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Rural peoples' perception, attitude, and engagement on invasive alien plants in Mount Manunggal, Cebu Island, Philippines

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ABSTRACT

This research examines the perceptions of rural residents of Mount. Manunggal, Cebu Island, Philippines, on the impact of unintentionally introduced invasive alien plants, such as Mikania micrantha, Lantana camara, and Chromolaena odorata, on their livelihoods. Results suggest that their perception of the impact of each species on their livelihood varies based on criteria such as: (1) the length of time invasive alien plants have been established in the forest, and (2) the kind of household. In addition, a household study revealed that forest-adjacent homes have reacted to invasive alien plants as both victims and beneficiaries. Most of the surveyed 77 families are likely to adapt to the invaded environment because they have a history of interacting with invasive alien plants and regard them as wonderful sources of necessities if appropriately involved. In addition, the data demonstrated rural residents are eager to invest in the control and management of invasive alien plants provided the government provides standardized and adequate technical methods and skills. Without government and stakeholder assistance, decreasing the invasion is seen as impossible, and the acceptance of invasive alien plants as part of the rural ecology is foreseen as a predictable result.

1. INTRODUCTION

Invasive alien plants (IAPs) are non-native plant species that pose a threat to native ecosystems and habitats, especially native species (Chandra & Idrisova, 2011; Early et al., 2016; Pyek et al., 2020). Intentionally or unintentionally introduced, these IAPs have ecological impacts that might influence economic operations in diverse nations (Holmes et al., 2009). Recent research shows that economic activities such as technology improvements, commerce, and domestic and international travel are contributing to the invasion of IAPs in forest ecosystems around the globe (Kramer, 2021). Introducing IAPs into forest ecosystems changes ecosystem structures and dynamics, including the number, diversity, and composition of plant species. IAPs are thus one of the primary causes of ecosystem change and the second greatest threat to forest ecosystems after habitat degradation (Egoh et al., 2020).

Garces (2019) and Garces & Genterolizo (2018) argue that the indirect negative impacts of IAPs on natural ecosystems are more complex than the direct negative effects. Despite the economic and aesthetic benefits of IAPs, there remain controversies over their classification as friend or foe, pest, or resource, and weed or marvel (Bellard et al., 2016). Consequentially, the continuous invasion of IAPs may cause problems in disturbed ecosystems, particularly in rural communities where people frequently and directly take part in forest management and where forest products (e.g.,

medicinal herbs, firewood, and fodder) are a major contributor to agricultural household production. This argues for the need of recognizing the importance of certain IAPs in local livelihoods as a component of good forest management policies and policymaking processes.

Besides disparities in the relationship between IAPs and rural livelihoods, previous research shows that IAPs have substantially invaded developed countries (Nunez & Pauchard, 2010). However, suitable control policies in developing countries may be more conducive to preserving biological diversity because these nations have more diverse habitats, and interventions to control the spread and invasion of IAPs may be more cost-effective because of the availability of cheaper labor than in developed nations (Russell et al., 2017). Understanding the attitudes and reliance of rural people on IAPs is necessary for sustainable forest management, particularly in dynamic forests where community-based forestry is the prevalent technique in continually degraded and deforested forests in the Philippines. This research examined (1) the perception and social attitudes of rural people about IAPs in the buffer zone of Mt. Manunggal, Cebu Island, Philippines, and (2) the effects of unintentionally transported IAPs, such as *Mikania micrantha*, *Lantana camara*, and *Chromolaena odorata*, on their livelihoods.

2. MATERIALS AND METHOD

2.1. Study sites and methods

Mt. Manunggal (Figure 1) is the tallest mountain peak in Brgy. Sunog, Balamban, Cebu, rising 1003 m above sea level about 35 km northwest of Cebu City. Its entire land area is 500 hectares, and its latitude and longitude are 10° 27' 39.41" north and 123° 46' 50.72" east. The water from the peak's secondary pocket forest, canyons, cliffs, caves, waterfalls, gullies, and stream drains into two major rivers: the Combado River in Balamban, which borders Cebu Central Park to the north, and the Banban River, which crosses the park's southern half. According to Republic Act 7586, sometimes referred to as the National Integrated Protected Area System (NIPAS), it lies inside the Central Cebu Protected Landscape (CCPL) enclave (Ong, 2002).

According to Garces (2019), a combination of native plants and IAPs predominate at the research site. Additionally, rare, and indigenous species of flora and wildlife were discovered at the research location. However, the site is dominated by IAPs, including *Elephantopus mollis*, *Ageratum conyzoides*, *Paspalum conjugatum*, *Imperata cylindrica*, *Axonopus compressus*, *Swietenia macrophylla*, and the three most dominant IAPs in the site, *Mikania micrantha* (mile-a-minute), *Chromolaena odorata* (triffid-weed), and *Lantana camara*. These species were identified based on the publication of Vila et al. (2009).

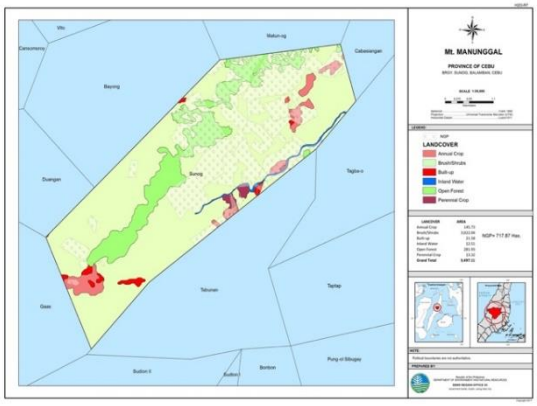

Figure 1. Geographic location of the study area at Mt. Manunggal, Cebu Island, Philippines

Mt. Manunggal is characterized by the third climate type. It has a rather wet period from October to April and a dry and cool season for the remainder of the year (Philippine Atmospheric, Geophysical, Astronomical, Services Administration [PAGASA], 2020). The lowest temperature is 17˚C, while the highest temperature is merely 32˚C. The mountain range and ridges are typically shrouded in fog before sunrise and after sunset. The forest had been a hub for recreational activities, resulting in a continuous flood of local and foreign tourists, mainly from the lowlands, and a lack of environmental awareness, which has led to the rapid deforestation of the region and exacerbated environmental degradation (Garces, 2019; Garces, 2018). Grazing, forest slashing and clearing, poaching, and hunting are some of the most common anthropogenic activities that cause the unintentional and deliberate introduction of IAPs.. Local villagers are engaged in abaca clearance and abaca processing/plantation, which are their means of subsistence (Garces, 2019).

The researcher obtained permission from the barangay Local Government Unit (LGU) to conduct a survey at the selected study sites. This was essential so that the LGU could offer a trail guide to accompany the researcher. Using the Census Method, a face-to-face interview was done with each household's head to collect vital information

such as informant's information, economic position, and the economic applications of plants. Mount Manunggal being a protected area, a free permit was obtained from Region VII of the Department of Environment and Natural Resources (DENR-7). The study sites in Mt. Manunggal, Cebu Island, Philippines, included a highly disturbed site (Site 1), which is a campsite with more anthropogenic activities occurring in the area, and a less disturbed site (Site 2), which is at the mountain's peak and where anthropogenic activities are less prevalent than in Site 1. Both sites have been invaded by IAPs, but the volume and intensity of human activity at each site vary. Less is known about the impact of unintended and intentional IAPs on rural populations. Although accidentally introduced IAPs like *Mikania*, *Lantana*, and *Chromolaena* have the potential to cause economic and environmental harm on a worldwide scale, these plants have significant utility for rural populations. This study seeks to determine the social attitudes of rural populations regarding the three IAPs of the study site: (1) *Mikania*, (2) *Lantana*, and (3) *Chromolaena*.

2.2. Household survey

The researcher performed a personal interview with the household's head using the Census method. These homes had close relationships with the IAPs Mikania, Lantana, and Chromolaena. In the overall study, semi-structured questionnaires were used to establish the demographic profile, economic position, and economic uses (part(s) used and category of use) of all native species and IAPs. The surveys contained three sections: (1) the demographic profile of the respondent (head of household), (2) the respondent's economic condition, and (3) the economical use of plant species. The economic applications of native plants and IAPs were examined. As a constraint of the study, only the scientific name, plant family, origin of introduction, and economic applications of each native plant and IAP species on Mt. Manunggal, Cebu Island, Philippines were recorded. For the economic utilization of rural communities for the three IAPs, the primary objective of this study is to determine how people value specific IAPs in terms of the change in their abundance, effects on their households, uses of IAPs, how they emerged in the area, and probable control management strategies. The home interviews were conducted between November 2016 and May 2017.

This study employed ordinal logistic regression (OLR) models to identify the variables that influence the effects of a particular IAP (Ei). In particular, the formula used is $E_i = \alpha + \beta_1 S_i + \beta_2 O + \beta_3 D + \beta_4 G + \beta_5 U_i$, where α is a constant term, and the β_1 to β_5 are the coefficients of the explanatory variables; status of the IAP (S_i), primary occupation of the respondents (O), distance between the forest and hose in km (D), gender of the respondents (G), and plant use (U_i). OLR models are among the most commonly used statistical methods in ecology, especially in this study, where the independent factors are utilized to determine the effects of plant invasion in the study site.

Table 1. Local name and occurrence of the IAPs

Species	Local name	Occurrence
Mikania micrantha	Bikas, Detitid, Tamburakan, Uoko	Agriculture land, swampy, riverine forests
Lantana camara	Bahug-bahug, Baho-baho, Bangbangsit, Diris, Koronitas, Kantutay, Lantana	Agriculture land, Grassland, swampy areas, floodplains, forests, and grasslands' edges
Chromolaena odorata	Agonoy, Hagonoy, Gonoy, Hulugonoi	Grassland, agriculture land, floodplains.

3. RESULTS AND DISCUSSION

3.1. Knowledge of invasive alien plants (IAPs)

All respondents were aware of the presence and distribution of IAPs in the remnant forests of Mt. Manunggal, Cebu Island, Philippines. They were familiar with the forest's IAPs and their occurrences. In addition, they could distinguish between the three IAPs, even though these plant species were all used as crop vegetation on the same plot of land. The three IAPs were popularly referred to by their respective names, namely *Mikania*, *Lantana*, and *Chromolaena* (Table 1). In addition, household respondents stated that the introduction and spread of IAPs were increased by various factors (i.e., extreme floods, undisturbed presence of IAPs, favorable environmental conditions, low environmental pollution, their constant growth,

application of chemical fertilizers, and unregulated grazing ban in the forests).

As showed in Table 2, most household respondents (n = 76; 96.10%) believe Mikania micrantha has increased rapidly over the past 5 to 10 years. It was also noted that a majority (n=41; 53.25%) of the household respondents believe Lantana camara is on the rise, but less than 6% are unaware that this IAP exists in the forest of Mt. Manunggal, Cebu Island, Philippines (Table 2). In contrast, there was no consensus whether Chromalaena odorata was increasing or decreasing based on the opinions of household respondents in areas covered by IAPs (Table 2).

Table 2. Respondents' view on a change in area covered by the IAPs in Mt. Manunggal, Cebu Island, Philippines

	Number of respondents [a]		
	Chromolaena odorata	*Lantana camara*	*Mikania micrantha*
Don't know	0 (0)	4 (5.19%)	0 (0)
Decrease	22 (28.57%)	11 (14.29%)	0 (0)
No change	15 (19.48%)	12 (15.58%)	0 (0)
Gradual increasing	24 (31.17%)	41 (53.25%)	3 (3.90%)
Rapidly increasing	16 (20.78%)	9 (11.69%)	74 (96.10%)

[a]*Percentage of the respondents using IAPs in parentheses.*

Table 3. Use of the IAPs in Mt. Manunggal, Cebu Island, Philippines

Species	Use	Number of HH using[a]
Chromolaena odorata	Fodder (during wet season mainly goat grazers)	20 (25.97%)
Lantana camara	Fuelwood, fodder, medicine (on cuts and wounds)	24 (31.17%)
Mikania micrantha	Fuelwood, fencing, compositing, fodder, bio-pesticide, medicine	33 (42.86%)

[a]*Percentage of the respondents using IAPs in parentheses.*

3.2. Effects of the IAPs on local livelihoods

Existing community forests are the primary source of fuelwood, fodder, and thatching materials for all the households surveyed on Mt. Manunggal, Cebu Island, Philippines. Less than 2% of residents in the study area individually own a section of land containing their principal source of forest products. Among them, *Mikania* had the greatest impact on their way of life (98%), while Lantana and *Chromolaena* had only moderate and low impacts, as stated by 45% and 48% of the household respondents, respectively.

Table 4. Key variables and coding

Variables	Description	Coding
Effects of IAPs	How people perceive the effects of the IAP on their livelihoods based on the forest products availability, condition of the forests and wildlife crop raiding?	4=High effect 3=Medium effect 2=Low effect 1=Don't know 0=No effect
Status of IAPs	How the IAP has spread in the landscape over the last 5-10 years, according to the individual evaluation of the respondents?	5=Rapidly increasing 4=Gradually increasing 3=No change 2=Decreasing 1=Off farm 0=Agriculture
Occupation	The primary occupation of the respondents	
Gender	Interviewed household heads, whether male or female	1=Female 0=Male
IAP use	Do households use the IAPs to meet the demands for their household needs?	1=Use 0=Not use
Distance	Walking distance between respondents' household and their respective community forests in minute.	

In this study, ordinal logistic regression was used to determine the variables that influence the effects of a certain IAP (Ei). This regression was based on the model: $E_i = \alpha + \beta_1 S_i + \beta_2 O + \beta_3 D + \beta_4 G + \beta_5 U_i$,

where α is a constant term, and the β_1 to β_5 are the coefficients of the explanatory variables; status of the IAP (S_i), primary occupation of the respondents (O), distance between the forest and hose in km (D), gender of the respondents (G), and plant use (U_i).

Table 4 contains the variables in question. Regarding socioeconomic characteristics, occupation, gender, and proximity to the forest were crucial aspects of forest product consumption on Mt. Manunggal, Cebu Island, Philippines. In addition, the effects of IAPs vary according on the quantity, aggression, and gender of these species.

Intriguingly, Table 5 revealed that the status of the IAPs significantly influenced the observed effects of a particular IAP on household respondents for all IAPs. Nonetheless, socioeconomic variables such as forest proximity, household occupation, and the use of a particular IAP were found to be relevant only for the species *Mikania* ($Coefficient_1$= -4,418 (0.455)). Regarding the observed effects of the three IAPs on males, there is no significant gender difference ($Coefficient_1$ = -0.215 (0.784), $Coefficient_2$ = -0.673 (0.452), and $Coefficient_3$ = 0.057 (0.224)).

Table 5. Variables that influence the effects of the IAPs

	Variables	Coefficients		
		$Coefficient_1$	**$Coefficient_2$**	**$Coefficient_3$**
		Mikania	*Lantana*	*Chromolaena*
Threshold	Effect=1	7.511 (2.244) **	2.116 (0.613) ***	1.664 (0.577) ***
	Effect=2	13.243 (6.813) ***	7.542 (0.701) ***	6.433 (0.345) ***
	Effect=3	13.054 (6.671) ***	10.441 (0.794) ***	9.542 (0.659) ***
Location	Distance	1.100 (0.280) ***	-0.004 (0.160) ^{ns}	-0.132 (0.179) ^{ns}
	Invasiveness status	7.222 (5.432) ***	2.887 (1.091) ***	2.553 (1.624) ***
	Occupation (off-farm)	-4.418 (0.445) ***	-0.225 (0.334) ^{ns}	0.045 (0.332) ^{ns}
	Male	-0.215 (0.784) ^{ns}	-0.673 (0.452) ^{ns}	0.057 (0.224) ^{ns}
	Plant use	3.43 (0.73) **	0.304 (0.132) ^{ns}	0.440 (0.313) ^{ns}
Model fitting	-2 Log likelihood	193.443/68.391	391.33/404.221	405.948/266.653
	Chi-square	58.488 ***	80.544 ***	79.431 ***
Pseudo R^2	Cox and Snell	0.410	0.515	0.505
	Nagelkerke	0.613	0.583	0.495

Standard error (SE) in parentheses.

**Indicate significant at 5%.*

****Indicate significant at 1%.*

^{ns}*Indicate not significant.*

3.3. Controlling the colonization of the IAPs

All household respondents started numerous control management actions for IAPs, showing that there was no external funding or organization support from public or private entities to restrict the spread of IAPs on Mt. Manunggal, Cebu Island, Philippines. Because of the presence of three IAPs on the same parcel of primarily privately held land, the site's control management requirements were not rigorously adhered to. Most respondents stated that the initial rationale for the introduction and control of IAPs is the same regardless of plant species. Most household respondents use measures such as burning, chemical application, cutting, grazing, strip cropping, and uprooting to combat the invasion of IAPs (Figure 2). It was determined that uprooting (n = 96%), cutting (n = 66%), and burning (n = 33%) are the most common strategies used by respondents to restrict the introduction and spread of IAPs. These methods are prevalent in their agricultural lands and surviving wooded regions. 38% of household respondents implied that there are "no control management mechanisms" for all three IAPs. They concluded that floods, which wash these IAPs out of the forest, are one of the natural strategies to control these pests. Most household respondents believed that uprooting (96%) was the most effective method for preventing the spread of IAPs at the site, followed by cutting (52%) and burning (25%). Most of the household-suggested control actions were comparable to the actual control measures. Similarly, the application of herbicides, cultivation, and grazing were some of the control management strategies practiced and suggested by household respondents to prevent the spread of IAPs.

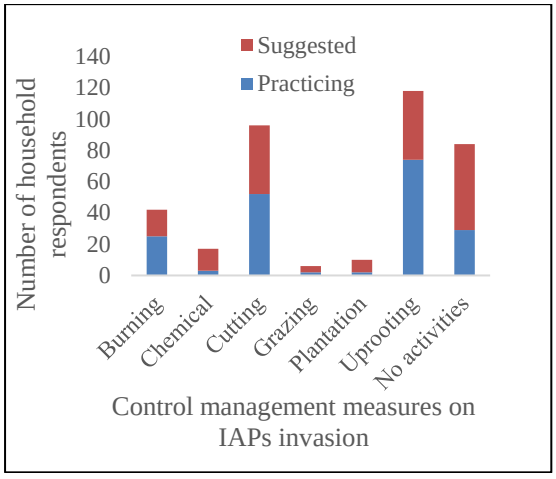

Figure 2. Number of household respondents in Mt. Manunggal, Cebu Island, Philippines

The effects of IAPs on the rural inhabitants of Mt. Manunggal, Cebu Island, Philippines, remain unclear and indirect. This could be because of differences in preferences among rural household respondents. According to the microeconomic theory of consumer preferences, consumers' preferences are influenced by their way of life, closeness to forests, and use of IAPs, as well as the use value and threat associated with IAPs (Ackerman, 1997). These regionally specified factors (residence time, planting intensity, species abundance, species richness, and species attributes) aid IAP invasion and establish rural communities' IAP usage (Dainese & Poldini, 2012). Since the type of goods and services given by these IAPs varies with time and technology, the preferences of rural populations about IAPs may evolve with time.

Most household respondents were also aware of the harmful effects of increased species richness and abundance of IAPs on local species in the woods of Mt. Manunggal, Cebu, Philippines. As an example, Mikania micrantha, a newly introduced species, grows more rapidly than other IAPs and native species identified in the sites. Catford et al. (2018) and Pyek et al. (2017) note that this has a substantial influence on native biodiversity by either moving them or removing them from their native environment over a longer period. Economically, this IAPs may enhance the susceptibility of rural populations' means of subsistence, given that the different uses of IAPs (e.g., firewood and fodder) are seasonal favorites. This implies that the inadvertent introduction and steady spread of IAPs such as *Mikania*, *Chromolaena*, and *Lantana* may undermine the disturbed forest's natural potential to recover and thrive (Parker et al., 2013).

Lack of external support is a significant issue in the difficulty of regulating the growth and spread of IAPs. It is obvious from the responses of households that they are implementing the most effective solutions to the worst conditions that currently exist. As a solution, they use IAPs as feed, fuelwood, fences, and even medicine to adapt to the shifting conditions caused by the proliferation and invasion of IAPs. In contrast, the negative effects associated with these IAPs can be transformed into helpful economic goods, albeit with external support because of their measurable but short-term profits (Sitzia et al., 2016). With *Chromolaena*, this IAP possesses wound-healing properties (Sirithipaporn & Jiraungkoorskul, 2017), antibacterial properties (Obiefu et al., 2021), and immunopotential properties (Vandebroek & Picking, 2020), all of which apply in Mt. Manunggal, Cebu Island, Philippines, and could diversify rural livelihoods with human intervention. Those who use *Chromolaena* outnumber those who do not, as more household respondents use *Chromolaena*.

The other newly introduced IAPs in this study (*Mikania* and *Lantana*) have notable positive and negative effects on the household respondents. For example, *Mikania* vines do not supply essential forest products required for daily use. Rural communities are compelled to exploit IAPs, however, because of organizations' lack of investment and strategies to stop the spread and invasion. This instance can be altered based on the presence of forest commodities at a certain period; rural communities are unlikely to benefit from the improvement of livelihood schemes such as traditional farming. In this study, nearly one-fourth of household respondents used Mikania vines as fodder during wet seasons, even though Mikania vines have detrimental effects on animal health. Certainly, these Mt. Manunggal respondents cannot adjust their livelihood strategies and prefer to battle with the least accessible option.

Those household respondents who have frequent and close interaction with IAPs are more likely to depend on IAPs. Those that rely on IAPs as their primary source of income have a greater impact than low-level users. This link suggests that the expansion and disruption of IAPs influence the households surveyed, as they alternative ecosystems and displace native species, hence affecting the presence of forest commodities. In addition, the

positive correlation for *Mikania* use (Coefficient1=1.100; Table 5) can be attributed to the fact that rural communities located closer to IAPs are not only subject to their detrimental effects but are also compelled to use them. The great supply of IAPs, which increases opportunity costs for people who do not use IAPs and promotes overexploitation, is one underlying cause (Hanley & Roberts, 2019).

Most women in rural economies play crucial roles in the production of forest products. Generally, the introduction of IAPs has a greater effect on women because they perform more household duties, such as gathering firewood and caring for livestock (Ghosh, 2021). These are crucial to their incomes, which in turn impact their well-being and domestic security. There was no significant difference between the effects of IAPs detected in males and females in this study (Coefficient1= -0.215; Coefficient2= -0.673; Coefficient3=0.057). This could be related to the negative and positive effects of IAPs as perceived by households rather than individuals. However, additional research is required to determine its impact.

There are also recorded disputes in this study on prospective IAP control management strategies. Some household respondents believed that the expansion of IAPs was the result of a grazing ban, which allowed the IAPs to proliferate. In addition, a high proportion of household respondents favored the usage of herbicides against IAPs. Implementation of such management measures may be disruptive, as IAPs can rapidly colonize disturbed ecosystems (Verrugge et al., 2021). Particularly, the practice of overgrazing can modify forest litters and transform them into bare ground, which can cause socioeconomic harm by increasing surface runoff and leading to the desertification of forest areas. To develop a more effective control management strategy, however, it is important to emphasize the need for rural communities to be more aware of the multifaceted effects of IAPs, as well as the importance of government and stakeholder collaboration. Therefore, the participation of the government, non-governmental organizations (NGOs), and its stakeholders is essential for designing a more effective control management measure for the proliferation of IAPs in forest ecosystems and enforcing this scheme with continuous updates on its implementation (Goyal et al., 2021; Cayot et al., 2021).

Although there are significant differences between the implemented and control management strategies on Mt. Manunggal, most household respondents favor uprooting and cutting (based on manuals) for preventing the development of IAPs. Evidently, a standardized guidebook can aid in enhancing the understanding of rural populations (i.e., the proper method of cutting and uprooting) regarding *Mikania*, *Chromolaena*, and *Lantana*, the three most prevalent IAPs on Mt. Manunggal, Cebu Island, Philippines. In community-based forests such as Mt. Manunggal, where most rural people consciously and unintentionally influence forest activities, the usage of a standardized manual is also appropriate. Monitoring and reducing the development of IAPs in disturbed and undisturbed ecosystems is facilitated by the availability of low-cost labor in developing nations, such as the Philippines (Hoare, 2021).

4. CONCLUSION

During the initial period of their invasion, the purposeful and unintentional introduction of IAPs with damaging growth rates has negative effects on rural lives. Collectively, the top 3 IAPs (*Mikania*, *Lantana* and *Chromalaena*) have detrimental effects on the surviving forests of Mt. Manunggal, Cebu Island, Philippines, and their expansion is likely reducing with time, as rural people respond to factors that threaten their economic well-being and attempt to regulate changes in ecosystem dynamics. These improvements may include: (1) controlling the spread of IAPs as a preventative strategy to mitigate forest harm; and (2) identifying IAP alternatives, such as native plants, as useful resources for rural livelihoods. However, it cannot be concluded that IAPs should be allowed to develop and invade readily until rural populations can adapt. As most IAPs continue to serve the secondary requirements of rural people on Mt. Manunggal, this could be a workable method for controlling the escalating spread of IAPs in the forest. To build this plan, households living in border regions must serve as the frontline, as they are both victims and creators of IAPs' commodity use. In rural communities, manual eradication is one of the most recommended methods, regardless of any gaps in practices and conventional control procedures. Despite deploying such control measures, which primarily target IAPs with a lengthy history in the environment, the potential of these IAPs should still be considered. In this study, there is also the risk of engaging in behaviors with negative repercussions, such as the widespread use

of free grazing and the kaingin system on Mt. Manunggal, Cebu Island, Philippines. By disrupting numerous ecosystems, these behaviors may provide a favorable climate for the spread of IAPs. The level of social consciousness is highlighted as one of the recurring obstacles in regulating the development of IAP in developing nations, such as the Philippines. As a result, it is recommended that rural populations be provided with awareness programs. Without establishing and regulating control measures in rural areas, farm households would continue to use IAPs for consumption; yet they can be commoditized to grow rural livelihoods with the help of external aid.

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