





From the wild to the market: Ornamental plant trade in Metro Cebu urban markets


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ABSTRACT

Unregulated ornamental plant trade (OPT) in highly urbanized cities (HUCs) can substantially modify native ornamental plants (NOPs) abundance, species richness, and biodiversity composition due to exotic ornamental plants (EOPs) dominance. This study: (1) quantified and compare the diversity, richness, composition, and abundance of NOPs across selected urban markets in Cebu, with particular emphasis on relative prevalence of EOPs and NOPs; (2) assessed the ecosystem services (ESs) provided by NOPs and EOPs, and evaluate how market-driven selection influence the functional diversity of ESs; (3) determined the conservation status of NOPs and EOPs traded in urban markets using IUCN classifications, and (4) investigate the socio-economic characteristics, knowledge, and perceptions of plant sellers. Three major markets—Taboan Market (S1), T. Padilla Market (S2), and Parkmall (S3) were investigated, employing field surveys and structured interviews, to capture both biological and socioeconomic dimensions of the OPT. Biodiversity indices was determined using species abundance, richness, Shannon–Wiener diversity (H'), Simpson's diversity (D), and Pielou's evenness (PE) indices. A total of 917 NOPs and EOPs were recorded, comprising 138 species across 48 families ($S_1 = 70$ species, $S_2 = 31$ species, and $S_3 = 50$ species). EOPs dominated the trade ($n=76.16\%$), while NOPs comprised only 21.85%, with 1.99% remaining undocumented. Market S1 exhibited high diversity ($H' = 3.82$; Simpson's $D = 0.48$), whereas S2 recorded the lowest diversity ($H' = 3.13$). Meanwhile, S3 the lowest Simpson's index ($D = 0.24$). PE indicated uneven species distributions across all markets. ESs assessment revealed a strong predominance of cultural services, reflecting market preference for aesthetically valued species. Socioeconomic findings further revealed that most traders operate under challenging economic conditions, with earnings below the family living wage despite long-term experience. The dominance of EOPs, marginalization of NOPs, limited regulatory oversight, and substantial knowledge gaps regarding ecological impacts highlight critical risks of biodiversity erosion and underscore the need for strengthened policy frameworks and sustainable trade practices in Cebu City.

RESUMO

O comércio irrestrito de plantas ornamentais na cidade de Cebu interrompe a abundância, a riqueza e a diversidade de espécies nativas. Este estudo foi conduzido para: (1) determinar o comércio de plantas ornamentais em mercados urbanos da região metropolitana de Cebu, Filipinas; (2) fornecer detalhes da distribuição e diversidade de plantas ornamentais nativas (PNOs) e plantas ornamentais exóticas (PNOs) e (4) tabular os serviços ecossistêmicos em três mercados urbanos selecionados na região metropolitana de Cebu: Mercado Taboan (S1), Mercado T. Padilla (S2) e Parkmall (S3). Pesquisas de campo e entrevistas foram conduzidas para determinar as dimensões biológicas e socioeconômicas do comércio de plantas ornamentais em S1, S2 e S3. Abundância, riqueza, uniformidade de Pielous, diversidade de Shannon e índices de diversidade de Simpson foram medidos. Um total de 917 indivíduos PNO e PEO foram documentados nos mercados. Para a riqueza de espécies, 138 espécies de plantas em 48 famílias foram identificadas ($S_1 = 70$, $S_2 = 31$ e $S_3 = 50$). Cerca de 76,16% eram EOPs, 21,85% eram NOPs e 1,99% eram indocumentados. S1 foi o mais diverso, com índices de Shannon e Simpson de ($H'=3,82$) e ($S=0,48$), respectivamente. S2 apresentou o menor índice de Shannon ($H' = 3,13$) e S3 apresentou o menor índice de Simpson ($H' = 0,24$). Todos os mercados apresentaram baixa uniformidade de Pielous. A análise dos serviços ecossistêmicos revelou que os serviços culturais foram os mais prevalentes em todos os locais. O estudo destaca as difíceis condições econômicas para os comerciantes de plantas na cidade de Cebu, já que muitos ganham abaixo do salário mínimo familiar, apesar da experiência. A venda generalizada de espécies de plantas de interesse cultural (POEs), a negligência com as espécies de plantas de interesse cultural (NOPs), a falta de regulamentação e as significativas lacunas de conhecimento dos comerciantes sobre os impactos ecológicos das POEs levantam preocupações sobre a superexploração dessas espécies em Cebu.

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Introduction

Ornamental plant trade (OPT) is a major pathway for the introduction of invasive alien species (IAS), contributing significantly to biological invasions worldwide (van Kleunen et al., 2018; Root et al., 2013). An estimated 75% of naturalized IAS originate from domestic gardens, highlighting the role of ornamental cultivation in ecosystem change (van Kleunen et al., 2018). In Turkey, misuse of exotic ornamental plants (EOPs) has degraded forest lands near urban areas, demonstrating biodiversity risks to native ornamental plants (NOPs). Eventual proliferation of IAS threatens biodiversity, ecosystem services, and human well-being (Walsh et al., 2016; Mazza et al., 2013). During the COVID-19 pandemic, increased plant trading as a coping mechanism intensified pressures on wild plant populations, with reports of overharvesting from natural areas (Abueg, 2017).

In the Philippines, such issues necessitated a targeted examination of the OPT within highly urbanized city (HUC) markets in Metro Cebu. Quantifying the occurrence of EOPs and NOPs being sold required further attention since these addresses existing knowledge gaps regarding the impacts of OPT on local biodiversity. Despite their relevance to evidence-based policymaking, the socioeconomic and socio-behavioral drivers influencing plant sellers also remain insufficiently explored (McDonald et al., 2019). Deficiencies in available data on wildlife and plant trafficking further constrain effective supply-chain surveillance and weaken regulatory enforcement mechanisms (Chapman & Bayron, 2018). Market sellers are therefore identified as key informants due to their pivotal role in plant supply and distribution, as well as their accessibility within established market settings.

As plant invasions are driven by repeated introductions through markets and the selection of “good garden subjects,” defined by ease of propagation, climatic suitability, and resistance to pests (Duncan, 2021; Vila et al., 2010), determining entry points of OPT and assessing propagule pressure from plant trade helps interpret invasion trends and anticipate future risks (van Kleunen et al., 2018). Ecological indices (e.g., species richness, abundance, diversity, and evenness) are essential for evaluating ecosystem condition and disturbance (Renault et al., 2022; Byun et al., 2017). Anthropogenic factors, including seller demographics, regulatory compliance, and pricing, further shape trade dynamics and consumer preferences. Integrating ecological, human, and economic dimensions is essential in providing a holistic assessment of the OPTs’ impacts on urban biodiversity and ecosystem services in Metro Cebu, Philippines.

Hence, this study aims to: (1) quantify and compare the diversity, richness, composition, and abundance of ornamental plant species across selected urban markets in Cebu, with particular emphasis on relative prevalence of EOPs and NOPs; (2) assess the ecosystem services (ESs) provided by traded NOPs and EOPs, and evaluate how market-driven selection influence the functional diversity of ecosystem services in HUC markets; (3) examine

the conservation status of NOPs and EOPs traded in HUC markets using IUCN classifications, and (4) investigate the socio-economic characteristics, knowledge, and perceptions of plant sellers. Employing a systematic approach to data collection and analysis will provide insights into the dynamics of the OPT and its impact on urban biodiversity.

Methods

Topography of Cebu and the study sites

Cebu City 10.3157° N, 123.8854° E (Fig. 1), located in the central Philippines, is characterized by its diverse topography, which includes coastal areas, low-lying plains, rolling hills, and mountainous regions. This geographical diversity contributes to a variety of microclimates and habitats, supporting a wide range of EOPs and NOPs. In this study, three HUCs were selected in Metro Cebu: Site 1 (S1: Taboan Market), Site 2 (S2: T. Padilla Market), and Site 3 (S3: Parkmall Market). These markets have significant involvement in the OPT and their potential impact on urban biodiversity (Fig. 2, 3, 4). The study was conducted during April to September of 2023.

Sampling Technique

The study employed a Ground Surveying Technique (adapted from Renault et al., 2022) to confirm the presence of EOPs and NOPs in selected HUC markets. This method is particularly relevant in Cebu City, where multiple ornamental plant markets exhibit varying characteristics and biodiversity levels. The sampling approach prioritized areas with the highest local invasion risk, ensuring a well-represented sample by dividing the population into relevant groups based on specific parameters.

Fig. 1.

Geographical location of the study area in Cebu, Philippines

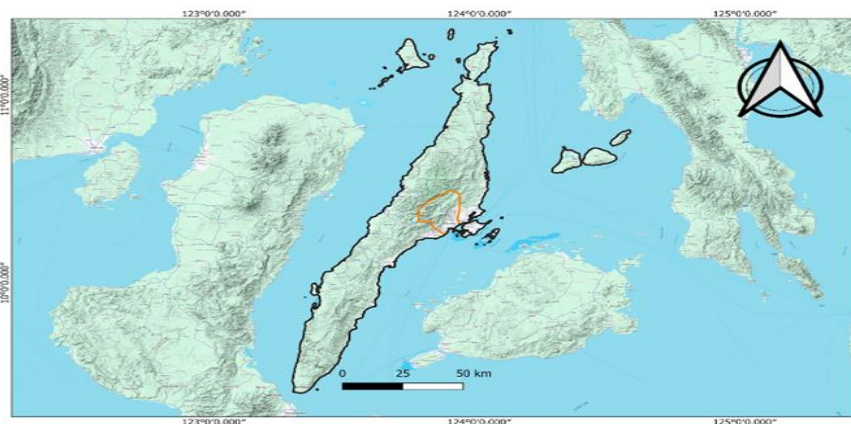


Fig. 2.
Site 1 (S1: Taboan Market)

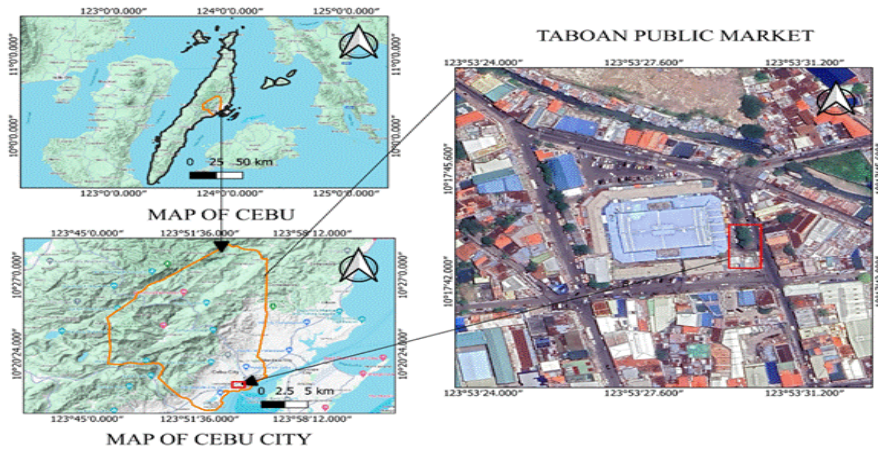


Fig. 3.

Site 2 (S2: T. Padilla Market)

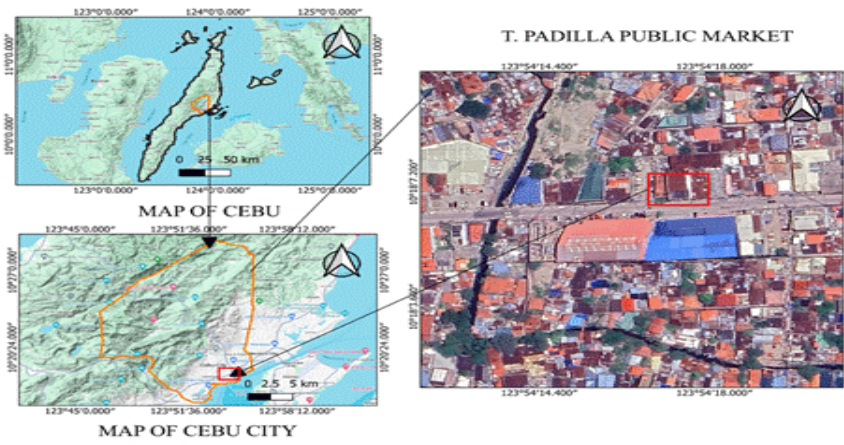
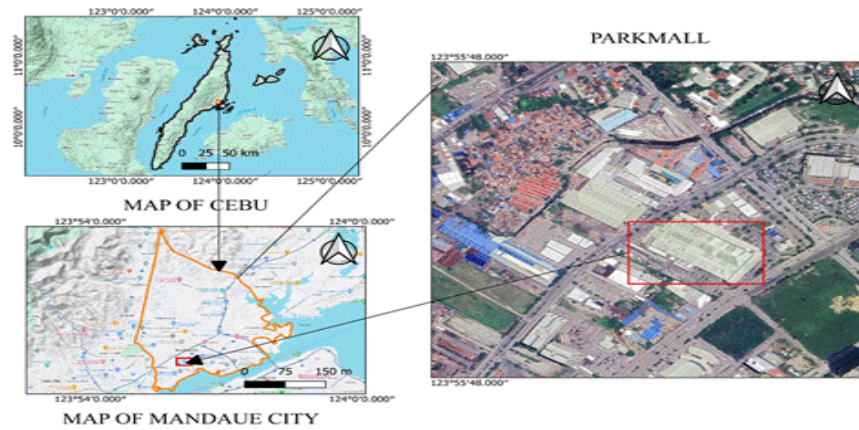


Fig. 4.

Site 3 (S3: Parkmall Market)



Parameters in Market Selection

Market selection was guided by criteria adapted from Kumar and Singh (2020) and supported by the studies of Quiason (1986) and the parameters included.

- a. Location: Markets located within Highly Urbanized Cities (HUCs) to assess urban biodiversity impacts.
- b. Geographic Accessibility: Proximity to transportation and ease of access for researchers to facilitate data collection.
- c. Market Reputation: The reputation of markets for selling a diverse range of ornamental plants, which may influence biodiversity.

Data Collection

A combination of research instruments was utilized to gather comprehensive data on the OPT. A structured questionnaire was developed to collect information from traders and customers regarding their knowledge of the impact of OPT on urban biodiversity. The questionnaire included sections on demographic information, awareness of biodiversity conservation, and attitudes towards the trade of EOPs and NOPs, adapted from Flores et al. (2020). A checklist was created to assess the diversity, richness, and composition of EOPs and NOPs sold in selected markets. This checklist recorded essential details such as the common name, scientific name, origin, size, price, and any other relevant information that could aid in assessing the impact of the OPT on urban biodiversity. Field visits and interviews were conducted to observe vendor and customer interactions and identify the types of EOPs and NOPs being traded. Observations focused on the market environment, vendor practices, and customer preferences. Detailed field notes were maintained throughout the data collection process. These notes included observations related to the market environment, infrastructure, waste management practices, and any interactions with stakeholders.

Preliminary Investigation

An initial exploration of the sites was conducted to gather essential information about the OPT. EOPs and NOPs available in HUC markets in Metro Cebu, Philippines were documented including their abundance and diversity. Market sellers were also interviewed to gain insights into the dynamics of the OPT and its impact on urban biodiversity. These interviews provided valuable perspectives on the challenges and opportunities associated with sustainable plant trade practices.

Ethical Considerations

The study adhered to Cebu Normal University's ethical guidelines throughout the research process. Informed consent was obtained from all participants involved in the surveys and interviews. Participants were assured of the confidentiality of their responses and the voluntary nature of their participation.

Floral Assessment, Identification and Biological Indices of EOPs and NOPs

Images of EOPs, and NOPs were captured during the interview and visit of three sites. Photos were used for identification as well as analyzing the species that are commercially traded. To ensure that these photos provide detailed information of the EOPs and NOPs, we followed the methodology of Matt Walter in "Plant Photographs and Caption for Identification" (2023). Finally, a plant taxonomist was consulted to validate species identification of EOPs and NOPs.

Taxonomic Identification and Nativity

The method outlined for taxonomic identification EOPs and NOPs is based on the Flora of Manila and Merrill (1922). Plants are classified into four categories: cultivated, casual, naturalized, and invasive. Identification will use credible sources such as The Plant List (<https://wfo.plantlist.org>), Philippine Native Plant Group, and Co's Digital Flora of the Philippines. Plants with many cultivars will be identified through horticultural publications. If identification is challenging, a cultivar name will be used. Additionally, regional plant guides, field manuals, and Google Lens can aid identification up to the series level. Species will be initially identified using related literature and compared with online images from sources like Co's Digital Flora of the Philippines, the International Plant Names Index, Plants of the World Online, and A Pictorial Encyclopedia of Philippine Plants. Photographs of plant parts, including flowers, leaves, stems, and roots, will be taken to ensure clear identification, following guidelines in Walter's "Plant Photographs and Caption for Identification."

Data Analysis

Quantitative analysis was performed on the collected data to derive means, percentages, and other relevant statistical measures. The analysis focused on selected socio-demographic variables, such as age, gender, and educational background of respondents. Additionally, survey results were synthesized to provide insights into consumer preferences regarding plant desirability, pricing, and characteristics deemed suitable for gardens.

A. **For Species abundance**, the formula is shown in Equation 1 and 2:

$$\chi = \frac{\text{total no. of exotic plant species found}}{\text{sum of total species found}} \times 100 \quad (1)$$

$$\chi = \frac{\text{total no. of native species found}}{\text{sum of total species found}} \times 100 \quad (2)$$

Higher values would indicate NOPs or EOPs population relative to the entire population in the species pool.

B) For Species richness, the formula is shown in Eq. 3 and 4

Species Richness EOP= number of EOP found in the market (3)

Species Richness NOP= number of NOP found in the market (4)

C) For Species evenness, the formula is shown in Eq. 5 Pielous' Evenness Index:

$$PE = \frac{H}{\ln(S)}$$

where H is the Shannon-Wiener Index.

ln = natural logarithm and S = total number of species

According to Jost (2010), the index ranges from 0 to 1, where 0 indicates complete unevenness (one species dominates) and 1 indicates perfect evenness (all species have equal abundances).

The **Shannon-Wiener Index** measures the diversity that takes the species richness and proportion of species in an area (Hennink & Zeven, 1990). This index considers the proportional share among the species as much as their numbers. A higher value for the index would suggest a more diverse and evenly distributed community, whereas a lower value would imply less diversity and greater inequality (Hennink & Zeven, 1990).

$$H = -\sum (P_i * \ln (P_i))$$

H is the Shannon-Wiener index.

Σ represents the summation symbol.

P_i is the proportion or relative abundance of the i-th species, calculated by dividing the number of individuals of the i-th species by the total number of individuals in the community.

ln (P_i) denotes the natural logarithm of P_i.

Lastly, **Simpson's Diversity index** will be used to calculate the diversity (D), formula shown in Equation 6.

$$D = 1 - (\Sigma ((n(n-1))/N(N-1))) \quad (6)$$

Where n_i= number of individuals, N=total number of species

The Simpson diversity index ranges from 0 to 1, where 0 indicates no diversity (one species dominates the community) and 1 indicates maximum diversity (all species are equally abundant). Higher values of the Simpson index indicate greater diversity. It quantifies the probability that two randomly selected individuals from a community belong to different species, providing insights into the dominance or concentration of species within a community (McLaughlin et al., 2016).

Ecosystem Services

This study adopted a structured assessment protocol derived from Potschin and Haines-Young (2011) to evaluate the ecosystem services implications of ornamental plant market biodiversity. The protocol comprised two primary components: (a) the identification and classification of ecosystem services relevant to market-based biodiversity, including cultural, regulating, and supporting services; and (b) the systematic documentation of biodiversity attributes within the markets, specifically species richness, abundance, and species composition.

To assess the ecosystem services provided by EOPS and NOPs, each recorded species was assigned to one or more ecosystem service categories based on functional traits and documented service contributions. The classification criteria for regulating, cultural, and supporting services were adapted from the framework and species-service associations presented by de Moura et al. (2024), ensuring a standardized and defensible approach to linking ornamental plant traits with ecosystem service provision.

Results and Discussions

A total of 48 plant families, 138 species, and 917 individual plants were recorded across the three HUC markets (Table 1), revealing distinct patterns in family and species dominance. In S1, the Araceae family was clearly dominant, represented by 468 individuals, largely driven by the high abundance of *Aglaonema commutatum*. Similarly, S2 was also dominated by Araceae with 327 individuals, with *Zamioculcas zamiifolia* being prominently displayed, while *Philodendron bipinnatifidum* emerged as the most abundant species with six individuals (Table 1).

In S3, Araceae again showed strong dominance with 468 individuals; however, Euphorbiaceae was the most abundant family overall, with 74 individuals, primarily *Codiaeum variegatum* cv. Within this market, *Dieffenbachia exotica* was recorded as the most abundant species with 122 individuals (Table 1). Additionally, *Philodendron verrucosum* was documented as the most frequently occurring species in S3, with seven individuals (Table 1). Collectively, these findings highlight the popularity of specific plant families and species in OPT across HUC markets. Such patterns provide valuable insights for market analysis and can support traders and growers in optimizing product selection and marketing strategies to better meet consumer demand.

Table 1.
List of ornamental plant species found in selected Metro Cebu urban markets, S1, S2, and S3 with richness and abundance.

Taxa Family	Plant Species	Plant Status (EOP/NOP)	Market 1	Market 2	Market 3	Total	Abundance %
Adiantaceae	<i>Adiantum pedatum</i> L.	EOP	0	4	0	4	0.44
Araceae	<i>Aglaonema commutatum</i>	NOP	3	0	0	3	0.33
Araceae	<i>Aglaonema commutatum</i> cv.	NOP	0	8	0	8	0.87
Araceae	<i>Aglaonema</i> cv.	NOP	0	0	11	11	1.20
Araceae	<i>Alocasia sanderiana</i>	NOP	0	0	7	7	0.76
Amaranthaceae	<i>Alternanthera</i> cv.	Undocumented	15	5	0	20	2.18
Araceae	<i>Anthurium andraeanum</i>	EOP	0	2	0	2	0.22
Araceae	<i>Anthurium andraeanum</i> linden	EOP	0	0	3	3	0.33
Araceae	<i>Anthurium coriaceum</i>	EOP	0	0	7	7	0.76
Araceae	<i>Anthurium plowmanii</i>	Undocumented	3	0	0	3	0.33
Araucariaceae	<i>Araucaria heterophylla</i>	EOP	8	0	1	9	0.98
Araucariaceae	<i>Araucaria columnaris</i>	EOP	8	0	0	8	0.87
Asparagaceae	<i>Asparagus densiflorus</i> Myers	EOP	3	0	0	3	0.33

	<i>Asparagus densiflorus Sprengeri</i>						
Asparagaceae		EOP	2	0	0	2	0.22
Aspleniaceae	<i>Asplenium musifolium</i>	NOP	8	8	0	16	1.74
Aspleniaceae	<i>Asplenium nidus cv.</i>	NOP	0	0	8	8	0.87
Begoniaceae	<i>Begonia coccinea</i>	EOP	3	0	0	3	0.33
Begoniaceae	<i>Begonia cv.</i>	EOP	0	0	13	13	1.42
Begoniaceae	<i>Begonia rex cv.</i>	EOP	0	2	0	2	0.22
Nyctaginaceae	<i>Bougainvillea spectabilis cv.</i>	EOP	9	0	0	9	0.98
Fabaceae	<i>Caesalpinia pulcherrima</i>	EOP	5	0	0	5	0.55
Araceae	<i>Caladium bicolor</i>	EOP	2	0	0	2	0.22
Araceae	<i>Caladium cv.</i>	EOP	0	2	0	2	0.22
Marantaceae	<i>Calathea louisae</i>	EOP	0	4	0	4	0.44
Marantaceae	<i>Calathea metalica</i>	EOP	0	4	0	4	0.44
Marantaceae	<i>Calathea ornata</i>	EOP	0	4	0	4	0.44
Marantaceae	<i>Calathea stromata</i>	EOP	4	0	0	4	0.44
Marantaceae	<i>Calathea zebrina cv.</i>	EOP	0	4	0	4	0.44
Boraginaceae	<i>Carmona retusa</i>	NOP	7	0	0	7	0.76
Arecaceae	<i>Caryota mitis</i>	NOP	0	0	3	3	0.33
Arecaceae	<i>Caryota monostachya</i>	EOP	5	0	0	5	0.55
Amaranthaceae	<i>Celosia cristata</i>	EOP	3	0	0	3	0.33
Asparagaceae	<i>Chlorophytum comosum</i>	EOP	2	0	0	2	0.22
Clusiaceae	<i>Clusia rosea</i>	EOP	0	0	3	3	0.33
Euphorbiaceae	<i>Codiaeum variegatum cv.</i>	NOP	59	15	0	74	8.07
Lamiaceae	<i>Coleus amboinicus</i>	EOP	5	0	0	5	0.55
Lamiaceae	<i>Coleus blumei cv.</i>	EOP	0	8	0	8	0.87
Asparagaceae	<i>Cordyline fruticosa cv.</i>						
Asparagaceae		EOP	20	6	4	30	3.27
Crassulaceae	<i>Crassula ovata</i>	EOP	0	0	5	5	0.55
Amaryllidaceae	<i>Crinum asiaticum</i>	NOP	2	0	0	2	0.22
Cycadaceae	<i>Cycas chamberlainii</i>	NOP	0	0	2	2	0.22
Cupressaceae	<i>Cypressus sempervirens</i>	EOP	3	0	0	3	0.33
Arecaceae	<i>Cyrtostachys renda</i>	EOP	1	0	0	1	0.11

Araceae	<i>Dieffenbachia cv.</i>	EOP	1	1	0	2	0.22
Araceae	<i>Dieffenbachia exotica</i>	EOP	0	1	0	1	0.11
Araceae	<i>Dieffenbachia reginae</i>	EOP	0	0	9	9	0.98
Asparagaceae	<i>Dracaena draco</i>	EOP	0	0	2	2	0.22
Asparagaceae	<i>Dracaena fragrans var</i>	EOP	0	0	7	7	0.76
Asparagaceae	<i>Dracaena multiflora</i>	EOP	1	0	0	1	0.11
Asparagaceae	<i>Dracaena reflexa</i>	EOP	0	2	0	2	0.22
Asparagaceae	<i>Dracaena sanderiana</i>	EOP	0	0	5	5	0.55
Asparagaceae	<i>Dracaena sanderiana var.</i>	EOP	0	2	0	2	0.22
Asparagaceae	<i>Dracaena surcolosa var. capitata</i>	EOP	0	1	0	1	0.11
Verbenaceae	<i>Duranta erecta</i>	EOP	1	0	0	1	0.11
Verbenaceae	<i>Duranta repens</i>	EOP	2	0	0	2	0.22
Arecaceae	<i>Dyopsis lutescens</i>	EOP	1	0	0	1	0.11
Crassulaceae	<i>Echeveria alba</i>	EOP	0	0	11	11	1.20
Boraginaceae	<i>Ehretia monopyrena</i>	EOP	1	0	0	1	0.11
Araceae	<i>Epipremnum aureum cv.</i>	EOP	0	1	0	1	0.11
Equisetaceae	<i>Equisetum hyemale</i>	EOP	2	0	0	2	0.22
Euphorbiaceae	<i>Euphorbia pulcherri</i>	EOP	0	0	34	34	3.71
Euphorbiaceae	<i>Euphorbia pulcherri cv.</i>	EOP	0	0	5	5	0.55
Euphorbiaceae	<i>Euphorbia pulcherrima</i>	EOP	8	0	0	8	0.87
Euphorbiaceae	<i>Euphorbia titthymaloides subsp. smallii</i>	EOP	1	0	0	1	0.11
Moraceae	<i>Ficus altissima</i>	NOP	0	0	6	6	0.65
Moraceae	<i>Ficus benjamina</i>	NOP	1	0	0	1	0.11
Moraceae	<i>Ficus elastica</i>	NOP	0	2	4	6	0.65
Moraceae	<i>Ficus lyrata</i>	NOP	0	0	5	5	0.55
Malpighiaceae	<i>Galphimia glauca</i>	EOP	8	0	0	8	0.87
Asteraceae	<i>Gazania rigens</i>	EOP	0	0	10	10	1.09
Cactaceae	<i>Gymnocalycium baldianum</i>	EOP	0	0	3	3	0.33
Cactaceae	<i>Gymnocalycium mihanovichii</i>	EOP	0	0	4	4	0.44
Bromeliaceae	<i>Guzmania lingulata var minor</i>	EOP	0	0	9	9	0.98

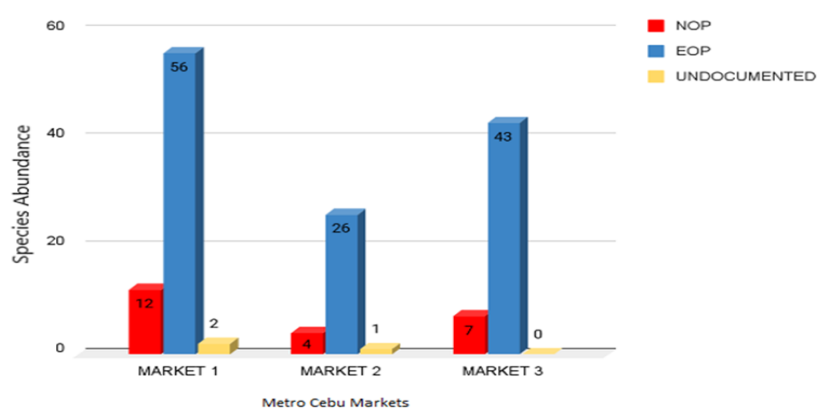
Asphodelaceae	<i>Haworthiopsis fasciata</i>	EOP	0	0	6	6	0.65
Malvaceae	<i>Hibiscus rosa-sinensis</i>	EOP	1	0	0	1	0.11
Malvaceae	<i>Hibiscus syriacus</i>	EOP	1	0	0	1	0.11
Arecaceae	<i>Homalomena sulcata</i>	EOP	5	0	0	5	0.55
Apocynaceae	<i>Hoya kerrii</i>	EOP	0	0	12	12	1.31
Arecaceae	<i>Hyophorbe lagenicaulis</i>	EOP	4	0	0	4	0.44
Rubiaceae	<i>Ixora cv.</i>	NOP	3	6	0	9	0.98
Cupressaceae	<i>Juniperus virginiana</i>	EOP	15	0	0	15	1.64
Verbenaceae	<i>Lantana camara</i>	NOP	15	0	0	15	1.64
Arecaceae	<i>Licuala grandis</i>	EOP	6	0	0	6	0.65
Liliaceae	<i>Lilium orientalis</i>	EOP	0	0	13	13	1.42
Apocynaceae	<i>Mandevilla sanderi</i>	EOP	9	0	0	9	0.98
Marantaceae	<i>Maranta arundinacea</i> <i>var. variegata</i>	EOP	0	1	0	1	0.11
Melastomataceae	<i>Medinilla pendula</i>	NOP	1	0	0	1	0.11
Myrtaceae	<i>Melaleuca linariifolia</i>	EOP	7	0	0	7	0.76
Cactaceae	<i>Melocactus bahiensis</i>	EOP	0	0	6	6	0.65
Araceae	<i>Monstera deliciosa</i>	EOP	0	0	5	5	0.55
Araceae	<i>Monstera</i> <i>karstenianum</i>	EOP	0	0	4	4	0.44
Araceae	<i>Monstera obliqua</i>	EOP	0	1	2	3	0.33
Rutaceae	<i>Murraya paniculata</i>	NOP	1	0	0	1	0.11
Rubiaceae	<i>Mussaenda</i> <i>erythrophylla</i>	EOP	2	0	0	2	0.22
Nephrolepidaceae	<i>Nephrolepis bisserrata</i>	EOP	10	0	0	10	1.09
Orchidaceae	<i>Oncidium cv.</i>	NOP	0	10	0	10	1.09
Araliaceae	<i>Osmoxylon</i> <i>geelvinkianum</i>	EOP	10	0	0	10	1.09
Acanthaceae	<i>Pachystachys lutea</i>	EOP	10	0	0	10	1.09
Pandanaceae	<i>Pandanus baptisti</i>	EOP	1	0	0	1	0.11
Euphorbiaceae	<i>Pedilanthus</i> <i>tithymaloides cv.</i>	EOP	0	3	0	3	0.33
Piperaceae	<i>Peperomia obtusifolia</i> <i>var</i>	EOP	0	0	3	3	0.33
Piperaceae	<i>Peperomia sandersii</i>	EOP	0	1	0	1	0.11
Solanaceae	<i>Petunia cv.</i>	EOP	10	0	0	10	1.09
Urticaceae	<i>Pilea cadierei</i>	EOP	0	1	0	1	0.11
Orchidaceae	<i>Phalaenopsis amabilis</i>	NOP	0	0	4	4	0.44
Orchidaceae	<i>Phalaenopsis cv.</i>	NOP	0	0	8	8	0.87

Araceae	<i>Philodendron billietiae</i>	EOP	0	0	6	6	0.65
Araceae	<i>Philodendron bipinnatifidum</i>	EOP	0	0	3	3	0.33
Araceae	<i>Philodendron cv.</i>	EOP	0	0	5	5	0.55
Araceae	<i>Philodendron pedatum var</i>	EOP	0	0	1	1	0.11
Araceae	<i>Philodendron pinnatifidum</i>	EOP	6	0	0	6	0.65
Araceae	<i>Philodendron verrucosum</i>	EOP	0	0	7	7	0.76
Araceae	<i>Philodendron x 'Florida Compacta'</i>	EOP	0	0	7	7	0.76
Araceae	<i>Philodendron 'Wendimbe Tricolor'</i>	EOP	0	0	4	4	0.44
Aspleniaceae	<i>Phyllittis scolopendrium</i>	EOP	0	0	3	3	0.33
Poaceae	<i>Phyllostachys nigra</i>	EOP	2	0	0	2	0.22
Apocynaceae	<i>Plumeria rubra forma acutifolia</i>	EOP	15	0	0	15	1.64
Podocarpaceae	<i>Podocarpus macrophyllus</i>	EOP	11	0	0	11	1.20
Araliaceae	<i>Polyscias balfouriana</i>	EOP	11	0	0	11	1.20
Rosaceae	<i>Rosa chinensis</i>	EOP	25	0	0	25	2.73
Rosaceae	<i>Rosa odorata</i>	NOP	5	0	0	5	0.55
Asparagaceae	<i>Sansevieria cylindrica</i>	EOP	0	0	7	7	0.76
Asparagaceae	<i>Sansevieria masoniana</i>	EOP	0	0	10	10	1.09
Asparagaceae	<i>Sansevieria trifasciata</i>	EOP	7	0	8	15	1.64
Araliaceae	<i>Schefflera arboricola</i>	EOP	7	0	0	7	0.76
Araceae	<i>Schismatoglottis wallichii</i>	NOP	0	5	0	5	0.55
Araceae	<i>Spathiphyllum commutatum</i>	NOP	12	7	0	19	2.07
Strelitziaceae	<i>Strelitzia nicolai</i>	EOP	1	0	0	1	0.11
Acanthaceae	<i>Strobilanthes dyerianus</i>	EOP	0	1	0	1	0.11
Araceae	<i>Syngonium podophyllum cv.</i>	EOP	0	0	5	5	0.55
Myrtaceae	<i>Syzygium myrtifolium</i>	EOP	2	0	0	2	0.22
Apocynaceae	<i>Tabernaemontana divaricata</i>	EOP	8	0	0	8	0.87
Asteraceae	<i>Tagetes erecta</i>	NOP	3	0	0	3	0.33
Combretaceae	<i>Terminalia catappa</i>	NOP	3	0	0	3	0.33
Combretaceae	<i>Terminalia mantaly var.</i>	EOP	0	0	7	7	0.76
Linderniaceae	<i>Torenia fournieri</i>	EOP	10	0	0	10	1.09

Apocynaceae	<i>Wrightia antidysenterica</i>	EOP	12	0	0	12	1.31
Araceae	<i>Zamioculcas zamiifolia</i>	EOP	10	0	10	20	2.18
TOTAL			468	122	327	917	100

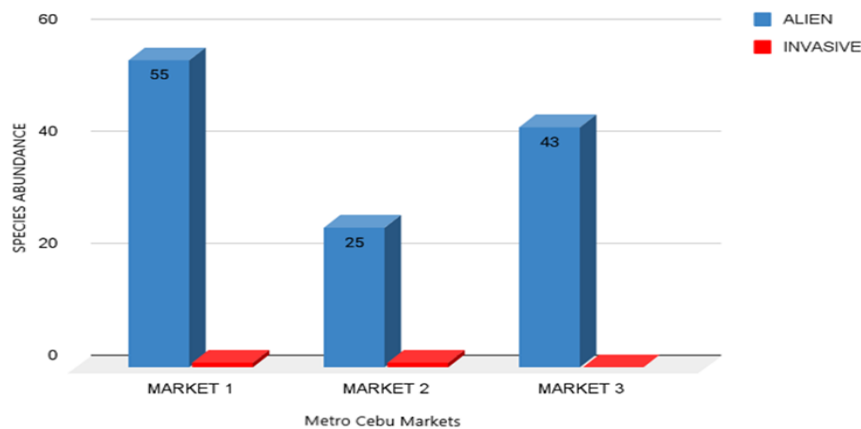
Fig. 5.

Number of NOP, EOP, and undocumented plant species found in S1, S2, and S3 Markets of Metro Cebu, Philippines.



In terms of species richness, S1 recorded 70 species, comprising 12 NOPs, 56 EOPs, and two undocumented species. In comparison, S2 exhibited lower richness with 31 species, including four NOPs, 26 EOPs, and one undocumented species, while S3 recorded 50 species consisting of seven NOPs and 43 EOPs, with no undocumented species. Across all markets, S1 contained the highest number of EOPs (56), followed by S3 (43) and S2 (26), resulting in a total of 117 EOPs documented across HUC markets.

NOPs were comparatively scarce, with a total of 19 NOPs recorded, most notably in S1 (12), followed by S3 (7) and S2 (4). Undocumented species were limited to three individuals, occurring only in S1 and S2. Overall, the findings indicate that OPT in these HUC markets is dominated by EOPs, reflecting the predominantly human-driven nature of plant availability in highly urbanized cities. Moreover, markets with greater urban intensity, such as S1, exhibited higher ornamental plant diversity, largely influenced by consumer preferences for visually appealing species, often at the expense of NOPs.

Fig. 6.*Breakdown of NOPs and EOPs classification.*

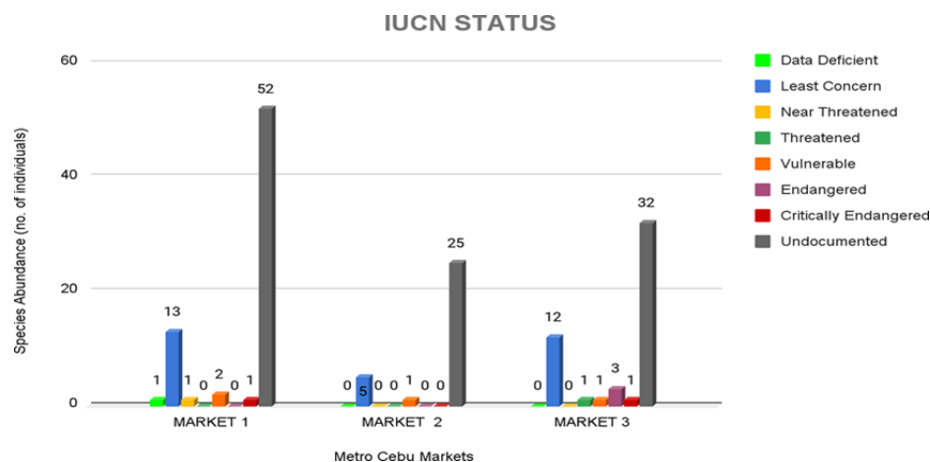
Analysis of ornamental plant composition across urban markets S1, S2, and S3 revealed a marked dominance of EOPs. *Cordyline fruticosa* cv. was consistently present across all markets, likely reflecting its widespread use in ornamental landscaping and persistent demand in urban environments (Tematio Fouedjou et al., 2023). Human-mediated activities—particularly cultivation and OPTs—have facilitated its dissemination through urban trade networks (Heath, 2020).

The species' high phenotypic plasticity, ability to thrive under tropical climatic conditions, vegetative reproduction, and rapid growth collectively enhance its persistence and competitive advantage over native flora (Tematio Fouedjou et al., 2023), increasing its likelihood of escape and establishment beyond cultivated settings. In addition to *C. fruticosa* cv., EOP were identified in S2 and S3, specifically *Epipremnum aureum* cv. and *Lantana camara*, respectively. *E. aureum* cv. exerts a strong influence on urban plant trade due to its distinctive morphological traits, perceived rarity, and extensive cultivar diversity, attributes that appeal to collectors and frequently command premium prices in urban markets (Srivastava & Meshram, 2014). This demand-driven trade pattern contributes to sustained propagule pressure, which may heighten invasion risk when plants are improperly discarded or escape cultivation. In contrast, *L. camara* remains popular primarily because of its vibrant floral characteristics and low cost, making it a widely accessible option for urban landscaping despite its well-documented invasive status (Lonare, 2012; Hariharan et al., 2024).

The distribution of International Union for Conservation of Nature (IUCN) conservation statuses was examined across three urban markets based on the EOPs and NOPs at each site. In S1, a total of 70 species were recorded, including one Data Deficient (DD), 13 Least Concern (LC), one Near Threatened (NT), two Vulnerable (VU), one Critically Endangered (CR), and a large proportion of Undocumented (UD) species ($n = 52$) (Table 2). S2 comprised 31 species, of which five were classified as Least Concern (LC), one as Vulnerable (VU), and 25 as Undocumented (UD) (Table 2). In S3, 50 species were documented, encompassing 12 Least Concern (LC), one Threatened (TH), one Vulnerable (VU), three Endangered (EN), one Critically Endangered (CR), and 32 Undocumented (UD) species.

Fig. 7.

Table of IUCN status of EOPs and NOPs found in 3 HUC markets, Metro Cebu, Philippines.



The presence of Near Threatened, Endangered, and Critically Endangered species—particularly in S1 and S3—highlights pressing conservation concerns within urban market systems. The high prevalence of Data Deficient and Undocumented classifications further signals substantial gaps in species-level information, underscoring the need for continued monitoring and improved documentation, as emphasized by Su and Pan (2024). The occurrence of threatened taxa in commercial settings raises ethical and regulatory concerns, likely linked to weak enforcement and market demand for rare species, pointing to the need for stronger policies, enhanced public awareness, and the promotion of sustainable ornamental plant alternatives.

Table 2.

Summary of species abundance, richness, and diversity of NOPs and EOPs in selected urban markets in Metro Cebu, Philippines.

	NOP	EOP	n	N	H'	PE	D
Taboan Market (S1)	14	21	468	70	3.82	0.73	0.48
T. Padilla Market (S2)	8	22	122	31	3.13	0.91	0.26
Parkmall (S3)	10	40	327	50	3.70	0.95	0.24
All markets	918	-	917	48	4.49	0.91	0.25

Note: Species Abundance (n); Shannon-Wiener Diversity Index (H'); Simpson's Diversity Index (D); Species Richness (N); Pielous' Evenness (PE)

Across the three markets, S1 recorded the highest number of ornamental plant individuals (n = 468; 51.04%), followed by S3 (n = 327; 35.66%) and S2 (n = 122; 13.30%). In S1, *Codiaeum variegatum* cv. was the most abundant species, followed by *Rosa chinensis* and *Cordyline fruticosa* cv., with several other species showing moderate representation, while several taxa occurred as single individuals. At S3, *Euphorbia pulcherrima* dominated the market, consistent with its popularity as a seasonal ornamental (Ninarska et al., 2018), whereas S2 was again led by *Codiaeum variegatum* cv., reflecting its

versatility and market demand (Magwilu et al., 2022). Diversity indices indicated high species diversity across all sites, with S1 exhibiting the highest H' at 3.82, followed by S3 ($H' = 3.70$) and S2 ($H' = 3.13$). Simpson's index values further suggested high diversity at all sites, though S1 showed comparatively greater dominance than S2 and S3 (Flores et al., 2020). PE was lowest in S1, indicating uneven species distribution, whereas S2 and S3 demonstrated more balanced assemblages. The dominance of *Codiaeum variegatum* cv. in S1 is likely driven by its ornamental appeal and reported medicinal value (Mollick et al., 2011; Mfotie Njoya et al., 2021). Overall, variations in diversity and dominance among markets appear to be shaped by consumer preferences, plant availability, economic capacity, and local environmental conditions (Leong et al., 2018; Flores et al., 2020; Soberón, 2019; Coelho et al., 2023).

EOPs and NOPs across sites documented a total of 917 individuals, with *Codiaeum variegatum* cv. emerging as the most abundant species ($n = 74$; 8.07%), followed by *Euphorbia pulcherrima* ($n = 34$; 3.71%) and *Cordyline fruticosa* cv. ($n = 30$; 3.27%). In contrast, several species, including *Cyrtostachys renda* and *Dypsis lutescens*, were represented by only one individual each (0.11%). Diversity indices indicated high overall diversity ($H' = 4.49$; $D = 0.25$) but relatively low evenness ($PE = 0.91$), suggesting dominance by a few species. The widespread occurrence of *Codiaeum variegatum* cv. is attributed to its striking foliage and multifunctional ornamental value (Mollick et al., 2011; Srivastava et al., 2021).

Similarly, the prominence of *Euphorbia pulcherrima* reflects strong seasonal demand (Nitarska et al., 2018), while *Cordyline fruticosa* cv. is favored for its ornamental appeal and commercial potential (Tematio Fouedjou et al., 2023). The abundance of *Rosa chinensis* and *Alternanthera* cv. further underscores the influence of aesthetic value and ecological relevance on market preferences (Sinu et al., 2022). Conversely, low representation of certain species may be linked to conservation concerns, such as the Near Threatened status of *Dypsis lutescens* (Rakotoarinivo et al., 2014), or to invasive risk, as observed for *Epipremnum aureum* cv. (Moodley et al., 2017), reflecting the combined effects of regulation, demand, and species availability.

Anthropogenic Assessment

Six plant sellers were interviewed across the three markets (S1 = 2, S2 = 2, and S3 = 2) during the second and third weeks of November 2023. The equal distribution of interviewees was coincidental and resulted from vendor availability, refusals, workload constraints, and the exclusion of underage sellers at the time of data collection. Overall, the respondents represented 55% of the total vendor population across the three markets (6 out of 11 sellers). Participation involved structured interviews, supplemented by informal follow-up questions to allow respondents to elaborate on their perspectives. To build rapport and enhance participant engagement, researchers also assisted with routine market activities such as cleaning stalls and organizing plants. This approach aligns with established anthropological field methods that facilitate observation, trust-building, and context-appropriate inquiry (Potschin & Haines-Young, 2011).

Table 4.
Socio-economic information of sellers in S1, S2, and S3.

Questions	General Answers	Number of Sellers
Sex/Gender	Female	6
Household size	3	2
	4	2
	5	2
Age	31-40	2
	51-60	4
Address	Guadalupe, Cebu City	2
	Budlaan, Cebu City	2
	Lorega, Cebu City	2
Educational Background	Primary school/elementary school	1
	High school/secondary school graduate	4
	College level	1
Main occupation	Plant seller	4
	Farmer	2
Income in plant selling	<5,000 PHP	2
	<15, 000 PHP	4

Socioeconomic data from the S1 and S2 markets were collected concurrently, while interviews in the S3 market were conducted on a later date to accommodate seller availability. All respondents were female and belonged to the 31–60-year age cohort, reflecting a mature and experienced segment of the urban ornamental plant workforce. The interviewees identified as native Cebuanos and long-term residents of the city, indicating strong local attachment and place-based knowledge. Educational attainment among sellers was heterogeneous, with the majority having completed secondary education (67%), while smaller proportions had attained elementary (17%) and tertiary (17%) levels. This variation in formal education may partly influence differences in botanical knowledge, regulatory awareness, and trading practices observed across markets. For the majority of participants, OPT constituted their primary source of livelihood, with the exception of the two sellers from S2. These S2 respondents were primarily farmers who engaged in plant selling as a supplementary income activity, participating in the local “tabo” from late Friday to Sunday morning and selling plants

sourced mainly from their backyards. Monthly income among S2 sellers was generally reported to be below PHP 5,000, while sellers from S1 and S3 earned average monthly incomes of less than PHP 15,000.

Table 4.1.

Structured interview questionnaire results in S1, S2, and S3.

Questions	General Answers	Participants who answered
Q1. Experience description	Childhood selling interest evolved into career for survival	3
	Only began selling later in life (~45+)	3
Q2. Years engaged in selling	5-10 years	1
	More than 10 years	5
Q3. Source of ornamental plants	Other markets within Cebu City	3
	Other cities or provinces in the Philippines	3
	Backyard planting	2
Q4. Top sellers	Flowering plants, colorful foliage	6
Q5. Safe keeping of ornamental plants	Watering and fertilizing	6
	Pruning and shaping	6
Q6. Changes in demand over the years	Increase in demand for certain types of plants	5
	Demand has remained relatively the same	1
Q7. Quality assurance	Plants are properly watered and fertilized	6
	Repot the plants when necessary	6
Q8. Legal issues encountered	Faced legal issues	2
	Not faced any legal issues	4
Q9. Impact of plant trade to environment	Livelihood; beautify surroundings	6
Q10. Wildlife trading	No	6

Q11. Presence of rare plants	Yes	6
	No	
Q12. Knowledge whether endangered or threatened	Yes	3
	No	3
Q13. Agency regulation to plant trade in Cebu	Yes	6
Q14. Wild plant collection	Decreased a lot	4
	Increased a lot	2
Q15. Change of ornamental plant type in markets over the years	Yes	6
Q16. Disposal of damaged ornamental plants	Sell at a discounted price	1
	Others (provide care)	5
Q17. Factors for pricing ornamental plants	Market demand	3
	Plant rarity	3
Q18. Authority involvement	Yes	1
	No	5
Q19. Inventory size of ornamental plant species	10-20	1
	21-50	1
	More than 50	4
Q20. Teach customers in plant management	Yes	6
Q21. Type of customers	More individual buyers	6
Q22. Government policy awareness regarding ornamental plants	Have some knowledge	3
	Not familiar	3
Q23. Participated in LGU seminars/training on regulations	Have received training	2
	Haven't received any training	4

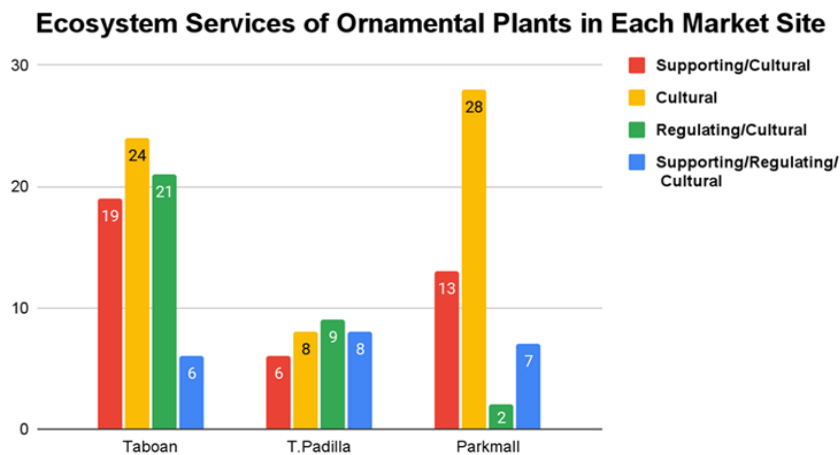
Findings in this study indicate that ornamental plant sellers exhibited heterogeneous sociodemographic characteristics and trading practices, with a substantial proportion of respondents (83%, N = 5) reporting more than a decade of experience in the OPT, suggesting a predominantly long-established and experienced vendor community. Market size varied

considerably, ranging from small clusters of 10–20 stalls to large markets exceeding 50 stalls, while plant sourcing strategies included local markets, inter-regional procurement, and backyard cultivation. Flowering plants and species with colorful foliage were unanimously identified as top-selling commodities, supported by routine maintenance practices such as watering, fertilization, and pruning. Damaged plants were primarily managed through rehabilitation efforts (N = 5) or, alternatively, sold at discounted prices, reflecting adaptive market strategies.

Most sellers (83%, N = 5) observed increasing demand for certain ornamental plants and reported noticeable shifts in plant types sold over time, likely driven by consumer preferences. Approximately 76% of inventoried plant species were EOPs of high economic value, whereas only about 24% comprised NOPs, with nearly half (N = 56) providing solely cultural ecosystem services. The dominance of EOPs raises concerns regarding their limited capacity to replace the ecological functions of displaced native flora, challenging efforts to enhance urban biodiversity and ecosystem resilience. HUCs are particularly vulnerable to IAPs' establishment due to increased propagule pressure, insufficient botanical knowledge, and uninformed purchasing behavior, which together heighten the risk of biological invasions and ecosystem degradation (Del Monte et al., 2004; Dawson et al., 2010; Geschke et al., 2018).

Fig. 8.

The distribution of ecosystem services across each Metro Cebu urban markets.



The distribution of ecosystem services (ESs) across the three market sites exhibited pronounced variation in service composition and relative dominance among categories. In S1, 70 plant species were assessed, with cultural ecosystem services dominating the inventory, represented by 24 species, while species providing combined supporting, regulating, and cultural services were least represented. In S2, 31 plant species were evaluated, with regulating–cultural services being the most common category (nine species), whereas supporting–cultural services were least represented (six species).

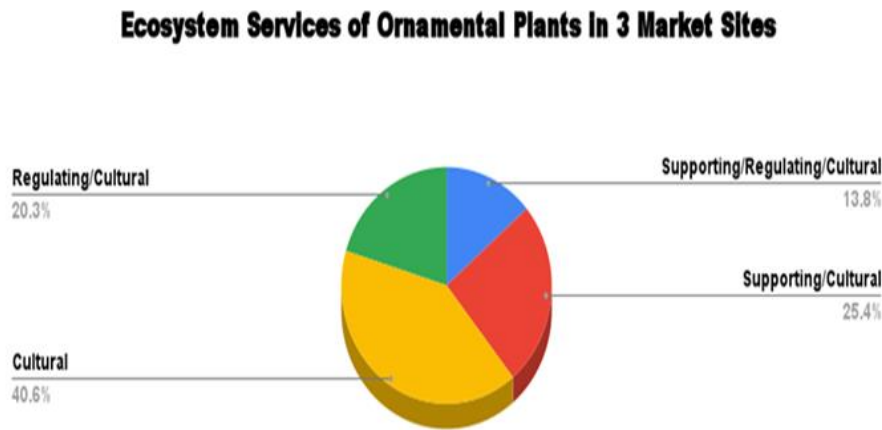
Notably, cultural services and regulating cultural services were evenly distributed in S2, indicating a relatively balanced ES profile. In contrast, S3 showed a pronounced dominance

of cultural ecosystem services, with 28 species falling under this category, compared to only two species providing regulating–cultural services.

Overall, cultural ecosystem services dominated all market sites, particularly in S3, reflecting strong consumer preference for aesthetically appealing ornamental plants (Beruto et al., 2024). S1 and S2, however, exhibited a more balanced representation of supporting and regulating services alongside cultural benefits, although these less tangible functions—such as pollination and biological control—are likely undervalued or poorly recognized by sellers and buyers (Frem, 2024). This distribution pattern underscores the primacy of aesthetic value in ornamental plant selection within urban markets, potentially at the expense of broader ecological functions essential for urban ecosystem sustainability.

Fig. 9.

The percentage of plant species possessing ecosystem services.



Distinct functional groupings were observed based when ornamental plants (n=138) were evaluated for their associated ecosystem services (Ess) (Fig. Of these, 13.8% (n = 19) provided a combination of supporting, regulating, and cultural ESs, underscoring their importance in sustaining multiple ecological processes. An additional 20.3% (n = 28) supplied regulating and cultural services, contributing to functions such as climate moderation, water regulation, and biological control (Mendes et al., 2024). Meanwhile, 25.4% (n = 35) of species offered supporting and cultural ESs, including roles in primary production and habitat formation. Notably, the largest proportion (n = 56; 40.6%) provided exclusively cultural ESs, reflecting their primary value for aesthetics and recreation (Hintural, 2024).

This dominance of cultural services indicates that consumer preferences are largely driven by visual appeal rather than less perceptible ecological benefits, presenting challenges for sustainable ornamental plant management (Chang et al., 2024). Given the substantial global economic valuation of ecosystem services, estimated at approximately USD 33 trillion annually, and their central role in human well-being, these findings highlight the need for a more integrated approach to ornamental plant selection that balances aesthetic demand with broader ecological functionality (Li et al., 2024).

Conclusion

A comprehensive evaluation of OPT in selected HUC markets in Metro Cebu, Philippines revealed a pronounced predominance of EOPs relative to NOPs. While markets exhibited high species richness and diversity, plant selection was overwhelmingly driven by aesthetic preferences, resulting in cultural ecosystem services being disproportionately represented relative to regulating and supporting services.

Prevalence of undocumented and data-deficient species, alongside the documented presence of threatened and critically endangered taxa, highlights significant gaps in plant identification, conservation oversight, and regulatory enforcement. Socioeconomic findings further demonstrate that seller practices, consumer demand, and limited awareness of conservation policies collectively shape plant availability and propagule pressure, positioning urban markets as both drivers of urban greening and potential entry points for biological invasions and ecosystem degradation. Sustainable planning within the OPT is recommended to strengthen regulatory frameworks, (i.e., routine market monitoring, mandatory taxonomic labeling, and systematic verification of conservation status) to prevent the circulation of IAPs. Capacity-building initiatives for sellers—particularly those addressing basic botanical knowledge, ecosystem services, and invasive species risks—should be institutionalized across both formal and informal markets.

Policy instruments that incentivize the cultivation and sale of NOPs with multifunctional ESs may help counterbalance current market biases toward aesthetics alone. Future research should adopt longitudinal and market-wide approaches that integrate seller and consumer perspectives, ESs valuation, and urban planning frameworks, thereby supporting evidence-based strategies that align ornamental plant trade with biodiversity conservation and urban sustainability goals.

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