BIODIVERSITAS
Volume 22, Number 7, July 2021
Pages: 2579-2588

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d220705

Assessing the utilization of naturalized alien plant species by community to inform its management strategy: A case study in Cibodas Biosphere Reserve, West Java, Indonesia

AISYAH HANDAYANI[1,3,♥], ERVIZAL A.M. ZUHUD[2,♥♥], DECKY INDRAWAN JUNAEDI[3]

[1]Natural Resources and Environmental Management Science Program, Graduate School, Institut Pertanian Bogor. Jl. Raya Pajajaran, Campus IPB Baranangsiang, Bogor 16000, West Java, Indonesia. Tel.: +62-251-8332779, ♥email: handayani88aisyah@apps.ipb.ac.id
[2]Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry and Environment, Institut Pertanian Bogor. Jl. Lingkar Akademik, Campus IPB Dramaga, Bogor 16680, West Java, Indonesia. Tel.: +62-251-8621677, Fax.: +62-251-8621256, ♥♥email: eamzuhud@apps.ipb.ac.id
[3]Cibodas Botanic Gardens, Research Center for Plant Conservation and Botanic Gardens, Indonesian Institutes of Sciences. Jl. Kebun Raya Cibodas, Sindanglaya, Cipanas, Cianjur 43253, West Java, Indonesia

Manuscript received: 6 April 2021. Revision accepted: 7 June 2021.

Abstract. *Handayani A, Zuhud EAM, Junaedi DI. 2021. Assessing the utilization of naturalized alien plant species by community to inform its management strategy: A case study in Cibodas Biosphere Reserve, West Java, Indonesia. Biodiversitas 22: 2579-2588.* Alien plant species can have two side effects, either positively in terms of the utilization of these species to fulfill human needs, or negatively in terms of their invasion which might threaten biodiversity and reduce land productivity. Yet, it is not clear how an introduced plant species can be carefully managed and utilized (so-called Naturalized Alien Plant Species/NAPS) so that the NAPS does not become Invasive Alien Plant Species (IAPS). Using Cibodas Biosphere Reserves (CBR), West Java, Indonesia as a case study, this study aims to investigate the utilization of Naturalized Alien Plant Species (NAPS) by local communities in the buffer zone of CBR and quantify the utilization of NAPS based on cultural perspective using Index Cultural Significance (ICS) framework. Data were collected by distributing questionnaires and interviewing 90 respondents in three locations around CBR: Bodogol, Cibodas, and Gekbrong. The results showed that the community used 72 Naturalized Alien Plant Species, with 30% of the utilized plants were from Asteraceae family. *Centella asiatica* was the most widely used species, but the species with the highest Index Cultural Significance value was *Artemisia vulgaris*. Based on the ICS classification, there were ten species (13.89%) with high significance values, 17 species (23.61%) with moderate significance, 30 species (41.67%) with low significance, and 15 species (20.83%) with very low significance. Species with high significance values were *Artemisia vulgaris, Chimonobambusa quadrangularis, Bidens pilosa, Mentha arvensis, Amaranthus spinosus, Centella asiatica*, *Cyphomandra betacea*, *Calliandra calothyrsus*, *Fragaria vesca*, and *Solanum torvum.* Based on these results, the recommended strategy is to regularly harvest the Naturalized Alien Plant Species with high ICS value to control their population and fulfill community needs.

Keywords: Asteraceae, alien species management, Gunung Gede Pangrango National Park, Index Cultural Significance

INTRODUCTION

Invasive alien species (IAS) have negative impacts on native ecosystems (Jeschke et al. 2014). The impacts of IAS are determined by the level of species invasiveness and its biological characteristics, and are often worsened by human involvement and global climate change (Rai and Kim 2020). In protected areas, the impacts of IAS can be in the form of the domination of IAS over native species which leads to the extirpation of biodiversity at a landscape scale and the degradation of ecosystem services provided by the protected areas (Jeschke et al. 2014; Foxcroft et al. 2017; Rai and Kim 2020; Rai and Singh 2020). In productive landscapes, for example, agricultural lands, the invasion of IAS can significantly affect the productivity of the land which eventually reduces the capacity of the landscape in fulfilling human needs (Rai and Singh 2020; Rai and Kim 2020).

Invasive Alien Plant Species (IAPS) is plant introduced into a new region away from its original geographical distribution which can quickly spread and invade the new region (Knezevic 2017; Rai and Singh 2020; Pyšek et al. 2020). On the other hand, Naturalized Alien Plant Species (NAPS) is defined as plant introduced into a new location where it can survive, live under biotic and abiotic factors, and form a self-sustaining population without human intervention (Richardson et al. 2000; Pyšek et al. 2017). Richardson et al. (2000) stated that invasive plant refers to introduced plant that produces reproductive offspring in areas distant from the initial location of the introduction at an approximate scales of more than 100 m with time span of fewer than 50 years for taxa spreading by seeds and other propagules, or more than 6 m in three years for taxa spreading by roots, rhizomes, stolons or creeping stems. By that, the term invasive can be used without any inference to environmental or economic impact.

Kueffer (2017) said that human-related factors could facilitate the invasion of an introduced species and play an essential role in biological invasion mechanisms. Therefore, social and economic aspects, including the utilization of NAPS, can be important to control NAPS population to prevent it from becoming invasive (i.e., to

avoid the NAPS becoming IAPS). Several studies showed that NAPS significantly contribute to fulfilling human needs such as food sources, medicinal uses, ornamental plants, fodders, firewoods, and other functional benefits (Zimdahl 2018; Shackleton et al. 2019; Shrestha et al. 2019). Similarly, several IAPS has the potentials to be used for phytoremediation and restoration of aquatic and terrestrial ecosystems, such as *Lantana camara* and *Eichhornia crassipes* (Rai and Singh 2015; Negi et al. 2019; Rai and Kim 2020). Other IAPS, such as *Ageratina adenophora* and *Ipomoea carnea* ssp. *fistulosa* can also be utilized to minimize flood and landslide risks (Shrestha et al. 2019).

While the definition between NAPS and IAPS can be clearly explained as mentioned above, the mechanism on how an introduced plant species is carefully managed and utilized so that the NAPS does not become IAPS is unclear. Using Cibodas Biosphere Reserves (CBR) as a case study, this study aims to investigate the utilization of Naturalized Alien Plant Species (NAPS) by local communities in the buffer zone of CBR and quantify the utilization of NAPS based on cultural perspective using Index Cultural Significance (ICS) framework (Turner 1988). There are only two studies on the utilization of alien plant species in CBR, i.e., alien plant species utilization study using secondary data (Handayani and Hidayati 2020) and ethnobotanical studies of *Passiflora edulis* at Sarongge (Setiawan et al. 2020). This study will complement the existing studies on alien plant species in CBR in the theme of species inventory (Mutaqien et al. 2011; Sunaryo et al. 2012; Kudo et al. 2014; Padmanaba et al. 2017), taxonomical studies (Damayanto and Muhaimin 2017) and ecological studies (Junaedi and Mutaqien 2018). We expect that through the social approach conducted in this study, proper management to prevent invasion risk of NAPS to become IAPS can be formulated.

MATERIALS AND METHODS

Study location and period

The study was conducted at three buffer zones of Cibodas Biosphere Reserve (CBR), namely Cibodas, Bodogol, and Gekbrong, which are directly located next to the CBR core zone (Gunung Gede Pangrango National Park forest areas) (Figure 1). The elevation of the sampling location in Bodogol was approximately 600 m above sea level (m asl.), sampling location in Cibodas area ranged from 1100 to 1200 m asl and the Gekbrong sampling location was located at 1200 m asl. Sampling and data collection were conducted from August 2020 to September 2020 with activities including the arrangement of administrative permission from local government, the early survey to sampling locations, and data collections.

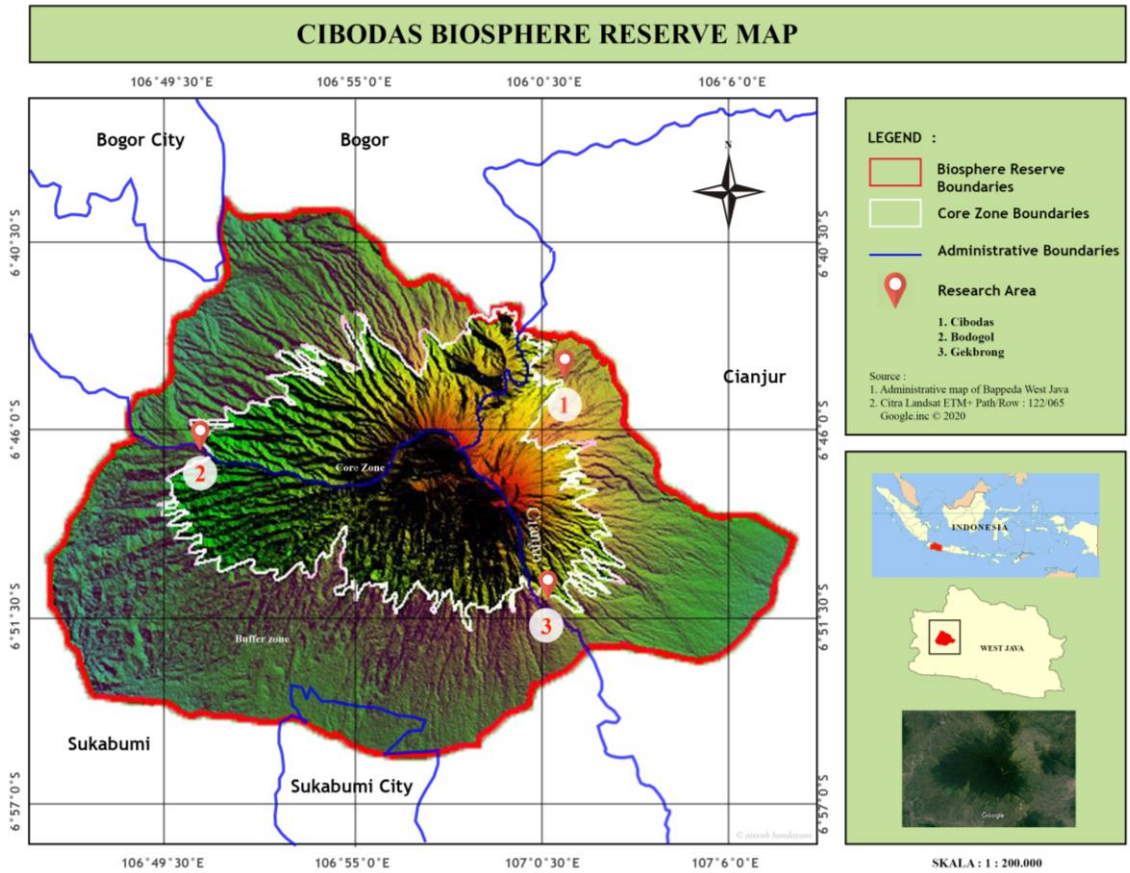

Figure 1. The three research sites in Cibodas Biosphere Reserve, West Java, Indonesia

Data collections

A survey was conducted to distribute questionnaire to 90 respondents from all sampling areas. Respondents were chosen by simple random sampling method. We used this sampling type based on the assumption that all residents have equal chances and access to utilizing Naturalized Alien Plant Species (NAPS) in the CBR forest area. Identification of utilized NAPS and its origin based on database of World Flora Online (http://www.worldfloraonline.org/) (WFO 2021) and Plants of the World Online by the Royal Botanic Gardens, Kew (http://www.plantsoftheworldonline.org/) (POWO 2021). The questionnaire was designed to capture the data needed to calculate/quantify the Index Cultural Significance (Turner 1988). The information filled in the questionnaire by the respondent consisted of personal information (i.e., age, gender, education, and occupation), category of utilization of the NAPS (i.e., medicine, food and other food as raw or cooked vegetables, ornamental plant, dye, aromatic and flavoring, fodder, firewood, functional food, timber, recreation, culture/tradition purposes, and other purposes), part of the plant being utilized (i.e., leaves, fruits, seeds, trunks, barks, flowers, roots and all parts of the plant), utilization processes if used as traditional medicine, where these species collected from (i.e., yard, farm, forest edges, and in the forest area), the intensity of this utilization (scores: 1-5), and the level of preference of this utilization (scores: 0,5, 1, and 2).

Data analysis

The Index of Cultural Significance (ICS) is a proper quantitative method to determine the value of utilized species by communities (Turner 1988). The ICS data can be obtained from interviews or questionnaires targeted to relevant respondents. The ICS value is calculated from the quantification of the categorization of species utilization (e.g., primary or secondary food, flavoring, animal food, primary or secondary material, dye, firewood, medicine, spiritual use, and miscellaneous), the intensity of use, and the species' exclusivity (Turner 1988). The intensity of use and exclusivity level are estimated subjectively based on the respondents' assessment of the used species. The more it is used and the more irreplaceable, the higher its ICS value.

Assessment with the ICS framework can identify the importance of Naturalized Alien Plant Species (NAPS) in the community observed in this study. The collected data from the questionnaire were processed in Microsoft Excel to extract the respondent profiles, the utilized NAPS, category of utilization, part of the plant that utilized, location of collected NAPS, and ICS scores. The ICS score/value was calculated using the following formula (Turner 1988):

$$\text{ICS} = \sum_{i=1}^{n} (q \text{ x } i \text{ x } e)u_i$$

Where: ICS is Index of Cultural Significance, *q* is utilization quality, *i* is utilization intensity, *e* is utilization exclusivity, and *n* is utilization category (1 to n).

The result of ICS calculation then was classified based on the following categorization proposed by Turner (1988): ICS > 100 (very high significance), 50-99 (high significance), 20-49 (medium significance), 5-19 (low significance), 1-4 (very low significance).

RESULTS AND DISCUSSION

The utilization of naturalized alien plant species

Based on questionnaire results, as many as 72 Naturalized Alien Plant Species (NAPS) from 25 families were utilized by local communities in CBR (Table 1). More than 30% of these utilized species belong to Asteraceae family (Figure 2). In this study, Asteraceae that were frequently utilized are: *Ageratum conyzoides, Artemisia vulgaris, Bidens pilosa, Cosmos caudatus, Galinsoga parviflora* and *Spilanthes acmella.* Asteraceae is the most prominent dicot family due to their widespread distribution, fast evolution, and high adaptation capacity to a new environment, making this family easy to be found everywhere and indicates that Asteraceae has a robust invasion mechanism (Carlquist 1976). Many studies have recorded the utilization of Asteraceae species as traditional medicine and food source. However, the studies of Asteraceae capacity to generate secondary metabolites are still understudied, and commercial product from this Asteraceae utilization is still limited (Panda et al. 2019). Asteraceae species also have potential use as organic pesticides due to their allelopathic capacities (Benvenuti et al. 2017).

Among the three surveyed sites, Cibodas had the highest utilization activities (i.e., 14 utilization activities per respondent on average) and the number of NAPS (i.e., 69 species) (Table 2). There are several possible explanations for these findings. First, the respondents in Cibodas mostly had farmland and yard areas where NAPS occurred. Second, several respondents who collected NAPS from the forest edges of GGPNP mostly come from the Cibodas area. Third, several respondents are Cibodas Botanic Gardens staff who have adequate understanding and knowledge about plants, including NAPS, and its utilizations for food, medicinal, and ornamental plants.

Based on the survey results, the most frequent NAPS utilization was for medicine, followed by ornamental plants, food, and fodder (Figure 3). There were 50 species utilized as medicine, 49 species as ornamental plants, 29 species as food and fodder. From a total of 50 species utilized as traditional medicine, the top five of the most-utilized ones were *Ageratum conyzoides, Centella asiatica, Artemisia vulgaris, Kalanchoe pinnata,* and *Physalis peruviana* (Table 1). Almost all of these species were utilized in all three survey locations, except for *Artemisia vulgaris* which were utilized at Bodogol and Cibodas only. Traditional medicine utilization was mainly to cure indigestion, sprue, body sore, fever, and skin diseases. *Ageratum conyzoides* was used to treat the wound and reduce gastritis, *Artemisia vulgaris* to eliminate body odor, *Kalanchoe pinnata* to reduce fever, and *Physalis peruviana* to treat muscle aches and pains.

Table 1. List of Naturalized Alien Plant Species (NAPS), geographical origin and utilization by respondents in Cibodas Biosphere Reserve, West Java, Indonesia

Species	Family	Lifeform	Origin of the species*	Utilization category
Ageratina riparia (Regel) R.M.King & H.Rob.	Asteraceae	Herbs	Mexico	F, M, O, D, Fd, OF, Fw, Ot
Ageratum conyzoides (L.) L.	Asteraceae	Herbs	Mexico	F, M, O, Fd
Ageratum houstonianum Mill.	Asteraceae	Herbs	Mexico to Central America	F, M, Fd
Amaranthus spinosus L.	Amaranthaceae	Herbs	Mexico to Tropical America	F, M, D, Fd, OF
Artemisia vulgaris L.	Asteraceae	Herbs	Temperate Eurasia to Indo-China, North Africa	F, M, O, Fd, OF, Fw
Austroeupatorium inulaefolium (Kunth) R.M.King & H.Rob.	Asteraceae	Shrub	Panama to South Tropical America, Trinidad	M, Fd, Fw, Ot
Bartlettina sordida (Less.) R.M.King & H.Rob.	Asteraceae	Shrub	Mexico to Guatemala	O
Bellucia pentamera Naudin	Melastomataceae	Tree	Mexico to S. Tropical America	F, O
Bidens pilosa L.	Asteraceae	Herbs	Topical, Subtropical America	F, M, O, Fd, OF, P
Browallia americana L.	Solanaceae	Herbs	Central Mexico to Tropical America	O
Brugmansia candida Pers. syn. *Brugmansia x candida* Pers.	Solanaceae	Tree	S. Colombia to Ecuador	M, O, Fw
Brugmansia suaveolens (Willd.)f Sweet	Solanaceae	Tree	Brazil	M, O, OF, Fw, Ot
Brugmansia versicolor Lagerh.	Solanaceae	Tree	W. Ecuador	O, Fw
Calathea lietzei É. Morren syn. *Maranta lietzei* (E.Morren) C.H.Nelson, Sutherl. & Fern.Casas	Marantaceae	Herbs	E. Brazil	O
Calliandra calothyrsus Meisn	Fabaceae	Shrub	South Mexico to Central America	F, O, Fd, OF, T, Fw, Ot
Centella asiatica (L.) Urb.	Apiaceae	Herbs	Caucasus, Old World to New Zealand, South West Pacific	F, M, O, Fd, OF
Cerastium glomeratum Thuill.	Caryophyllaceae.	Herbs	Europe, Macaronesia to Assam	O, Ot
Cestrum aurantiacum Lindl.	Solanaceae	Shrub	Mexico to Venezuela	M, O, Fw
Cestrum elegans (Brongn. ex Neumann) Schltdl.	Solanaceae	Shrub	Mexico	M, O'
Chimonobambusa quadrangularis (Fenzl) Makino	Poaceae	Bamboo	SE. China to Vietnam, Taiwan	F, O, OF, T, Fw, P, Ot
Cinchona pubescens Vahl	Rubiaceae	Tree	Costa Rica to W. South America	M, T, Fw
Clibadium surinamense L.	Asteraceae	Shrub	Tropical America	Fd, Fw
Clidemia hirta (L.) D. Don	Melastomataceae	Shrub	Mexico to Tropical America	F, M, O, D, Fd, OF
Cobaea scandens Cav.	Polemoniaceae	Climber	Mexico	M, O
Cosmos caudatus Kunth.	Asteraceae	Herbs	Mexico to South Tropical America	F, M, O, C, Fd, OF
Cyphomandra betacea (Cav.) Sendtn. syn. *Solanum betaceum* Cav.	Solanaceae	Shrub	S. Tropical America	F, M, O, OF
Dichrocephala bicolor Schltdl. syn. *Dichrocephala integrifolia* (L.f.) Kuntze	Asteraceae	Herbs	Turkey-in-Europe to Asia, Pacific	Fd
Dracaena fragrans (L.) Ker Gawl.	Asparagaceae	Shrub	Tropical Africa	M, O, Ot
Drymaria cordata (L.) Willd. ex Schult.	Caryophyllaceae	Herbs	Mexico to S. Tropical America, Tropical, S. Africa	O
Emilia sonchifolia (L.) DC. ex DC.	Asteraceae	Herbs	Old world	F, M, O, OF
Erechtites valerianifolius (Wolf) DC.	Asteraceae	Herbs	Mexico to Tropical America	F, M, O, Fd, OF
Eryngium foetidum L.	Apiaceae	Herbs	Mexico to Tropical America	F, M, OF, Ot
Euphorbia hirta L.	Euphorbiaceae	Herbs	Tropical, Subtropical America	F, M
Euphorbia prostrata Aiton	Euphorbiaceae	Herbs	Macaronesia to West Siberia, Pakistan	F, Fd
Fragaria vesca L.	Rosaceae	Herbs	Europe	F, M, O, D, Fd, Ot
Galinsoga parviflora Cav.	Asteraceae	Herbs	Mexico to Tropical America	M, Fd
Gnaphalium purpureum L.	Asteraceae	Herbs	E. Canada to Tropical America	O
Hyptis brevipes Poit.	Lamiaceae	Herbs	Southeast Mexico to Tropical America	Fd, P
Indigofera suffruticosa Mill.	Fabaceae	Shrub	Tropical, Subtropical America	M, D
Kalanchoe pinnata (Lam.) Pers. syn. *Bryophyllum pinnatum* (Lam.) Oken	Crassulaceae	Herbs	Madagascar	M, O
Lantana camara L.	Verbenaceae	Shrub	Mexico to Tropical America	O, P
Maesopsis eminii Engl.	Rhamnaceae	Tree	Liberia to South Sudan, Zambia	Fd, T, Fw, Ot
Melastoma malabathricum L.	Melastomataceae	Shrub	Seychelles, Tropical and Subtropical Asia to N. and E. Australia	F, M, O, D, Fd, Fw
Mentha arvensis L.	Lamiaceae	Herbs	Europe to Kamchatka, Nepal	F, M, O, Fv, OF
Mikania cordata (Burm.f.) B.L.Rob.	Asteraceae	Climber	Old World	M, Fd
Oxalis barrelieri L.	Oxalidaceae	Herbs	Tropical America	F, M, O, Fv
Oxalis corniculata L.	Oxalidaceae	Herbs	Mexico, Venezuela, Peru, Caribbean	F, M, O, Fv, Ot
Oxalis latifolia Kunth.	Oxalidaceae	Herbs	Tropical and Subtropical America	F, M, Fv, OF

Passiflora edulis Sims	Passifloraceae	Climber	Brazil to North-East Argentina	F, M, O, OF
Passiflora ligularis Juss	Passifloraceae	Climber	Panama to Venezuela, Peru	F, M, O
Passiflora suberosa L.	Passifloraceae	Climber	Caribbean	F, M, O
Physalis peruviana L.	Solanaceae	Herbs	Bolivia to West Brazil	F, M, O, Fd
Piper aduncum L.	Piperaceae	Tree	Mexico to Tropical America	M, O, Fd, Fw
Podachaenium eminens (Lag.) Sch.Bip. ex Sch.Bip.	Asteraceae	Shrub	Mexico to Colombia	Fw, Ot
Salvia hispanica L.	Lamiaceae	Herbs	Mexico to Ecuador	O
Sida rhombifolia L.	Malvaceae	Shrub	Tropical and Subtropical Old World	F, M, O, Fd, Ot
Solanum aculeatissimum Jacq.	Solanaceae	Shrub	Southeast and South Brazil to South Central Paraguay	O
Solanum americanum Mill.	Solanaceae	Herbs	New World	F, M, D, Fd, OF, Ot
Solanum torvum Sw.	Solanaceae	Shrub	Mexico to South America, Caribbean,, East Brazil	F, M, O, Fd, OF, Fw
Solanum verbascifolium Kunth syn. *Solanum bicolor* Willd.	Solanaceae	Shrub	Florida, Bahamas, Texas to Guatemala	M, Fw
Sonchus arvensis L.	Asteraceae	Herbs	Europe to Siberia, Caucasus	M, Fd,
Sonchus asper (L.) Hill	Asteraceae	Herbs	Temp. Eurasia, N. Africa to Sahel, Somalia	M
Sonchus oleraceus (L.) L.	Asteraceae	Herbs	Macaronesia, Europe to Medit., Sahara to Arabian Peninsula	M, OF
Spilanthes acmella (L.) L.	Asteraceae	Herbs	Tropical and Subtropical Asia to Queensland (Torres Strait Islands)	F, M, Fd, OF
Stachytarpheta jamaicensis (L.) Vahl	Verbenaceae	Shrub	East USA to Tropical America	M
Stellaria media (L.) Vill.	Caryophyllaceae.	Herbs	Temp. Eurasia, N. and NE. Tropical Africa	M
Taraxacum officinale (L.) Weber ex F.H.Wigg. syn. *Taraxacum campylodes* G.E. Haglund	Asteraceae	Herbs	East USA to Tropical America	M, O, OF
Tetrapanax papyrifer (Hook.) K.Koch	Araliaceae	Shrub	Central and S. China, Taiwan	O
Thunbergia coccinea Wall.	Acanthaceae	Climber	Indian Subcontinent to China (Yunnan), Indo-China	O
Tithonia rotundifolia (Mill.) S.F.Blake	Asteraceae	Shrub	Mexico to Central America	M, O
Viola odorata L.	Violaceae	Herbs	Europe to W. and N. Iran, NW. Africa	M, O
Wedelia trilobata (L.) Hitchc. syn. *Sphagneticola trilobata* (L.) Pruski	Asteraceae	Herbs	Mexico to S. Tropical America, Trinidad	M, O, Fd, Fw

Note: F: Food; M: Medicine; O: Ornament; D: Dye; Fv: Flavouring and aromatic; Fd: Fodder; OF: Other food; T: Timber; Fw: Firewood; P: Playing and recreation; O: Other. *: data from Plants of the World Online (http://www.plantsoftheworldonline.org/)

Table 2. The number of respondents, utilized Naturalized Alien Plant Species (NAPS) and the type of utilization across the surveyed sites in Cibodas Biosphere Reserve, West Java, Indonesia

	Bodogol	**Cibodas**	**Gekbrong**
∑ Respondents	22	39	29
∑ Utilized NAPS	25	69	39
Average of utilization per respondent	3.32	13.77	1.93

The most utilized NAPS for food were *Passiflora ligularis*, *Passiflora edulis*, *Fragaria vesca*, and *Physalis peruviana* as the source of fruits. *Solanum americanum*, *Centella asiatica*, *Amaranthus spinosus*, *Mentha arvensis*, *Chimonobambusa quadrangularis* were utilized as vegetable sources.

Centella asiatica (local name: antanan) was the most utilized NAPS with the most frequent use for medicine and food source (Table 3). The utilization of *C. asiatica* as medicine and food is already recorded in many plant utilization studies in Indonesia (Wakhidah and Mustaqim 2020). Based on many clinical tests, *C. asiatica* can cure neurological diseases and skin diseases (Sun et al. 2020). Related to its invasive characters, *C. asiatica* can quickly propagate vegetatively, have a high growth rate, and is a shade-tolerant species but also grows under full sun conditions, adaptable in different soil conditions, and a cosmopolitan species that occurs from 300 to 1450 m asl. (CABI 2020; Devkota and Jha 2009; PIER 2014). Even though *C. asiatica* is classified as high risk based on invasiveness scoring, there is no report about the negative impact of this species on economy yet (CABI 2020; PIER 2014).

The most commonly used part of the plant in NAPS utilization in CBR was the leaves (Figure 4). The sensible explanation for this result is that leaves are more abundant than other plant's parts and are easier to collect. The many uses of the leaves of NAPS cause no need for the cultivation of these species since the leaves can be harvested from wild plants. Another part that been used quite large was all parts of the plant. This method is usually applied to herbaceous plants.

Table 3. List of top ten utilized Naturalized Alien Plant Species (NAPS) (10 out of 72) in Cibodas Biosphere Reserve, West Java, Indonesia the highest number of utilization activities

Species	Family	Local names	Number of utilization activities	Number of respondents
Centella asiatica (L.) Urb.	Apiaceae	Antanan	83	38
Calliandra calothyrsus Meisn	Fabaceae	Kaliandra	58	24
Ageratum conyzoides (L.) L.	Asteraceae	Babadotan	50	37
Chimonobambusa quadrangularis (Fenzl) Makino	Poaceae	Kirisi	47	20
Mentha arvensis L.	Lamiaceae	Keresmen	44	24
Artemisia vulgaris L.	Asteraceae	Artemisia	43	23
Cosmos caudatus Kunth.	Asteraceae	Ramidang	41	16
Kalanchoe pinnata (Lam.) Pers. syn. *Bryophyllum pinnatum* (Lam.) Oken	Crassulaceae	Cocor bebek	34	22
Amaranthus spinosus L.	Amaranthaceae	Bayem	33	16
Bidens pilosa L.	Asteraceae	Hareuga	33	16

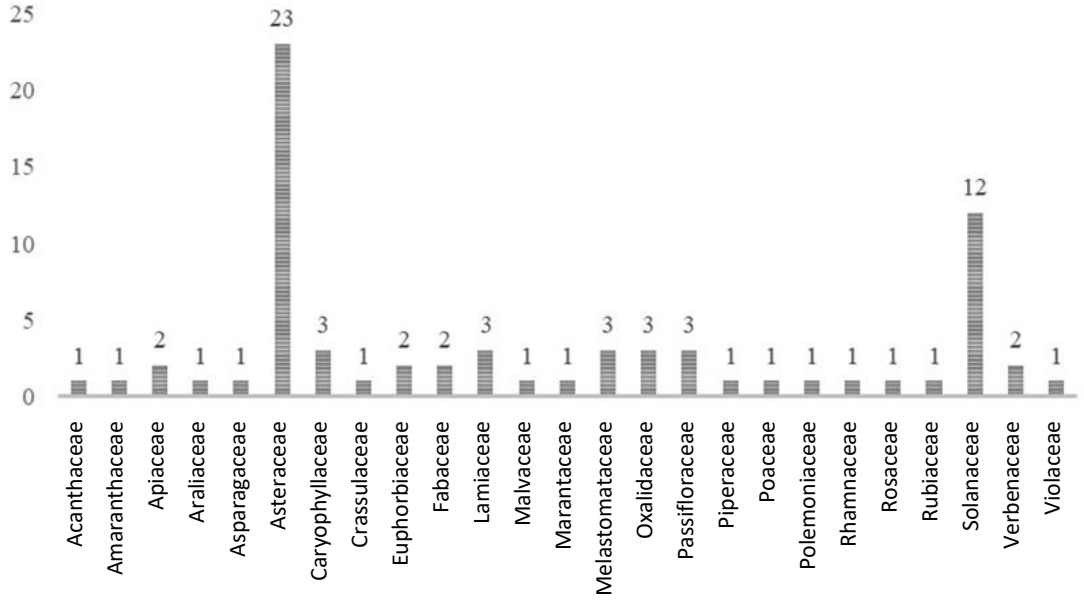

Figure 2. The number of utilized Naturalized Alien Plant Species (NAPS) in Cibodas Biosphere Reserve, West Java, Indonesia across family

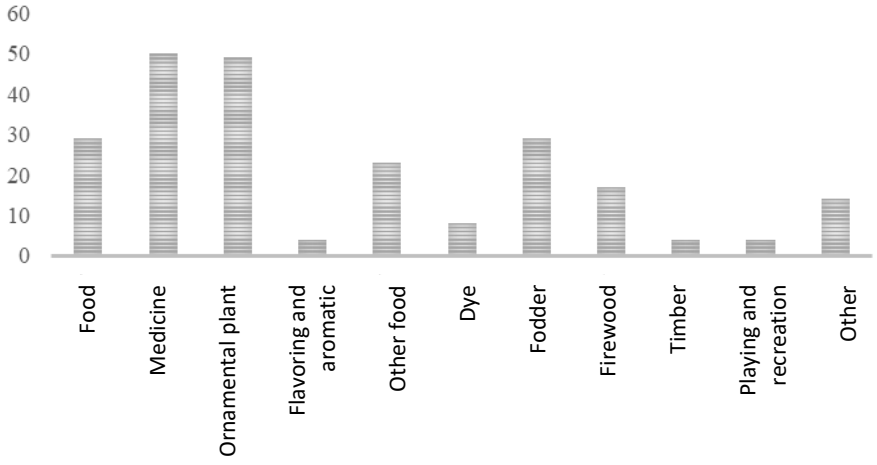

Figure 3. The number of utilized Naturalized Alien Plant Species (NAPS) in Cibodas Biosphere Reserve, West Java, Indonesia based on utilization categories

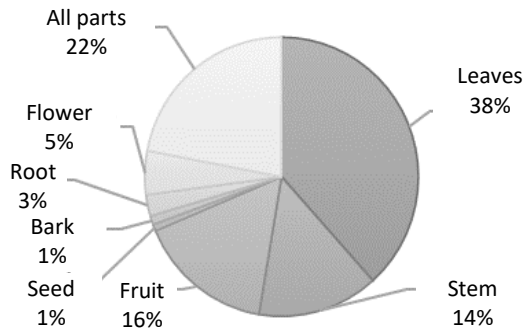

Figure 4. The proportion of the plant part of utilized Naturalized Alien Plant Species (NAPS) in Cibodas Biosphere Reserve, West Java, Indonesia

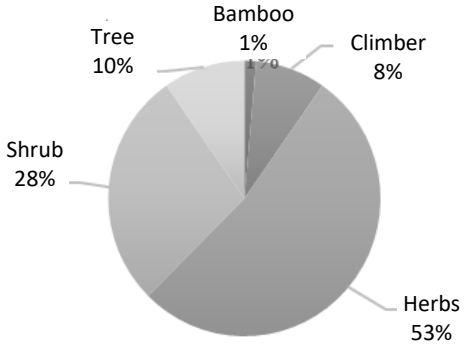

Figure 5. The proportion of lifeform of utilized Naturalized Alien Plant Species (NAPS) in Cibodas Biosphere Reserve, West Java, Indonesia

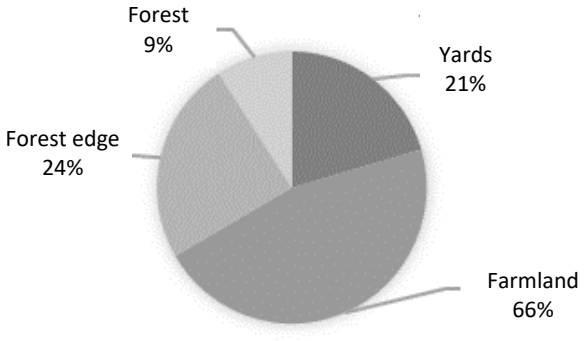

Figure 6. The proportion of the collection site of utilized Naturalized Alien Plant Species (NAPS) in Cibodas Biosphere Reserve, West Java, Indonesia

Based on the life form, most utilized NAPS were in the form of herbaceous plants (Figure 5). This is not surprising since herbaceous plants can be easily obtained, easy to harvest, and easy to process.

Based on the questionnaire results, most of the utilized NAPS were collected from farmland (46%) and followed by forest edges (24%) (Figure 6). From 72 plant species, only eight species were obtained from forest areas in which these eight taxa had low utilization rates. Based on that data, the NAPS utilization activity does not significantly impact the NAPS population in the forest area.

Index of Cultural Significance (ICS)

Based on the calculation of Index of Cultural Significance (ICS), the utilized NAPS in Cibodas Biosphere Reserve can be classified as four: high significance (14% or 10 species), moderate significance (24% or 17 species), low significance (42% or 30 species), and very low significance (20% or 15 species). Most of the high significance taxa were utilized for food sources and traditional medicine. This finding is in concordance with da Rocha Silva and de Holanda Cavalcante Andrade (2006), which stated that plant-utilized species for food sources and medicine have relatively high ICS scores than other purposes. These utilized NAPS with high ICS scores were mostly common plants on farmland or yards area, including *Artemisia vulgaris, Mentha arvensis, Centella asiatica, Cyphomandra betacea, Fragaria vesca,* and *Solanum torvum.*

The utilized NAPS with the highest ICS score was *Artemisia vulgaris* (Table 4). This species was primarily utilized as a food source and traditional medicine. There were 23 respondents who utilized *A. vulgaris* as food and medicine. This species is a well-known traditional medicinal plant. In the middle ages, *A. vulgaris* was known as "mother of herbs" due to their importance and significance in medicine's history (Ekiert et al. 2020). The Greek language took the genus name Artemisia from Artemis, a God that protects pregnant and gives birth's mothers (Ekiert et al. 2020).

Artemisia vulgaris is an introduced exotic species in Java. In the context of Cibodas Botanic Gardens history, during the 1800s (between 1840-1850), there were a massive exotic plant introduction in Cibodas Botanic Gardens area and its adjacent Mount Gede-Pangrango forests. Among these introduced species were *Fragaria vesca* (strawberry), *Rubus* spp. and *Cinchona pubescens* (quinine) (van Steenis and van Steenis-Kruseman 1953). Ekiert et al. (2020) stated that herbal material from *A. vulgaris* has essential oil content and other bio-active compounds. The essential oil content is used as a raw material in the cosmetic and food industries (Ekiert et al. 2020).

The result of ICS also in concordance with the intensity of NAPS utilization. NAPS with high ICS scores were highly used species. These species were *Centella asiatica, Calliandra calothyrsus, Chimonobambusa quadrangularis, Mentha arvensis, Artemisia vulgaris, Amaranthus spinosus,* and *Bidens pilosa.* Supiandi et al. (2019) stated that species with high ICS scores tend to be maintained by communities. Based on that, it certainly needs management to control the population of utilized NAPS to prevent their risk of invasion.

Table 4. The top ten utilized Naturalized Alien Plant Species (NAPS) in Cibodas Biosphere Reserve with the highest score of Index of Cultural Significance (ICS)

Species name	Local name	Family	ICS	Number of utilization activities	Number of respondents
Artemisia vulgaris L.	Lokatmala	Asteraceae	98.32	43	23
Chimonobambusa quadrangularis (Fenzl) Makino	Kirisi	Poaceae	76.52	29	20
Bidens pilosa L.	Hareuga	Asteraceae	67.81	47	16
Mentha arvensis L.	Keresmen	Lamiaceae	63.39	33	24
Amaranthus spinosus L.	Bayam	Amaranthaceae	61.14	44	16
Centella asiatica (L.) Urb.	Antanan	Apiaceae	60.17	33	38
Cyphomandra betacea (Cav.) Sendtn. syn. *Solanum betaceum Cav.*	Terong belanda	Solanaceae	55.04	24	13
Calliandra calothyrsus Meisn.	Kaliandra	Fabaceae	54.24	58	24
Fragaria vesca L.	Stroberi	Rosaceae	53.62	29	21
Solanum torvum Sw.	Takokak	Solanaceae	50.29	31	21

Zimdahl (2018) stated that the same plant could act as a weed in one place and as a beneficial plant in another. This statement means that if these NAPS are found in some locations as an invasive species, it could be that the species is not invasive in other places, even beneficial both social-economically or ecology. For example, *Calliandra calothyrsus* is commonly used for landslide mitigation (Zakaria et al. 2013; Hairiah et al. 2020) and also suitable for wood energy as renewable energy in anticipating decreasing fossil energy resources (Hendrati and Nurrohmah 2019). From this study, we only knew the benefits and levels of NAPS utilization in CBR, while studies of the invasion risk from these NAPS have not been carried out. There are only a few studies on NAPS' ecological condition in the GGPNP forest area. For example, the high population and diversity of alien plant species around the trail (Padmanaba et al. 2017), the distribution of *Cobaea scandens* in riparian part of Cibodas Botanic Garden areas (Efendi et al. 2019) and the spread of *Chimonobambusa quadrangularis* from the Cibodas Botanical Garden into the forest area GGPNP (Damayanto and Muhaimin 2017). Therefore, it is necessary to assess the risk level of invasion of these species, whether the risk level of invasion is higher or lower than the economic and cultural benefits.

A study by Kannan et al. (2016) showed that the use of *L. camara* in a village in South India was proven to help control this species' population. Without any cultivation activities, this species is harvested periodically for making handicrafts so that such activities can control the population of *L. camara*. Based on that case, a conventional management program could incorporate utilization strategy as several approaches towards NAPS management. The advantages of this approach are this is inexpensive method, it can sustain over many years, and more importantly, unlike top-down approach through eradication programs which are usually one-off and maybe not effective in the long run in preventing species recurrence, this method can involve local communities and empower and improve their livelihoods (Kannan et al. 2016).

Wittenberg and Cock (2001) stated four main strategies to deal with alien species that have already established invading populations: eradication, containment, control, and mitigation. Based on these strategies, we recommend to control the population of utilized NAPS in Cibodas Biosphere Reserve by regular harvesting. The community can harvest the species for sale in the traditional market for several high-economic value species. Based on this study, the traditional market in Cibodas area is usually selling seasonal fruit or vegetables, among which are the NAPS recorded in this study. We can also do containment through these utilization activities, which is a management strategy to prevent these NAPS spread more widely. Containment is a deliberate action to prevent the establishment of the species outside a determined area (Grice et al. 2020). Containment is also a management option when eradication cannot be applied or may cause unexpected side effects (Junaedi 2012). Furthermore, Wagh and Jain (2018) stated that in some cases of over-exploitation of native plant species, utilization of alien plant species as an alternative could reduce the pressure on native plant species, thus leading to conservation of the diversity of these native plants.

To conclude, the rate of Naturalized Alien Plant Species (NAPS) utilization in Cibodas Biosphere Reserve (CBR) buffer zone areas was relatively high because local communities utilized more than 80% of NAPS species in CBR. On the other hand, most of the utilized NAPS were collected from farmland areas. Thus, NAPS' utilization seems not to significantly impact the NAPS population in the CBR core zone, Gunung Gede Pangrango National Park forests. Therefore, utilization of NAPS can be carried out with regular harvesting to control NAPS' population and to prevent the population spread more widely. Also, an assessment of the level risk of NAPS invasion is needed to know which species have a high risk of invasion to prevent the risk arises and harmful to the ecosystem.

ACKNOWLEDGEMENTS

The authors thank LPDP for the research funding support (FR2682020225854). The authors also thank Muslim from Cibodas, Jamaludin from Bodogol, and Uden from Gekbrong, who assisted the NAPS identification and

supported all fieldwork activities and the questionnaire survey for data collection.

REFERENCES

Benvenuti S, Cioni PL, Flamini G, Pardossi A. 2017. Weeds for weed control: Asteraceae essential oils as natural herbicides. Weed Res 57 (5): 342-353. DOI: 10.1111/wre.12266.

CABI. 2020. Invasive Species Compendium: *Centella asiatica* (*Asiatic pennywort*). CABI, UK. https://www.cabi.org/isc/datasheet/12048

Carlquist S. 1976. Tribal interrelationships and phylogeny of the Asteraceae. Aliso A J Syst Evol Bot 8 (4): 465-492. DOI: 10.5642/aliso.19760804.10.

Damayanto IPGP, Muhaimin M. 2017. Notes on *Chimonobambusa quadrangularis* (Franceschi) Makino (Poaceae: Bambusoideae) as an invasive alien plant species in Indonesia. Floribunda 5 (7): 253-257. DOI: 10.32556/floribunda.v5i7.2017.201.

Devkota A, Jha PK. 2009. Variation in growth of *Centella asiatica* along different soil composition. Bot Res Int 2 (1): 55-60.

Efendi M, Muhaimin M, Suherman D. 2019. Sebaran populasi *Cobaea scandens* CAV. sebagai tumbuhan invasif di Kebun Raya Cibodas dan sekitarnya. Al-Kauniyah J Biol 12 (1): 103-111. DOI: 10.15408/kauniyah.v12i1.9033.

Ekiert H, Pajor J, Klin P, Rzepiela A, Slesak H, Szopa A. 2020. Significance of *Artemisia vulgaris* L. (common mugwort) in the history of medicine and its possible contemporary applications substantiated by phytochemical and pharmacological studies. Molecules 25 (19): 1-32. DOI: 10.3390/molecules25194415.

Foxcroft LC, Pyšek P, Richardson DM, Genovesi P, MacFadyen S. 2017. Plant invasion science in protected areas: progress and priorities. Biol Invasions. 19 (5): 1353-1378. DOI: 10.1007/s10530-016-1367-z.

Grice AC, Murphy HT, Clarkson JR, Friedel MH, Fletcher CS, Westcott DA. 2020. A review and refinement of the concept of containment for the management of invasive plants. Aust J Bot 68 (8): 602-616. DOI: 10.1071/BT20092.

Hairiah K, Widianto W, Suprayogo D, Van Noordwijk M. 2020. Tree roots anchoring and binding soil: Reducing landslide risk in Indonesian agroforestry. Land 9 (8): 256. DOI: 10.3390/land9080256

Handayani A, Hidayati S. 2020. Utilization of Invasive Alien Species (IAS) by communities around Cibodas Biosphere Reserve (CBR): A recommendation for invasive alien species management and policy. IOP Conf Ser Earth Environ Sci 533 (1). DOI: 10.1088/1755-1315/533/1/012017.

Hendrati RL, Nurrohmah SH. 2019. Breeding for better growth of *Calliandra calothyrsus* Meissn., a fast growing legume for wood-energy. Jurnal Perbenihan Tanaman Hutan 7 (1): 13-20. DOI: 10.20886/bptpth.2019.7.1.13-20.

Jeschke JM, Bacher S, Blackburn TIMM, Dick JTA, Essl F, Evans T, Gaertner M, Hulme PE, Mrugała A, Pergl JAN, et al. 2014. Defining the impact of non-native species. Conserv Biol 28 (5): 1188-1194. DOI: 10.1111/cobi.12299.

Junaedi DI. 2012. Invasive plants in mountainous remnant forest: Recommendation for choosing best decision for invasive species management of *Cestrum aurantiacum* Lindl. Bul Kebun Raya 15 (1): 37-47. DOI: 10.21009/jgg.011.04.

Junaedi DI, Mutaqien Z. 2018. Predicting invasion probability from botanic gardens using exotic species traits. Biosaintifika J Biol Biol Educ 10 (3): 539-545. DOI: 10.15294/biosaintifika.v10i3.15500.

Kannan R, Shackleton CM, Krishnan S, Shaanker RU. 2016. Can local use assist in controlling invasive alien species in tropical forests? The case of *Lantana camara* in Southern India. For Ecol Manag 376: 166-173. DOI: 10.1016/j.foreco.2016.06.016.

Knezevic SZ. 2017. Invasive Plant Species. In: Thomas B, Murray BG, Murphy DJ (eds) Encyclopedia of Applied Plant Sciences. Elsevier, UK. DOI: 10.1016/B978-0-12-394807-6.00021-6.

Kudo Y, Mutaqien Z, Simbolon H, Suzuki E. 2014. Spread of invasive plants along trails in two national parks in West Java, Indonesia. Tropics 23 (3): 99-110. DOI: 10.3759/tropics.23.99.

Kueffer C. 2017. Plant invasions in the Anthropocene. Science 358 (6364): 724-725. DOI: 10.1126/science.aao6371.

Mutaqien Z, Tresnanovia V, Zuhri M. 2011. Penyebaran tumbuhan asing di hutan Wornojiwo Kebun Raya Cibodas, Cianjur, Jawa Barat. In: Zuhri M, Kurnita NI, Normasiwi S, Lailati M, Destri, Rahman W (eds) Prosiding Seminar Nasional HUT Kebun Raya Cibodas Ke-159. Kebun Raya Cibodas, Cianjur, 7 April 2011. [Indonesian]

Negi GCS, Sharma S, Vishvakarma SCR. 2019. Ecology and use of *Lantana camara* in India. Bot Rev 85 (2): 109-130. DOI: 10.1007/s12229-019-09209-8.

Padmanaba M, Tomlinson KW, Hughes AC, Corlett RT. 2017. Alien plant invasions of protected areas in Java, Indonesia. Sci Rep 7 (1): 1-11. DOI: 10.1038/s41598-017-09768-z.

Panda SK, Cláudio L, Sahal D, Leonti M. 2019. Editorial: Ethnopharmacological studies for the development of drugs with special reference to Asteraceae. Front Pharmacol 10: 955. DOI: 10.1038/srep41254.

PIER. 2014. Pacific Islands ecosystems at risk: *Centella asiatica* (L.) Urb., Apiaceae. http://www.hear.org/pier/species/centella_asiatica.htm

POWO. 2021. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/.

Pyšek P, Hulme, PE, Simberloff D, Bacher S, Blackburn TM, Carlton JT, Dawson W, Essl F, Foxcroft LC, Genovesi P, Jeschke JM,Kuhn I, Liebhold AM, Mandrak NE, Meyerson LA, Pauchard A, Pergi J, Roy HE, Seebens H, van Kleunen M, Vila M, Wingfield MJ, Richardson DM. 2020. Scientists' warning on invasive alien species. Biol Rev 95 (6): 1511-1534. DOI: 10.1111/brv.12627.

Pyšek P, Pergl J, Essl F, Lenzner B, Dawson W, Kreft H, Weigelt P, Winter M, Kartesz J, Nishino M, et al. 2017. Naturalized alien flora of the world: Species diversity, taxonomic and phylogenetic patterns, geographic distribution and global hotspots of plant invasion. Preslia 89 (3): 203-274. DOI: 10.23855/preslia.2017.203.

Rai PK, Kim K. 2020. Invasive alien plants and environmental remediation : A new paradigm for sustainable restoration ecology. Restor Ecol 28 (1): 3-7. DOI: 10.1111/rec.13058.

Rai PK, Singh JS. 2020. Invasive alien plant species: Their impact on environment, ecosystem services and human health. Ecol Indic. 111: 106020. DOI: 10.1016/j.ecolind.2019.106020.

Rai PK, Singh MM. 2015. *Lantana camara* invasion in urban forests of an Indo-Burma hotspot region and its eco-sustainable management implication through biomonitoring of particulate matter. J Asia-Pac Biodivers 8 (4): 375-381. DOI: 10.1016/j.japb.2015.09.003.

Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD, West CJ. 2000. Naturalization and invasion of alien plants: Concepts and definitions. Divers Distrib 6 (2): 93-107. DOI: 10.1046/j.1472-4642.2000.00083.x

da Rocha Silva AJ, de Holanda CAL. 2006. Cultural significance of plants in communities located in the Coastal Forest Zone of the state of Pernambuco, Brazil. Hum Ecol 34 (3): 447-465. DOI: 10.1007/s10745-006-9026-0.

Setiawan M, Rahayu M, Susiarti S. 2020. Studi etnobotani spesies tumbuhan asing invasif 'konyal' (*Passiflora edulis*) dan peran ekonominya bagi masyarakat lokal Desa Sarongge, Kabupaten Cianjur, Jawa Barat. Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia, Bogor, 12 Oktober 2019. [Indonesian]

Shackleton RT, Shackleton CM, Kull CA. 2019. The role of invasive alien species in shaping local livelihoods and human well-being : A review. J Environ Manag 229: 145-157. DOI: 10.1016/j.jenvman.2018.05.007.

Shrestha BB, Shrestha UB, Sharma KP, Thapa-Parajuli RB, Devkota A, Siwakoti M. 2019. Community perception and prioritization of invasive alien plants in Chitwan-Annapurna Landscape, Nepal. J Environ Manag 229: 38-47. DOI: 10.1016/j.jenvman.2018.06.034.

van Steenis CGG, van Steenis-Kruseman M. 1953. Brief sketch of the Tjibodas Mountain Garden. Flora Malesiana Bull 10 (1): 313-348.

Sun B, Wu L, Wu Y, Zhang C, Qin L, Hayashi M, Kudo M, Gao M, Liu T. 2020. Therapeutic potential of *Centella asiatica* and its triterpenes : A review. Front Pharmacol 11: 1-24. DOI: 10.3389/fphar.2020.568032.

Sunaryo, U T, Tihurua EF. 2012. Jenis tumbuhan asing invasif yang mengancam ekosistem Taman Nasional Gunung Gede Pangrango, Resort Bodogol, Jawa Barat. Berk Penelit Hayati 17: 147-152. DOI: 10.23869/bphjbr.27.2.20124 [Indonesian]

Supiandi MI, Mahanal S, Zubaidah S, Julung H, Ege B. 2019. Ethnobotany of traditional medicinal plants used by Dayak Desa Community in Sintang, West Kalimantan, Indonesia. Biodiversitas 20 (5): 1264-1270. DOI: 10.13057/biodiv/d200516.

Turner NJ. 1988. The importance of a rose: Evaluating the cultural significance of plants in Thompson and Lillooet interior salish. Am Anthropol 90 (2): 272-290. DOI: 10.1525/aa.1988.90.2.02a00020.

Wagh VV, Jain AK. 2018. Status of ethnobotanical invasive plants in western Madhya. South Afr J Bot 114: 171-180. DOI: 10.1016/j.sajb.2017.11.008.

Wakhidah AZ, Mustaqim WA. 2020. *Centella asiatica* (L.) Urb. Apiaceae. In: Franco FM (ed) Ethnobotany of the Mountain Regions of Southeast Asia. Springer Nature, Switzerland AG. DOI: 10.1007/978-3-030-14116-5_72-1.

WFO. 2021. World Flora Online. Published on the Internet. http://www.worldfloraonline.org.

Wittenberg R, Cock MJ. 2001. Invasive alien species: A toolkit of best prevention and management practices. CABI. DOI: 10.1079/9780851995694.0000.

Zakaria Z, Muslim D, Sophian RI, Kuswaryan S, Tanuwirya UH. 2013. Bio-engineering, melalui pemanfaatan tanaman kaliandra *(Caliandra calothyrsus)* di wilayah zona rawan longsor, Jawa Barat. Bulletin of Scientific Contribution 11 (3): 168-175. DOI: 10.24198/bsc%20geology.v11i3.8297.g3844 [Indonesian]

Zimdahl RL. 2018. Uses of Weeds - Ethnobotany. In: Fernandez BJ (ed) Fundamentals of Weed Science: Fifth Edition. Academic Press, UK. DOI: 10.1016/B978-0-12-811143-7.00004-4.