

Research Paper

Bridging biodiversity and food systems: A nationwide synthesis of non-conventional food plants (PANCs) in Brazil



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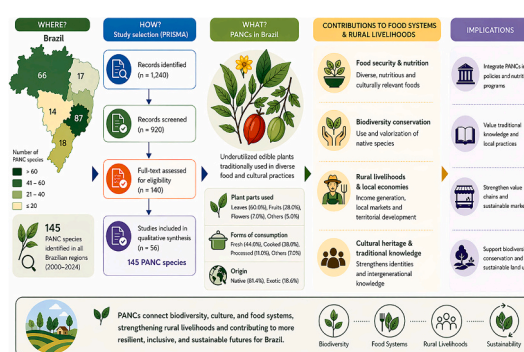
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HIGHLIGHTS

- Maps 145 Brazilian PANCs across regions and biomes.
- Links edible biodiversity to policy-relevant food-system outcomes.
- Identifies policy gaps: regulation, procurement, safety, value chains.
- Proposes actions to connect biodiversity with sustainable food policies.
- Evidence to integrate PANCs into school meals and public procurement.

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor: Mark van Wijk

Keywords:

Non-conventional food plants
PANCs
Food systems
Agroecology
Biodiversity

ABSTRACT

Context: The increasing erosion of agrobiodiversity and the growing demand for sustainable food systems have intensified interest in non-conventional food plants (PANCs, a term originally proposed in Brazil) as strategic resources for enhancing food security, biodiversity conservation, and rural livelihoods. In Brazil, PANCs are deeply embedded in socioecological systems and traditional knowledge. However, existing studies remain fragmented, region-specific, and lack integrative analyses at the national scale.

Objective: This study aims to provide a nationwide synthesis of PANCs in Brazil, analyzing their distribution, uses, and socioecological roles across five macro-regions, and evaluating their contributions to sustainable food systems.

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<https://doi.org/10.1016/j.agsy.2026.104782>

Received 3 April 2026; Received in revised form 21 April 2026; Accepted 23 April 2026

Available online 16 May 2026

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Methods: A structured narrative review was conducted using systematic search principles across Scopus, Web of Science, SciELO, and Google Scholar, covering 2000–2024. Studies were selected using defined criteria, and 145 species were compiled. Analyses combined descriptive statistics with qualitative socioecological interpretation of ecological, cultural, and territorial dynamics.

Results and conclusions: Results reveal strong regional heterogeneity. The North and Northeast regions have strong links to traditional knowledge, supporting food security and climate adaptation. Southeast and South reflect revalorization driven by markets and agroecology. Central-West highlights tensions between intensification and conservation. PANCs exhibit multifunctionality, contributing to nutrition, ecosystem services, and livelihoods, but face barriers, including limited knowledge and weak value chains.

Significance: This study provides the first nationwide synthesis of non-conventional food plants (PANCs) in Brazil, bridging biodiversity and food systems through an integrated socioecological perspective. It highlights PANCs as strategic leverage points for inclusive, diversified, and climate-resilient food systems. Furthermore, the findings support their integration into public policies, including school feeding programs and institutional procurement initiatives, strengthening their role in promoting food security, rural development, and biodiversity conservation.

1. Introduction

The ongoing erosion of agrobiodiversity represents one of the most pressing challenges for global food systems, with profound implications for food security, rural livelihoods, and climate resilience. Over the last century, agricultural production has become increasingly concentrated in a limited number of staple crops, with wheat, maize, and rice accounting for a substantial proportion of plant-derived caloric intake worldwide (FAO, 2021). This process of agricultural homogenization has contributed to the loss of genetic resources, reduced dietary diversity, and increased vulnerability of rural systems to environmental and economic shocks (Khoury et al., 2022). In response, international frameworks such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) have emphasized the need to reconnect biodiversity conservation with food systems, highlighting the interdependencies between ecosystems, human well-being, and governance structures (IPBES, 2019).

Within this context, increasing attention has been directed toward neglected and underutilized species (NUS), also referred to as orphan crops, which encompass a wide range of plant species traditionally used in local food systems but marginalized by industrial agriculture (Mayes et al., 2020). These species are increasingly recognized not only for their nutritional and ecological value but also for their potential to support rural development, strengthen local economies, and enhance the resilience of socioecological systems. In many regions of the Global South, NUS play a critical role in sustaining traditional agricultural practices, maintaining cultural identity, and diversifying income sources for smallholder farmers.

In Brazil, this discussion is framed through the concept of non-conventional food plants (Plantas Alimentícias Não Convencionais - PANCs), a term widely used to describe native or naturalized edible species that are not commonly integrated into formal agricultural systems (Kinupp and Lorenzi, 2014). PANCs are deeply embedded in traditional knowledge systems, particularly among Indigenous communities, quilombolas, and smallholder farmers, where they contribute to food security, medicinal practices, and cultural continuity (Jacob and Albuquerque, 2020; Santos et al., 2022). Brazil's exceptional biodiversity, distributed across six major biomes (Amazon, Cerrado, Atlantic Forest, Caatinga, Pampa, and Pantanal), provides a unique context for exploring the role of these species in bridging ecological diversity and food systems.

Beyond their ecological and nutritional attributes, PANCs represent strategic assets for rural development and socioecological resilience. Their adaptability to marginal environments, low input requirements, and compatibility with agroecological practices make them particularly relevant in the context of climate change and sustainable land use. Moreover, their integration into local markets, short supply chains, and public food programs, such as school feeding initiatives, can help strengthen territorial food systems and promote food sovereignty. However, despite these potential benefits, PANCs remain largely

underutilized in formal food systems, facing barriers such as knowledge erosion, limited value chains, regulatory constraints, and low consumer awareness (Almeida and Silva, 2023; da Costa Santos, 2024).

Although a growing body of ethnobotanical and nutritional research has documented the diversity and uses of PANCs in Brazil, existing studies are often fragmented, focusing on specific regions, communities, or species. As a result, there is a lack of integrative analyses that connect biodiversity patterns with socio-cultural practices, rural livelihoods, and food system dynamics at the national scale. Furthermore, limited attention has been given to how these species can contribute to broader debates on sustainable rural development, governance, and food system transformation, particularly within the framework of biodiversity-food-society interactions emphasized by global assessments such as the IPBES Nexus.

Another critical gap concerns the spatial distribution of PANCs across Brazil's regions and biomes and how these patterns relate to socioecological factors. While regional studies provide valuable insights, there is still no consolidated nationwide synthesis that systematically compares species diversity, uses, and cultural relevance across different territorial contexts. Such an approach is essential for identifying biodiversity hotspots, understanding regional disparities, and informing targeted strategies to integrate PANCs into sustainable rural development pathways.

Within this framework, this study aims to provide a comprehensive national synthesis of non-conventional food plants (PANCs) in Brazil, positioning them within the broader framework of rural development and socioecological systems. Specifically, the study seeks to: (i) map the distribution of 145 PANC species across Brazil's five macro-regions and major biomes; (ii) analyze patterns of use in relation to ecological, cultural, and territorial contexts; and (iii) discuss the potential of PANCs to contribute to sustainable food systems, rural livelihoods, and biodiversity conservation. By bridging biodiversity data with socioecological interpretation, this review advances current knowledge and provides insights to support policy development, agroecological strategies, and the strengthening of territorial food systems in Brazil and beyond.

Despite the growing body of regional and species-specific studies, a comprehensive nationwide synthesis integrating biodiversity patterns with socioecological dynamics remains lacking. This gap limits the understanding of how PANCs contribute to food system transformation at broader territorial scales. Therefore, this study advances beyond fragmented analyses by providing the first integrative national assessment, explicitly connecting ecological distribution, cultural practices, and rural development processes across Brazil.

2. Methodology

This study adopts a structured narrative review approach, which enables the integration and critical interpretation of heterogeneous evidence from ethnobotanical, nutritional, and agricultural studies. This approach is particularly suitable for synthesizing dispersed knowledge

and identifying patterns across socioecological systems, as commonly applied in interdisciplinary rural and food system research (Snyder, 2019).

2.1. Literature search strategy

A comprehensive literature search was conducted across four major databases: Scopus, Web of Science, SciELO, and Google Scholar, to ensure broad coverage of both international and regional publications. The search combined keywords related to non-conventional food plants and socioecological systems, including: “non-conventional food plants”, “PANC”, “underutilized species”, “neglected crops”, “ethnobotany”, “agrobiodiversity”, “food systems”, and “Brazil”.

To minimize language bias and capture region-specific knowledge, searches were conducted in English, Portuguese, and Spanish, addressing a limitation commonly identified in ethnobotanical reviews. The temporal scope of the review covered the period from 2000 to 2024. This timeframe was selected because it corresponds to the consolidation and expansion of scientific research on agrobiodiversity, ethnobotany, and sustainable food systems in Brazil and globally, particularly following increased international attention to biodiversity–food system linkages in

the early 21st century.

For greater transparency and reproducibility, the study selection process was structured according to PRISMA 2020 (Page et al., 2021) principles adapted for a structured narrative review, as illustrated in Fig. 1. The final dataset consisted of 56 studies selected based on predefined inclusion criteria. Additional references, including institutional reports and theoretical frameworks, were used to support the interpretation and discussion but were not included in the PRISMA flow diagram.

2.2. Inclusion and exclusion criteria

Studies were included if they:

- reported edible plant species classified as PANCs or equivalent categories (e.g., NUS);
- provided information on at least one of the following: geographic distribution, edible parts, food use, or socioecological context;
- were conducted in Brazil or included relevant data on Brazilian species;

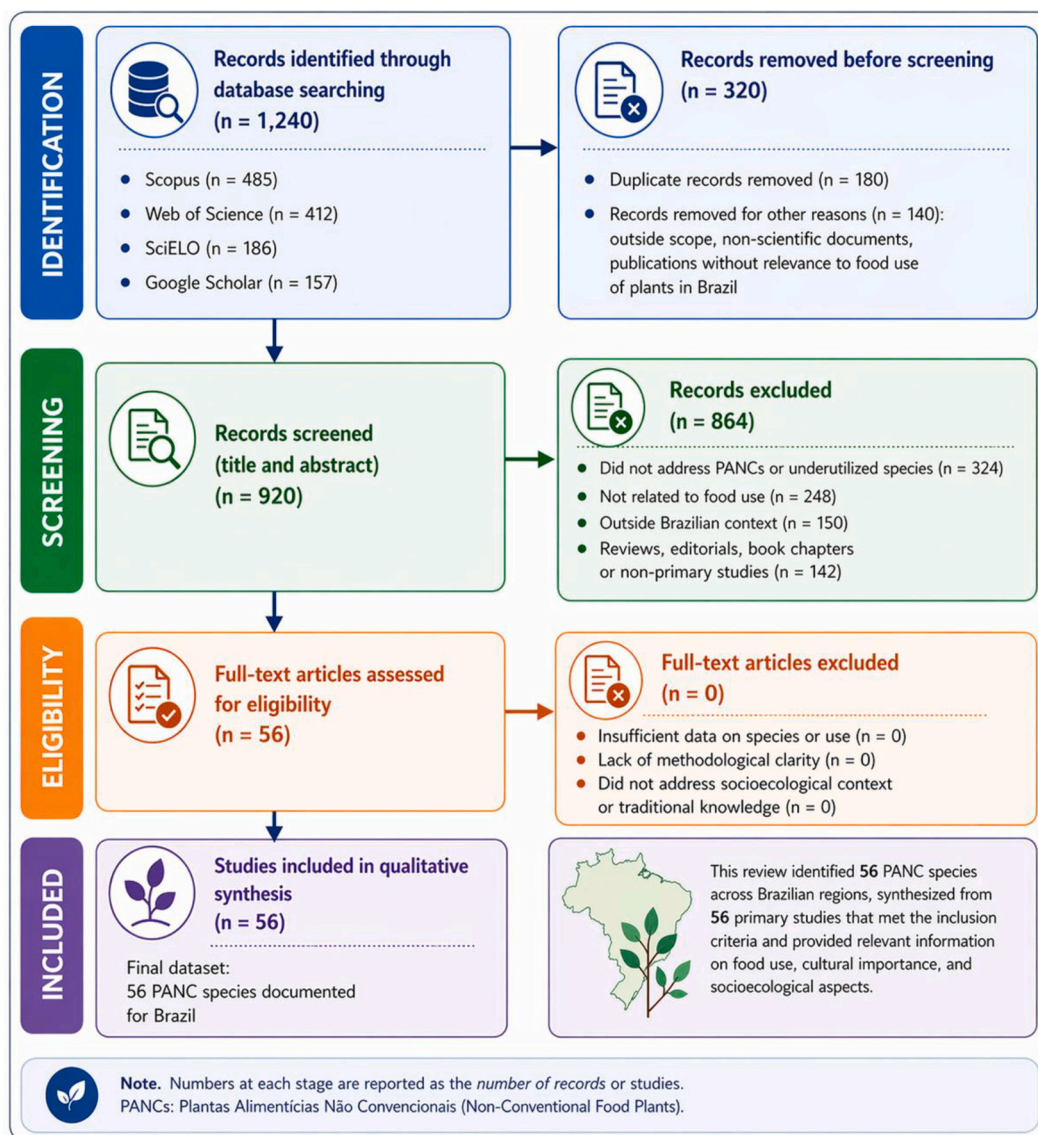


Fig. 1. PRISMA flow diagram illustrating the literature selection process, including identification, screening, eligibility, and inclusion stages based on predefined criteria for PANC-related studies in Brazil.

- were published in peer-reviewed journals, books, or institutional reports.

Studies were excluded if they:

- lacked a clear methodological description or traceable data;
- did not relate to food use;
- were purely agronomic without relevance to human consumption or socioecological systems.

2.3. Selection of core sources and dataset construction

From the initial corpus of literature, a subset of key reference studies was selected to construct the analytical database. These sources were chosen based on their comprehensive coverage of multiple Brazilian regions and biomes, methodological clarity, and frequent citation in the literature (e.g., Barreira et al., 2015; Biondo et al., 2018; Santos et al., 2020; Jacob and Albuquerque, 2020).

Based on these sources and complementary studies, a dataset of 145 PANC species was compiled. This subset was selected as a representative sample of the approximately 3000 edible plant species recorded in Brazil, prioritizing species for which consistent and comparable information was available.

The inclusion of species followed three criteria:

1. identification of at least one region of occurrence;
2. specification of the edible plant part;
3. description of at least one form of food use.

These criteria ensured analytical consistency and allowed for cross-regional comparison.

2.4. Data organization and variables

The dataset was organized into a structured database including the following variables:

- scientific name of the species;
- common name;
- edible plant parts (leaves, fruits, flowers, stems, seeds, underground organs, shoots);
- region of occurrence (North, Northeast, Central-West, Southeast, South);
- form of food use (e.g., fresh consumption, cooked, processed);
- bibliographic source.

This structure enabled both quantitative description and qualitative interpretation of patterns across regions and socioecological contexts.

2.5. Analytical approach

To account for potential biases related to uneven regional research intensity, the analysis explicitly considered differences in data availability and documentation across regions. Accordingly, the results should be interpreted as reflecting both ecological distribution and knowledge visibility.

The analytical framework combined descriptive and interpretative approaches. A frequency-based descriptive analysis was performed to identify patterns in species distribution across regions, the most frequently used plant parts, predominant forms of consumption, and the relative occurrence of native versus exotic species. This approach provides a structured overview of patterns within the compiled dataset, consistent with the exploratory nature of the study, rather than aiming at inferential statistical modeling.

In parallel, a qualitative socioecological analysis was conducted to interpret these patterns in relation to ecological conditions (biomes and

environmental characteristics), cultural practices and traditional knowledge systems, regional food practices, and rural livelihoods and territorial dynamics. This interpretative layer is essential for understanding how biodiversity data translate into food system functions and rural development processes.

The qualitative interpretation was further supported through triangulation of multiple sources, including ethnobotanical studies, regional analyses, and cross-referenced datasets, ensuring consistency and interpretative robustness.

2.6. Regional comparison framework

To enhance analytical depth, a comparative framework was applied across Brazil's five macro-regions. The analysis considered:

- differences in species diversity and composition;
- variation in plant parts and culinary uses;
- relationships between biodiversity and socio-cultural practices;
- potential biases related to research intensity and data availability.

This comparative approach allows the identification of regional patterns and asymmetries, contributing to a more nuanced understanding of how PANCs interact with territorial and socioecological dynamics.

2.7. Limitations

Some limitations should be acknowledged. First, the dataset reflects the availability of documented knowledge, which may lead to under-representation of regions with limited research coverage. Second, differences in terminology and classification across studies may introduce inconsistencies. Third, despite efforts to include multiple languages, some local or Indigenous knowledge may remain undocumented in scientific literature.

Recognizing these limitations is essential for interpreting the results and for guiding future research toward more inclusive and comprehensive approaches.

3. Results and discussion

This section presents an integrated analysis of the distribution, uses, and socioecological relevance of non-conventional food plants (PANCs) across Brazil. The compiled dataset (Table 1) includes 145 species distributed across the five macro-regions, allowing both descriptive and interpretative examination of patterns related to biodiversity, food practices, and territorial dynamics.

As illustrated in Fig. 2, the distribution of PANC species is uneven across regions, with higher concentrations in the North and Southeast. This pattern reflects not only ecological factors, such as the high biodiversity of the Amazon and Atlantic Forest, but also differences in research intensity, documentation efforts, and the persistence of traditional knowledge systems. Therefore, the observed distribution should be interpreted as a combination of biophysical availability and knowledge visibility, rather than purely ecological abundance.

The visual synthesis provided in Fig. 2 reinforces the interpretation that species distribution is not solely determined by ecological availability, but also reflects socioecological dynamics, including knowledge systems, cultural practices, and research intensity across regions.

Across all regions, a consistent pattern emerges regarding the predominance of specific plant parts. Leaves constitute the most frequently consumed component, followed by fruits and flowers. This distribution reflects both functional and cultural factors: leaves are generally more accessible, require minimal processing, and are strongly embedded in traditional culinary practices. Fruits, in turn, play a central role in both subsistence and local economies, particularly in biodiversity-rich regions, where they are often associated with extractivist systems and

Table 1

List of edible wild plants: scientific and common names, parts used, and regional sources.

Scientific Name	Common name (Portuguese)	Used parts	Region	Reference
<i>Abelmoschus esculentus</i> (L.) Moench	quiabo	fruits	North	3
<i>Allophylus edulis</i> (A. St.-Hil., A.Juss. & Cambess.) Hieron.	olho-de-pomba	fruits	South	2,4
<i>Alstroemeria caryophylla</i> Jacq.	lírio-dos-incas	flowers; roots	South	2
<i>Alternanthera dentata</i> (Moench) Stuchlík ex R.E. Fr.	perpétua ou cibalena	leaves; stems	North	3
<i>Alternanthera sessilis</i> (L.) R.Br. ex DC.	orelha-de-macaco	leaves	North	3
<i>Amaranthus hybridus</i> L.	caruru	leaves	Southeast	1
<i>Amaranthus melancholicus</i> L.	brede ou caruru	leaves	North	3
<i>Amaranthus viridis</i> L.	brede, caruru, caruru-verdadeiro	leaves; stems; seeds	Northeast	4
<i>Amaranthus viridis</i> L.	caruru	seeds	South	2,4
<i>Ananas bracteatus</i> (Lindl.) Schult. & Schult.f.	abacaxi-branco, abacaxi-do-mato	fruits	South	2
<i>Ananas bracteatus</i> var. <i>albus</i>	ananás do mato	fruits	Southeast	1
<i>Annona sylvatica</i> A. St.-Hil.	araticum do mato	fruits	Southeast	1
<i>Annona sylvatica</i> A. St.-Hil.	araticum-do-mato	fruits	South	2,4
<i>Anredera cordifolia</i> (Ten.) Steenis	lobrobó verdadeiro	leaves	Southeast	1
<i>Anredera cordifolia</i> (Ten.) Steenis	bertalha-coração	leaves; tubers	South	2,4
<i>Anredera krapovickasii</i> (Duch.) Sparre	bertalha-do-cabinho-roxo	leaves	South	2,4
<i>Arrabidaea chica</i> (Bonpl.) Benth.	crajiru ou pariri	leaves	North	3
<i>Arracacia xanthorrhiza</i> Bancr.	mandioquinha	roots; leaves	Central-West	2,4
<i>Arracacia xanthorrhiza</i> Bancr.	batata-baroa	roots; leaves	Southeast	2,4
<i>Arracacia xanthorrhiza</i> Bancr.	batata-salsa	roots; leaves	South	2,4
<i>Artocarpus altilis</i> (Parkinson) Fosberg	fruta-pão-de-massa	fruits	North	3
<i>Artocarpus heterophyllus</i> Lam.	jacá	fruits	North	3
<i>Astrocaryum aculeatissimum</i> (Schott) Burret	coco de brejaúva	endosperm; seeds	Southeast	1
<i>Attalea dubia</i> (Mart.) Burret	coco indaiá	pulp; seeds	Southeast	1
<i>Basella rubra</i> L.	bertalha	leaves	Southeast	1
<i>Begonia cucullata</i> Willd.	azedinha	flowers	South	2,4
<i>Bidens pilosa</i> L.	picão	leaves	Southeast	1
<i>Bidens pilosa</i> L.	picão	leaves; stems; flowers	North	3
<i>Boehmeria nivea</i> (L.) Gaudich.	rami	leaves	Southeast	1

Table 1 (continued)

Scientific Name	Common name (Portuguese)	Used parts	Region	Reference
<i>Bromelia antiacantha</i> Bertol.	bananinha-do-mato, gravatá	fruits	South	2,4
<i>Bryophyllum pinnatum</i> (Lam.) Oken	pirarucu	leaves	North	3
<i>Campomanesia pubescens</i> (DC.) O.Berg	gabirola do mato	fruits	Southeast	1
<i>Campomanesia xanthocarpa</i> O. Berg	guabirola	fruits	South	2,4
<i>Cenostigma pyramidale</i> (Tul.) Gagnon & G.P. Lewis	catingueira	leaves	North	3
<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants	mastruz	leaves; stems	North	3
<i>Cichorium intybus</i> L.	almeirão de árvore	leaves	Southeast	1
<i>Cinnamomum verum</i> J.Presl	caneleira-verdadeira	leaves; stems	North	3
<i>Colocasia esculenta</i> (L.) Schott	inhame ou inhame roxo	leaves; roots	North	3
<i>Colocasia esculenta</i> var. <i>antiquorum</i>	inhame-rosa	roots	South	2,4
<i>Costus spicatus</i> (Jacq.) Sw.	canaficha ou cana-do-brejo	leaves	North	3
<i>Cucumis anguria</i> L.	maxixe	fruits	North	3
<i>Diclidanthera elliptica</i> Mart.	jabuticaba de rama	fruits	Southeast	1
<i>Dioscorea alata</i> L.	cará-roxo	roots	North	3
<i>Dioscorea bulbifera</i> L.	cará	roots	North	3
<i>Dioscorea bulbifera</i> L.	cará-do-ar	tubers	South	2
<i>Diospyros kaki</i> L.f.	caqui	fruits	North	3
<i>Dipteryx odorata</i> (Aubl.) Willd.	cumarú	fruits	North	3
<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants	mastruz, menstruz, etc.	leaves	Northeast	4
<i>Echinodorus grandiflorus</i> (Cham. & Schldl.) Micheli	chapéu-de-couro	leaves	North	3
<i>Emilia sonchifolia</i> (L.) DC.	serralhinha	leaves	Southeast	1
<i>Erechites valerianaefolia</i> (Wolf) DC.	capicova	leaves	Southeast	1
<i>Eugenia involucrata</i> DC.	cereja brasileira	fruits	South	2
<i>Eugenia myrtifolia</i> Sims	laranjinha do mato	fruits	Southeast	1
<i>Eugenia uniflora</i> L.	pitanga	fruits	South	2
<i>Eugenia uniflora</i> L.	pitanga	fruits	Southeast	1
<i>Eupatorium ayapana</i> Vent.	japana	leaves; stems	North	3
<i>Ficus maxima</i> Mill.	caximuba	fruits; roots	North	3
<i>Fleurya aestuans</i> (L.) Gaudich.	cansação	leaves	Southeast	1
<i>Garcinia gardneriana</i> (Planch. & Triana) Zappi	bacupari	fruits	Southeast	1
<i>Hedychium coronarium</i> J. Koenig	gingibre-do-brejo	flowers; tubers	South	2
<i>Hibiscus sabdariffa</i> L.	vinagreira	leaves; flowers	Southeast	1

(continued on next page)

Table 1 (continued)

Scientific Name	Common name (Portuguese)	Used parts	Region	Reference
<i>Hibiscus sabdariffa</i> L.	caruru-azedo, quiabo-roxo, vinagreira	flowers; fruits; seeds	North	3
<i>Hibiscus sabdariffa</i> L.	vinagreira	flowers	South	2
<i>Hymenaea courbaril</i> L.	jatobá	fruits	North	3
<i>Inga vera</i> Willd.	ingá banana	fruits	Southeast	1
<i>Ipomoea batatas</i> (L.) Lam.	folha de batata-doce	leaves	Southeast	1
<i>Ipomoea fistulosa</i> Mart. ex Choisy	maniorana ou algodão-do-campo	leaves	North	3
<i>Ipomoea grandifolia</i> (Dammer) O'Donnell	corda-de-violã	leaves; stems; flowers	North	3
<i>Kalanchoe fedtschenkoi</i> Raym.-Hamet & H.Perrier	calanchoe e saião-fantasma	leaves; flowers	South	2
<i>Lactuca canadensis</i> L.	almeirão roxo	leaves	Southeast	1
<i>Lepidium pseudodidymum</i> Thell.	mentrasto	leaves	Southeast	1
<i>Solanum lycopersicum</i> L.	folha de tomate	leaves	Southeast	1
<i>Mangifera indica</i> L.	mangueira	leaves; fruits	North	3
<i>Manihot esculenta</i> Crantz	folha de mandioca	leaves	Southeast	1
<i>Marcgravia coriacea</i> Vahl	mão-de-onça	leaves; stems; flowers	North	3
<i>Melothria cucumis</i> Vell.	pepininho-do-mato	fruits	South	2
<i>Mentha aquatica</i> L.	vega-morta	leaves	North	3
<i>Mentha arvensis</i> L.	viqe	leaves; stems	North	3
<i>Mentha spicata</i> L.	hortelã	leaves; stems	North	3
<i>Mikania lindleyana</i> DC.	folha-de-sucurijá	leaves	North	3
<i>Momordica charantia</i> L.	melão-de-são caetano	seeds	South	2,4
<i>Monstera deliciosa</i> Liebm.	costela-de-adão	fruits	South	2,4
<i>Ocimum basilicum</i> L.	manjerição	leaves	North	3
<i>Ocimum selloi</i> Benth.	atroveran	leaves; stems	North	3
<i>Operculina macrocarpa</i> (L.) Urb.	batatão ou jalapa	roots	North	3
<i>Opuntia ficus-indica</i> (L.) Mill.	figo-da-índia, palma, etc.	leaves; fruits; flowers	Northeast	4
<i>Oxalis corniculata</i> L.	trevo azedo	leaves	Southeast	1
<i>Oxalis latifolia</i> Kunth	trevinho, azedinho	leaves; flowers	South	2,4
<i>Passiflora amethystina</i> J.C. Mikan	maracujá do mato	fruits	Southeast	1
<i>Passiflora tenuiflora</i> Killip	maracujá-de-cobra	fruits	South	2,4
<i>Passiflora vitifolia</i> Kunth	maracujá mirim	fruits	Southeast	1
<i>Pedilanthus tithymalooides</i> (L.) Poit.	coramina	leaves; stems	North	3
<i>Pereskia aculeata</i> Mill.	lobrobô miúdo	leaves	Southeast	1
<i>Pereskia bahiensis</i> Gürke	ora-pró-nóbis ereta	leaves	Southeast	1
<i>Pereskia grandiflora</i> Haw.	lobrobô graúdo	leaves	Southeast	1

Table 1 (continued)

Scientific Name	Common name (Portuguese)	Used parts	Region	Reference
<i>Physalis angulata</i> L.	juá manso (juá pocã)	fruits	Southeast	1
<i>Piper jaborandi</i> Holmes	jaborandi	leaves	Southeast	1
<i>Plantago coriacea</i> Lam.	transagem do mato	leaves	Southeast	1
<i>Plantago major</i> L.	transagem da horta	leaves	Southeast	1
<i>Plantago major</i> L.	tansagem	leaves	South	2,4
<i>Plinia edulis</i> (Vell.) Sobral	cambucá	fruits	Southeast	1
<i>Portulaca oleracea</i> L.	beldroega, caaponga, etc.	leaves; stems; flowers	Northeast	4
<i>Portulaca oleracea</i> L.	beldroega	leaves	Southeast	1
<i>Portulaca oleracea</i> L.	beldroega	leaves	South	2,4
<i>Poupartia amazonica</i> Aubl.	jacaicá	fruits	North	3
<i>Psidium cattleianum</i> Sabine	araçá-da-praia	fruits	South	2,4
<i>Psidium cattleianum</i> Sabine	araçá vermelho	fruits	Southeast	1
<i>Psidium cattleianum</i> Sabine	araçá	fruits	North	3
<i>Psidium guineense</i> Sw.	araçá do campo	fruits	Southeast	1
<i>Rubus cf. sellowii</i> Cham. & Schlttdl.	amora-do-mato	fruits	South	2,4
<i>Rubus rosifolius</i> Sm.	morango-do-mato	fruits	South	2,4
<i>Rubus rosifolius</i> Sm.	amora do mato	fruits	Southeast	1
<i>Rumex acetosa</i> L.	azedinha/labaça	leaves	Southeast	1
<i>Rumex obtusifolius</i> L.	língua-de-vaca	leaves	South	2,4
<i>Schinus terebinthifolia</i> Raddi	aroeira vermelha	fruits; seeds	South	2,4
<i>Sicana odorifera</i> (Vell.) Naudin	maracujina	fruits	Southeast	1
<i>Sicana sphaerica</i> Vell.	melão croá	fruits	Southeast	1
<i>Sinapis arvensis</i> L.	mostarda silvestre	leaves	Southeast	1
<i>Solanum juciri</i> Mart.	jequiri	fruits	Southeast	1
<i>Solanum americanum</i> Mill.	erva moura	fruits	Southeast	1
<i>Sonchus arvensis</i> L.	serralha lisa	leaves	Southeast	1
<i>Sonchus asper</i> (L.) Hill	serralha espinhenta	leaves	Southeast	1
<i>Sonchus oleraceus</i> L.	serralha do mato	leaves	Southeast	1
<i>Sonchus oleraceus</i> L.	serralha peixinho	leaves	South	2,4
<i>Stachys byzantina</i> K.Koch	peixinho	leaves	Southeast	1
<i>Stachys byzantina</i> K.Koch	peixinho	leaves	Southeast	1
<i>Syagrus coronata</i> (Mart.) Becc.	coco licuri	pulp; seeds	Southeast	1
<i>Syagrus romanzoffiana</i> (Cham.) Glassman	gerivá	fruits	South	2,4
<i>Syzygium cumini</i> (L.) Skeels	jambolão	fruits	Southeast	1
<i>Talinum fruticosum</i> (L.) Juss.	cariru, beldroega-graúda, etc.	leaves; stems; flowers	Northeast	4

(continued on next page)

Table 1 (continued)

Scientific Name	Common name (Portuguese)	Used parts	Region	Reference
<i>Talinum paniculatum</i> (Jacq.) Gaertn.	major-gomes, maria-gorda	leaves; seeds	South	2,4
<i>Taraxacum officinale</i> F.H. Wigg.	dente de leão	leaves; flowers	South	2,4
<i>Taraxacum officinale</i> F.H. Wigg.	dente de leão	leaves	Southeast	1
<i>Tradescantia fluminensis</i> Vell.	trapoeraba	leaves	Southeast	1
<i>Tropaeolum majus</i> L.	capuchinha	leaves; flowers	Southeast	1
<i>Tropaeolum pentaphyllum</i> Lam.	raiz amarga	flowers; roots	South	2,4
<i>Turnera subulata</i> Sm.	chanana, damiana, etc.	leaves; flowers	Northeast	4
<i>Typha angustifolia</i> L.	taboa	shoots	Southeast	1
<i>Tropaeolum majus</i> L.	capuchinha	leaves; flowers	South	2,4
<i>Typha domingensis</i> Pers.	taboa, tifa	pollen; shoots; stem	South	2,4
<i>Urera baccifera</i> (L.) Gaudich. ex Wedd.	urtiga-roxa, urtigão	leaves; fruits; seeds	South	2,4
<i>Vasconcellea quercifolia</i> A.St.-Hil.	mamãozinho-do-mato, jaracatiá	fruits; stem	South	2,4
<i>Vernonanthura patens</i> (Kunth) H. Rob.	cambará	leaves	Southeast	1
<i>Vigna unguiculata</i> (L.) Walp.	feijão-de-corda	leaves; seeds	North	3

Note: The recurrence of some plant species reflects their occurrence across multiple regions, diverse forms of use, and documentation in different studies. These entries represent the multifunctionality and wide geographical distribution of PANC species rather than duplication.

Sources: ¹ Barreira et al. (2015); ² Biondo et al. (2018); ³ Santos et al. (2020); ⁴ Jacob and Albuquerque (2020).

regional markets.

The species compiled in Table 1 further illustrate these patterns, highlighting the multifunctionality and regional relevance of PANCs. Representative images of selected species are provided in the Supplementary Material (Fig. S1) to support their visual identification and characterization.

Beyond descriptive patterns, the data reveal important socio-ecological dynamics. The widespread occurrence of species such as *Portulaca oleracea* and *Amaranthus viridis* across multiple regions indicates high ecological adaptability and cultural acceptance, making them strategic candidates for scaling biodiversity-based food systems. Their presence in both rural and urban contexts suggests potential for strengthening short supply chains, urban agriculture, and public food programs.

At the same time, regional asymmetries highlight structural challenges. Lower representation in the Central-West, for example, may reflect not only ecological factors but also the impacts of agricultural homogenization and limited ethnobotanical documentation. These patterns underscore the importance of integrating biodiversity conservation with rural development strategies, particularly in regions under pressure from large-scale agriculture.

Overall, the results indicate that PANCs function not merely as isolated plant resources but as components of broader territorial food systems, linking biodiversity, cultural practices, and rural livelihoods. The following sections explore these dynamics in detail across Brazil's regions.

3.1. North region: biodiversity, traditional knowledge, and forest-based livelihoods

The North Region of Brazil stands out as the most biodiverse context for PANCs, as reflected in the high number of species recorded in Fig. 2. This pattern is strongly associated with the Amazon biome, which provides favorable ecological conditions for a wide range of edible species and supports complex socioecological systems rooted in traditional knowledge (IPBES, 2019; FAO, 2021). However, this concentration cannot be explained solely by ecological abundance. It also reflects the persistence of culturally embedded food practices and a greater continuity of ethnobotanical knowledge compared to other regions, where processes of modernization and land-use transformation have contributed to knowledge erosion (Jacob and Albuquerque, 2020; Santos et al., 2022).

As illustrated in Fig. 3, the region's geographic extent overlaps with areas of high ecological integrity, where Indigenous and traditional communities play a central role in maintaining biodiversity and associated food practices (IPBES, 2019). In these territories, PANCs are not marginal or alternative resources but integral components of local food systems, contributing simultaneously to subsistence, health, and cultural identity (Kinupp and Lorenzi, 2014). Their use is embedded in daily practices, seasonal cycles, and local ecological knowledge, reinforcing their relevance beyond purely nutritional aspects. This embeddedness highlights the role of PANCs as biocultural resources, linking ecological diversity with cultural continuity and social organization (Santos et al., 2022).

The dataset presented in Table 1 highlights several species that exemplify these dynamics. Species such as *Euterpe oleracea* (açai), *Mauritia flexuosa* (bacaba), *Dipteryx odorata* (cumarú), and *Artocarpus heterophyllus* (jackfruit) demonstrate the multifunctionality of PANCs in the region. These plants are used in diverse ways, including fresh consumption, beverages, processed products, and ingredients for local gastronomy (Kinupp and Lorenzi, 2014). In addition to their dietary importance, many of these species are closely linked to forest-based livelihoods, particularly in extractivist systems that integrate food production with biodiversity conservation. These systems represent a key model of sustainable resource use, in which economic activities are aligned with ecological processes (FAO, 2021; Altieri, 2018).

As shown in Fig. 4, these species are associated with multiple value chains, ranging from subsistence use to regional and international markets. For instance, açai has become a globally traded product, illustrating how a traditional food resource can be incorporated into modern value chains while maintaining its cultural significance (Santos et al., 2022). However, this transition is not neutral. While commercialization creates income opportunities for rural and riverine communities, it also introduces risks of overexploitation, land-use pressure, and unequal distribution of economic benefits, particularly when market expansion is not accompanied by adequate governance mechanisms (FAO, 2021; IPBES, 2019).

This dual dynamic highlights the importance of governance and territorial regulation in shaping sustainable outcomes. Without adequate institutional frameworks, the expansion of high-value PANCs may reinforce existing inequalities or contribute to environmental degradation. Conversely, when supported by community-based management, certification systems, and agroecological practices, these value chains can strengthen local economies while maintaining ecological integrity and social cohesion (Altieri, 2018; FAO, 2021). This reinforces the need to integrate biodiversity-based production systems into broader rural development strategies.

Other species listed in Table 1, such as *Brosimum gaudichaudii* and *Ananas comosus*, further illustrate the diversity of functions associated with PANCs in the North Region. These plants combine food, medicinal, and economic uses, reinforcing their role within integrated socio-ecological systems (Kinupp and Lorenzi, 2014). Their presence in both traditional and emerging markets suggests opportunities to diversify

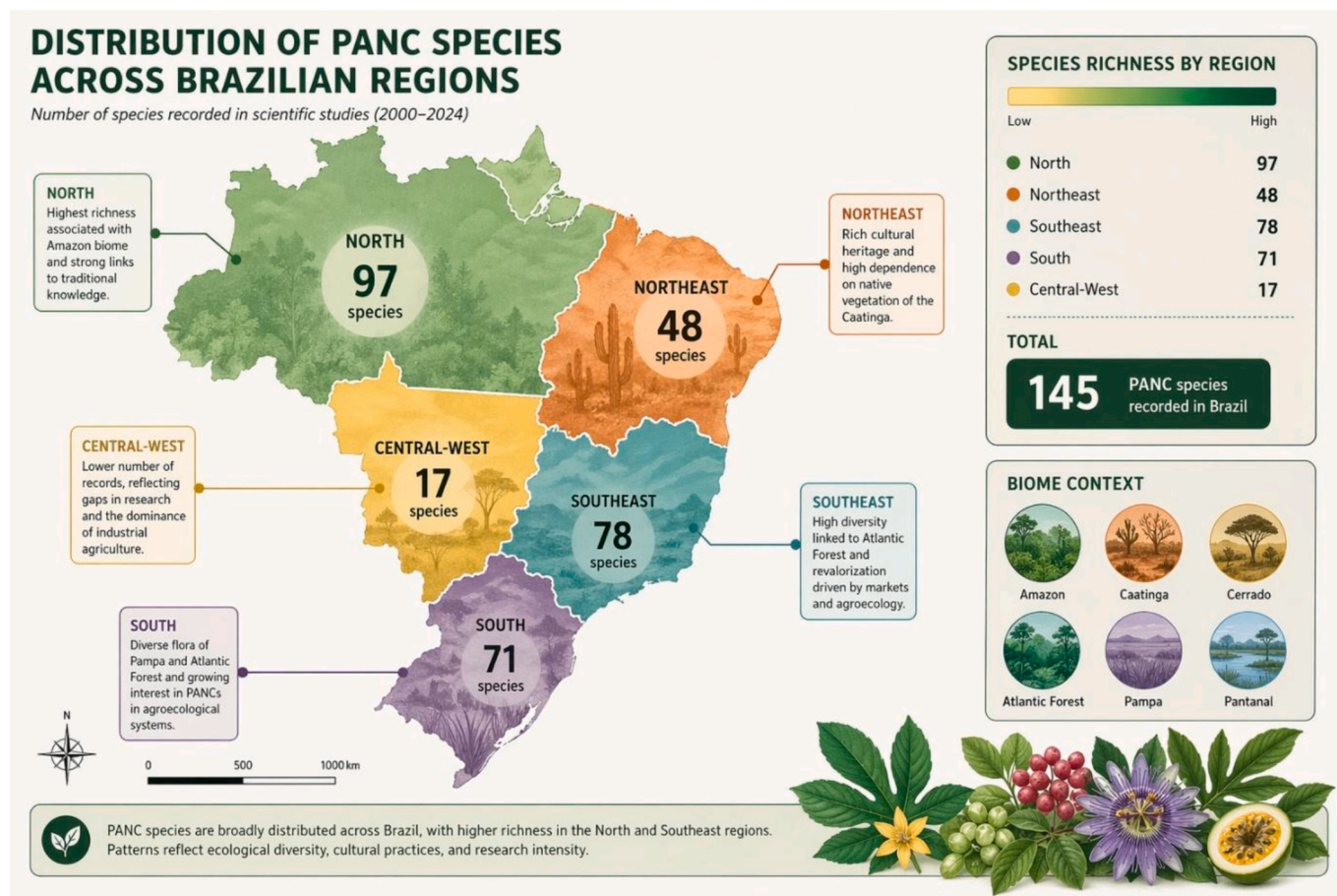


Fig. 2. Spatial distribution of PANC species across Brazilian regions. The map highlights regional heterogeneity in species richness and illustrates the influence of ecological diversity, cultural practices, and research intensity on the observed patterns.

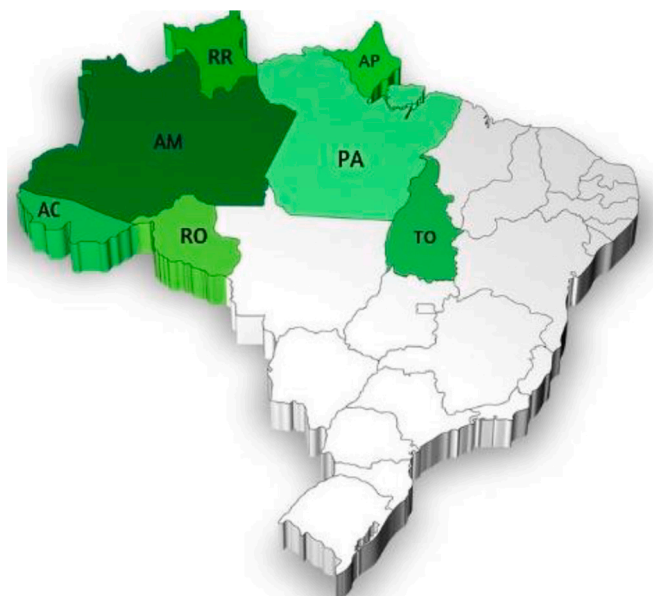


Fig. 3. Geographic distribution of the North Region of Brazil and its corresponding states. Legend: AC – Acre, AP – Amapá, AM – Amazonas, PA – Pará, RO – Rondônia, RR – Roraima, TO – Tocantins.

rural livelihoods, particularly in contexts where conventional

agricultural expansion is limited or environmentally constrained. This multifunctionality is particularly relevant for smallholder and traditional communities, which rely on diversified resource use to cope with environmental and economic uncertainties (Santos et al., 2022).

Importantly, the North Region demonstrates how PANCs can support forest-compatible food systems, in which biodiversity conservation and food production are not mutually exclusive but mutually reinforcing. Agroforestry systems, extractivist practices, and community-managed landscapes enable the sustainable use of native species while preserving ecosystem services such as soil fertility, water regulation, and carbon storage (Altieri, 2018; FAO, 2021). These systems represent viable alternatives to conventional agricultural expansion, particularly in ecologically sensitive regions.

From a rural development perspective, these findings indicate that PANCs can function as strategic assets for strengthening territorial food systems in the Amazon. Policies that promote local processing, short supply chains, and public procurement (e.g., school feeding programs) can enhance the socioeconomic role of these species while supporting local economies (FAO, 2021). At the same time, integrating traditional knowledge into formal governance frameworks is essential to ensure that development pathways remain culturally appropriate and environmentally sustainable (Jacob and Albuquerque, 2020).

Taken together, the North Region demonstrates how PANCs operate at the interface between biodiversity conservation, food systems, and rural livelihoods. Rather than functioning as isolated resources, these species are embedded in complex socioecological systems that require integrated and context-specific governance approaches. In this regard, the expansion of PANC-based value chains must be carefully managed to balance economic opportunities with concerns related to equity,



Fig. 4. Representative PANC species in the North Region, illustrating their ecological and food system roles.

biocultural integrity, and environmental sustainability.

3.2. Northeastern region: food security, climate resilience, and adaptive rural systems

The Northeastern Region of Brazil presents a distinct socioecological context for PANCs, characterized by climatic variability, semi-arid conditions, and strong cultural traditions. As indicated in Fig. 2, the region exhibits moderate species diversity compared to the North and Southeast; however, its relevance extends beyond species richness, reflecting the critical role of PANCs in food security and rural resilience (FAO, 2021; Santos et al., 2022). This highlights that, in resource-constrained environments, the functional importance of species may outweigh their numerical abundance.

As shown in Fig. 5, the region encompasses diverse ecosystems, including the Caatinga, Cerrado, and coastal zones. Among these, the semi-arid Caatinga biome is particularly significant, as it imposes environmental constraints that limit conventional agricultural production. In this context, PANCs emerge as adaptive resources, capable of supporting local food systems under conditions of water scarcity, poor soils, and climatic instability (IPBES, 2019; FAO, 2021). Their ecological plasticity makes them especially relevant in areas affected by desertification and increasing climate variability.



Fig. 5. Geographic distribution of the Northeastern Region of Brazil and its corresponding states.

Legend: AL – Alagoas, BA – Bahia, CE – Ceará, MA – Maranhão, PB – Paraíba, PE – Pernambuco, PI – Piauí, RN – Rio Grande do Norte, SE – Sergipe.

The dataset presented in Table 1 highlights several species that illustrate these adaptive dynamics. Species such as *Moringa oleifera*, *Cissampelos pareira*, *Cochlospermum regium*, and *Carya illinoensis* demonstrate resilience to drought and low-input conditions, making them suitable for agroecological systems in semi-arid regions. These plants are used in multiple ways, including fresh consumption, infusions, processed foods, and medicinal applications, reflecting their multifunctional role in rural livelihoods (Kinupp and Lorenzi, 2014). This multifunctionality is particularly important in vulnerable regions, where plants often fulfill multiple roles within household economies.

Beyond their nutritional value, these species contribute to livelihood diversification and risk reduction. In environments with highly variable agricultural productivity, incorporating PANCs into farming systems enables smallholders to reduce their dependence on conventional crops and enhance system stability (Altieri, 2018). This is particularly relevant in subsistence-oriented contexts, where access to diverse food sources can directly influence household food security and nutritional outcomes (FAO, 2021).

As illustrated in Fig. 6, the use of PANCs in the Northeast is closely associated with traditional knowledge systems, which guide plant selection, preparation methods, and seasonal use. These knowledge systems are especially important in rural and semi-arid communities, where formal agricultural inputs are limited and local ecological knowledge plays a central role in resource management (Jacob and Albuquerque, 2020). However, as highlighted in previous sections, this knowledge is increasingly threatened by socio-economic changes, including urbanization and generational shifts.

At the same time, the region also demonstrates the potential to integrate PANCs into emerging value chains. The expansion of species such as *Moringa oleifera* into functional food markets and agroecological initiatives demonstrates how traditional resources can be incorporated into broader economic systems (Santos et al., 2022). However, as in the North Region, this transition requires careful management to avoid the loss of local control over resources and knowledge, as well as the concentration of economic benefits in external actors (IPBES, 2019).

Another important dimension highlighted by Table 1 is the dual role of many PANCs as both food and medicinal resources. This multifunctionality reinforces their importance in rural systems where access to healthcare and diversified diets may be limited. In such contexts, PANCs contribute simultaneously to nutrition, preventive health, and economic resilience, illustrating their relevance as integrated components of socioecological systems (Kinupp and Lorenzi, 2014; Santos et al., 2022).

From a territorial perspective, the Northeastern Region exemplifies how PANCs can support climate-resilient rural systems. Their adaptability to harsh environmental conditions makes them strategic components of agroecological transitions, particularly in regions affected by desertification and climate variability (Altieri, 2018). Integrating these species into public policies, technical assistance programs, and rural development strategies can enhance both ecological sustainability and social resilience.

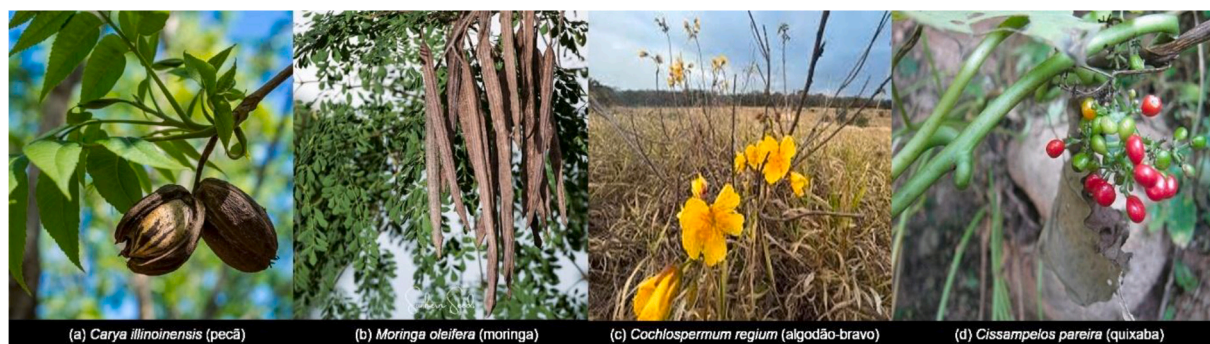


Fig. 6. Representative PANC species in the Northeastern Region, illustrating their ecological and food system roles.

However, the region also faces structural challenges. Limited infrastructure, restricted market access, and the gradual erosion of traditional knowledge, especially among younger generations, pose barriers to the broader adoption and valorization of PANCs (FAO, 2021). Addressing these challenges requires integrated approaches that combine education, rural extension services, and support for local value chains, along with policies that recognize the importance of biocultural diversity.

These findings indicate that, in the Northeastern Region, PANCs function as adaptive resources that link biodiversity to food security, rural livelihoods, and climate resilience. Their incorporation into territorial development strategies represents a viable pathway to strengthen sustainable food systems in environmentally vulnerable contexts while simultaneously supporting the preservation of cultural practices and ecological diversity. In this sense, PANCs play a strategic role in advancing broader sustainability agendas, particularly those related to resilient rural development and socioecological adaptation (IPBES, 2019).

3.3. Central-west region: agricultural expansion, biodiversity loss, and opportunities for diversification

The Central-West Region of Brazil is a complex socioecological landscape where high agricultural productivity coexists with significant environmental pressures and biodiversity loss. As indicated in Fig. 2, this region presents a comparatively lower number of documented PANC species, a pattern that cannot be explained solely by ecological factors but must also be interpreted in light of land-use transformation, agricultural intensification, and the erosion of traditional knowledge systems (FAO, 2021; IPBES, 2019). These dynamics reflect broader processes of agricultural modernization that have reshaped rural landscapes and reduced agrobiodiversity.

As illustrated in Fig. 7, the region is predominantly composed of the Cerrado and Pantanal biomes, both internationally recognized for their ecological richness. However, the Cerrado has been extensively converted into large-scale agricultural systems, particularly for soybean production and cattle ranching. This process has led to the simplification of landscapes, reduction of native vegetation, and marginalization of non-conventional food plants within dominant production systems (IPBES, 2019). The expansion of monocultures has not only reduced ecological diversity but also limited the space for diversified and traditional food systems.

Despite this context, the species listed in Table 1 reveal that the region still retains important elements of agrobiodiversity. Native species such as *Caryocar brasiliense* (pequi) play a central role in regional food culture and local economies, being widely used in traditional dishes and increasingly explored in processed products such as oils and condiments (Kinupp and Lorenzi, 2014). Similarly, *Bixa orellana* (annatto) represents a species with both cultural and commercial relevance, widely used as a natural colorant and increasingly valued in sustainable



Fig. 7. Geographic distribution of the Central-West Region of Brazil and its corresponding states.

Legend: DF – Distrito Federal, GO – Goiás, MT – Mato Grosso, MS – Mato Grosso do Sul.

production systems. These species illustrate how native biodiversity can be integrated into both traditional and emerging economic activities.

Other species, including *Annona squamosa*, *Mimosa caesalpinifolia*, and *Erythrina velutina*, further illustrate the multifunctional role of PANCs in the region. These plants are associated not only with food uses but also with medicinal applications and ecological functions, such as soil improvement and biodiversity support (Altieri, 2018). Their presence in the dataset highlights the persistence of diversified plant use, even within a landscape dominated by monocultures, suggesting that pockets of socioecological resilience remain.

As shown in Fig. 8, many of these species are still primarily associated with smallholder systems, traditional communities, and localized food practices. In these contexts, PANCs contribute to dietary diversification, reduce dependence on external inputs, and support complementary income sources (Altieri, 2018). However, their integration into broader agricultural systems remains limited, reflecting structural barriers such as a lack of technical support, limited market access, and low institutional recognition (FAO, 2021).

This scenario reveals a critical tension between agricultural expansion and biodiversity conservation. While the Central-West Region is a cornerstone of Brazil's agribusiness economy, it is also among the most threatened regions for native biodiversity (IPBES, 2019). The



Fig. 8. Representative PANC species in the Central-West Region, illustrating their ecological and food system roles.

dominance of simplified production systems reduces opportunities for integrating diverse plant species, including PANCs, into agricultural landscapes, reinforcing a model of production that prioritizes yield over diversity.

From a rural development perspective, however, this context also represents a significant opportunity. The ecological characteristics of the Cerrado, particularly its rich native flora and resilience to climatic variability, provide a strong foundation for the development of diversified, sustainable production systems. Integrating PANCs into agroforestry systems, crop diversification strategies, and low-input agriculture could enhance both environmental sustainability and economic resilience (Altieri, 2018).

Expanding value chains based on native species such as pequi and annatto has the potential to diversify rural economies, reduce dependence on commodity crops, and increase the added value of local production (Santos et al., 2022). Such strategies align with broader debates on sustainable rural development, particularly those that emphasize balancing agricultural productivity with biodiversity conservation and promoting more inclusive and resilient food systems (FAO, 2021).

However, the effective integration of PANCs into regional development strategies depends on consistent institutional support, including public policies that encourage diversification, agroecology-oriented extension services, and mechanisms to strengthen local markets. In the absence of these conditions, PANCs are likely to remain marginal within production systems largely shaped by industrial agriculture (IPBES, 2019).

In this context, the Central-West Region can be understood as a key frontier for reconciling agricultural expansion with biodiversity-based approaches. The coexistence of high agricultural productivity and significant environmental pressures reveals both structural constraints and opportunities for repositioning PANCs within more diversified, resilient, and sustainable rural systems.

3.4. Southeastern region: urban-rural linkages, market valorization, and food system innovation

The Southeastern Region of Brazil represents a distinct socio-ecological context in which PANCs are increasingly shaped by the interaction between rural production systems and urban demand. As indicated in Fig. 2, this region exhibits high species diversity, a pattern reflecting both ecological richness, particularly associated with the Atlantic Forest biome, and a strong concentration of research institutions, markets, and innovation networks (FAO, 2021; IPBES, 2019). This combination creates a dynamic environment in which biodiversity, knowledge production, and market forces converge, shaping the reconfiguration of food systems.

As illustrated in Fig. 9, the region is characterized by a mosaic of ecosystems combined with intense urbanization and economic activity. This duality plays a central role in redefining the place of PANCs within food systems. Unlike in more isolated rural contexts, where these plants



Fig. 9. Geographic distribution of the Southeastern Region of Brazil and its corresponding states.

Legend: ES – Espírito Santo, MG – Minas Gerais, RJ – Rio de Janeiro, SP – São Paulo.

are primarily linked to subsistence and traditional practices, in the Southeast, they are increasingly integrated into diversified food networks that connect rural producers with urban consumers (Santos et al., 2022). This reflects broader transformations in food systems, in which proximity, sustainability, and traceability have become key attributes.

The species listed in Table 1 highlight this transition. Plants such as *Portulaca oleracea*, *Pereskia aculeata* (ora-pro-nóbis), *Passiflora edulis*, and *Cichorium intybus* illustrate how PANCs are being incorporated into both traditional and contemporary food practices. These species are used in multiple forms, including fresh consumption, processed products, functional foods, and gourmet gastronomy (Kinupp and Lorenzi, 2014). Their versatility contributes to their growing acceptance in urban markets and reinforces their potential to bridge diverse segments of the food system, from subsistence contexts to high-value niche markets.

As shown in Fig. 10, the increasing visibility of PANCs in the Southeastern Region is closely associated with the expansion of short supply chains, urban agriculture initiatives, organic markets, and alternative food networks. These dynamics help reconnect consumers with biodiversity-based foods while strengthening local production systems (FAO, 2021). Within this framework, PANCs function as connectors between rural territories and urban consumption patterns, reinforcing the concept of territorial food systems and localized value



Fig. 10. Representative PANC species in the Southeastern Region, illustrating their ecological and food system roles.

creation.

A particularly relevant dimension in this region is gastronomic innovation. Chefs, restaurants, and local food movements have been instrumental in revalorizing PANCs, transforming them from underutilized resources into high-value ingredients (Santos et al., 2022). This process not only increases demand but also reshapes cultural perceptions of these plants, associating them with sustainability, health, and culinary creativity. However, this valorization process may also generate tensions, particularly when traditional knowledge is appropriated without adequate recognition or when access to these foods becomes restricted to niche markets, reinforcing social and economic inequalities (IPBES, 2019).

In addition to market-driven dynamics, institutional mechanisms have also played a significant role in promoting PANCs. Public policies aimed at strengthening family farming and improving food security, such as school feeding programs, have facilitated the incorporation of species like *Pereskia aculeata* into institutional supply chains (FAO, 2021). These initiatives demonstrate the potential of PANCs to contribute simultaneously to nutritional improvement, local economic development, and social inclusion, particularly when integrated into structured procurement systems.

Another important aspect highlighted by Table 1 is the coexistence of native and exotic species within the regional PANC landscape. Native species are often associated with biodiversity conservation and cultural identity, while exotic species such as *Cichorium intybus* and *Carya illinoensis* reflect the adaptability and openness of local food systems (Kinupp and Lorenzi, 2014). This coexistence indicates that PANC-based systems in the Southeast are not static but continuously shaped by ecological, cultural, and economic interactions, reflecting hybridization processes typical of highly urbanized regions.

Despite these advances, important challenges remain. The increasing demand for PANCs in urban markets may lead to supply limitations, variability in product quality, and difficulties in scaling production. Smallholder farmers often face constraints related to technical knowledge, certification processes, and market access, which can limit their ability to benefit from expanding demand (FAO, 2021). Furthermore, the lack of standardized production and regulatory frameworks can hinder the broader integration of these species into formal markets, limiting their contribution to food system transformation.

From a rural development perspective, the Southeastern Region illustrates how PANCs can support the emergence of hybrid food systems, in which traditional knowledge, agroecological production, and modern market dynamics coexist and interact (Altieri, 2018). Strengthening these systems requires coordinated efforts to ensure that economic benefits are equitably distributed, that biodiversity is conserved, and that cultural heritage is respected, particularly in contexts marked by strong urban-rural interactions.

In the Southeastern Region, PANCs emerge as key connectors between rural production systems and urban food networks, reflecting their role in shaping hybrid and innovation-driven food systems. The interaction between biodiversity, market valorization, and gastronomic

innovation positions the region as a dynamic space for reconfiguring food practices and consumption patterns. At the same time, this process underscores the need for governance frameworks that balance market expansion with social equity, cultural recognition, and environmental sustainability, ensuring that the valorization of PANCs contributes to inclusive and resilient food systems (IPBES, 2019).

3.5. Southern region: family farming, agroecology, and regional food identity

The Southern Region of Brazil presents a socioecological context in which PANCs are closely associated with family farming systems, agroecological practices, and regional food traditions. As indicated in Fig. 2, this region shows a relatively high species richness, reflecting both favorable climatic conditions and a strong tradition of small-scale agriculture (FAO, 2021). Unlike regions dominated by large-scale monocultures, the South is characterized by diversified production systems that facilitate the incorporation of non-conventional food plants and support more resilient agricultural landscapes (Altieri, 2018).

As illustrated in Fig. 11, the region encompasses temperate and subtropical environments, which support a wide variety of plant species adapted to seasonal variability. These conditions, combined with a strong presence of family-based farming, create an enabling environment for maintaining and integrating PANCs into local food systems.



Fig. 11. Geographic distribution of the Southern Region of Brazil and its corresponding states.

Legend: PR – Paraná, RS – Rio Grande do Sul, SC – Santa Catarina.

Within this framework, biodiversity is often preserved through everyday agricultural practices rather than isolated conservation efforts, reflecting the close relationship between production systems and ecological processes (Altieri, 2018; *IPBES, 2019*).

The species listed in [Table 1](#) highlight the diversity and multifunctionality of PANCs in the Southern Region. Plants such as *Lactuca serriola*, *Porophyllum ruderale*, *Myrciaria cauliflora*, *Schinus terebinthifolia*, and *Chenopodium quinoa* illustrate how these species are integrated into both traditional diets and emerging markets. These plants are used in salads, cooked dishes, condiments, beverages, and processed products, demonstrating their versatility and relevance for diversified food systems (*Kinupp and Lorenzi, 2014*). This multifunctionality reinforces their importance within farming systems that prioritize diversity over specialization.

As shown in [Fig. 12](#), many of these species are cultivated or collected within agroecological systems that prioritize biodiversity, soil health, and reduced reliance on external inputs. In such systems, PANCs contribute not only to dietary diversification but also to ecological functions, including nutrient cycling, pest regulation, and resilience to climatic variability (Altieri, 2018). This integration reinforces the role of PANCs as components of sustainable agricultural practices and highlights their contribution to ecosystem services.

A defining characteristic of the Southern Region is the strong connection between PANCs and regional food identity. Many of these plants are embedded in local culinary traditions and are increasingly being revalued through regional markets, farmers' markets, and gastronomic initiatives (*Santos et al., 2022*). This cultural dimension plays a key role in sustaining the use of PANCs, as it reinforces consumer familiarity and acceptance, facilitating their continued integration into everyday diets while preserving elements of biocultural heritage.

In addition to traditional uses, the region has also seen a growing interest in the commercialization of PANC-based products. Small-scale producers and cooperatives have begun to explore value-added products, including flours, preserves, condiments, and functional foods derived from native and naturalized species. These initiatives contribute to income diversification and strengthen local economies, particularly when supported by short supply chains and regional branding strategies (*FAO, 2021*). This process reflects broader trends in rural development that emphasize local value creation and territorial identity.

However, despite these favorable conditions, challenges remain. The expansion of conventional agriculture in certain areas, particularly soybean production, poses risks to biodiversity and may limit the space available for diversified systems (*IPBES, 2019*). Furthermore, the standardization requirements of formal markets can create barriers for small producers seeking to commercialize PANCs, particularly in relation to certification, processing infrastructure, and regulatory compliance (*FAO, 2021*). These constraints highlight the need for supportive institutional frameworks.

From a rural development perspective, the Southern Region illustrates how PANCs can be effectively integrated into agroecological and

family-based farming systems, supporting both sustainability and economic viability. The combination of traditional knowledge, diversified production, and access to local markets creates a favorable environment for consolidating PANC-based food systems (Altieri, 2018). This integration demonstrates the potential of PANCs to contribute to more resilient and locally embedded agricultural models.

At the same time, the region highlights the importance of institutional support in scaling these initiatives. Policies that promote agroecology, strengthen family farming, and support local food networks are essential to ensure that the benefits of PANCs are widely distributed (*FAO, 2021*). Educational initiatives and rural extension services also play a critical role in maintaining knowledge transmission and encouraging innovation within these systems, particularly during generational transitions.

In the Southern Region, PANCs play a central role in shaping resilient, diversified, and culturally embedded food systems. The convergence of ecological sustainability with strong social and cultural foundations positions the region as a relevant reference for integrating biodiversity into rural development strategies. In this context, PANCs underscore their importance in broader discussions on sustainable agriculture and territorial development, particularly in relation to locally grounded, socially inclusive food system models (*IPBES, 2019*).

3.6. Cross-regional synthesis: PANCs as drivers of socioecological resilience and rural transformation

The cross-regional analysis demonstrates that PANCs function as strategic components within interconnected socioecological systems rather than isolated biological resources. These results align with global debates on neglected and underutilized species (NUS), emphasizing their role in enhancing dietary diversity, strengthening resilience, and supporting sustainable food systems. In Brazil, PANCs exhibit high adaptive capacity and multifunctionality, reinforcing their importance in addressing global challenges related to food security and biodiversity conservation. By integrating patterns observed across regions with species-level data, it becomes clear that these plants operate at the intersection of ecological adaptation, cultural practices, and rural livelihoods (*IPBES, 2019; FAO, 2021*), contributing to food system resilience and adaptive capacity in the face of environmental change (*Mayes et al., 2020; Khoury et al., 2022*).

A pronounced regional gradient emerges from the analysis. In the North and Northeast, PANCs are deeply embedded in traditional knowledge systems and subsistence practices, contributing directly to food security, cultural continuity, and ecological adaptation (*Santos et al., 2020; Nascimento et al., 2024a*). Ethnobotanical evidence highlights that these systems are not merely repositories of knowledge but active socioecological strategies that sustain biodiversity through use (*de Aquino and Almeida Flores, 2021*). In contrast, the Southeast reflects a process of revalorization driven by urban demand, gastronomic innovation, and alternative food networks, while the South illustrates



Fig. 12. Representative PANC species in the Southern Region, illustrating their ecological and food system roles.

their integration into agroecological and family-based farming systems (Biondo et al., 2018; Tuler et al., 2019). The Central-West, however, represents a critical frontier marked by the coexistence of high biodiversity potential and strong pressures from agricultural intensification, resulting in reduced incorporation of PANCs into dominant production systems (Khoury et al., 2022).

Another key dimension is the multifunctionality of PANCs. As shown in Table 1, these species often play multiple roles, including nutritional, medicinal, ecological, and economic. This multifunctionality has been widely documented in studies on Brazilian PANCs, particularly regarding their bioactive compounds and nutritional composition (Barreira et al., 2021; Bezerra et al., 2021). In rural contexts, this diversity of functions enhances livelihood resilience by reducing dependence on single crops and increasing adaptive capacity under environmental and economic uncertainty.

At the same time, the analysis reveals important structural constraints. Despite their potential, PANCs remain marginal in many formal food systems due to limited technical knowledge, lack of standardized production protocols, and fragmented value chains (Padilha et al., 2023). These barriers are particularly evident in regions with weak institutional support and market infrastructure, reinforcing territorial inequalities.

Furthermore, the growing interest in PANCs within urban markets introduces new dynamics that reshape their role in food systems. While increased demand may enhance their visibility and economic value, it may also lead to selective valorization, in which only a subset of species is incorporated into commercial circuits (Simonetti et al., 2021; Silva de Rossi and Giannoni, 2024). This process risks marginalizing other species and weakening the diversity that characterizes PANC systems.

Taken together, these findings demonstrate that PANCs' contribution to food system transformation depends on their integration into broader socioecological and institutional frameworks. Their potential lies not only in their biological characteristics but in their capacity to connect biodiversity, culture, and livelihoods within diversified and resilient territorial systems.

3.7. Cultural dynamics, market integration, and governance challenges of PANCs

The trajectories of PANCs in Brazil are shaped by a complex interplay between biocultural heritage, market dynamics, and governance structures. While the diversity of species reflects rich socioecological systems, their integration into contemporary food systems is mediated by uneven access to knowledge, resources, and institutional support (Kinupp and Lorenzi, 2014; Jacob and Albuquerque, 2020).

Traditional knowledge remains central to the identification, use, and management of PANCs, particularly in the North and Northeast. These knowledge systems are closely linked to cultural identity, seasonal cycles, and local ecological conditions, forming the basis of diversified food practices (Nascimento et al., 2024b; Santos et al., 2020). However, socio-economic transformations, such as urbanization, migration, and dietary homogenization, have contributed to the erosion of this knowledge, particularly among younger generations (Lima et al., 2022). This process represents not only a cultural loss but also a reduction in the diversity of food systems.

Simultaneously, PANCs are increasingly being incorporated into urban and peri-urban markets, where they are reinterpreted as sustainable, functional, and culturally distinctive foods. This phenomenon is particularly evident in the Southeast, where chefs, alternative markets, and agroecological movements have played a key role in revalorizing these species (Silva de Rossi and Giannoni, 2024; Simonetti et al., 2021). While this process enhances visibility, it also introduces selective pressures that favor species with higher commercial potential.

This selective valorization generates important socio-economic implications. Smallholder farmers and traditional communities, who are often the primary custodians of these resources, may face barriers to

accessing emerging markets due to certification requirements, limited infrastructure, and a lack of institutional support (FAO, 2021). Consequently, value addition may occur outside producing territories, limiting local economic benefits and reinforcing existing inequalities.

The fragmentation of value chains further complicates this scenario. The distribution of PANCs across markets does not necessarily reflect their ecological availability but is strongly influenced by logistics, research investment, and policy support (Padilha et al., 2023). This creates a mismatch between biodiversity-rich regions and economically integrated regions, constraining the potential for equitable territorial development.

Despite their multifunctionality, PANCs face significant barriers that limit their integration into formal food systems. These include the erosion of traditional knowledge, particularly among younger generations; fragile and poorly structured value chains; limited technical assistance; and regulatory gaps that restrict commercialization. For example, the lack of standardized production protocols and food safety guidelines often prevents smallholder farmers from accessing formal markets. Additionally, logistical constraints and limited processing infrastructure further hinder value addition and distribution, especially in biodiversity-rich but economically marginalized regions.

Governance plays a decisive role in addressing these challenges. Policies such as public procurement programs and support for family farming have demonstrated potential to integrate PANCs into formal systems (Ranieri et al., 2024). However, these initiatives often lack coordination and scale, limiting their overall impact. In addition, the protection of traditional knowledge and biocultural heritage remains insufficient, raising concerns about appropriation and unequal distribution of benefits (IPBES, 2019).

These dynamics highlight that the integration of PANCs into food systems is inherently political, involving negotiations over access to resources, control of knowledge, and distribution of benefits. Addressing these issues requires integrated governance approaches that promote equity, sustainability, and participation.

3.8. PANCs in sustainable agriculture and food system transformation

The integration of PANCs into agricultural systems represents a promising pathway to advancing sustainability, particularly amid climate change, biodiversity loss, and the need for more resilient food systems. However, their contribution depends on how they are embedded within broader socioecological and institutional frameworks (Altieri, 2018; Mayes et al., 2020).

One of the main contributions of PANCs lies in their role in enhancing ecosystem services. These species support soil regeneration, nutrient cycling, water retention, and biodiversity conservation, particularly when integrated into agroecological systems such as agroforestry and polycultures (Altieri, 2018). Their adaptability to low-input conditions makes them especially relevant in regions facing environmental constraints, including semi-arid and degraded landscapes.

From a nutritional perspective, PANCs also offer significant advantages. Studies have demonstrated their richness in vitamins, minerals, and bioactive compounds, reinforcing their potential to improve dietary quality and contribute to public health (Barreira et al., 2021; Neri-Numa et al., 2018). This is particularly relevant in contexts of food insecurity, where diversified diets are essential.

However, the transition toward PANC-based systems involves important trade-offs. The expansion of these species into market-oriented systems may lead to standardization and reduced diversity, potentially undermining their ecological benefits. In addition, the lack of technical knowledge, standardized cultivation practices, and infrastructure limits their scalability (Padilha et al., 2023).

Regional differences further highlight these dynamics. In the Northeast, PANCs directly support climate adaptation by enabling production under water scarcity. In the North, they are integrated into extractivist systems that combine biodiversity conservation with

economic activity (Santos et al., 2020). In contrast, in the Southeast and South, their role is increasingly shaped by market dynamics and innovation.

The alignment between production and consumption is another critical factor. Expanding PANC-based systems requires not only increasing production but also strengthening demand through consumer awareness, institutional procurement, and market development (Ranieri et al., 2024). Without this alignment, their potential remains underutilized.

Ultimately, PANCs should be understood as components of broader food system transformations rather than isolated solutions. Their effectiveness depends on their integration into agroecological practices, inclusive governance frameworks, and territorial development strategies. When properly integrated, they can support the transition toward more diversified, resilient, and sustainable food systems.

4. Conclusion

This nationwide review demonstrates that non-conventional food plants (PANCs) in Brazil represent far more than underutilized biological resources; they are integral components of socioecological systems that connect biodiversity, cultural heritage, and rural livelihoods. By integrating evidence across regions, this study shows that the distribution, use, and valorization of PANCs are shaped by a complex interplay of ecological conditions, knowledge systems, market dynamics, and governance structures.

The findings reveal a marked territorial heterogeneity. While the North and Northeast regions are characterized by strong links between PANCs and traditional knowledge systems, the Southeast and South illustrate processes of market integration, agroecological innovation, and revalorization. In contrast, the Central-West highlights the tensions between agricultural intensification and biodiversity conservation. These regional differences underscore that the role of PANCs in food systems is context-dependent and mediated by socio-economic and institutional factors.

Importantly, this study identifies PANCs as strategic resources for advancing food system resilience. Their multifunctionality, adaptability to marginal environments, and compatibility with low-input agricultural practices position them as key components of sustainable and climate-resilient production systems (Altieri, 2018; Mayes et al., 2020). At the same time, their nutritional and functional properties reinforce their potential to contribute to healthier and more diverse diets (Barreira et al., 2021; Neri-Numa et al., 2018).

However, integrating PANCs into contemporary food systems is not without challenges. Structural barriers, including limited technical knowledge, fragmented value chains, regulatory constraints, and unequal access to markets, continue to limit their broader adoption. Moreover, the commercialization of selected species raises concerns regarding the appropriation of traditional knowledge and the unequal distribution of benefits, particularly among smallholder and traditional communities (IPBES, 2019; Jacob and Albuquerque, 2020).

From a rural development perspective, the results highlight the need for coordinated, multi-level governance. Strengthening the role of PANCs requires policies that promote agroecology, support family farming, enhance local processing and short supply chains, and protect biocultural knowledge systems. In this sense, PANCs can act as leverage points for more inclusive and sustainable territorial development strategies.

These findings are closely aligned with global sustainability agendas, particularly the Sustainable Development Goals (SDGs) related to zero hunger (SDG 2), climate action (SDG 13), and life on land (SDG 15), reinforcing the strategic role of PANCs in advancing integrated biodiversity-food system approaches.

Future research should move beyond descriptive inventories and focus on the scalability, economic viability, and environmental impacts of PANC-based systems. There is also a need for participatory and

transdisciplinary approaches that integrate scientific knowledge with local practices, ensuring that innovation processes remain socially inclusive and context-specific.

This nationwide synthesis demonstrates that PANCs represent key leverage points for the development of inclusive, diversified, and climate-resilient food systems in Brazil. Their integration into public policies, such as institutional procurement programs and school feeding initiatives, provides a strategic pathway to simultaneously promote biodiversity conservation, food security, and rural development.

Author contribution

All authors contributed to the methodology and validation stages. Douglas Neil Rutledge contributed to the critical reading of the manuscript. Flávia Aparecida Reitz Cardoso assisted with the manuscript assembly and final proofreading.

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CRedit authorship contribution statement

Gustavo Barreto Costa: Writing – review & editing, Writing – original draft, Conceptualization. **Luiz Henrique Silva Lopes:** Writing – review & editing, Writing – original draft, Conceptualization. **Karina Pinheiro Martins:** Writing – review & editing, Writing – original draft, Conceptualization. **Nathália Letícia Hernandez Brito:** Writing – review & editing, Writing – original draft, Conceptualization. **Jhony Silva Ramos:** Writing – review & editing, Writing – original draft, Conceptualization. **Ana Caroline Silvestre Barbosa Alessi:** Writing – review & editing, Writing – original draft, Conceptualization. **Ana Elisa Melo da Silva:** Writing – review & editing, Writing – original draft, Conceptualization. **Thais Aparecida Santos:** Writing – review & editing, Writing – original draft, Conceptualization. **Ornella Monique Pereira Ferri:** Writing – review & editing, Writing – original draft, Conceptualization. **Maria João de Almeida Coelho de Sousa:** Writing – review & editing, Writing – original draft, Conceptualization. **Sandrina Alves Heleno:** Writing – review & editing, Writing – original draft, Conceptualization. **Douglas Neil Rutledge:** Writing – review & editing, Writing – original draft, Project administration, Conceptualization. **Flávia Aparecida Reitz Cardoso:** Writing – review & editing, Writing – original draft, Project administration, Funding acquisition, Conceptualization.

Ethical approval

Not applicable. This article is a narrative review and does not involve studies with human participants or animals.

Funding

The authors acknowledge the financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico – Brazil (CNPq) - grant number 302078/2023-1 with Flávia Aparecida Reitz Cardoso and this research was funded by national funds through FCT/MCTES (PIDDAC): CIMO, UIDB/00690/2020 (doi:10.54499/UIDB/00690/2020) and UIDP/00690/2020 (doi:10.54499/UIDP/00690/2020) and SusTEC, LA/P/0007/2020 (doi:10.54499/LA/P/0007/2020), national funding by FCT-Foundation for Science and Technology, through the institutional scientific employment program-contract with Sandrina A. Heleno. The authors also acknowledge the support of the Central Analítica Multiusuário at UTFPR Campus Campo Mourão (CaMulti UTFPR-CM).

Declaration of competing interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.agry.2026.104782>.

Data availability

No data was used for the research described in the article.

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