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Unveiling Peru's Agricultural Diversity: Navigating Historical and Future Trends in a Post-COVID-19 Context

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Abstract: Over a comprehensive 5-year assessment, and extrapolating it prospectively until 2025, a thorough examination was conducted of productive agrobiodiversity in nine rural agricultural districts across Peru. The present study involved in-depth interviews with 180 representative farmers of the Coast, Highlands, and Jungle natural regions. Employing the Shannon–Weiner diversity index and the Margalef species richness index, the dynamics within years and across different zones were analyzed. Utilizing quadratic trend models, we assessed the frequency of each crop, aiming for the optimal fit concerning absolute deviation from the mean, mean squared deviation, and mean absolute percentage error. These findings revealed five distinct crop types—tuberous, fruits, cereals, legumes, and roots—distributed across 25 diverse families. Looking ahead to 2025, our projections indicated positive trends in 15 families and negative trends in 9 crop families. The nuanced mathematical distinctions observed in crop management decisions varied significantly depending on the specific area and year, underscoring the importance of localized considerations in agricultural planning.

Keywords: agrobiodiversity; sustainability; quadratic trend models; agricultural projections

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1. Introduction

Factors such as global food demand, scarce cereal stocks, and climate change are emerging challenges to be confronted for the stability of food systems at the national and global levels [1–3]. Likewise, hunger has increased in Latin America and the Caribbean [4] and threatened a massive resurgence amid the coronavirus/COVID-19 pandemic [5–7]. Peru has a commodity-based economy in which agriculture plays an essential role in the nation's development [8,9].

Various critical factors, including increased global food demand and the pervasive impacts of climate change, pose substantial threats to the stability of food systems both nationally and globally [2,3]. The escalation of hunger in Latin America and the Caribbean [4] has been exacerbated amid the challenges posed by the COVID-19 pandemic [7]. Peru, with its economy heavily reliant on commodities, underscores the pivotal role of agriculture in national development [9]. Species diversity, defined as the variability of living organisms in ecosystems [10–12], has long been acknowledged for its crucial role in ecosystem functioning [13,14]. Particularly in spaces dedicated to food cultivation, the correlation between biodiversity and nutritional security becomes evident [7,15]. The alarming decline in agricultural biodiversity on a global scale underscores the urgent need for the development of multifunctional and sustainable agriculture [4,16]. Recognizing the significance of productive agricultural biodiversity, it becomes imperative to make informed decisions for conservation and cultivation. Numerous indices have been proposed to measure species diversity and richness [17,18]. The Shannon Diversity Index was primarily used to identify species richness and diversity. In 1958, Margalef popularized the concept of species diversity among the scientific community [19]. Assessments of species uniformity, diversity, and richness have been instructive for future research in various forest ecosystems at spatial scales [20,21].

Agriculture is the second largest economic sector in Peru after mining [22] and faces numerous challenges. Now, it is known that Peru's agricultural industry has experienced remarkable growth in recent decades due to consumer demand for healthier, fresher, and more convenient food products [9]. Nutrition, food systems, and food biodiversity in smallholder farmers are being transformed in the Andean countries, despite urgent concerns for food sovereignty, uneven geographic development, and climate change [7].

The role of Peruvian rural agriculture in supporting employment, ancillary businesses, and environmental services remains largely unknown. Understanding the prospective planting of specific crops is crucial for effective agricultural production planning, facilitating inventory control of agricultural commodities, and optimizing the allocation and conservation of natural resources. Regrettably, detailed information regarding the future planting of crops is generally scarce [23]. Therefore, this research aims to document the historical facets of Peru's productive agricultural diversity, forecasting future trends, and elucidating their implications for food security. This study will provide insights that will enhance agricultural management in Peru. Consequently, the historical variability of agricultural crops across the three natural regions of Peru was identified, calculating indices of agricultural diversity and trends. Models are being presented for projecting crop types and families, offering valuable guidance for Peruvian farmers in optimizing their agricultural practices.

2. Materials and Methods

2.1. Location of the Study

Peru is a South American country located on the Pacific coast (0°02′, 18°20′ south and 68°30′, 81°25′ west) and has an area of 1,285,215 km^2 [24]; due to the variability of climate change, each zone of the country has very specific and different characteristics [24].

A total of 180 rural farmers located in the different districts of the three natural regions of Peru were randomly identified: from the coast (Sapillica, Guadalupe, and Atico), the highlands (Lucanas, Lonyachico, and Sapillica), and the jungle (Villa Rica, Jepelacio, and Santa Rosa). Each site was georeferenced according to map 1 and represents the productive agricultural diversity of Peru (Figure 1).

2.2. Historical Variability of Agricultural Crops

Data were collected through semi-structured interviews with 180 farmers. We recorded the values of crops planted each year, and then we registered the scientific name in the different databases according to procedures already established in Excel [25].

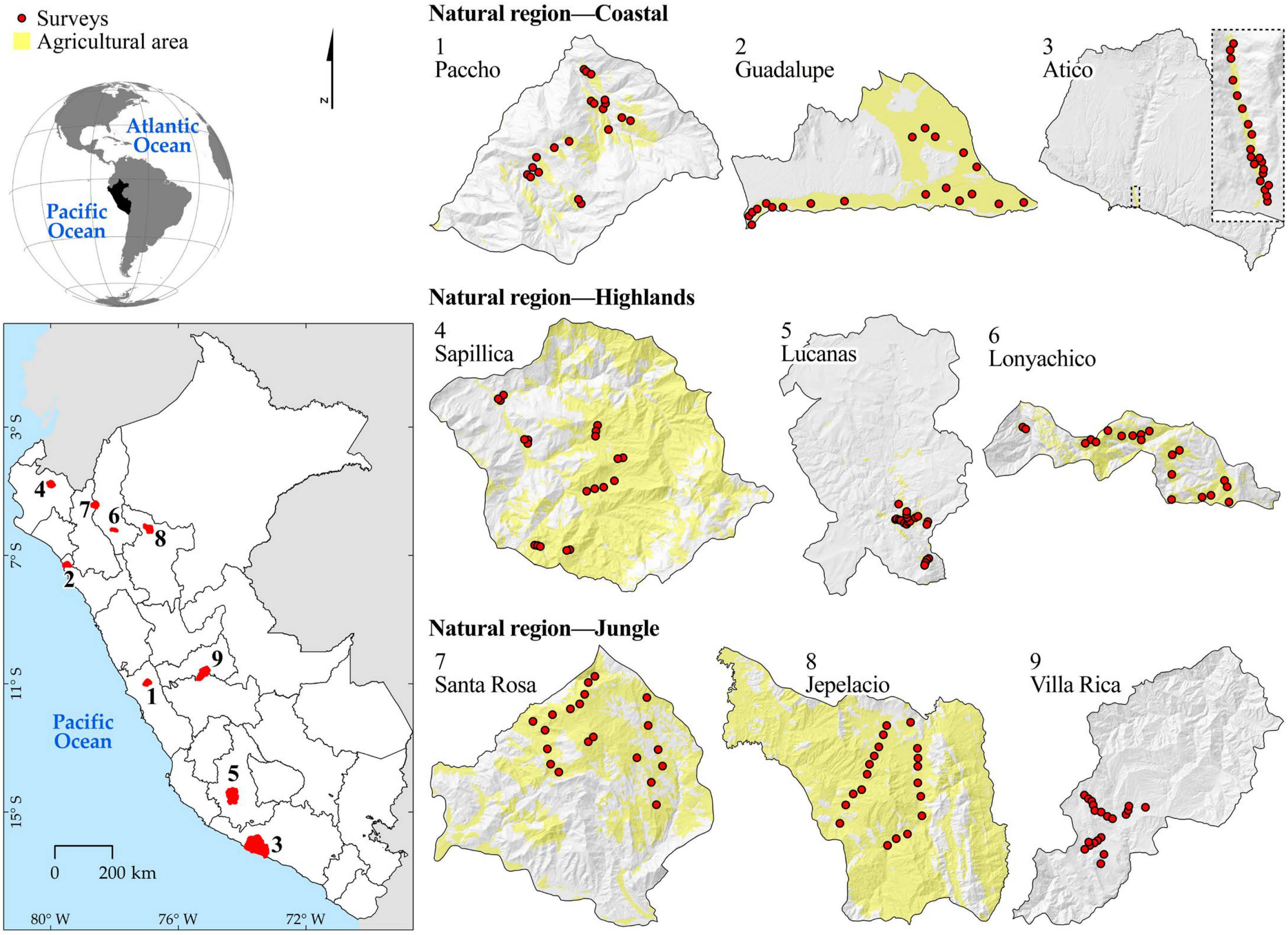


Figure 1. Geographic location of districts in Peru, where the surveys were conducted.

2.3. Index of Agricultural Diversity and Trends for 9 Districts of the Three Natural Regions of Peru

The present study identified the concentration of species among the productive agricultural diversity in nine districts of the three natural regions of Peru. Five-year data (2018–2022) was collected for two indices of ecological indicators and their trends were plotted. The Shannon–Weiner index (H′) (to assess species diversity) and the Margalef index (SR) (to assess species richness) were evaluated [10].

The Shannon–Weiner index (H′) was determined with the following formula [26]:

$$\mathrm{H}/ = \sum_{i=1}^{S} p_i \ln p_i \quad (1)$$

where

H/ = Shannon–Weiner index
p_i = Proportion of individuals belonging to species i
ln = natural logarithm

The Margalef index (SR) was determined with the formula [27]:

$$SR = \frac{S-1}{\ln(N)} \quad (2)$$

where

SR = Margalef Species Richness Index

S = Number of species
N = Total number of individuals

2.4. Current Models for Future Trends in Agricultural Species, According to Crop Type and Crop Families

To generate the graphs for annual trend values, as well as the model formulas, the quadratic model was chosen in all cases because it has the greatest fit in the absolute deviation of the mean (MAD), the mean square deviation (MSD), and the mean absolute percentage error (MAPE) [28].

3. Results

The presence of 47 crops was recorded for 5 years (2018–2022) in the nine districts of the three natural regions of Peru. When we divided the crops according to type, 13.51% were cereals, 13.51% were legumes, and fruits corresponded to 51.35% of the total types of crops, registering as the highest percentage. As for the roots, they were registered as 24.32% of the total, the tuberous with 2.70% and the vegetables correspond to 21.62% with respect to the type of crop (Table 1).

Table 1. Historical Variability of Agricultural Crops in the Three Natural Regions of Peru.

N°	Type	Common Name	Scientific Name	Family	F. 2018	F. 2019	F. 2020	F. 2021	F. 2022
1	C.	Maíz	*Zea mays* L.	Poaceae	61	62	55	63	65
2	L.	Fréjol	*Phaseolus vulgaris* L.	Fabaceae	33	33	29	29	29
3	F.	Café	*Coffea arabica* L.	Rubiaceae	60	62	61	61	61
4	F.	Caña de azúcar	*Saccharum officinarum* L.	Poaceae	7	8	8	9	8
5	F.	Plátano	*Musa paradisiaca* L.	Musaceae	26	28	28	26	25
6	R.	Yuca	*Manihot esculenta* C.	Euphorbiaceae	26	22	25	18	23
7	Le.	Arverja	*Pisum sativum* L.	Fabaceae	25	20	23	20	21
8	Le.	Habas	*Vicia faba* L.	Fabaceae	16	14	17	13	21
9	C.	Trigo	*Triticum aestivum* L.	Poaceae	28	27	30	23	24
10	L.	Maní	*Arachis hypogaea* L.	Fabaceae	2	1	0	3	3
11	F.	Cacao	*Theobroma cacao* L.	Malvaceae	1	1	0	0	0
12	V.	Pepinillo	*Cucumis sativus* L.	Cucurbitaceae	0	0	1	0	0
13	V.	Caigua	*Cyclanthera pedata* L.	Cucurbitaceae	0	0	1	0	0
14	V.	Lechuga	*Lactuca sativa* L.	Asteraceae	1	1	1	2	2
15	R.	Rabanito	*Raphanus sativus* L.	Brassicaceae	0	0	0	0	1
16	T.	Papa	*Solanum tuberosum* L.	Solanaceae	29	28	27	26	27
17	R.	Camote	*Ipomoea batatas* L.	Convolvulaceae	5	4	5	4	11
18	F.	Olivo	*Olea europaea* L.	Oleaceae	12	14	11	9	6
19	F.	Palta	*Persea americana* M.	Lauraceae	2	1	4	5	9
20	F.	Ciruela	*Prunus domestica* L.	Rosaceae	1	0	0	1	0
21	F.	Manzana	*Malus domestica* B.	Rosaceae	2	1	0	1	1
22	F.	membrillo	*Cydonia oblonga* M.	Rosaceae	1	0	0	0	0
23	R.	Cebolla	*Allium cepa* L.	Amaryllidaceae	1	1	0	0	0
24	F.	Higo	*Ficus carica* L.	Moraceae	1	1	1	0	1
25	F.	Pacae	*Inga feuilleei* DC	Fabaceae	1	0	0	0	2
26	F.	Naranja	*Citrus sinensis* L.	Rutaceae	1	1	1	0	2
27	F.	Granada	*Punica granatum* L.	Lythraceae	1	0	0	2	3
28	F.	Durazno	*Prunus persica* L.	Rosaceae	6	7	5	6	9
29	V.	Alfalfa	*Medicago sativa* L.	Fabaceae	9	10	10	8	8

Table 1. *Cont.*

N°	Type	Common Name	Scientific Name	Family	F. 2018	F. 2019	F. 2020	F. 2021	F. 2022
30	F.	Limón	*Citrus limon* L.	Rutaceae	0	1	1	1	1
31	F.	Níspero	*Eriobotrya japonica* T.	Rosaceae	0	0	0	1	0
32	C.	Cebada	*Hordeum vulgare* L.	Poaceae	13	8	7	11	15
33	R.	Ollucos	*Ullucus tuberosus* C.	Basellaceae	1	1	1	3	1
34	R.	Mashua	*Trapeolum tuberosum Ruiz & Pav.*	Tropaeolaceae	2	1	0	0	1
35	R.	Oca	*Oxalis tuberosa* M.	Oxalidaceae	5	6	9	5	3
36	C.	Quinoa	*Chenopodium quinoa* W.	Amarantaceae	1	2	4	3	1
37	C.	Avena	*Avena sativa*	Poaceae	1	0	0	0	1
38	F.	Granadilla	*Passiflora ligularis* J.	Passifloraceae	1	1	1	2	1
39	F.	Rocoto	*Capsicum pubescens Ruiz & Pav*	Solanaceae	0	0	0	1	1
40	V.	Ají	*Capsicum annuum* L.	Solanaceae	1	1	1	1	1
41	F.	Sandía	*Citrullus lanatus* T.	Cucurbitaceae	1	0	0	0	0
42	R.	Bituca	*Colocasia esculenta* L.	Araceae	1	1	1	1	1
43	R.	Racacha	*Arracacia xanthorrhiza* B.	Apiaceae	4	4	4	4	3
44	V.	Zapallo	*Cucurbita Maxima* D.	Cucurbitaceae	1	0	0	0	0
45	V.	Repollo	*Brassica oleracea* L.	Brassicaceae	0	0	0	0	2
46	V.	Zanahoria	*Daucus carota* L.	Apiaceae	2	3	2	3	3
47	L.	Chocho	*Lupinus mutabilis* S.	Leguminosae	1	1	1	1	1

F/year = absolute frequency over 180 farmers interviewed. C = cereal, L = legume, F = fruit, R = root, T = tuberose, V = vegetable.

The crops (with common names and their respective scientific names) were matched in 25 plant families that showed the diversity of Peruvian foods. The case of corn and coffee leads in frequency with respect to their presence in all locations and years recorded. The frequencies with which the farmers registered their crops the most in 2018 were corn (61 farmers) and coffee (60 farmers). For 2019, they were also corn and coffee (with 62 farmers), followed by beans (33 farmers). For 2020, the frequency of corn was 61 and coffee was 55, while for 2021 these crops reached frequencies of 65 and 61 farmers, respectively (Table 1).

The trend in the average number of species grown by farmers in the districts is represented (Table 2). In the coastal region, and for all years (2018–2022), the highest values were presented in the district of Paccho, with up to 3.9 crops (2018); however, this district presents a variability of −12.82%. In Atico, the trend is increasing (24.53%), as well as in Guadeloupe 6.45%, while in the highland region, the highest values for average number of crops per farmer are in Lonya Chico with up to 4.75 average crops in 2018. However, this district shows a reduction in crop variability (−5.26%), as well as in Sapillica with up to a −27.66% reduction. On the contrary, in Lucanas, there was greater variability with 7.25%. For the jungle region, in Jepelacio, there was the highest average for the number of crops per farmer (3 in 2018), despite the fact that the variability trend is reduced by −11.67%. In Santa Rosa, the value of 1.65 crops was maintained and in Villa Rica, there was a trend of a 4.76% increase.

If analyzed from various approaches (context according to natural regions, according to districts, even according to the post-COVID-19 pandemic impact), Table 2 shows the great dynamics existing in the indicators of agrobiodiversity, which can be exploited by farmers, and the great need to manage the conservation of current crops. Furthermore, the results reinforce the need to join efforts to avoid the reduction in the average number of crops per farmer, which currently varies by −2.87% at a general level.

Table 2. Historical records of the average number of agricultural species cultivated per farmer in nine districts of the three natural regions of Peru.

Region	District	Average Number of Agricultural Species Cultivated per Farmer					Δ 2018–2022	Tendency
		2018	2019	2020	2021	2022		
Coast	Atico	2.65 ± 1.50	2.1 ± 1.02	2.15 ± 0.88	2.25 ± 1.25	3.3 ± 1.42	24.53%	
	Guadalupe	1.55 ± 0.51	1.6 ± 0.60	1.65 ± 0.59	1.65 ± 0.59	1.65 ± 0.59	6.45%	
	Paccho	3.9 ± 1.17	3.8 ± 1.20	3.4 ± 0.94	3.3 ± 0.80	3.4 ± 0.82	−12.82%	
Highlands	Lucanas	3.45 ± 1.28	2.9 ± 0.97	2.75 ± 1.12	3.25 ± 0.85	3.7 ± 1.34	7.25%	
	Lonya Chico	4.75 ± 1.37	4.4 ± 1.60	4.4 ± 1.60	4.4 ± 1.54	4.5 ± 1.50	−5.26%	
	Sapillica	2.35 ± 1.09	2.2 ± 1.11	1.8 ± 0.77	1.8 ± 0.700	1.7 ± 0.60	−27.66%	
Jungle	Santa Rosa	1.65 ± 1.09	1.65 ± 0.99	1.65 ± 0.99	1.65 ± 0.99	1.65 ± 0.99	0.00%	
	Jepelacio	3.00 ± 1.08	2.8 ± 1.01	2.9 ± 0.79	2.7 ± 0.98	2.65 ± 0.99	−11.67%	
	Villa Rica	1.05 ± 0.22	1 ± 0.01	1 ± 0.01	1.05 ± 0.22	1.1 ± 0.45	4.76%	
	Summary	2.71 ± 1.57	2.49 ± 1.44	2.41 ± 1.36	2.45 ± 1.36	2.63 ± 1.49	−2.87%	

3.1. Indices of Agricultural Diversity and Trends for 9 Districts of the Three Natural Regions of Peru

From the Shannon index, the maximum number of species was recorded along with their uniform distribution; on the coast, it was the district of Guadalupe (H/ =2,94) in 2018 and Paccho in the years 2019–2022 (H/ =2.94 and H/ = 2.95, H/ = 2.96, respectively). In the highland region, the highest Shannon index was presented in Lonya Chico for the year 2018; Lucanas in the years 2019, 2021, and 2022 (H/ = 2.92, H/ = 2.09, H/ = 2.95, and H/ = 2.93, in the given order); and Sapillica in 2020 (H/ = 2.90). Likewise, from the Shannon index, the maximum number of species was recorded along with their uniform distribution for the jungle region, and the indices with the highest values were in the district of Villa Rica (H/ = 2.98) in 2018, 2019 (H/ = 2.99), and 2020 (H/ = 2.99). This analysis resulted in lower values for diversity indices for the district of Santa Rosa in all years (2018–2022) due to the consideration of both the number of species recorded and their relative abundance in the forest (Table 3).

Table 3. Retrospective values of the Agricultural Diversity Index, and trends for 9 districts of the three natural regions of Peru.

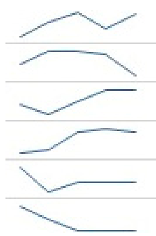
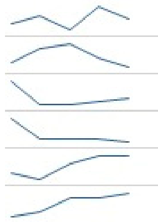
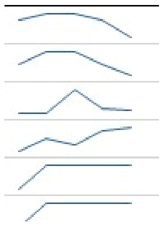
Natural Region	District	Index	2018	2019	2020	2021	2022	Trend
Coast Region	Atico	Shannon_H	2.84	2.88	2.91	2.86	2.9	
		Margalef	4.79	5.08	5.05	4.99	4.53	
	Paccho	Shannon_H	2.96	2.95	2.96	2.97	2.97	
		Margalef	4.36	4.39	4.5	4.53	4.5	
	Guadalupe	Shannon_H	2.94	2.93	2.94	2.94	2.94	
		Margalef	5.33	5.48	5.43	5.43	5.43	

Table 3. *Cont.*

Natural Region	District	Index	2018	2019	2020	2021	2022	Trend
Highlands Region	Lucanas	Shannon_H	2.92	2.94	2.91	2.96	2.93	
		Margalef	4.49	4.68	4.74	4.55	4.41	
	Lonyachico	Shannon_H	2.95	2.91	2.91	2.91	2.2	
		Margalef	4.17	4.02	4.02	4.02	4	
	Sapillica	Shannon_H	2.89	2.88	2.91	2.92	2.93	
		Margalef	4.94	5.02	5.30	5.30	5.39	
Jungle Region	Villa Rica	Shannon_H	2.98	2.3	3.00	2.98	2.94	
		Margalef	6.24	6.34	6.34	6.24	6.14	
	Jepelacio	Shannon_H	2.93	2.93	2.96	2.94	2.94	
		Margalef	4.64	4.72	4.68	4.76	4.79	
	Santa Rosa	Shannon_H	2.8	2.86	2.86	2.86	2.86	
		Margalef	5.15	5.43	5.43	5.43	5.43	

Regarding the value of the Margalef species richness index, it is directly related to the number of species present in each district. Thus, for the coastal region, the highest values were recorded in Guadalupe in the 5 years (SR 2018= 5.53, SR 2019= 5.48, SR 2020 = 5.43, SR 2021 = 5.43, and SR 2022 = 5.43). In the highland region, the highest SR was in all years for Sapillica (SR 2018 = 4.93, SR 2019 = 5.02, SR 2020 = 5.30, SR 2021 = 5.30, and SR 2022 = 5.38); and in the jungle, for the 5-year study, the highest index values were presented in Villarica (SR 2018 = 6.24, SR 2019 = 6.34, SR 2020 = 6.34, SR 2021 = 6.24, and SR 2022 = 6.14). The lowest value with respect to the total corresponded to Lonya Chico (highland region, 2022) with an SR index of 4.

3.2. Models of Historical and Future Trends for Productive Agricultural Diversity at the Level of Crop Type and Family

The annual frequency (2018–2022) on average was represented in trend models for the different types of crops. In all cases, the best fit (according to MAPE, MAD, and MSD) was presented using the quadratic trend model. MAD values showed values of 0.27 in tuberoses, 0.07 in fruits, 0.09 in cereals, 0.29 in legumes, and 0.30 in roots. Since tuberous are the lowest value, it means that they had the best fit for crop types. For all crop types, the model forecasts a positive upward trend (Figure 2). Regarding the ASM for crop type, the forecast for roots is wrong by 6.80%, this being the highest value of error identified. The rest of the ASM values for crop types are between 2.12% (legumes) and 0.46% (cereals). For the MSD measure, the accuracy of the adjusted values of the time series ranges from 0.07 in fruits (highest fit) to 0.27 in tuberoses, representing the lowest fit (Figure 2).

The historical trend and projection models to 2025 for productive agricultural diversity, according to crop family, are presented in Figures 3 and 4. A total of 25 plant families were identified in the three natural regions, corresponding to nine districts of Peru. In this sense, the MAPE, MAD, and MSD values had the best fit for the quadratic trend model in all cases. For the year 2025, the projections in a positive trend correspond to the families of the poaceae, rutaceae, rosaceae, solanaceae, tropaeolaceae, malvaceae, lythraceae, moraceae, lauraceae, fabaceae, euphorbiaceae, convolvulaceae, brassicaceae, asteraceae, and amarillydaceae. On the other hand, the projections in a negative trend correspond to the families of passifloraceae, rubiaceae, olaceae, oxalidaceae, musaceae, cucurbitaceae, basellaceae, apiaceae, and amarantaceae.

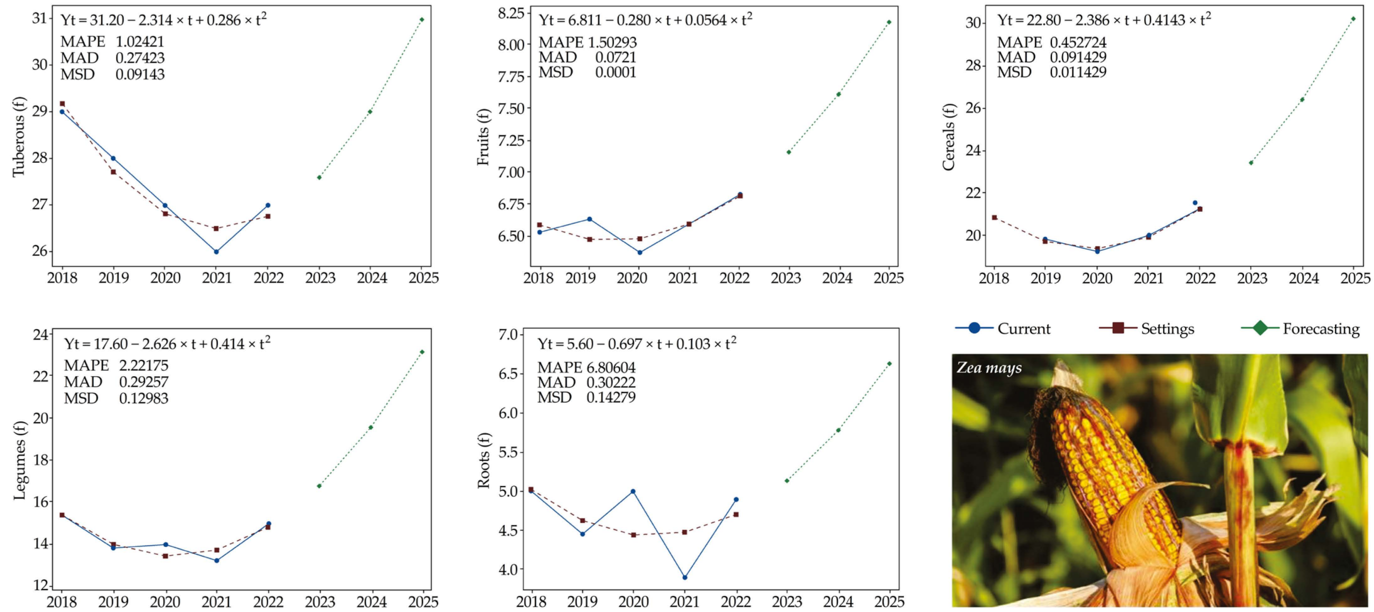
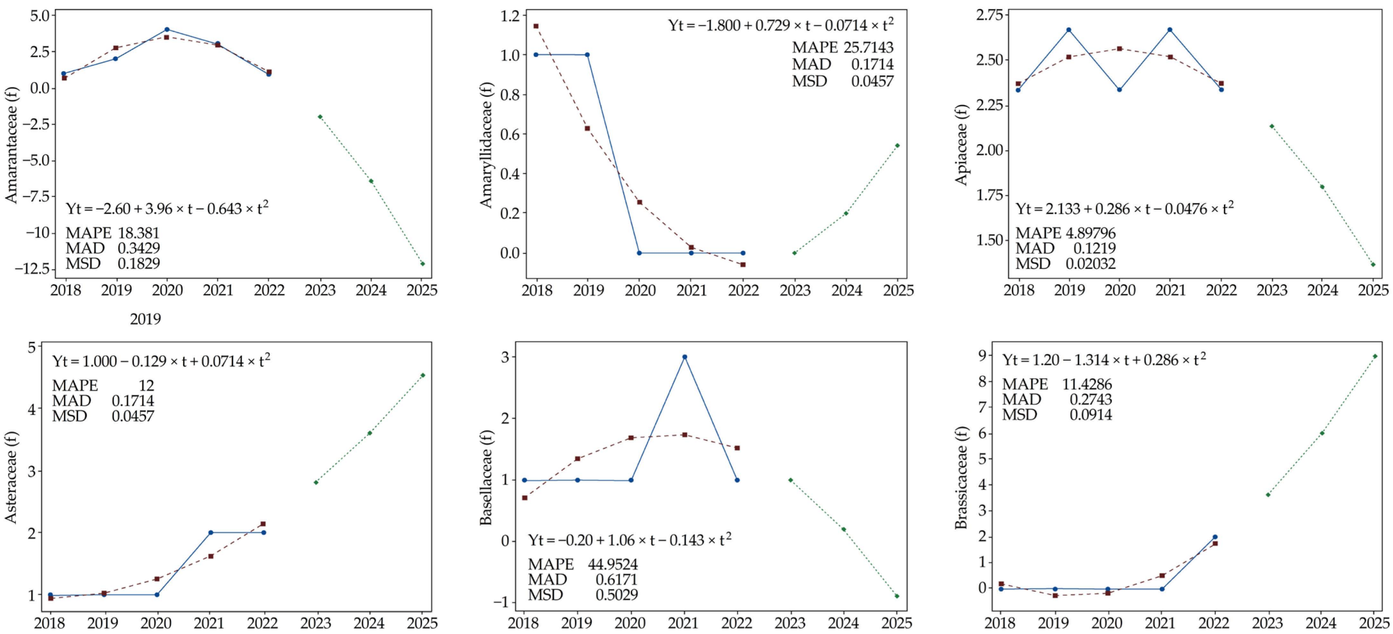


Figure 2. Historical trend model and projection to the year 2025 for productive agricultural diversity by crop type.



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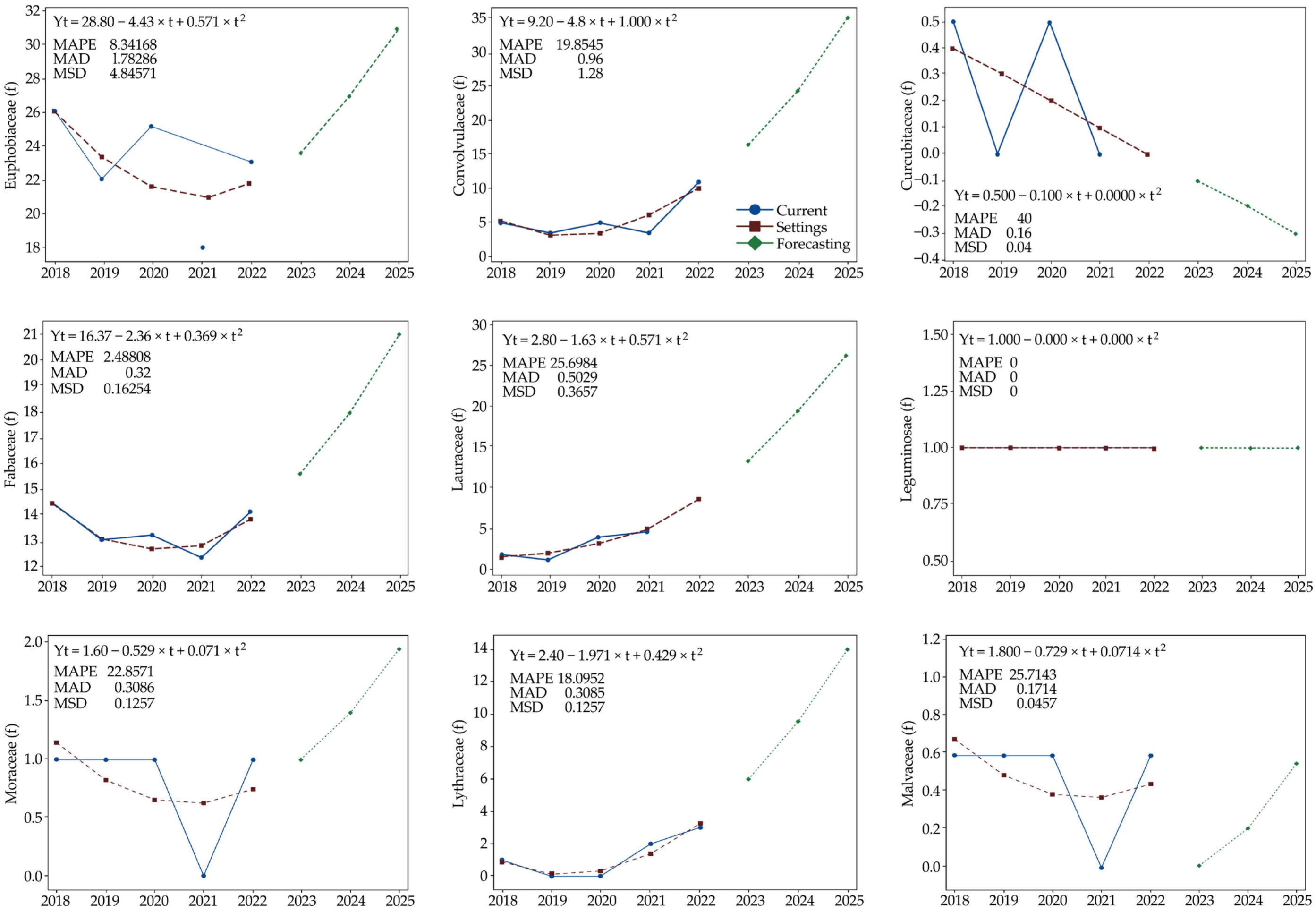
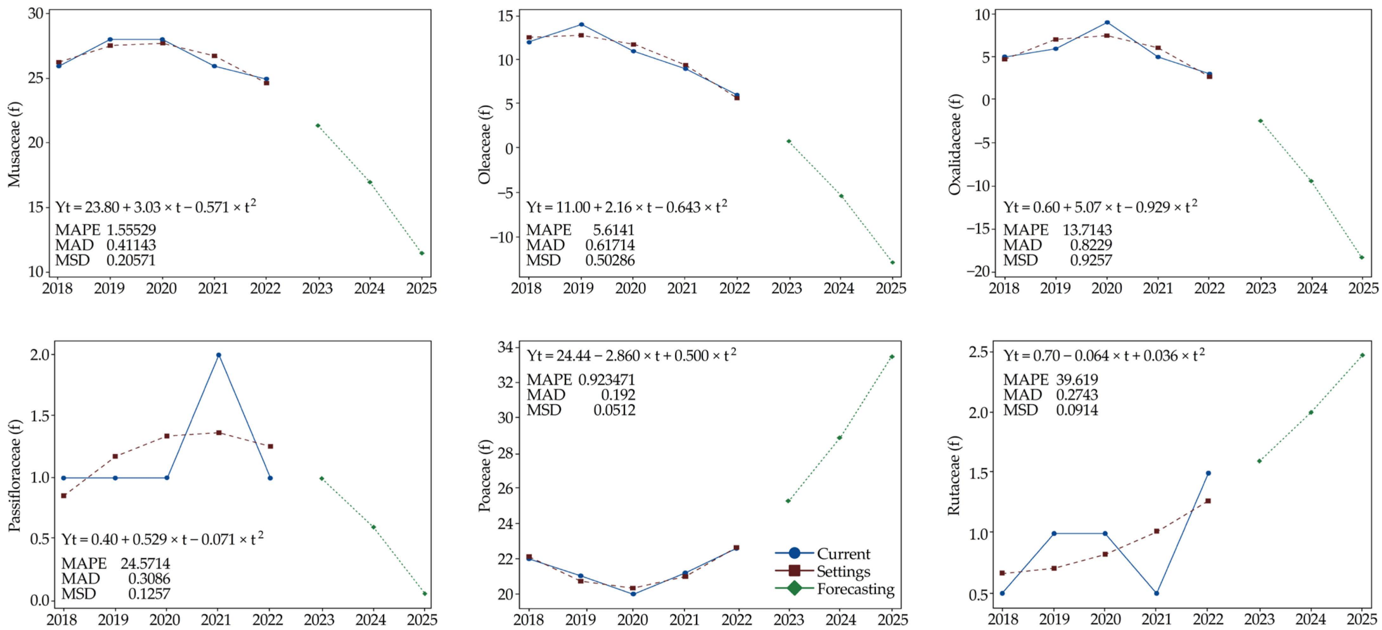


Figure 3. Historical trend model and projection to 2025 for productive agricultural diversity by crop family (Part A).



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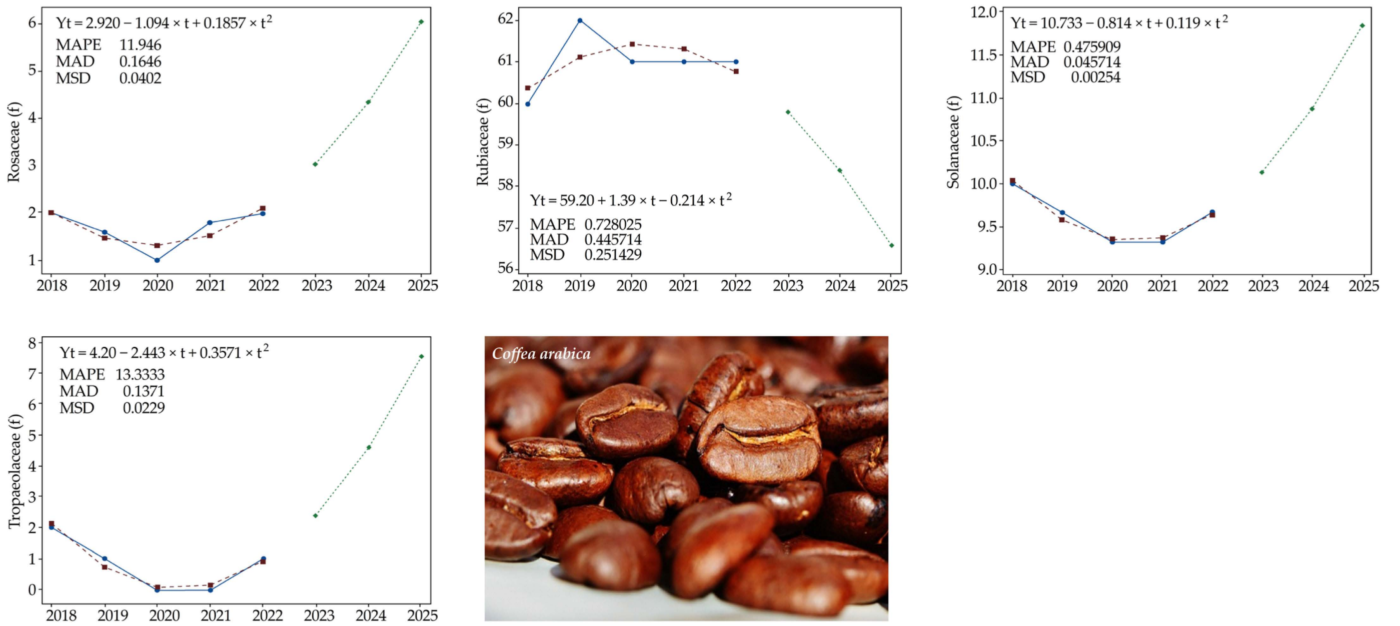

Figure 4. Historical trend model and projection to 2025 for productive agricultural diversity by crop family (Part B).

4. Discussion

Agrobiodiversity is underutilized in national food systems; although this is critical for healthy agro-ecosystems [29]. The present study focused on investigating the historical variability of agricultural crops in the three natural regions of Peru; from these crops, the indices of agricultural diversity and trends were obtained, to finally present models for the projection of crop types and crop families for the Peruvian farmer. The diversity of crops is very dynamic between years and areas. Genetic diversity is not only necessary to maintain among species [30] but it is also responsible for the diversity of food, medicines, and fibers available to humans in ecosystems. Therefore, it is essential to adopt differentiated approaches to the conservation and promotion of agrobiodiversity in local contexts. Natural and modified ecosystems provide a multitude of functions and services that contribute to human well-being [2]. It has long been recognized that biodiversity plays an important role in the functioning of ecosystems [31,32]. It is proposed to use crop-specific planting frequency data as indicators to provide indirect information on the planting of future crops [23]. While later studies suggest that a few dominant species can provide most ecosystem services [26], the case of productive agricultural diversity requires wealth and abundance. Therefore, they are dependent on many complementary species to provide ecosystem services. Changes in the response of ecosystem services to biodiversity can operate in combination [33]. Depending on the type of crop, farmers assess the yield of marketable crops on acreage and also on the basis of the weight of the fruits or seeds [9].

The Peruvian economy has grown at a dizzying pace in recent decades. Peru's GDP has more than tripled, from \$60 billion in 1990 to \$215 billion in 2019 [34]. In line with economic growth, Peru is facing a higher consumption of food, so the data from this research show an alert for conservation and the search for new sources to strengthen food security in the countryside and the city [9]. Smallholder farmers are the most important custodians of plant genetic resources for in situ conservation. Despite this, the complexity of rural agricultural Peru incorporates the conditions of poverty and development in a geographical context, which are combined with the transformation of food systems and climate change [7]. The retrospective diversity values in this study will allow us to relate to the availability of food in each area. Likewise, prospective trends will allow us to look for strategies to anticipate this lack of future food in terms of quantity and availability for local consumption. It is, therefore, reaffirmed that the emerging capacities of agrobiodiversity actively provide a partial degree of food sovereignty [35].

This dynamic of productive agricultural diversity can be attributed to various factors such as the adoption of agricultural practices and sustainable agricultural developments. The literature reports that biologically diverse communities are also more likely to contain species that confer resilience to that ecosystem because, as a community accumulates species, there is a greater likelihood that any of them will have traits that allow them to adapt to a changing environment [36,37]. Such species could buffer the system against the loss of other species [38]. These findings highlight the importance of promoting agrobiodiversity conservation and management strategies to ensure food security and sustainable development in Peru.

Studies have documented the effects of COVID-19 on public health, as measures to contain the disease pose significant risks to food and nutrition security due to declines in food production, distribution, and access [39–41]. This phenomenon primarily affected low-income families in poorer areas of Lima and the main cities. Faced with the situation, they had to migrate back to their centers of origin in the hope of finding better conditions [42–44]. Reverse migration can have both positive and negative effects on agrobiodiversity [45,46]. On the one hand, it can promote the revitalization of traditional agricultural practices and the use of local varieties, which contributes to the conservation of agrobiodiversity. Also, the pandemic offers opportunities to rethink the whole aspect of migration, and, using the innate or acquired skills of returning migrants, outstanding problems in the rural sector can be tried to solve [47–49]. On the other hand, reverse migration has wide-ranging direct and indirect effects on biodiversity loss and ecosystem health. Due to financial, cultural, and many other factors, people engage in activities that promote deforestation and wildlife trade to support their livelihoods. Certain policy actions, such as subsidies to extractive, agricultural, and development industries, can generate rapid economic growth, but they can also exacerbate land use changes, biodiversity loss, greenhouse gas emissions, and unsustainable agricultural intensification, all of which can create conditions for future emerging diseases [50]. Therefore, it is also necessary to implement appropriate management strategies and policies that promote the sustainability of agrobiodiversity in the context of reverse migration.

The diversity indices of 47 crops recorded in rural areas of Peru are grouped into types of crops that are part of the country's food security [51], as well as crops of economic importance such as coffee and cacao. This research will allow for decisions to be made to prioritize and zone territories with aptitudes for these crops, as has been performed for potatoes [52], coffee [53], and cocoa [54]; there have even been studies of the potential distribution of crop species of medicinal importance in the country [25] and of the floral resources for bees in rural areas [55].

5. Conclusions

In conclusion, this study reveals significant changes in the diversity of agricultural species cultivated in different districts of Peru during the period from 2018 to 2022, influenced by the phenomenon of reverse migration caused by the COVID-19 pandemic.

These results highlight the importance of adopting differentiated approaches for the conservation and promotion of agrobiodiversity in local contexts, as well as implementing appropriate management strategies and policies to ensure the sustainability of agrobiodiversity in the context of reverse migration. Future research could deepen the analysis of the drivers of these changes and assess the impact of agrobiodiversity conservation policies and programs in the context of reverse migration.

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