewers, toothpicks, etc. The bird is favored as a vegetable, and it is said that its taste is not inferior to the Betung bamboo shoots (*Dendrocalamus asper*).

#### 3) Gurung/Aur Bamboo

Gurung bamboo/aur (*Bambusa vulgaris*) is a type of bamboo that is widely planted by the community or grows in all sub-districts in less number than the Betung and Pering bamboos. Bamboo aur or ampel has

many other uses besides building materials, including as raw material for paper and vegetables from bamboo shoots. There are yellow varieties with green stripes (*Bambusa vulgaris* var. *Striata*) known as yellow bamboo or ivory bamboo and are used as ornamental plants, yard markers, and traditional medicinal ingredients. Known as ampel bamboo, gurung or aur, the local Bajawa are ngura guru and guru sese. The population of guru ngura (green) is more than that of guru sese (yellow bamboo). Gurung or ampel bamboo grows well in hot and humid lowland areas, ampel bamboo can grow to an altitude of 1,200 m above sea level. However, its growth stunts above 1,000 m. above sea level. In places with strong dry seasons, this bamboo can also grow even though it is often withered. In the Ngada Regency area, ampel bamboo is often found wild along rivers, roadsides, abandoned areas, and open spaces.

Gurung bamboo grows in clumps and is not too tight and the rhizome has sympodial branches. Bamboo shoots are yellow or green, covered with brown to black miang soft hairs. Its reed is upright, reaches a height of 10-20 m, straight or slightly zigzagged and the tip is curved. Internodes 20-45 cm long and 4-10

cm in diameter, 7-15 mm thick; glossy green, yellow or yellow with green stripes, with dark, dark, fallen downed miang hairs and a whitish wax coating when young; the books are slanted, slightly protruding, the books are bottom with aerial roots. Although the reeds are not very straight, ampel bamboo is the most widely used among the various types of bamboos for various purposes: sail posts, flagpoles, rudders, boat ornaments, supports, and fences; as well as for rafters and house poles, although this bamboo is less resistant to powder beetle attack and is only used for building materials when other better materials are not available. Bamboo is also widely used in the furniture industry, and from its reeds, it produces pulp which is good for people to eat as a vegetable. Yellow bamboo shoots are used to treat hepatitis [9].

### 3.1.2 The population of Ngada Bamboo

There are three kinds of bamboo in Ngada that most polluted and have been around since ancient times. The three types of bamboo are Betung Bamboo (*Dendrocalamus asper*) with the local designation Bheto, Pering Bamboo (*Gigantochloa atter*) as locally known as Peri, and Bambu Gurung (*Bambusa vulgaris*) as local Gurung as shown in Fig. 1.



Fig. 1 Figures of three types of Ngada bamboo.

The third potential of bamboo in Ngada Regency is presented in Table 2. It is the results of data collection carried out in 12 sub-districts in three ways namely library research conducted through publications and

other electronics, field research conducting interviews and observations while for literature studies looking for data originating from related agencies as well as from internet sources.

**Table 2 Data of potential of bamboo Ngada plants in 2014-2018.**

| The Various of Ngada Bamboo | 2014   |           | 2015   |            | 2016   |            | 2017   |            | 2018   |            |
|-----------------------------|--------|-----------|--------|------------|--------|------------|--------|------------|--------|------------|
|                             | Clumps | Steam     | Clumps | Steam      | Clumps | Steam      | Clumps | Steam      | Clumps | Steam      |
| Betung/Bheto                | 47.187 | 1.595.250 | 52.378 | 19.143.000 | 58.663 | 21.440.160 | 66.289 | 24.227.381 | 75.570 | 27.619.214 |
| Peri/Ater                   | 4.075  | 146.650   | 4.890  | 175.980    | 6.357  | 228.774    | 7.628  | 274.529    | 10.680 | 384.340    |
| Guru/Ampel                  | 3.977  | 116.290   | 4.772  | 139.548    | 6.204  | 181.412    | 7.445  | 217.695    | 10.423 | 304.773    |
| <b>Total</b>                | 55.239 | 1.858.190 | 62.040 | 19.458.528 | 71.224 | 21.850.346 | 81.362 | 24.719.604 | 96.672 | 28.308.327 |

The data presented in Table 2 showed that Ngada bamboo had the potential to be developed and utilized. The development of the Ngada bamboo is intended to maximize the socio-cultural function, economy, and ecology of bamboo. The development can be carried out by expanding the planting area and improving bamboo cultivation and processing technology. The wider bamboo planting area with the required cultural technology will improve the good function of bamboo, one of which is as a watershed conservation plant.

During a period of 5 years, there was an increase in the number of clumps and bamboo culms/spikes each year. The addition of bamboo sticks occurs due to the natural planting or growth of new clumps, as well as the proliferation of existing clumps or clumps. Meanwhile, the addition of new clumps occurred due to new planting by the community, technical agencies, as well as natural growth. Planting by the community is carried out with small-scale tillers/seedlings prepared by them or assisted by government programs or foundations/NGOs. Since 2010, every year, the environmental agency, the forest engineering service unit and other agency facilitate 500 bamboo saplings planted over rivers spring areas, and on community lands.

The data in Table 2 also showed that the annual production of asper bamboo culms is 1,133,550 pieces. The existing longer potential is quite potential to develop a bamboo industry on a household scale.

Whereas for the interests of large industries, assuming that it requires 5,000 bamboo sticks/day, it must be followed by large-scale bamboo cultivation activities so that the continuity of the availability of raw materials is maintained. With the presence of the industry, the potential of existing bamboo can make a new economic source for the region and society in Ngada Regency.

### *3.2 Benefits of Bamboo for the Sustainability of the AF Watershed Function*

One of the 5 priority programs/activities recommended so that the function of the AF watershed can be sustainable (socially, economically, and ecologically) is the development of bamboo cultivation and processing technology [1]. Currently, the condition of the AF Watershed is increasingly concerning; almost all watershed AF sub-areas have experienced a decline in quality with an indication of the extent of critical land, frequent floods, drought, landslides, and water pollution that harm people's lives and the environment. Besides, there are many poor people who live along the river.

From the total area of the AF area of 129,005 ha, the land classified as critical is 64,337 ha, 34,566 ha is very critical and 25,345 ha is slightly critical. Meanwhile, those classified as potentially critical and non-critical have a very small area, wherein the upstream part of the AF watershed that is not critical is only 67 ha [1, 10].

The extent of the critical land indicates a decrease in environmental quality as a result of the use of land resources that is not wise and does not comply with existing regulations. Land that is included in the critical land category will lose its function as water retention, erosion control, nutrient cycling, microclimate regulator, and carbon retention.

One of the efforts to restore critical watershed conditions is forest and land rehabilitation activities with bamboo plants. Land rehabilitation activities are carried out both inside and outside forest areas which are focused on critical land, empty land, and unproductive land. It is an attempt to restoring, maintaining, and enhancing the functions of forests and land so that their carrying capacity, productivity, and role in supporting life support systems are maintained. The aim of implementing land rehabilitation is to reduce forest and land degradation and restore damaged/critical lands so that they can function as production media and water management media. Land rehabilitation activities will be successful and also need to use a community empowerment approach, where people are encouraged to be more active in land rehabilitation activities through groups' farmers and community groups.

The experience in the current land rehabilitation implementation system, both from the government and the community, often the selection of tree seedlings is based more on their economic functions and benefits, while the ecological function in soil and water conservation has not been given much attention. These conditions resulted in the majority of fast-growing plant seeds and the harvest period that was not too long. It is feared that this phenomenon will have an impact on the ecological side because the majority of plants are harvested simultaneously so that there is a long lag in the percentage of land cover to return to normal. From this concern, an alternative choice of plant species that can boost the community's economy while at the same time supporting environmental

sustainability and social and cultural benefits is the commodity bamboo.

The development of bamboo plants can be done by expanding the planting area and improving cultivation technology. In terms of ecological benefits, bamboo plants have the ability to maintain environmental balance because their root system can prevent erosion and regulate water management, and can grow on marginal lands. The upstream area of the AF is dominated by high critical land ( $\pm 42,986$  ha) so it needs to be conserved with bamboo plants. It can conserve soil and water, presenting a type of tree vegetation that was previously dominated by savanna fields [1].

Based on the data on the potential of Ngada bamboo above, compared to the high critical land in the upstream AF area, we can see that the use of bamboo as a rehabilitation plant has not attracted enough interest for the community. In general, the use of bamboo plants includes economic, socio-cultural, and ecological aspects. The role of bamboo in the economic sector can be seen in plain view, where people, especially in rural areas, are accustomed to using bamboo as a building material, household utensils, foodstuffs, and other uses. In socio-cultural terms, bamboo is part of the arts and customs of the Ngada people. Bamboo development is also capable of growing creative industries so that they can create jobs, reduce unemployment, prevent urbanization and encourage tourism development.

Bamboo has advantages/benefits in terms of ecology that can be developed especially for critical land rehabilitation activities or soil and water conservation activities. The advantage is because bamboo has a fibrous root system with very strong rhizome roots, allowing it to maintain the hydrological system as soil and water. Bamboo can also maintain the hydrological system as a binder for water and soil. Bamboo plants can bind the soil on slopes, thereby reducing erosion, sedimentation, and landslides. Bamboo plants can also be able to absorb a large amount of rainwater through an interception mechanism so that the possibility of



direct flow and erosion over the land surface with the dominance of bamboo becomes small. Meanwhile, in relation to climate change mitigation efforts, the development of bamboo plants can also increase carbon absorption by more than 62 tons/ha/year of carbon dioxide [11].

Bamboo plants have the potential to be an alternative solution to a number of environmental problems. According to Widjaja (2004) [11], the rapid growth of bamboo compared to wooden trees makes bamboo a superior candidate to reduce the problem of deforestation. With the facts about the many benefits that can be obtained from these bamboo plants, bamboo should be used as an alternative type of plant for RHL activities. It is hoped that through bamboo planting, a balanced benefit can be obtained between the economic side and the ecological side.

Bamboo is a type of grass that has strong and flexible stems. Bamboo stalks are able to withstand windstorms, so they are very suitable to be used as forage plants around the watershed. Bamboo is also able to withstand drought conditions and grows on steep land at an altitude of 1 to 1500 meters above sea level, so it can be an option for landslide protection plants. The potential of bamboo as a plant for environmental conservation has not been maximized by the community. Severity, the various varieties of bamboo in Indonesia are also endangered. The demand for bamboo for economic purposes is very high, if it is not matched by sufficient production, then bamboo will become a rare plant in Ngada and Indonesia. Therefore, bamboo cultivation and its use as environmental conservation plants must be carried out. Apart from maintaining bamboo populations, other benefits such as increasing groundwater reserves and maintaining soil stability can also be obtained.

The recommendations for activities that must be carried out in an effort to increase the area of planting and the interest of the community to plant bamboo include socialization of the benefits of bamboo so that the impression of bamboo as a haunted plant and

snake's nest can be defeated by "branding" bamboo as a multipurpose plant where almost all parts can be utilized. Further awareness to the community in the perspective of soil and water conservation through the use of bamboo is also continuously carried out through the creation of a rehabilitation model area for the conservation of sloping lands that are prone to landslides and critical lands. In the future, if these steps can be taken, the community will automatically be motivated to plant bamboo and at the same time participate in efforts to reduce deforestation and forest degradation through bamboo planting activities with good cultivation techniques. Apart from that, the government needs to provide incentives to business actors to cultivate and build a bamboo industry in Ngada, also inland rehabilitation activities it is necessary to replace timber plants with bamboo plants.

#### **4. Conclusion**

The results of the study on the potential of resources and utilization of Ngada bamboo for the sustainability of the AF watershed can be concluded and recommended that: 1) The AF watershed is currently in a damaged condition mainly due to the high area of critical land so that it needs to be restored through expanding the planting area and improving bamboo cultivation technology. Bamboo plants have the advantage of being able to grow on critical land and once planted the next harvest is harvesting social, economic, and ecological benefits; 2) Ngada Regency has the potential for bamboo resources such as of betung type, pering type, and gurung type. This potential is supported by cultured bamboo cultivation, suitable climate and land potential, especially critical land; and 3) The government and bamboo stakeholders need to make efforts to provide incentives for the development of bamboo cultivation and industry for the business world as well as to increase public interest in planting bamboo as a multipurpose plant or industrial tree as well as from the perspective of soil and water conservation.



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