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REGULAR RESEARCH ARTICLE

The Dynamics of Sustainable Livelihoods and Agroforestry in Gunungkidul Karst Area, Yogyakarta, Indonesia

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ABSTRACT

The livelihoods of farmers in developing countries are often associated with the existence of forests, especially agroforestry. The dynamics of agroforestry and livelihoods could not be separated from the political context and developments in Indonesia. In this paper, the dynamics of Sustainable Livelihood Assets (SLA) owned by smallholder farmers are explored using three political sequences, namely the New Order Era, the Reform Era, and the Post-Reform Era. The result showed that the development of agroforestry in Gunungkidul had been primarily influenced by political initiatives that have a connection with vegetation coverage, livelihood assets, and species composition in the systems. The livelihoods possessed by farmers have been relatively sustainable during the past five decades; only a slight change could be observed in the ownership of capital. The political initiatives have been an enabling environment for agroforestry development that support sustainable livelihoods. The study recommends that the socio-political culture needs to consider the traditional agroforestry system in order to sustain the livelihoods of the people.

KEYWORDS

Sustainable Livelihood Assets; Politics; Agroforestry; Karst; Gunungkidul.

1. INTRODUCTION

Agroforestry systems have been practiced worldwide with various plant compositions, forest structures, and functions. In Europe, the most common agroforestry systems were hedgerows, windbreaks, and orchard intercropping (Nerlich, Graeff-Hönninger & Claupein, 2013). In Asia and the Pacific, agroforestry is widely carried out as multifunctional home gardens and agrisilvicultural systems. Agroforestry produces timbers, animal fodder, and medicine (Nerlich, Graeff-Hönninger & Claupein, 2013) and provides ecosystem services (Shin et al., 2020). Generally, the system is vital to sustain food security and maintain biodiversity, cultural, and ecological functions (Bardhan et al., 2012; Rendón-Sandoval et al., 2020; Shin et al., 2020).

Traditionally, farmers own and manage agroforestry on their agricultural land. The system integrates crops, timbers, and medicinal plants in semi-domesticated ecosystems (Chirwa et al., 2008; Rendón-Sandoval et al., 2020). This integrated system shows a nexus between agroforestry and biodiversity conservation (McNeely & Schroth, 2006; Udawatta, Rankoth, & Jose, 2019; Yashmita-Ulman et al., 2021) and between agroforestry and livelihoods (Chirwa et al., 2008; Gifford, 2016). Many important species are found to be protected in agroforestry systems, for example, bird diversity (Gifford, 2016; Rocha et al., 2019), invertebrates (Boinot et al., 2019), and orchids (Herrera-Cabrera et al., 2020).

In Java, Indonesia, the early agroforestry study was conducted by Reijntjes et al. (1992) and van der Poel & van Dijk (1987). The work classifies traditional agroforestry into homegarden (*pekarangan*), mixed garden (*kebon tatangkalan/talun*), and trees in open garden. Generally, Java has been seen as fertile land with abundant agricultural produce. However, several areas of Java are considered drylands that rely on rice in the rain-impounding field (*tadah hujan*). The environment brings inhabitants to optimize their land for meeting the needs of food, crops, timber, and firewood and thus integrate crop planting and timber planting into agroforestry systems. Such a scenario could be observed in the dryland karst of Java, including Gunungkidul Karst, as showcased in this study.

In the 1600s, the karst of Gunungkidul was ruled by the Sultan of Yogyakarta. During its reign, the Sultanate claimed the land and timber from the area. During the Colonial Government under the Dutch East India Company (VOC, 1619-1810), the forest resources were explored to meet the needs of shipbuilding, warfares, factories, and houses (Peluso & Vandergeest, 2001; Septariska & Ekaputri, 2001; Parthesius, 2010). The thick forests were also converted into plantations to accommodate commodities such as tea, tobacco, coffee, and cocoa. At this time, the landscape had been opened to accommodate plantations and agriculture. By the early independence of the Republic of Indonesia in 1945, Gunungkidul had become barren land with little tree coverage. In the 1960s, the government encouraged regreening the karst land by building Wanagama Forest. Later, people improved their traditional systems of agroforestry to enhance timber production, namely *pekarangan* (home gardens), *kitren/karangkitri* (woodlots), and *tegalan* (intercropping between crops and woods). In addition, there are *galengan* (trees along the border) (Wardhana et al., 2012) or border planting (Roshetko et al., 2013). These systems significantly contribute to local farmers' livelihoods, mainly due to timber produce (Oktalina et al., 2015). The Central Statistics Bureau (BPS) reported that the total timber production reached 78.280,24 m^3 in 2019 and was dominated by teak (Central Statistics Agency, 2020).

Several studies explore the relationship between sustainable livelihoods and agroforestry development worldwide. For example, in Kenya, households practicing agroforestry have high SLA scores and thus can sustain their livelihoods (Quandt, Neufeldt & McCabe, 2019). Similarly, in Pakistan, agroforestry improved livelihoods by providing incomes from timber, non-timber produce, and firewood(Ahmad, Caihong & Ekanayake, 2021).

The contributions of agroforestry in sustaining livelihoods may accelerate the Sustainable Development Goals (SGDs) that depend on financial support, political commitments, and appropriate legal measures (Plieninger et al., 2020). Some studies show that agroforestry development is primarily affected by political commitments and appropriate legal frameworks. In India, the adoption of agroforestry and preservation of traditional agroforestry systems has been successful due to the implementation of the National Agroforestry Policy 2014 (Chavan et al., 2015). On the contrary, in Western Europe, the Common Agriculture Policy (CAP) has not successfully promoted agroforestry in the area (Santiago-Freijanes et al., 2018).

In Gunungkidul, agroforestry has been encouraged by the government since the 1930s. It is claimed that Gunungkidul karst is an example of a thriving forest rehabilitation program. The forest transition from barren land before the 1950s to a high vegetation coverage in recent years was attributed to the agroforestry system (Iskandar et al., 2016; Reijntjes et al., 1992). Wardhana et al. (2012) reported that forest transition occurred in Gunungkidul for five decades.

Agroforestry development in the area has been hypothesized to meet sustainable livelihoods. Several authors argue that effective intercropping and multispecies plantations can guarantee food security that contributes to sustainable livelihoods (Khasanah et al., 2015; Maharani et al., 2022). In addition, smallholder agroforestry systems have been able to rehabilitate soil and lands, diversify incomes, and improve food security.

Although there is a wealth of literature discussing the success of agroforestry, the dynamis of livelihoods due to political interventions in this karst landscape have not been widely covered. There have been several studies about teak agroforestry (Maharani et al., 2022; Roshetko et al., 2013; Udayana et al., 2020) and livelihoods (Seruni et al., 2021), but the political aspects are still missing, although several studies indicate that the successfulness of the agroforestry program in Gunungkidul was widely linked with political movements initiated by the governments. (Awang et al., 2001). Several policies induced by governments include *karangkitri* (Oktalina et al., 2015) and the National Movement of Greening and Land Rehabilitation (GERHAN) (Nawir et al., 2007). The program acknowledges agroforestry as a significant factor in increasing plant coverage. Several authors suggested that agroforestry development in Gunungkidul could be linked with the country's political situation. For example, Awang (2001) described agroforestry development during the New Order Era, whereas other authors highlighted several policies on timber production during the Post Reform Era (Fujiwara et al., 2011; Roshetko et al., 2013; Maryudi et al., 2015). A small section of the study described the event occurring during the Reform Era and its link to agroforestry, such as Wicaksono et al. (2020) and Sunderlin (1999).

While the previous work shows that political dynamics may affect agroforestry development, there is still a gap in evaluating the policy and its link to sustainable livelihoods. This paper, therefore, aims to demonstrate that agroforestry development in dryland karst is promoted by political initiatives that support sustainable livelihoods. This paper divides the political dynamics into three, The New Order Era (from 1970-to 1997), The Reform Era (from around 1997-to 2003), and the Post Reform Era (from 2004-now). In addition, a vegetation survey is conducted to understand the structure and composition of species that compose the agroforestry system in Gunungkidul. The knowledge of species diversity may contribute to livelihoods and thus is needed to understand the agroforestry system fully. The objectives of this paper are (1) to examine the dynamics of vegetation coverage in Gunungkidul that partly represents the agroforestry system starting from the New Order Era to the Post Reform Era, (2) to study the dynamics of the sustainable livelihoods assets that occur in karst Gunungkidul based on the political sequences in the country. Lastly, to understand the current situation, this study explores the species compositions and the community's perception of agroforestry practices.

2. MATERIALS AND METHODS

2.1 The context

The study was conducted in three districts (Semanu, Panggang, and Girisubo) located in Gunungkidul Regency, Yogyakarta Province. All of the districts are part of Gunungkidul karst which geologically is composed of limestone and marl. Gunungkidul karst is described as *kegelkarst* (cone), characterized by sinusoidal or hemispherical hills (Haryono & Day, 2004). Located in a humid tropical climate, the karst geomorphology of Gunungkidul has developed so extensively that severe water availability prevails over agricultural productivity (Nibbering, 1991). Junghunn made the initial observation of Gunungkidul ecology in 1845. This old work mentioned that the original landscape of Gunungkidul was composed of a high virgin forest stand.

Based on the political context in modern Indonesia, this research divides the political dynamics into three, namely, the New Order Era (from 1970 to 1998), the Reform Era (from around 1999 to 2003), and the Post Reform Era (from 2004-now).

2.1.1 The New Order Era (1970-1998)

The New Order Era emphasized the regreening program under President Decree No. 5/ 1977. Several species were planted for regreening private lands, such as teak, which was then widely accepted in by farmers as smallholders of agroforestry (Roshetko et al., 2013). Some other species include mahogany (*Swietenia macrophylla*) and nitrogen-fixing trees such as *lamtoro* (*Leucaena leucochepala*) and *turi* (*Sesbania grandiflora*). In addition, several farmers opted to plant exotic fruits such as cashew (*Anacardium occidentale*), *melinjo* (*Gnetum gnemon*), citrus (*Citrus sp*), *mango* (*Mangifera indica*), and stink bean (*Parkia speciosa*) (Nibbering, 1991; Filius, 1997).

2.1.2 The Reform Era (1999-2003)

During the Reform Era (1999 to 2003), the government carried out the regreening program under the National Movement of Land and Forest Rehabilitation (GERHAN). The protection of agrobiodiversity relied on developing private forests, community forests, and agricultural practices. Community Forestry is acknowledged by Decree No. 41/1999, and the program was successful due to financial stimuli and subsidies (Fujiwara et al., 2011).

2.1.3 The Post-Reform Era (2004-now)

The Post Reform Era (2004-now) acknowledged the importance of Privately-owned forests and community forestry under the Ministry of Forestry's Decree No.49/2008. The Department of Forestry successfully increased tree coverage through forest rehabilitation programs (Wardhana et al., 2012). Gunungkidul experienced increased timber production, including teak, mahogany, and acacia.

2.2 The dynamics of vegetation coverage

In this research, the development of forestry is represented by vegetation coverage. Although it does not necessarily represent exactly agroforestry, it is still helpful for understanding the development of agroforests in the area. It is important to note that the total area categorized as agroforests was 44,110.87 ha in 2019, and this number exceeded the total area allocated for state-owned forests at about 14.367,05 ha (Dinas Lingkungan Hidup dan Kehutanan, 2019). The vegetation coverage was calculated using the *Normalized Difference Vegetation Index* (NVDI), which generates vegetation patterns using multi-spectral imagery (Huang et al., 2021). The use of NVDI follows Liu et al. (2019). Several satellite images were used in this research to represent each decade from the 1970s to the 2000s (Table 1).

Table 1. The source of satellite images

Decades	Satellite images	Image source	Political situation
The 1970s	LMSS_128066_19721016	Landsat 1 MSS	The New Order Era
The 1990s	LTM_120065_19910831	Landsat 5 TM	The New Order Era
The 2000s	LETM_120065_20020821	Landsat 7 ETM+	The Reform Era
The 2010s	LOLI_119066_20180802	Landsat 8 OLI	The Post Reform Era

The criteria for the NDVI score are as follows:

- NDVI 0-0.10 = low density of vegetation coverage,
- NDVI 0.11-0.2 = moderate density of vegetation coverage,
- NDVI 0.21-1 = high density of vegetation coverage, and
- NDVI -1-0 = open area/water/cloud

The vegetation coverage trend from the 1970s to the recent period shows a decrease in the low density of vegetation (NDVI 0-0,1). On the contrary, vegetation with moderate density (NDVI 0.1-0.2) decreased during the Reform Era but slowly increased during the Post Reform Era.

2.3 The dynamics of sustainable livelihoods

Sustainable livelihood frameworks illustrate the dynamics of capital/assets as the source of people's livelihood. In this framework, assets are categorized into five: natural capital (land, forest, trees, wildlife), human capital (skill, knowledge, and capacity), social capital (relationship, network, and membership of groups), physical capital (infrastructure, transport, and shelter), dan financial capital (incomes, savings, credits, and remittance). We adopted the instruments for collecting the SLA data from DFID (Solesbury, 2003). The sustainable livelihood approach categorizes capital/assets into natural, human, social, physical, and financial (Chambers & Conway, 1992). For each capital, several indicators are chosen for analysis (table 2).

Table 2. Livelihood assets/capitals and the indicators (developed based on Riddel (2013))

E	Indicators
Human capital	level of education
	skill and working experience
	characters and motivation
Natural capital	land ownership
	land productivity
	ecosystem services
	natural resource use
Social capital	participation in farmers' organization
	social network and power relations
	social status and family relationship
Physical capital	Access to infrastructure
	Access to working tools and equipment
	Transportation
Financial capital	Incomes in household
	Cash in household
	Access to social assistance funds (*bantuan sosial*)

Respondents associated the dynamics of their livelihoods with the political situation that governs the country. Therefore, this research explored three time-frames of the livelihood dynamics, a similar time frame used to analyze the vegetation coverage in the above section.

The surveys were conducted using DFID's framework of SLAs (Solesbury, 2003) in three districts in Panggang, Semanu, and Girisubo. The districts have been chosen to represent the western, middle, and eastern parts of Gunungkidul Karst. There were 109 respondents representing each household. The respondents were chosen purposefully among those who have managed agroforestry for at least 20 years and have experienced three political periods defined in this research. Several gatekeepers helped the researcher to determine the respondents based on the criteria. Observation and diary were generated during 21 field visits to the respondents' hamlets. Additionally, 19 respondents were interviewed to represent the elderly, the community leader, and the NGOs.

Table 3. Respondents profile in Semanu, Panggang, and Girisubo

Criteria	Semanu	Panggang	Girisubo
Number of respondents	37	30	42
Gender:			
Male	21	16	28
Female	16	14	14

Criteria	Semanu	Panggang	Girisubo
Age (average year)	67.2	63.2	63.1
Experiences in agroforestry (average year):			
20-30 years	23	25	36
>30 years	14	5	6
Level of education			
Primary	16	21	30
Secondary	7	5	1
Tertiary	2	1	4

[Source: Primary data]

A combination of techniques adopted by Amberntsson (2011) was used to collect information about current and past livelihoods. The techniques included surveys, informal interviews, and group interviews. We visited all respondents in their home villages. The interviews explored five capitals composing the SLA: human capital (HC), natural capital (NC), physical capital (PC), social capital (SC), and Financial Capital (FC). The respondents express the assets by indicating a score between 0 to 4. The lower the number means, the fewer assets possessed by the respondents.

The criteria for the SLA score are:

- SLA <2 = very low,
- SLA 2.1-4 = low,
- SLA 4.1-6 = moderate,
- SLA 6.1-8 = high, and
- SLA > 8 = very high.

2.4 The structure and composition of vegetation in traditional agroforestry

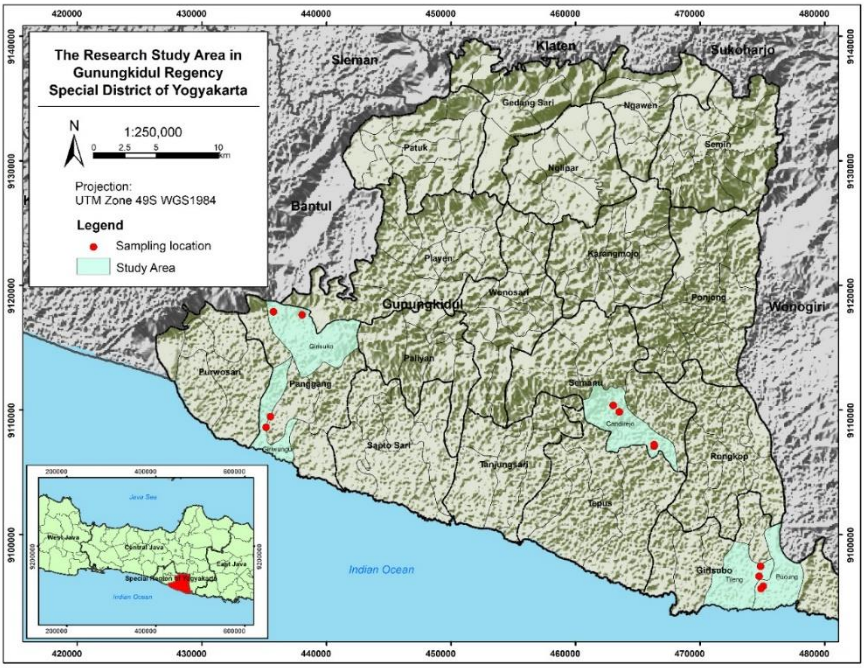


Figure 1. Study areas consist of three districts in Gunungkidul. The location for data collection is represented in dots
[Source: Authors' analysis]

Vegetation surveys were conducted to understand the structure and composition of species in agroforestry systems. The vegetation survey is essential to determine species diversity and the contribution of the group of species to the livelihoods. Knowledge of the structure and composition of species in agroforestry systems is needed to understand farmers' choice of functional biodiversities that contribute to sustaining people's livelihoods. To measure the diversity, we quantify and characterize agroforestry practices according to the degree of diversity index (H') and the importance value index (IVI).

The number of locations sampled in this research was 11 sites in three districts. The three districts were Kecamatan Semanu, Kecamatan Panggang, and Kecamatan Girisubo. In total, there were 99 quadrats placed in the locations. We adopted the purposeful sampling approach in selecting the study location for the vegetation survey. First, we contacted the head of the villages and the gatekeeper to list farmers who have managed traditional agroforestry systems. Based on the initial list, we categorized three types of agroforestry in the area, namely *ngoro-oro* (mixed forests in karst valleys), *gunung/perengan* (mixed forest in karst hills), and *pekarangan* (home gardens located around settlements). We choose the sampling locations representing three types of agroforests in the area. The size of quadrats and sampling area were determined by following previous research by Hutchinson et al. (1999) and Hapsari et al. (2020). For each hamlet, we placed one quadrat for each type of agroforest. Because we have 11 hamlets, in total, we have 33 quadrats.

The parameters were calculated using the following formula:

$$\text{Density} = \frac{\text{Total number of species A}}{\text{Total area (m}^2\text{)}} \quad (1)$$

$$\text{Relative Density} = \frac{\text{Density of species A}}{\text{Total density of all recorded species}} \times 100\% \quad (2)$$

$$\text{Dominance} = \frac{\text{Total base area (area covered by Species A)}}{\text{Total area(m}^2\text{)}} \quad (3)$$

$$\text{Relative Dominance} = \frac{\text{Dominance of Species A}}{\text{Total dominance of all species}} \times 100\% \quad (4)$$

$$\text{Frequency} = \frac{\text{Total number of plots inhabited by species A}}{\text{Total plots}} \quad (5)$$

$$\text{Relative Frequency} = \frac{\text{Frequency of all species}}{\text{Total frequency of all species}} \times 100\% \quad (6)$$

$$\text{Importance value (IV)} = \text{Relative Density} + \text{Relative Dominance} + \text{Relative Frequency} \quad (7)$$

In addition to the above formula, the diversity index is calculated using the Shannon-Wiener Diversity Index (H').

$H' = -\Sigma\, P_i \ln (P_i)$, where $P_i = (n_i/N)$

H'= Shannon-Wiener diversity index

n_i = number of individuals of species i

N = The number of individuals of all species

The criteria for the diversity index's score are as follows:

H' < 1: low diversity

1< H' ≤3: moderate diversity

H'> 3:high diversity

2.5 Community's perception of agroforestry and plants conservation

A combination of several interview techniques was conducted during the study to explore the community's perception of agroforestry practices. During this stage, several questions were asked, such as the kinds of species planted, the motivation for agroforestry practices, the successfulness of the practices, and incomes from agroforestry practices. The following is the profile of the respondents: A world cloud image was generated using a word cloud application (www.wordclouds.com) to illustrate the list of species mentioned by the respondents.

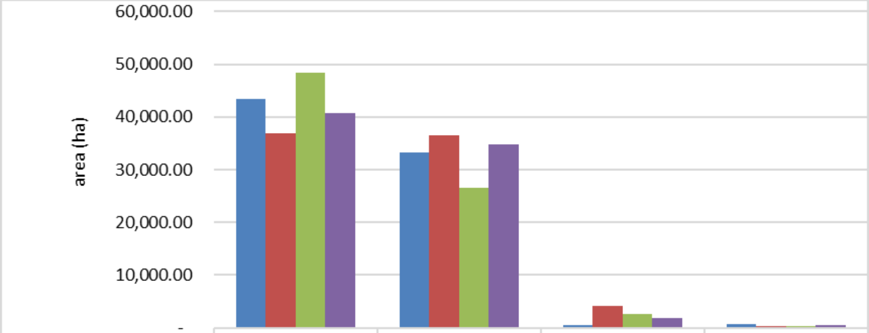
2.6 Ethical consideration

The data collection of this research occurred during the Covid-19 Pandemic. Although our study's locations experience relatively low incidents of Covid-19, we took careful measures to get the data. Hence, the most bias from this research is the distanced interaction between researchers and respondents. Secondly, as an ethical consideration, we always seek permission (both written and oral consent) from the village's head and all respondents involved in the study. We also obtained written permission to conduct the research from the authorities in Semanu, Panggang, and Girisubo districts. Formal letters were also sent to the leaders of each village. The interview data were recorded in MP3 format using a digitalized recorder, and the interview was then transcribed using software called Inqscribe. The transcribed text was then stored in a password-protected computer.

3. RESULTS

3.1 The dynamics of vegetation coverage

The vegetation coverage trend from the 1970s to the recent period shows a decrease in the low density of vegetation (NDVI 0-0,1). On the contrary, Vegetation with moderate density (NDVI 0.1-0.2) tends to decrease during the Reform Era, but it slowly increases during the Post Reform Era.



	Low density (NDVI 0-0.1)	Moderate density (NDVI 0.1-0.2)	High density (NDVI 0.2-1)	Open area, water, and/or cloud (NDVI -1-0)
The New Order Era I	43,494.30	33,303.62	403.42	638.52
The New Order Era II	36,824.45	36,575.10	4,199.95	240.29
The Reform Era	48,425.46	26,517.76	2,649.27	247.37
The Post Reform Era	40,775.46	34,758.67	1,908.46	397.27

Figure 2. The dynamics of vegetation coverage (ha) expressed in NDVI
[Source: Authors' analysis]

Vegetation with high density (NDVI 0.2-1) was at its highest during the late New Order Era (around the 1990s) but slowly decreased in the Post Reform Era. In the 1970s, low-density vegetation was observed at around 43,494.30 ha. This number decreased to 40,775.46 ha in the Post Reform Era in the 2011s. During the Reform Era, represented by LETM_120065_20020821, vegetation coverage with low density increased, while the coverage of high-density vegetation tended to decrease.

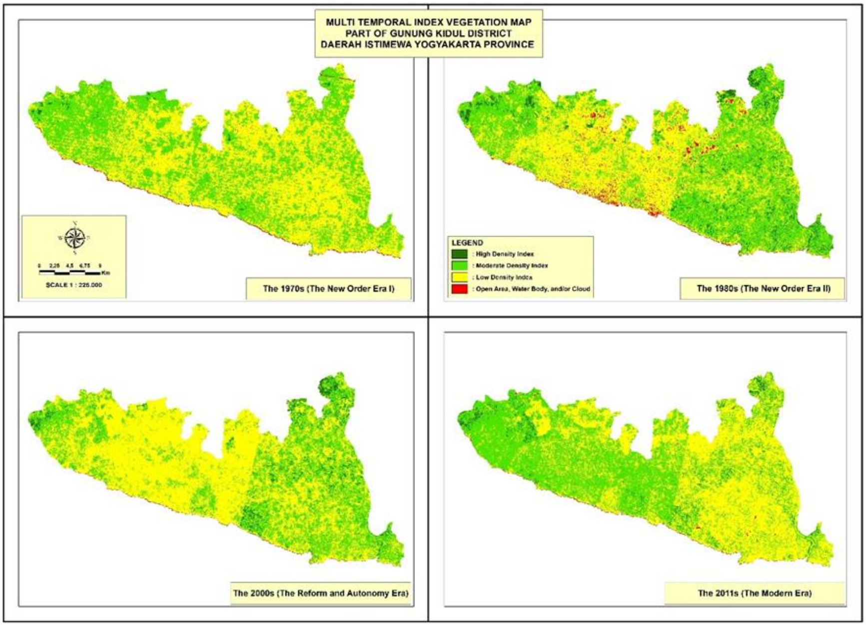


Figure 3. NDVI measures the dynamics of vegetation coverage. The image was created based on the political sequences in Gunungkidul karst that represent the New Order Era, the Reform Era, and the Modern/Post Reform Era
[Source: Authors' analysis]

3.2 The dynamics of sustainable livelihood assets

Table 4. The Dynamics of Sustainable Livelihoods Assets in Gunungkidul during the New Order Era, the Reform Era, and the Post-Reform Era.

1	The New Order Era				The Reform Era				The Post-Reform Era			
	S	P	G	Average**	S	P	G	Average**	S	P	G	Average**
HC	4.56	3.92	4.17	4.22 (M)	5.80	4.69	5.05	5.18 (M)	4.82	4.57	4.57	4.65 (M)
PC	3.06	2.48	3.42	2.99 (L)	3.73	4.49	4.21	4.14 (M)	4.18	4.37	4.75	4.43 (M)
SC	7.24	6.03	5.9	6.41 (H)	7.92	5.79	6.42	6.71 (H)	7.21	5.62	6.37	6.40 (H)
NC	5.84	5.37	5.2	5.47 (M)	5.81	5.8	5.23	5.61 (M)	5.85	5.56	5.32	5.58 (M)
FC	4.34	4.49	3.7	4.18 (M)	4.91	4.98	3.94	4.61 (M)	5.19	5.01	3.99	4.73 (M)

*S= Semanu District, P=Panggang District, G=Girisubo District. ** VL= very low (SLA <2), L= low represented in red (2.1-4), M=moderate represented in green (SLA 4.1-6), H=high represented in red (SLA 6.1-8), and VH=very high represented in blue (SLA >8.1).

Table 3 presents the calculation of sustainable livelihood assets among the studied households. Overall, the possession of SLA among the respondents is relatively stable, and most fall into the low and moderate categories. There was a slight increase in human capital (HC) from the New Order to the Post Reform Era. A steady increase is reported in physical capital (PC). On the other hand, the social capital (SC) is relatively steady, and the score of SC is the highest among all capitals. The natural capital (NC), however, shows a slight variation. It began at 5.47 in the New Order Era, dropped to 5.23 in the Reform Era, and bounced back to 5.58 in the Post-Reform Era. Lastly, the financial capital (FC) climbs slowly from 4.18 during the New Order Era to 4.61 in the Reform Era and 4.73 in the Post-Reform Era.

Figure 4 illustrates the dynamics of livelihood assets in Gunungkidul from the New Order Era to the Post-Reform Era. It shows that social capital has the highest value of all periods, whereas the lowest is in financial capital. In addition, human capital and natural capital are relatively steady. Meanwhile, the physical capital experience an increase due to the development of infrastructures and the ownership of transportation means, especially during the Reform and Post Reform Era.

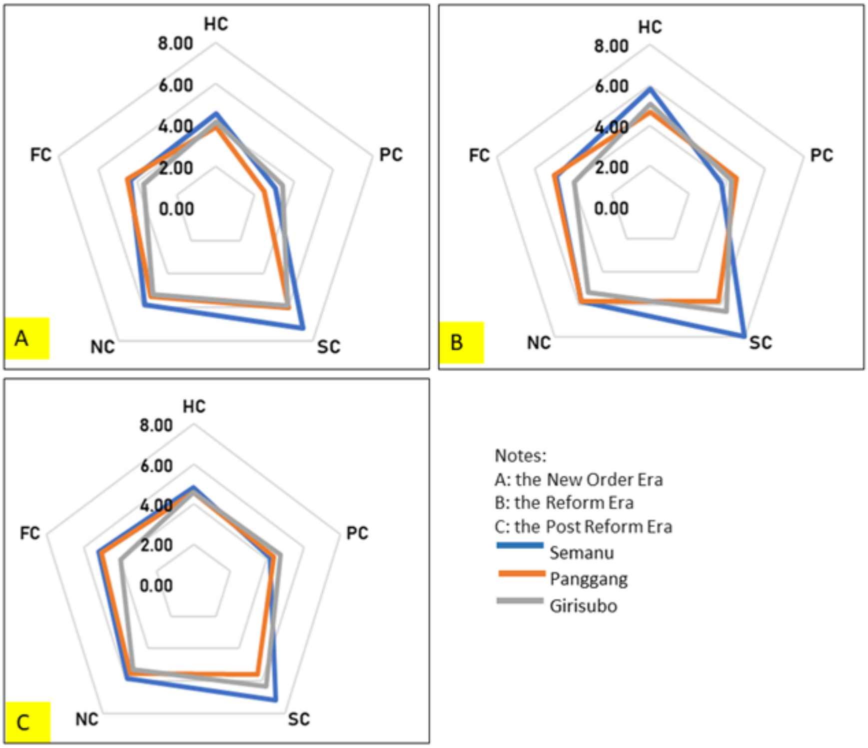


Figure 4. The pentagon of the SLA in Gunungkidul during the New Order Era, the Reform Era, and the Post-Reform Era
[Source: Authors' analysis]

3.3 The structure and composition of vegetation in the agroforestry systems.

The vegetation surveys represent the current situation of the agroforest ecosystem. The data could still represent the situation in the last 50 years because, according to the interviews with locals, the species composition in the karst ecosystem is relatively unchanged. The data were also cross-checked with previous research, especially by Faida et al. (2017), who studied the species composition in the area from the prehistoric period until the current era. This study differentiates three different types of agroforestry based on the condition of lands, namely agroforestry in karst valleys (*ngoro-oro*), hills (*gunung/perengan*), and home gardens (*pekarangan*).

3.3.1 In Karst Valleys (ngoro-oro)

The surveys found that a relatively homogenous species inhabits the agroforest in karst valleys (*ngoro-oro*). Several species are present in Semanu, Panggang, and Girisubo, namely albizia (*Albizzia chinensis*), teak (*Tectona grandis*), and *gamal* (*Gliricidia* *sepium*). The H' value is relatively low, between 0.51and 0.83, which means the biodiversity is low.

Table 4. Five species with the highest importance value index (IVI) and the diversity index (H') in karst valleys (*ngoro-oro*) of Semanu, Panggang, and Girisubo

Local name	Species	Family	N	FR.	KR	CR	IVI	H'
Semanu								
Sengon	*Albizia chinensis*	Fabaceae	4	83.33	85.71	86.96	256.0	0.5 1
Lamtoro	*Leucaena leucocephala*	Fabaceae	2	11.11	7.14	7.25	25.50	
Gamal	*Gliricidia sepium*	Fabaceae	2	5.56	7.14	5.80	18.50	
Jati	*Tectona grandis*	Lamiaceae	2	9.09	4.65	0.70	14.45	
Petai	*Fabaceae*	Parkia speciosa	1	4.55	2.33	5.63	12.50	
Panggang								
Jati	*Tectona grandis*	Lamiaceae	22	51.52	48.89	61.63	162.04	0.63
Sengon	*Albizia chinensis*	Fabaceae	13	42.11	41.94	45.22	129.26	
Gamal	*Gliricidia sepium*	Meliaceae	12	18.18	26.67	17.55	62.40	
Mahoni	*Switenia macrophyla*	Lamiaceae	6	21.05	19.35	13.04	53.45	
Akasia	*Acacia mangium*	Fabaceae	6	18.18	13.33	14.29	45.80	
Girisubo								
Jati	*Tectona grandis*	Lamiaceae	30	42.86	78.95	63.46	185.27	0.84
Nangka	*Artocarpus heterophyllus*	Moraceae	1	7.14	2.63	22.44	32.21	
Sengon	*Albizia chinensis*	Fabaceae	2	14.29	5.26	5.13	24.68	
Lamtoro	*Leucaena leucocephala*	Fabaceae	2	14.29	5.26	4.74	24.29	
Gamal	*Gliricidia sepium*	Fabaceae	2	14.29	5.26	3.21	22.75	

3.3.2 In Karst Hills (perengan/gunung)

Several species that compose agroforestry in karst hills include teak (*Tectona grandis*), mahogany (*Swietenia macrophylla*), and acacia (*Acacia auriculiformis*). The diversity index (H') falls into the low category (0.47 in Semanu) and moderate category (1.26 in Panggang and 1.30 in Girisubo). Overall, the H' of agroforestry in karst hills is higher than in karst valleys.

Table 5. Five species with the highest importance value index (IVI) and the diversity index (H') in the karst hills (*gunung/perengan*) of Semanu, Panggang, and Girisubo

Local name	Species	Family	Ni	FR.	KR	DR	I.V.I.	H'
Semanu								
Jati	*Tectona grandis*	Lamiaceae	65	76.92	89.04	88.72	254.68	0.47
Mahoni	*Switenia macrophyla*	Meliaceae	2	7.69	2.35	4.94	14.98	
Pete	*Parkia specieosa*	Fabaceae	1	3.85	1.37	3.08	8.29	
Kelapa	*Cocos nucifera*	Araceae	1	3.85	1.37	2.05	7.27	
Johar	*Senna siamea*	Fabaceae	1	3.85	1.18	2.47	7.49	
Panggang								
Jati	*Tectona grandis*	Lamiaceae	63	80.00	90.00	80.99	250.99	1.26
Mahoni	*Switenia mahogany*	Meliaceae	8	22.22	18.60	15.87	56.70	
Gamal	*Gliricidia sepium*	Fabaceae	9	16.67	20.93	15.26	52.85	
Akasia	*Acacia auriculiformis*	Fabaceae	7	16.67	16.28	12.79	45.73	
Sonokeling	*Dalbergia latifolia*	Leguminoceae	2	6.67	2.86	4.93	14.45	

Local name	Species	Family	Ni	FR.	KR	DR	I.V.I.	H'
Girisubo								
Jati	*Tectona grandis*	Lamiaceae	60	89.55	76.92	86.21	252.68	1.30
Mahoni	*Switenia mahogany*	Meliaceae	12	31.58	23.53	33.66	88.768	
Johar	*Senna siamea*	Fabaceae	3	7.895	8.824	5.882	22.601	
Acacia	*Acacia auriculiformis*	Fabaceae	2	2.985	7.692	8.79	19.467	
Lesenu	*Pipturus argenteus*	Malvaceae	2	5.263	5.882	7.353	18.498	

3.3.3 In Homegardens (pekarangan/pecuri)

The species that compose home gardens consist of trees that provide timber and plants as food sources. The trees that supply timber are teak (*Tectona grandis*), mahogany (*Swietenia macrophylla*), and *sengon* (*Albizia chinensis*). In addition, home gardens are inhabited by plants as a source of vegetables and food, for example, cassava (*Manihot esculenta*), *melinjo* (*Gnetum gnemon*), and *bauhinia* (*Bauhinia purpurea*). The diversity index (H') falls into the moderate category, that is, 2.08 in Semanu, 1.94 in Panggang, and 2.62 in Girisubo. Overall, the diversity of plants in home gardens is higher than that of karst valleys and karst hills.

Table 6. Five species with the highest importance value index (IVI) and the diversity index (H') in home gardens (*pekarangan/pecuri*) of Semanu, Panggang, and Girisubo

Local name	Species	Family	Ni	FR.	KR	DR	I.V.I.	H'
Semanu								
Ketela pohon	*Manihot esculenta*	Euphorbiaceae	12	29.17	38.71	32.08	99.95	2.08
Gamal	*Gliricidia sepium*	Fabaceae	5	16.67	16.13	14.15	46.95	
Jati	*Tectona grandis*	Lamiaceae	2	35.29	6.90	18.63	60.82	
Melinjo	*Gnetum gnemon*	Gnetaceae	2	8.33	6.45	11.32	26.11	
Mahoni	*Swietenia macrophylla*	Meliaceae	1	5.88	3.45	8.70	18.03	
Panggang								
Mahoni	*Swietenia macrophylla*	Meliaceae	13	24.24	24.53	30.70	79.47	1.94
Gamal	*Gliricidia sepium*	Fabaceae	15	18.18	28.30	8.12	54.60	
Jati	*Tectona grandis*	Lamiaceae	6	12.12	11.32	23.41	46.86	
Bauhinia	*Bauhinia purpurea*		6	15.15	11.32	4.68	31.15	
Melinjo	*Gnetum gnemon*	Gnetaceae	2	6.06	3.77	3.43	13.27	
Girisubo								
Jati	*Tectona grandis*	Lamiaceae	12	14.29	18.46	24.89	57.63	2.62
Sengon	*Albizzia chinensis*	Fabaceae	7	7.14	10.77	17.19	35.11	
Papaya	*Carica papaya*	Caricaceae	7	10.71	10.77	6.79	28.27	
Lesenu	*Pipturus argenteus*	Malvaceae	4	6.78	18.18	2.69	27.65	
Kersen	*Muntingia calabura*	Malvaceae	4	7.14	6.15	6.11	19.41	

3.4 The community's perception of agroforestry

3.4.1 List of species planted by respondents

The respondents listed 155 species in the agroforestry systems, either planted or of wild origin. Of the 155 species, 25 frequently mentioned species are analyzed descriptively (figure 5). The respondents mentioned that the five most common species found in their agroforestry systems are peanut (*Arachis hypogaea*), teak (*Tectona grandis*), *gude* bean (*Cajanus cajan*), albizia (*Albizia chinensis*), and cassava (*Manihot esculenta*). Other species present in the agroforestry system hold many benefits for the community. They serve as a source of food (rice, chili, papaya, corn, and bean), timber (teak, albizia, coconut), and animal fodder (Sesbania, Leucaena).

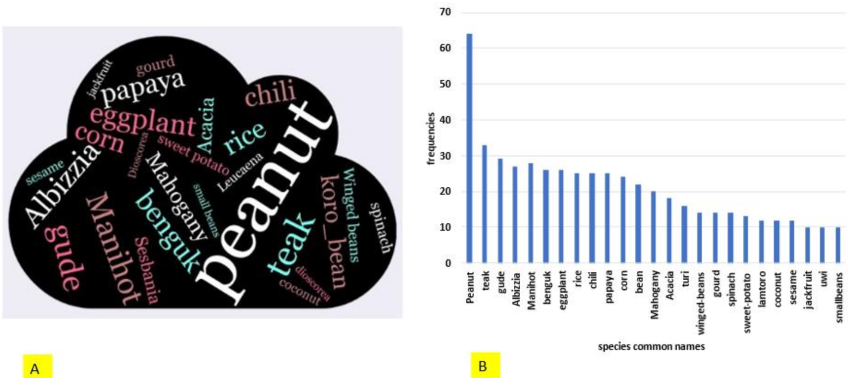
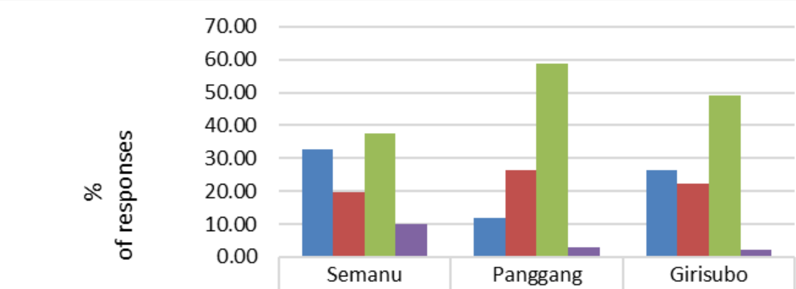


Figure 5. List of species planted by respondents. A. The word cloud illustrates the species list based on the respondent's perception, and the biggest font means that the species is more frequently mentioned, B. The graph shows species names and frequency mentioned by the respondents
[Source: World cloud illustration from www. Wordart.com]

3.4.2 The motivation for agroforestry practices

The question in this section is, what is the respondents' primary influence for practicing agroforestry? The respondents were asked to choose from 5 options: (a) meeting primary livelihood, (b) personal interest in developing agroforestry, (c) external motivation from parents and other farmers, (d) expanding business in timber and agroforestry produce. The result shows that respondents have high motivation from external sources in practicing their agroforestry systems. During the in-depth interview, this external motivation arrives from the government projects, CSOs, and NGO interventions. Several programs were cited by the respondents, namely Gelatik Program, GERHAN, and *Gerakan Penghijauan*. Usually, the programs provide farmers with several aids such as seeds, fertilizer, and to some extent, funds for maintaining the plants.



	Semanu	Panggang	Girisubo
Main income of livelihood	32.79	11.76	26.53
personal interest	19.67	26.47	22.45
external motivation	37.70	58.82	48.98
expanding bussiness	9.84	2.94	2.04

Figure 6. The motivation for practicing agroforestry (expressed in the percentage of responses by the respondents)

The second motivation comes from the benefit of agroforestry to sustain livelihoods. In Semanu, 32.79% of respondents indicate that the main motivation for practicing agroforestry is to meet livelihood, whereas the percentage in Panggang and Girisubo is only 11.79% and 26.53%. Interestingly, expanding business is not the primary motivation for respondents. The percentage in this category is only between 2.04% and 9.84%, much lower than other categories.

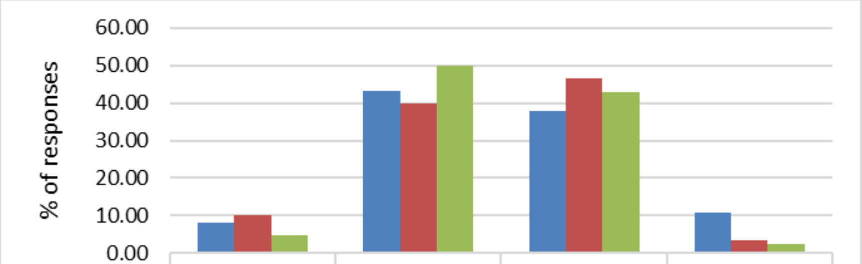
In terms of qualitative responses, several respondents cited that agroforestry helps them to meet their daily needs. Several respondents' statements are cited as follows:

> *"...rely on <u>rencek</u>* [tree branches] *for cooking and to make charcoal. The charcoals are sold in the local market, that* [how] *we made our living."* (Sm, Panggang, personal interview, 24 November 2020).

> "*I am a carpenter, hence to have a stock of timber is compulsory because If I go to buy timber from merchants, the timber is costly and is not as good as my own produce*" (Kw, personal interview, Semanu, 22 October 2020).

3.4.3 The successfulness of the practices

The question asked in this section is how respondents rate their success in the practice. The respondents were asked to score their success from one to four. A small percentage of respondents rate their efforts in agroforestry as very successful (2.38%-10.81%). Similarly, the percentage of respondents who see that their advancement in agroforestry is unsuccessful is also relatively low (4.76%-10.00%). Overall, most respondents view their success in agroforestry as moderate and successful.



	unsuccessful	moderate	success	very successful
Semanu	8.11	43.24	37.84	10.81
Panggang	10.00	40.00	46.67	3.33
Girisubo	4.76	50.00	42.86	2.38

Figure 7. The successfulness of agroforestry (expressed by the percentage of responses by the respondents)

Although respondents rate their success as moderate, some concerns are that their agricultural and agroforestry produce was likely to decline in recent years. The interviews with respondents indicate that there have been many obstacles in farming and agroforestry. Remarkably, they express that the lands have become drier and infertile. Some respondents' statements are as follows:

> *"... in the beginning, we cultivated the land around the 1980s, we had to clear the lands from shrubs and bush, then we put a lot of manure and organic fertilizer, but ten years ago, as the teaks grow big, our land becomes infertile and hard. Now we used chemical fertilizer, and the land became drier* [than without fertiizer]*, even the teaks died."* (Skm, personal interview, Semanu, 29 September

2020, notes added by authors are in brackets)

"[We have] *drylands in ngoro-oro* [karst valleys], … *planted teaks along the borders, but we sold them all in 2006. Now we only have small trees and cannot grow big*. [There is] *no water,* [the land] *gets dry, we have to draw water from luweng* (underground river)" (Spd, personal interview, Panggang, 2 March 2021, notes added by authors are in brackets)

3.4.4 Assets related to agroforestry practices

The average area for cultivation for each household in Gunungkidul is between 2,342.14 m^2 in Girisubo and 4,097.67 m^2 in Panggang. Not all farmers own the land. It could be rented for a specific price and period based on the agreement between the landlord and the farmer. The price for renting a piece of land, which people call *sak cluwik*[1] (around 1,000 m^2), is Rp. 750,000 – 900,000[2] per year. The price is negotiable based on the fertility of the land, the location, and access to the land. The estimated value of timbers per household is relatively low because the price of timber does not only depend on the size of the timbers but also the location of the agroforest. If the location of the timber is far from the main road, the price will be meager regardless of the size of the log. In Girisubo, the number of timbers owned by a household is considerably less than in Semanu and Panggang.

Table 7. Assets related to agroforestry in Semanu, Panggang, and Girisubo

Name of assets/practices	Semanu	Panggang	Girisubo
Average area cultivated by a household* (m^2)	3,492.16	4,097.67	2,342.14
The average number of timbers per household (DBH** ≥ 20 cm)	30.0	42.7	23.5
Estimated income from timber in Rupiah (average per household)	Rp. 4,675,000	Rp. 5,099,000	Rp. 3,850,000

*The number represents all areas cultivated by a household, including open fields for farming, rented lands (*tanah garapan*), and shared ownership with other family members; **DBH is the diameter of a breast-high, that is, a measuring method for a tree diameter at the breast level.

4. DISCUSSION

4.1 The dynamics of livelihoods, vegetation coverage, and political situations

During the New Order Era, regarding sustainable livelihood assets, the score of Human Capital, Natural Capital, and Financial Capital was moderate, and the score of Physical Capital was low. The highest score was measured in Social Capital. Farmers' natural capital was observed in moderate categories in all studied districts. At the same time, the analysis reveals that high-density vegetation increased from 403.42 ha in the early New Order Era to 4,199.95 ha in the late New Order Era. It could be assumed that the increase in vegetation coverage may help to sustain farmers' livelihoods at this time. The increasing trend of vegetation coverage, in turn, was supported by political initiatives during the New Order Era. The start of regreening programs in the 1960s, which increased vegetation coverage, may contribute to it. The program began with small demo plots in the newly opened Wanagama Forest in the northern part of Gunungkidul. The regreening project in Gunungkidul was highly supported by President Decree No. 5/ 1967 on the Basic Provision of Forestry. Although it was highly top-down,

[1] *Sak cluwik* literally means a small piece of land. Iinstead of quantitative measurement, locals used a descriptive measuring system. A relatively detailed glossary about the use of qualitative measurement was compiled by Nibbering (1991).

[2] The currency rate (as of 14th April 2022 is 1 USD equals to Rp. 14,353.60)

local authorities supported the program by enacting local policies such as the requirement to plant teak at school (*wiyata jati*) and to sow teak before marriage (*palokromo jati*) (Wicaksono, Awang & Suryanto, 2020).

The agroforestry development during this era could also be linked with Green Revolution, which aimed at increasing food resources through modern agriculture. The Green campaign includes plantation, forestry, cattle farming, and fisheries (Lohanda, 2017). Law No. 12/ 1992 on Plant Cultivation System provided a foundation for farmers to choose agricultural methods that suits their needs. At the local level, intercropping and traditional agroforestry systems were popular among the farmers. At this time, the choice of plants, fertilizers, and crop management was still influenced by the government through the officer from agricultural extension agents (*penyuluh*) (Indraningsih et al., 2010; Yumi et al., 2015).

The Mass Guidance (Bimbingan Masyarakat/BIMAS) during the New Order Era supported the implementation of the Five Principles of Complete Training (Panca Usaha Tani) as guidance to modernize agriculture based on the idea of Green Revolution (Nawiyanto, 2013). Panca Usaha Tani had allowed the use of chemical fertilizers, so the production of certain crops, such as cassava, maize, and peanuts, increased. The increase in food production improved food security. Therefore local farmers have less pressure to provide spaces for timber and non-timber plants (Filius, 1997).

To support the regreening projects and provide food security, the government encouraged local people to establish farmer groups. In turn, the farmers' organization served as social assets for villagers. Several farmers' organizations include the Agroforestry Farmer group (*Kelompok Tani Hutan Rakyat*/KTHR) in Girisuko Village and the Women Farmer Group (*Kelompok Tani Wanita*/KWT) in Pejaten Village. The establishment of these organizations was highly regulated and had been formulated since the Old Order Era (before the 1960s).

At the end of the New Order Era, the economic crisis hit Indonesia for a short time (around1997-1999), and then the Reform Era brought a new perspective to forest management, including in the agroforestry sector. During the transition from Reform Era to the Post-Reform Era, high-density vegetation coverage fell from 2,649.27 ha to 1,908.46 ha. It is no clear answer for this fall. However, several authors associated this occurrence with the economic and political crisis that struck Indonesia in the late New Order Era in 1997 (Sunderlin & Resosudarmo, 1997; Sunderlin, 1999). Sunderlin (1999) mentions that the increasing poverty during the crisis led to land clearings and tree felling. The case is confirmed by the NDVI analysis that shows a slight decrease from the early New Order Era to the late New Order Era.

Interestingly, although there was a reduction in vegetation coverage, the community did not experience a significant decline in livelihoods, especially in terms of Natural Capital and Physical Capital. The monetary crisis, which reduced vegetation coverage, did not pose a dangerous threat to people" livelihoods because farmers could sustain their basic needs, especially food. Farmers managed crop species in their land through agroforestry in the form of intercropping, alley cropping, and home gardens. The agroforestry system in Gunungkidul mainly consisted of low to moderate vegetation coverage. Farmers prefer trees with scarce foliage and moderate canopy coverage to provide space for food production. As can be observed in figure 5, several crops are cultivated under the canopy, such as peanut (*Arachis hypogaea*), cassava (*Manihot esculenta*), and rice (*Oryza sativa*). As financial assets, people see trees as their savings. The culture of *tebang butuh* (harvesting a tree when the farmer has urgent spending) (Fujiwara et al., 2011; Rohadi & Manalu, 2015) contributes to the availability of a safety net that sustains the financial capital.

Even though the crisis in 1997-1998 posed a danger to vegetation coverage, at the same time, it brought an opportunity to establish a new policy of decentralization and autonomy in forest management. The decentralization of forest management was expected based on Law UU No. 22/1999 and UU No.25/1999 on Local Government. Despite a chaotic political situation, Law No. 41/1999 on Forestry has involved the local community through public participation in forest management. As a result, the participation of native people in forest management and recognition of community forestry are expected. In Gunungkidul, acknowledgment of community forestry has been shown by the increase of vegetation with medium coverage, which consists of valuable timber and non-timber produce. With reform and autonomy, local governments encouraged local communities to tap the benefits of the forestry sector.

The regreening program under the National Movement of Land and Forest Rehabilitation (GERHAN) was enacted in 2003. The program encouraged tree planting in the state and privately-owned land and allowed local participation of farmers in forest management. Community Forestry and Small-scale Private Forests were acknowledged by Decree No. 41/1999, and the program was considered successful due to financial stimuli and subsidies (Fujiwara et al., 2011).

The Post-Reform Era or existing situation experienced an increase in vegetation coverage with moderate density from 26,517.76 ha to 32,74,758.67 ha. However, there is a decline in vegetation coverage with high density. This situation indicates a challenge in the agroforestry sector in Gunungkidul, mainly associated with the decline in wood quantity and quality. At the same time, people have more opportunities to sustain their livelihoods by entering the international wood markets. However, it was widely criticized that wood production in Gunungkidul had low quality and did not meet the criteria for ecolabeling and wood certification. The limitation was due to the incapabilities of forest management conducted by traditional farmers.

Private Forest Management Units were established in 2004 under the Governor's Decision No.95/2005. Under this legal framework, a sustainable private forest working group (POKJA-HRL) was also inaugurated. Later, local people developed a cooperative system for private forest management under the Koperasi Wana Manunggal (KWML). The cooperation helps farmers to increase their capacity to meet the requirements of wood certification. In addition, several NGOs and CSOs, including WALHI, Javlec, SOBI, and Kanopi, have aided farmers in sustaining their livelihoods by entering the international timber market (Roshetko et al., 2013; Sulistyaningsih, 2013).

An increasing economic situation in Indonesia marks the Post Reform Era. Access to the villages and market opens economic opportunities and increases the ownership of physical capital. In turn, people could sustain their livelihoods more effortlessly due to this growth. For example, in the 1970s, when the only transport available for farmers to go to the markets was the four-wheel car called Colt (Nibbering, 1991), farmers could only go to the market once a week. Today, with the increasing ownership of motorcycles, people can go to the market as needed. Increasing access to transportation is essential for the wood industry in Gunungkidul. It was reported that the price of wood in the remote areas of Gunungkidul has always been underpriced (Perdana, Roshetko & Kurniawan, 2012). One of the major causes is the high cost of transportation. The low price has also been associated with low human capital in Gunungkidul, hampering farmers from obtaining information and conducting price negotiations with wood buyers (Maryudi et al., 2015).

In addition, the quality of timber has been a significant concern for wood buyers. Despite the efforts to introduce modern silviculture techniques, farmers poorly manage their trees. They only fertilize, prune, and weed their trees during the intercropping phase. It explains why crop species still dominate most agroforest systems in

Gunungkidul. Hence cassava (Manihot esculenta) and papaya (Carica papaya) are measured with high important value index.

Although people enjoy the rapid development of infrastructure and the ownership of physical capital, in terms of human capital and natural capital, the figure has not been increasing noticeably. Both human and natural capital remains to fall into the low and moderate categories. It could be linked to the respondents' formal education that only finished elementary school. With limited access to improve their knowledge of forestry, most respondents rely on traditional methods of planting and tree maintenance. There have been several programs to increase farmers' knowledge of forest management, for instance, the establishment of *Sekolah Lapangan* (Field School) for farmers under the supervision of the Department of Forestry (Yumi et al., 2015) and the Master Treegrower Traning Program (Anggraini et al., 2021). Previous studies confirmed that the farmers' adoption of innovative approaches is low; hence it poses a challenge to modern forest management (Anggraini et al., 2021; Seruni et al., 2021). Rather than acquiring innovation, farmers who hold extensive lands are more likely to manage their timbers (Sabastian et al., 2014, 2019).

4.2 The Structure and Composition of Species

The result shows that majority of the respondents are categorized as smallholder farmers who hold less than 0.5 ha of land for cultivation. The smallholder farmers are often called *petani gurem* (BPS, 2013). Most plants in the agroforestry system are newly introduced species and hybrid crops such as rice and corn. With this kind of composition, it is no surprise that the observed diversity index (H') in the agroforestry system range from low to moderate. Species with a high IVI value are typically woody species, such as teak and albizia. It shows that the farmers assess the choice of plants based on their economic value and contribution to livelihoods. Moreover, the ability to allocate assets such as knowledge (human capital), land (natural capital) and social influence (social capital) determine the choice of plants that will support sustainable livelihoods. Due to this reason, wild species, such as Ficus and Euphorbiaceae, tend to gain less attention in the system.

Several woody species have high IVI values, such as teak, albizia, acacia, and mahogany. The presence of those species in the ecosystem could be linked with the government's regreening program in the early New Order Regime. It was reported that Wanagama Forest pioneered the regreening project in Gunungkidul (Ernawati, 2016). The project began with the replanting of barren land with teak, albizzia, acacia, mahogany, and some nitrogen-fixated species such as lamtoro (*Leucaena*) and turi (*Sesbania)*. Hence, the spread of the species in the agroforestry system could not be separated from the establishment of Wanagama Forest.

Although the dominant species are woody, the vegetation survey confirms that there are some crop species, such as cassava (*Manihot esculenta*), papaya (*Carica papaya*), and melinjo (*Gnetum gnemon*). Mixing woody species, perennial trees, and crops are widespread in the agroforestry system of Gunungkidul (Haryono et al., 2022). Similarly, tubers, such as *garut* (*Maranta arundinacea*), kana (*Canna edulis*), and uwi (*Dioscorea esculenta*), are also planted in between trees to provide carbohydrate sources for farmers. The finding confirms previous research by Maharani et al. (2022) and Purnomo et al. (2013).

Despite the goal of meeting livelihoods, farmers' choice of species reflects political initiatives that influence Gunungkidul. For example, teak (*Tectona grandis*) has always had high importance value index. It shows the dominance of teak in the system due to several enabling policies. Local policies of Palokromo Jati and Wiyata Jati that were established during the New Order Era may contribute to such popularity of teak agroforestry in Gunungkidul. On the other hand, several species have been introduced recently, such as Acacia. It had just been introduced in Indonesia in 1993 following the robust development of pulp industries (Griffin et al., 2011).

4.3 The Community's Perceptions

First, the community confirms that the primary motivation for planting trees in the agroforestry system is to meet basic livelihood needs. Only a tiny percentage of respondents (4,94 %) aim at expanding their timber production to meet the industrial markets. Generally, trading timber produced by smallholder farmers in developing countries faces constant low returns (Aoudji et al., 2012; Rohadi & Manalu, 2015), difficulty meeting market demands, and negotiating prices (Arvola et al., 2019). In Gunungkidul, it was reported that the possession of more extensive land grants farmers to allocate more land devoted to planting trees (Sabastian et al., 2014). Hence, it is challenging for farmers to accept agroforestry as a business model due to limited ownership of lands and the few trees they can plant on their farms. As this study found, on average, a household owns between 23 and 40 trees with a diameter of more than 20 cm.

Secondly, the community believes that their success rate for on and off-farm incomes from agroforestry is only moderate. It could be proven by the income from agroforestry which ranges from Rp. 3,850,000 to Rp. 4,675,000. The income is slightly different from a survey conducted by Fujiwara et al. (2018), who revealed that the average yearly income was 5,7 million rupiahs. The difference is due to respondents citing that the price of wood has been decreasing in recent years. Recently, farmers reported a higher cost of production because of the price of inorganic fertilizers and the expense of drawing water from underground rivers.

The general summary of the dynamics of agroforestry and livelihoods in Gunungkidul is presented in figure 8.

Figure 8. The dynamics of agroforestry, livelihoods, and vegetation compositions in Gunungkidul karst.

5. CONCLUSION

This study demonstrates the dynamics of agroforestry development in Gunungkidul, which corresponds to political initiates set up by the country's administration in the New Order Era, Reform Era, and Post-Reform Era. The regreening project in the Early New Order Era has been a successful example of a forest rehabilitation program. However, the success of reforestation in Gunungkidul faced an economic crisis at the end of the New Order Era. The decline of vegetation coverage during this period confirms this situation. Entering the Reform Era, vegetation coverage with moderate density has increased steadily. There has been an improvement in the forestry sector due to several government initiatives and policies. In terms of SLA, there has been no significant change in people's livelihoods. Generally, the SLA falls into low and moderate categories. A slightly increasing trend could be observed in the physical and financial capital. Overall, the political initiatives have enabled agroforestry development to support sustainable livelihoods. Next, regarding respondents' perception, generally, people manage agroforestry to meet basic needs. Finally, based on vegetation surveys, it could be reported that people manage agroforestry in karst valleys, hills, and home gardens. The system consists of a mixture of plants that supply timbers, foods, and fodder which reflects the farmers' ability to allocate the available assets to sustain their livelihoods. In addition, the composition and species found in the system also represent the influence of policies and governments on agroforestry development. Based on the findings, the study suggests a connection between political initiatives, livelihoods, and agroforestry development. Future agroforestry management should pay more attention to the livelihood contribution of agroforestry systems.

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