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The Archeological Landscape of the Chanchán Basin and Its Agroecological Legacies for the Conservation of Montane Forests in the Western Foothills of the Ecuadorian Andes

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Abstract: This article shows a set of agroecological practices that were incorporated into the archeological landscape of the Chanchán basin by pre-Hispanic Kañaris societies for 1200 years (240–1438 AD), a millennium before the arrival of the Incas, and that continue to be used in this landscape by certain indigenous communities of the 21st century. The use of archeobotanical techniques, contrasted with ethnobotanical sources, has allowed us to interpret how these societies structured their cultivation systems, agroecological practices, and landscape management, for the conservation of agroecosystems in the western Andean foothills. Agroecological legacies show how the stability, adaptability, and elasticity of Andean agriculture can be sustained under models of progressive intensification without this causing irreversible environmental damage in the agroecosystems. Kañaris agroecological practices configured the Chanchán landscape as a great cultural artifact, wherein the non-human agency of plants (cultivated and wild) was more than a mere adaptation to the niches culturally constructed by human populations. Non-humans are active subjects in recovering the functional and structural integrity of agroecosystems after a social or ecological disturbance. All this is part of landscape management based on an "Ecological Diversification Model", where plant species are adapted to the ecotones and ecological floors of the western Andean foothills, to diversify and increase the availability of food crops that are bioculturally appropriate given the present agrobiodiversity.

Keywords: Chanchán basin landscape; Andean archeological landscape; pre-Hispanic agroecological legacies; Andean ancient agroecology; Joyagzhí terraces

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1. Introduction

The archeological landscape of the Chanchán basin presents a long historical trajectory of the appropriation, use, and socio-ecological transformation of its landscape, which is located in the western foothills of the Ecuadorian Andes. The process extended during pre-Hispanic times for 2000 years, from the Late Formative Period (543–381 cal BC) to the final phase of the Integration Period (1386–1438 cal AD) [1,2], and it continued to operate until the present (21st century) through the use of certain agroecological cultural patterns in indigenous communities located in this landscape [3].

In the pre-Hispanic context, the use of ecological principles in the process of the agriculturalization of the Chanchán basin allowed the configuration of a ritualized agricultural landscape, constituted by a wide diversity of biocultural codes that imprinted a cultural signature on the landscape for the fabrication of a unique social being [1,2]. Next to Mount Puñay (3270 masl), which is the most outstanding montological element in the physiography of the Chanchán basin, since it stands out like the tip of an iceberg in the middle of this water system [3], there are materialized systems of extensive agricultural fields through permanent crop fields (chakras), intensive agricultural systems such as terraces (patas), domestic sites (tolas), territorial milestones between human settlements (landmarks), and ceremonial sites (pukaras) built on the tops of mountains or blades, as is the case of Mount Puñay [1,4,5] (Figure 1).

Figure 1. Archeological landscape of the Chanchán basin with the reference to "Mount Puñay" and the montane cloud forest of the western Andean foothills.

In the case of extensive and intensive cropping systems, these act as a transforming agent of space, imprinting the configuration of three types of landscapes: domestic, social, and sacred [1]. They also play a role in the materialization of an agriculturalization process that allowed the intensification of agriculture progressively, without this causing irreversible damage to the ecosystem processes in the montane forests of the western Andean foothills, due to anthropogenic impacts related to the production of their crops [2].

The elasticity of the paleo-agroecosystems of the Chanchán basin could have been sustained for two millennia by the use of the agroecological practices of the pre-Hispanic Kañaris societies, and rather than by the influence of diffusionist cultural processes related to the Inca expansion between 1450 and 1530 AD [6], within the context of the so-called ecological imperialism that was perceived in other pre-Hispanic agricultural sites in Ecuador and other regions of the Andes [7–10].

The history of pre-Hispanic agriculture in the Andes of Ecuador begins in the Early Holocene with the domestication of plants by the first hunter–gatherers, and it culminated with the Inca imperial expansionism when Andean societies had developed highly efficient cropping systems that lasted for thousands of years [11]. However, even though agroecology is a cultural practice [12] as old as the origins of agriculture [13,14], based on the use of socio-ecological principles, techniques, and practices to manage both agricultural production and the conservation of agroecosystems efficiently [15,16], no investigations in Ecuador has so far allowed a better understanding of these agroecological cultural practices used by pre-Hispanic societies in their trajectory and historical continuity. This has caused a reduction in the food security of the indigenous peoples of the Andes of Ecuador, since recently, they have lost the ability to be self-sufficient and produce healthy, nutritious, and culturally appropriate food with their available agrobiodiversity.

Therefore, this research aims to contextualize the pre-Hispanic agroecological legacies of the landscape of the Chanchán specifically obtained from the Joyagzhí archeological terraces, during the years 240 AD to 1438 AD. Additionally, legacies persist into the 21st century from traditional indigenous societies in the form of the Nizag community. This enables us to learn from the past lessons regarding how pre-Hispanic societies structured their agroecological systems and practices for managing their crops in the western Andean foothills, and how they organized their territory to configure their agricultural diversity.

One of the lines of research in seeking to understand pre-Hispanic agriculture is paleoethnobotany or archaeobotany. Archeobotanical research is a way to understand pre-Hispanic Andean agriculture and its relationship with agroecological practices. Systematic sampling of archeological sites makes it possible to recover plant remains in contexts that are directly associated with radiocarbon chronologies [17–19], and thus analyze the interrelationships that emerged between humans and plants [20–23].

This archeobotanical information has been contrasted with referential sources of ethnobotany, which focus on studying the co-relationships between plants and human beings in the historical context of current traditional societies [24–26]. The application of ethnoarcheological models is present through the production process, recognizing archeological products, by-products, and residues characteristic of the activity that has generated them [27,28]. In the case of the material evidence generated by the crop systems, each agricultural operation results in a sample type with a unique and specific botanic composition [29]. Ethnobotanical data allow one to obtain a reference collection for interpreting these systems in the archeobotanical record through relational analogy [20,30], connected to the singularities of every historical context.

1.1. Landscape: A Sociocultural Product

There are multiple approaches to landscape studies with different theoretical and methodological perspectives [31–36], with the common denominator of integrating the dynamic and interdependent relationships that human beings maintain with the physical, social, and cultural dimensions of their environment, through time and space [31,37].

One perspective on which this research is based is that of the landscape, and this includes varied subjectivities of space, from structured experiences of meanings to dialectically articulated practices and socio-ecological relations [38]. When speaking of landscape, reference is made to a socially constructed space, where human beings transform the natural space into a place that is inhabited, perceived, named, and narrated [39,40].

Landscapes are sociocultural products that manifest through time structural and organizational principles of morphology, planning, and coherent meaning [41]. They operate as management systems for significant symbols of human actions and the material and imaginary by-products they generate [31], helping to define habitual relationships based on differentiated historical information as cultural constructs, which allow the materialization of cultural signatures of identity [42,43]. Such relations not only express the social role of humans concerning external nature [44], but in the subjective construction of space, the intervening modeling agents exceed these, and involve the agency of beings and things (mountains, volcanoes, ecosystems, plants, and animals) [45].

In this sense, a constructive social reading of the landscape makes it possible to isolate the elements and formal relationships that constitute it, considering not only the visible physical features but also significant elements of cultural processes such as agroecological practices. This is because being is reflected in living and building, to the point that construction and its forms give a reason for being and thinking [46].

1.2. Agriculture at a Landscape Scale

Agriculture has been commonly defined as the set of economic and technical activities related to treating the soil and cultivating plants for food production [47,48]. It thereby refers to all forms of the management of crops that may or may not be completely domesticated [49–51]. However, from a broader spatial and temporal perspective, agriculture can be the result of the cultivation of ecosystems (the domestication of the landscape), plus the management of genetic diversity (the domestication of plant populations), the management of water (recruitment and distribution), and labor organization [1], where the cultivation and domestication of plants are the fundamental elements determining the form of land use and the economy [52].

In this context, agriculture is the result of biocultural modifications of ecosystems to satisfy the basic needs for food, fibers, and other materials [53], which, according to the conditioning factors of co-evolution, are met by the relations of nature–culture, territories–populations, and habitats–societies. These, when materialized, inevitably cause interrelationships between human decisions and some properties of natural systems, such as stability, vulnerability, and elasticity [54].

More specifically, within a certain agricultural landscape, in addition to the agricultural cultivation system within the agriculturalization process, other crop systems can materialize, such as horticulture, cultural management, and control cultural [1]. Horticulture is the cultivating of plants indoors or in house gardens through cultural practices that consider a multitude of wild adventitious taxa and weeds [55,56]. Horticulture can also refer to domestication processes related to the selective preservation of certain plants [20,45]. Management is manipulating and controlling wild species of plants without cultivation or morphological changes [57]. In comparison, cultural control is the regulation of ecosystems and biotic communities to increase the long-term availability of specific plant resources of economic importance before the manifestation of morphological indicators of plant domestication [58,59].

1.3. Agriculturalization in the Andes: Extensive and Intensive Systems

In agriculturalization, the progressive and gradual use of land to incorporate certain crop systems includes expanding agricultural frontiers and intensifying productive yields [8,9,60,61]. The expansion of agricultural frontiers implies changes in land use to increase arable land without maximizing short-term productivity [62], using plots of crops located near residence sites [63]. For its part, the search for higher yields implies changes in production techniques to obtain more resources in a given space–time unit [64], gradually incorporating fences, canals, aqueducts, and/or level surfaces for terrace systems [8].

Legacies of a long history of changes in agriculture and land cover in the Andes can be seen in many geomorphological landscape characteristics [65]. In pre-Hispanic times, this process of agriculturalization materialized in extensive and intensive cropping systems, which can be identified in archeological sites of agricultural production and the landscape [8,9,66,67]. Extensive agriculture can generally be evidenced on flat topography soils from 3500 BC in the Formative Period [11], while intensive agriculture appeared with the construction of terraces after 2000 BC [8]. This shows that the emergence of intensive systems did not annul extensive systems, and that both have persisted at the same time in the Andean landscapes until today [65].

These systems entail social transformations, such as the reduction in mobility and the appearance of more stable and numerous settlements, which together imply a trend toward greater social complexity [68]. This does not exclude that other factors and economic conditions that sustain intensification processes may also depend on more intense and competitive social relationships, and increased interaction and circulation of goods [69].

Two types of crop systems can currently be identified in the archeological landscape of Mount Puñay [1–3]. The permanent fields (chakras) are plots located next to the sites of pre-Hispanic domestic occupation and are still used for the production of extensive crops.

The terraces (pata) are staggered constructions on steep slopes and are the most visible landscape transformation used for intensive agricultural production.

In the case of terraces, pre-Hispanic Andean societies developed these monumental technologies to facilitate intensive agriculture in the mountainous highlands [70] and to mitigate the topographic, hydrological, and edaphic conditions associated with the sloping terrain [71]. These large-scale human landscapes emerged as growing populations intensified their land use practices and formalized their regional land tenure systems [70,71].

Agricultural terraces both in the past and present historical context serve many agroecological functions. These include mitigating soil erosion on steep terrain, increasing topsoil depth, draining soils, increasing ambient temperatures to insulate crops from high-altitude frost, the retention of organic matter, the distribution–control–mitigation of the supply of water, and building flat surfaces necessary for the cultivation of plants of economic value such as maize [9,70,72–74].

1.4. Pre-Hispanic Agroecological Practices Recorded in the Andes

Agroecology is a cultural practice [75] that uses socio-ecological principles, techniques, and practices to efficiently manage agricultural production for the conservation of agroecosystems [16,76]. In the case of the Andean area, agroecology was incorporated to mitigate and regulate certain biophysical, climatic, and environmental limitations and contingencies of the ecosystems [77], which are focused primarily on sloping topography, soil degradation, irregular rainfall, extreme weather risks (drought and frost), and the spread of pests and phytopathogenic diseases [1,2].

The pre-Hispanic indigenous agriculturists, over time, developed innovative and efficient agroecological practices such as the artificialization of ecosystems, the conservation and fertilization of the soil, the regulation of water, the protection of crops, the diversification of a wide phylogenetic variability, and the identification of agroecological zones [70,78–84] (Table 1).

Table 1. Pre-Hispanic agroecological practices registered in the Andean area.

Agroecological Practice	Definition
Green manures	Consists of the incorporation of plants that are sown in rotation or associated with crops of cultivated plants, seeking to maintain, improve, or restore the physical, chemical, and biological properties of the soil [79].
Cover crops	Uses plant layers to protect the soil from water erosion, the loss of nutrients, and the presence of weeds and pests [80].
Crop diversification or polycultures	Practice essential in enhancing yields, conducted by planting two or more crop species within sufficient spatial proximity to result in competition or complementation [81].
Construction of terraces	Provides a platform for a deep soil matrixm which facilitates the improvement of cultivation, the control of erosion and moisture, the development of sustainable micro-climates, and higher levels of soil organic matter content [70,72,78].
Intentional fire	Used to burn and eliminate deleterious microflora and microfauna and allow nutrient-rich ash integration into agricultural soil [82].
Trap crops	Adventitious plants that attract insects or other organisms such as nematodes to protect economically valuable crops from pest damage [83].
Implementation of vegetal barriers	Used to mitigate the erosion of fertile soil, assist in bettering climate resilience (frost and wind), reduce water loss from plants and soil (evapotranspiration), and increase CO^2 assimilation through the utilization of plants for the delimitation of plots and terraces [84].

1.5. Agroecological Zones of the Ecuadorian Andes

In the Andes, the development of agriculture highlights an inexorable geomorphological relationship between the altitudinal succession of ecological floors and the topographic and climatic variability of the Andean mountain range [85]. In the Ecuadorian Andes, the Yunga, Quechua, and Páramo areas respond fundamentally to the co-adaptive interrelationships between humans and the ecosystem through changes in the life cycles of domesticated, semi-domesticated, and wild plants (e.g., foliar loss, flowering, fruit ripening, etc.) [1,2] (Table 2).

Table 2. Agroecological zones recorded in the Chanchán basin.

Agroecological Zones	Altitude (masl)	Description
Yunga Zone	500 to 2300	It corresponds to an area of plateaus and ravines with a warm climate. This area includes Andean food crops such as the following: cereals (*Zea mays*), legumes (*Phaseolus vulgaris*), cucurbits (*Cucurbita ficifolia*, *C. maximum* and *Cyclanthera pedata*), fruit trees (*Annona cherimola*, *Capsicum baccatum*, *Carica papaya*, *Carica pubescens*, *Inga feuilleei*, *Juglans neotropica*, *Opuntia aequatoralis*, *Passiflora cumbalencis*, *Passiflora ligularis*, *Persea americana*, *Physalis peruviana*, *Pouteria lúcuma*, *Prunus serótina*, *Psidium guajava*, *Rubus glaucus* and *Solanum muricatum*), roots (*Arracacia xanthorrhiza*, *Canna indica*, *Ipomoea batatas* and *Manihot esculenta*), and tubers (*Smallanthus sonchifolius*).
Quechua Zone	2300 to 3500	It corresponds to a hillside located on a moderate slope with a mild climate. The crops present in this region are *Zea mays*, accompanied by legumes (*Lupinus mutabilis*) and cucurbits (*C. ficifolia* and *C. maxima*). Many of the crop plots in this area are in the form of agricultural terraces.
Páramo Zone	3500 to 4500	It corresponds to the cold highlands of the mountain range, where tubers (*Oxalis tuberosa*, *Solanum tuberosum*, *Tropaeolum tuberosum* and *Ullucus tuberosus*) are the only cultivable species.

1.6. Archeobotanical Evidence in the Ecuadorian Andes

The pre-Hispanic era of Ecuador has been organized into five chrono-cultural periods [86,87]. The presence of hunter–gatherers defined the Paleoindian Period (PP) (10,000–3500 BC). The Formative Period (FP) (3500–300 BC) corresponds to the presence of sedentary farmers. The Regional Development Period (RDP) (300 BC–800 AD) is distinguishable by the regionalization of theocratic tribal societies. The Integration Period (IP) (800–1530 AD) is determined by the formation of ethnic lordships or chiefdoms. Finally, the Inca Period (1450–1530 AD) was characterized by the Inca state's expansion.

The archeobotanical records of the PP have provided the oldest evidence of the domestication of *Zea mays* in the Andean highlands of Ecuador and South America. Starch grains from this plant have been identified in lithic tools at the Cubilán site, dated between 6128 and 6009 cal BC, along with various nutritional plants such as *Phaseolus* spp., Dioscoreaceae, *Manihot esculenta*, *Sagittaria* spp., *Capsicum* spp., and *Calathea* spp. [88].

During the FP, in the origins of agriculture, fragments of charred cobs of *Zea mays*, dated 2000 BC, have been recorded at the Cerro Narrío site [89]. Similar charred remains, dated between 750 and 600 BC, have also been documented at the Pirincay site [90]. In addition, evidence of macroremains of *Zea mays*, *Gossypium barbadense*, *Solanum tuberosum*, *Oxalis tuberosa*, *Lupinus* sp., *Chenopodium quinoa*, and *Amaranthus* sp. have been recorded at multiple sites such as the Cotocollao (1500–500 BC) [91], Nueva Era (760–670 BC) [92], and Chimba (690 BC–40 AD) [93]. Finally, charred maize grains were recorded in the permanent fields (chakras) of the Yalancay site between 543 and 381 cal BC [1,2].

However, no information on archeobotanical remains has been reported in the RDP until recently. In contrast, during the IP, starch grains of *Zea mays*, *Phaseolus* sp., *Manihot esculenta*, *Solanum tuberosum*, *Ipomoea batatas*, *Ullucus tuberosus*, and *Oxalis tuberosa* were reported at the sites of Cochasquí I and II (910–730 cal AD/630–520 cal AD) [94].

2. Materials and Methods

2.1. Paleoenvironmental Records in the Ecuadorian Western Andes

Few paleoenvironmental records are available in the Western Andes of Ecuador [95–97]. However, pollen and charcoal records in the southwestern foothills show warmer and drier conditions in the early to mid-Holocene (6050–1950 cal BC), while during the late Holocene (300 cal BC–1893 cal AD), five warm and humid phases were recorded [96].

Precisely, the percentages of pollen from the humid montane forest after 2050 cal BC increase together with the pollen of *Zea mays*, Ambrosia, and Chenopodiaceae [95], suggesting in this time the appearance of anthropic activities such as forest clearance and the emergence of regional agriculture [95]. Later, around 50 cal BC, the percentages of some pollen taxa from humid montane forests decreased, while weed/disturbance types increased, showing continuity in forest clearing and agriculture [95]. These data also coincide with the paleoenvironmental records from the inter-Andean plateau of Ecuador, where an episode of climatic humidity between 400 and 1200 AD is evident, which may have influenced the development of pre-Hispanic Andean cultures [98].

2.2. Chrono-Cultural Context of the Archeological Landscape of the Chanchán Basin

The human occupations recorded in this archeological landscape correspond to the pre-Hispanic Kañaris societies, which had an extensive territory in the Central–Southern Andes of Ecuador, including its western and eastern foothills [2,99,100]. In this space, the different social occupations were marked by geographical particulars that influenced the materialization of various cultural patterns at the regional level, as was the case in the Chanchán river basin [101] (p. 39). Regionalization gave rise to the formation of several political–territorial units (archeological localities) up until the 16th century with the same ethnic self-definition, cultural content, and language [102,103].

The archeological surveys carried out in the upper basin of the Chanchán have established the following cultural phases: Alausí and Cerro Narrío I (1000 BC–100 AD) corresponding to the FP, Cerro Narrío II (100–700/800 AD) corresponding to the PRD, and Tacalshapa (700/800–1100 AD) and Cashaloma (1100–1480 AD) belonging to the IP [2,4,5,104,105].

In the archeological Joyagzhí site, ceramic materials corresponding to the phases of Narrío, Tacalshapa and Cashaloma have been recorded [2]. Narrío ceramics are characterized by the presence of three types of ceramics with a uniform and well-fired paste, with extremely thin and light walls [2,4,101]. One polished bichrome is called "Narrío fine red on cream", the other highly polished and slipped red material is known as "Polished Cañar", and the third is named "Polished Coffee". The three correspond to social occupations associated with the late FP (543–381 cal BC) to the RDP (574–656 cal AD) [2] (Figure 2).

Later, two types of ceramic materials associated with the Tacalshapa phase were registered (negative and incised–anthropomorphic plastic), and the Cashaloma phase has been associated with two ceramic types (red slipped-on fawn and smooth white incised) [2,4,5]. Both phases correspond to the IP (757–879 cal AD to 1386–1438 cal AD) [2] (Figure 2).

Figure 2. Ceramic styles are recorded in the archeological landscape of the Chanchán Basin. (**a**) Polished brown; (**b**) red on fine fawn; (**c**) red slipped; (**d**) negative; (**e**) red slipped on fawn; (**f**) ocher slipped; (**g**) fawn smoothed; (**h**) incised white.

2.3. Research Areas

The archeological landscape of the Chanchán basin is located in the western foothills of the Ecuadorian Andes (Figure 3). This basin drains its waters into the Guayas River macrobasin on the Pacific Ocean slope. The geomorphology is characterized by high and unstable slopes that facilitate the transport of its watercourses towards the lower depression in the Chanchán River [1–3]. The climate is pluviseasonal, with an annual rainy season (December to May) and another dry season (June to November) [3]. The temperature ranges from 10 to 24 °C, the precipitation is between 300 and 1300 mm per year, and the relative humidity is between 40% and 90% [106]. At the ecological level, montane cloud forests (1400–3100 masl) are evident, which are multi-stratified evergreen forests, with a canopy that reaches to between 20 and 30 m, trees covered with bryophytes, a high representation of epiphytic vascular plants, and a herbaceous stratum with dense cover and a large number of ferns [107].

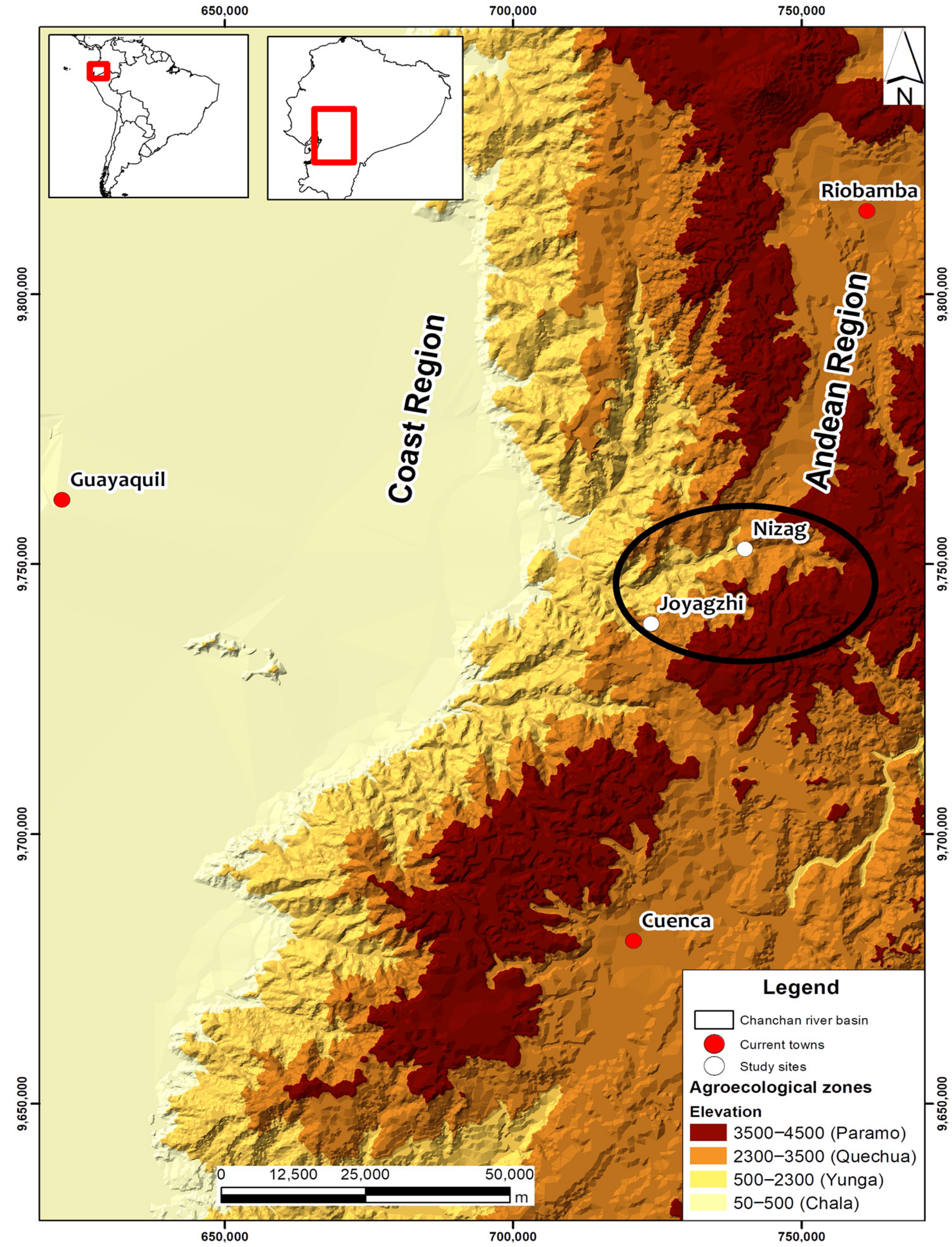

Figure 3. The geographical location of the archeological landscape of the Chanchán basin, concerning the Joyagzhí archeological terraces and the Nizag community (Andes of Ecuador).

2.3.1. Ethnobotanical Research Area: Nizag Community

The ethnobotanical research was carried out in the indigenous community of Nizag, located in the same basin of the Chanchán River (coordinates UTM 17M 9753056/7409530) (Figure 3). It has a territory of 1320 ha, distributed in an altitude range from 1840 to 3160 masl (Yunga and Quechua agroecological zones). Topographic peculiarities have facilitated the geographical connection with other agroecological zones, such as the Chala de la Costa (hot plains of 0–500 masl) and the Páramo (cold high Andean mountains of 3500–4500 masl). Nizag has 2100 inhabitants who self-identified ethnically with the Kañari indigenous people, maintaining a subsistence economy based on traditional agricultural production.

2.3.2. Archeological Research Area: Joyagzhí Terraces

Archeological Excavations

Joyagzhí is a set of land terraces located at the geographic coordinates UTM 17M 9737569/726534, within the Quechua agroecological zone, in an altitude range from 2835 to 3026 masl [1]. These terraces have an extension of 4 km, the largest being those that reach 630 m in length, 6 m in width, and 4 m in height on their slopes [3] (Figure 4).

Figure 4. Joyagzhí archeological terraces in the Chanchán basin.

Excavations carried out in 14 stratigraphic units (1.5 m × 1 m) revealed Inceptisol soils arranged in two strata [1,2]. Horizon "A" is characterized by a high content of organic matter. This horizon was excavated to a thickness of 161 cm, and archeobotanical findings of burnt sedimentary materials were recorded, with the presence of Kañaris cultural materials (ceramic and lithic fragments) and botanical macroremains carbonized (wood and seeds) corresponding to the RDP and IP [1,2]. The "B" horizon shows a natural illuvial, sterile and moist consistency [1,2].

Radiocarbon Chronology

The radiocarbon dates of the samples recovered at the terraces of Joyagzhí are between 240–384 cal AD and 1293–1393 cal AD, while the permanent field recorded chronologies from 598–678 cal AD to 1386–1438 cal AD [2] (Table 3 and Figure 5). The radiocarbon dates of the archeological contexts found corresponded to the Regional Development (RDP) and Integration Period (IP) chrono-cultural phases of the region.

Table 3. Radiocarbon dating of botanical macroremains recorded at the Joyagzhí site (Calibration with OxCal 4.2, Southern Hemisphere curve SHCal13).

Site	No. Ref. Lab. *	^{14}C años AP	Cal 2 σ AC/DC	Carbonized Dated Material	Archeobotanical Context Unite/Level/Depth	Macrobotanical Assemblages
Terraces	536,794	900 +/− 30	1146–1235 cal DC	Wood	J4/N4/40 cm	*Calandrinia ciliata* and *Phytolacca rivinoides*
Terraces	536,793	1290 +/− 30	757–879 cal DC	Kernel maize	J4/N7/70 cm	*Zea mays* and *C. ciliata*
Terraces	536,795	1420 +/− 30	626–684 cal DC	Kernel maize	J4/N10/100 cm	*Z. mays*
Terraces	536,796	1480 +/− 30	574–656 cal DC	Kernel maize	J4/N12/120 cm	*Z. mays* and *P. rivinoides*
Terraces	536,798	1380 +/− 30	646–693 cal DC	Wood	J5/N8/80 cm	*Nicandra physalodes*, *Vicia andicola*, *P. rivinoides*, *Rubus roseus*, *Amaranthus spinosus*, *Passiflora* sp., *Malva* sp., *Vaccinium* sp. and *Solanum* sp.
Terraces	536,799	1090 +/− 30	960–1038 cal DC	Wood	J6/N5/50 cm	*V. andicola* and *P. rivinoides*
Terraces	536,800	1770 +/− 30	240–384 cal DC	Wood	J6/N14/140 cm	*Phaseolus vulgaris*
Crop field	536,801	590 +/− 30	1386–1438 cal DC	Wood	J7/N5/50 cm	*Lupinus pubescens*, *N. physalodes* and *Verbena litoralis*
Crop field	536,802	1440 +/− 30	598–678 cal DC	Wood	J7/N10/100 cm	*Z. mays*, *Rumex andinus*, *Arenaria lanuginosa*, *V. litoralis*, Asteraceae Type 3 and Poaceae Type 2
Terraces	536,803	940 +/− 30	1044–1214 cal DC	Kernel maize	J8/N3/30 cm	*Z. mays*, *P. vulgaris*, *C. ciliata*, *P. rivinoides*, *Plantago linearis*, *Salvia* sp., *Galinsoga* sp., *Polygonum* sp. and Poaceae Type 3
Terraces	536,804	680 +/− 30	1293–1393 cal DC	Wood	J9/N4/40 cm	*Z. mays*, *Lupinus mutabilis*, *C. ciliata*, *P. rivinoides*, *Trifolium amabile*, *V. andicola*, *Chenopodium petiolare*, *Eupatorium* sp., Poaceae Type 1 and Poaceae Type 3
Terraces	536,805	1380 +/− 30	646–693 cal DC	Wood	J9/N10/100 cm	*C. ciliata*, *Lathyrus* sp., *Salvia* sp., *Galium* sp., Fabaceae Type 1 and Asteraceae Type 1
Terraces	505,659	860 +/− 30	1150–1256 cal DC	Seed *Passiflora ampullacea*	J15/N3/30 cm	*Passiflora ampullacea* and *Ipomoea* sp.
Terraces	505,658	880 +/− 30	1158–1267 cal DC	Wood	J15/N3/30 cm	*P. ampullacea* and *Ipomoea* sp.
Terraces	505,660	1320 +/− 30	672–789 cal DC	Kernel maize	J16/N4/40 cm	*Z. mays*, *Eupatorium* sp. and Fabaceae Type 1
Terraces	505,661	1270 +/− 30	762–885 cal DC	Wood	J16/N4/40 cm	*Z. mays*, *Eupatorium* sp. and Fabaceae Type 1

* Beta Analytic Laboratory.

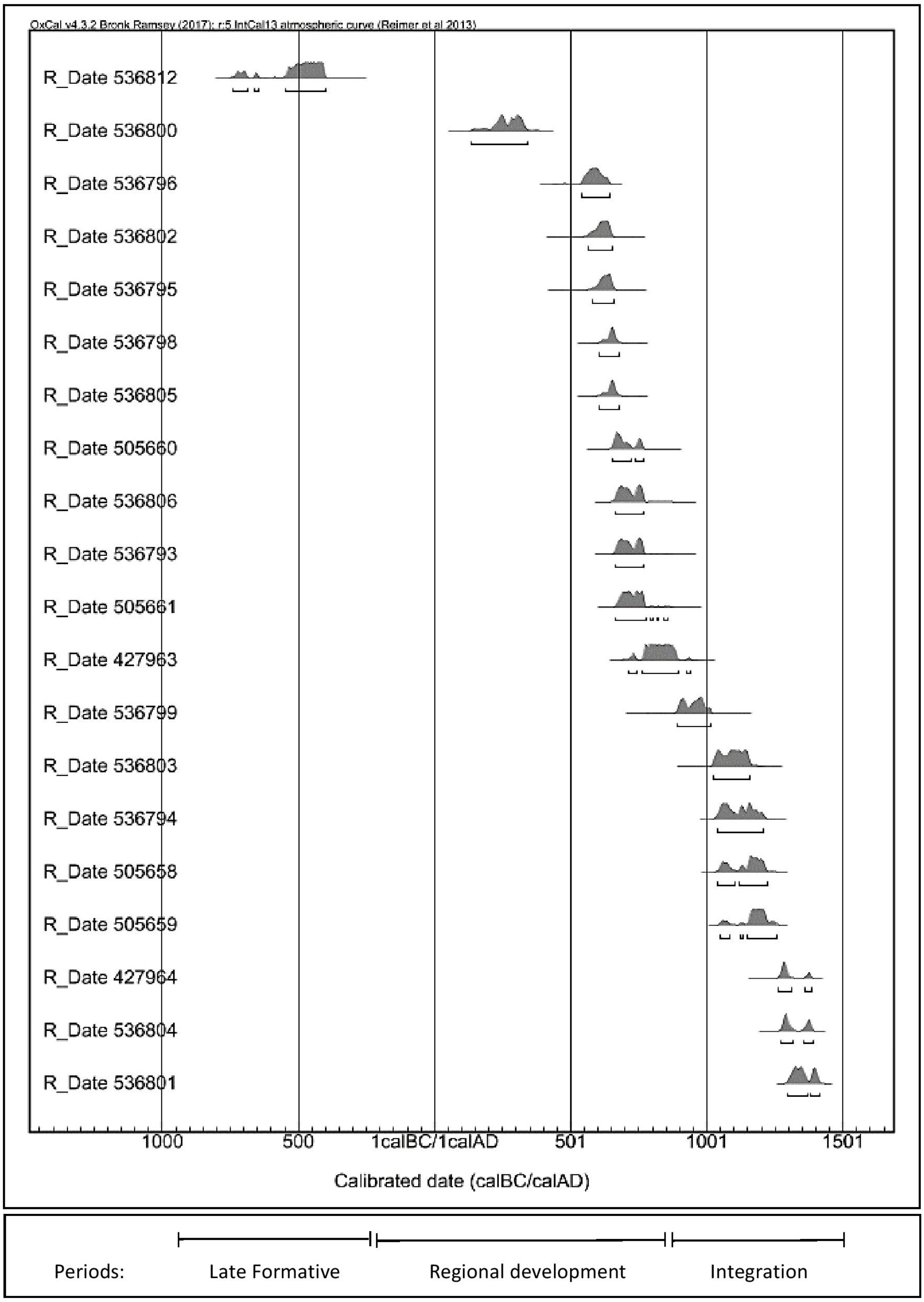

Figure 5. The probability graph of the radiocarbon dating calibrated to 2 σ, corresponding to the agriculturization processes of the archeological landscape of the Chanchán basin.

2.4. Methods

2.4.1. Ethnobotanical Method

The ethnobotanical research was carried out in the fields of crops (Yunga plots, Quechua plots, orchards, and agricultural terraces) of the indigenous community of Nizag, with the free and prior informed consent of a Nizag community association. A total of 327 field trips were carried out under an emic perspective to carry out the participant observation and the interview with open-ended questions in the Kichwa language. A total of 54 indigenous farmers were interviewed on several occasions to document the agricultural tasks related to the vegetative cycles of the crops. The average age of the interviewees was 61 years (Max. = 88/Min. = 30; 45 women and 9 men). The selection criteria of the interviewees depended on their knowledge of agrobiodiversity, cropping systems, agroecological practices, ethnobotanical uses of cultivated and wild plants, harvested products and byproducts, and discarded plant residues.

2.4.2. Archeobotanical Method

In 2019 and 2020, archeobotanical assemblages were analyzed, including the recovery, taxonomic identification, quantification, and interpretation of macrobotanical remains [108]. Stratified random sampling was used for the distribution of the excavation units. Samples were taken from the 12 terraces and one permanent field located next to them. Afterward, an orthophotography survey and the generation of three-dimensional digital models with LiDAR were carried out for the location of the excavation units. A total of 14 units of 1 × 1.5 m were excavated. Sedimentary samples were taken to recover archeobotanical remains during the excavation, considering the natural strata and artificial levels of 10 cm thickness.

A probabilistic sampling method was selected to collect sediment in excavation units [109]. Thirty liters of dispersed sediment were collected for each artificial level [110]. The charred macrobotanical remains were recovered using a manually operated flotation system containing column sieves with 4, 2, and 0.5 mm meshes. The total volume of floated sediment collected was 3900 L. Of the materials recovered, 16 organic samples (seeds and charred wood) were selected to be tested for the radiocarbon dating of archeobotanical contexts. These sediment samples responded to the methodological strategies stated above, providing evidence of the chronological formation of agricultural sedimentary deposits and the use of certain ecological practices.

Each sample's identification, classification, and photo documentation were conducted in the Archaeobotany Laboratory of the Escuela Superior Politécnica de Chimborazo (ESPOCH), utilizing a Nikon SMZ800N stereomicroscope and NIS-Elements software. Charred macrobotanical remains (fruits and seeds) were identified taxonomically by morphological and biometric analysis (length, width, thickness, area, perimeter, ratio 1: l/a*100, and ratio 2: g/a*100) for the subsequent comparison of modern reference materials in the field with the application of current catalogs and publications. Furthermore, identifiable macroremains with diagnosable characteristics were quantified as taxa, solely using the Type category of the botanical family for level identification.

For the quantification of each sample, the criteria of relative frequencies (proportions) and ubiquity values were used [111], measuring from the third artificial level of excavation, signifying the starting point at which charred macroremains were recorded. We thus developed a correspondence level between the proportions of samples in which a taxon was found. These two techniques have methodological advantages and disadvantages; however, when compared, they may reflect the following: the economic relevance of taxa cultivated in the past, and an ecological spectrum of other adventitious and ruderal plant taxa that may have been part of a former crop systems [112]. Additionally, these techniques were used to standardize data and compare contexts, sites, and periods. The composition of taxonomic macrobotanical remains was explored by correspondence analysis [113].

3. Results

3.1. Ethnobotanical Research

3.1.1. Agrobiodiversity in the Nizag Community

Diversity of Landscapes

Three landscape use zones can be distinguished within the 1320 ha that make up the territory of Nizag. The first zone, "pampa", is located on the fluvial plateau (Figure 6). This covers an area of 179 ha and is characterized by flat grasslands with scattered trees that are part of the Yunga agroecological zone (1960–2300 masl). The production in this zone focuses on food plant farming (vegetables, fruit, and roots), plus medicinal, ceremonial/ritual, foraging (plus pasturage for *Cavia porcellus*), materials, and agroecological (plants used in the ecological management of agroecosystems). This zone is located near the dwellings. Irrigation channels, road networks, and fences of crop fields were observed in the area.

Figure 6. Biodiversity levels of the Nizag community. (**a**) Diversity of landscapes: sub-Páramo, kinray, and pampa zones; (**b**) chacras kinray agroecosystem; (**c**) chacras pampa agroecosystem; (**d**) biological diversity (*Annona cherimola*).

The second zone extends across the mountain slopes, with an area of 1001 ha, and is called "kinray" (Figure 6). This territory is part of the Quechua agroecological zone (2300–3195 masl). It comprises an extensive mosaic of cereal, legume and tuber parceled crops. Agricultural terraces, road networks, and archeological sites built on the tops of the hills (*pukaras*) are spread across this zone.

The third zone is located in the upper part of the Quechua zone, on the border with the Andean sub-Páramo (Figure 6). It has an extension of 93 ha and is dominated by native arboreal vegetation (*Alnus acuminata*). Its access is more limited for the use of productive activities, as this zone provides water for the Nizag community.

Diversity of Agroecosystems

The agroecosystems in these Nizag land-use zones differ: (1) The chacras kinray (CK) fields are plots located on the Quechua zone's slopes for cultivating domesticated plants. Agricultural terraces (TA) can be seen in these agroecosystems (Figure 6). (2) The chacras pampa (CP) includes plots located in the Yunga zone's plateau, used to cultivate domesticated and semi-domesticated species (Figure 6). (3) Orchards (HU) include plots located within households in the ecotone of the Yunga and Quechua zones for the cultivation of domestic, semi-domesticated, and wild plants.

Species Diversity

Field interviews have provided data on biological diversity, registering a total of 237 species belonging to 75 families (Figure 6). Of these, 73% are native plants (N = 172), and 27% are introduced species (N = 64). In total, 181 species have ethnobotanical uses defined by the Kichwa agriculturists of the Nizag community (Supplementary Material Table S1). Of the total documented plants, 95 are cultivated plants, 45 originated in America, and 50 were introduced from the Old World.

Genetic Diversity

Regarding the genetic diversity of the cultivated plants, eight species still present local varieties identified by the agriculturists of Nizag. These are differentiated by the seeds' color and size or by the color of propagules (rhizomes and tubers) in plants with asexual propagation. The agriculturists also differentiate sweet, salty, bitter, and spicy flavors in the cases of plants used as food ingredients. Food preparation also distinguishes identifiable varietal preferences in the case of cereals and legumes. Within the cereals, *Zea mays* appear in seven varieties. The legumes comprise *Lupinus mutabilis* and *Phaseolus vulgaris*, each with two varieties. Among the fruit, the shrubs are *Opuntia aequatorialis* with four varieties, *Capsicum baccatum* with two, and *Cucurbita maxima* with three. Roots such as *Ipomoea batatas* comprise three varieties, while *Arracacia xanthorrhiza* has three, and *Canna indica* has two.

3.1.2. Crop Systems

Regarding agroecological cropping systems, we have identified four production strategies. The "agricultural cycle" corresponds to the treatment of the soil and care of the plants through a series of cultural tasks (tilling, planting, weeding, fertilization, pruning, irrigation, and harvesting). Other systems with different treatment and care approaches and ethnobotanical purposes include the "horticulture" strategy, as well as another two that have been categorized in this study as "management" and "cultural control".

Agriculture

Agriculture, seen as the production of food crops (cereals, legumes, cucurbits, and highland tubers) and forage crops, includes soil treatment and the care of domesticated plants. Its production is extensive (use of large hectares of land under uncontrolled environmental conditions) in the chacras Quechua with dry land and the chacras Yunga with irrigation (Figure 7).

Horticulture

Horticulture deals with the intensive production of crops in household orchards located in the Yunga and Quechua zones' ecotones (use of small plots for the production of various crops), with irrigation or rain land. These agricultural strategies include soil treatment and care for domesticated, semi-domesticated, and wild plants used for food (fruits and vegetables), medicinal (e.g., *Amaranthus quitensis* and *Schinus molle*), ceremonial/ritual (e.g., *Brugmansia arborea* and *Nicotiana glauca*) and toxic (e.g., *Ambrosia arborescens*) purposes (Figure 7).

Management

Management consists of the production of arboreal fruit crops and food roots, including sowing and harvesting domesticated plants without any soil treatment. This form of production takes place in the Yunga area, within the fences of the chacras in the case of fruit trees (e.g., *Inga insignis* and *Juglans neotropica*), and in the chacras and specific ecological niches (such as ditches and ciénegas) in the case of roots (*Smallanthus sonchifolius*, *Arracacia xanthorrhiza*, *Canna indica*, *Ipomoea batatas*, and *Manihot esculenta*) (Figure 7).

Cultural Control

Cultural control is based on collecting wild plants for their ethnobotanical use through agroecological practices that include conserving them for the benefit of cultivated plants. In this way, a form of conscious selection that culturally defines the existence, abundance, function, and distribution of wild species in the agricultural landscape is undertaken. Examples include the cases of *Agave Americana* and Furcraea andina, which provide an important variety of uses (food, fodder, medicine, fuel, textiles, building materials, cosmetics, and detergents), and are included in agroecological practices such as protection fences around agricultural fields (Figure 7).

Figure 7. Agroecological cropping systems of the Nizag community. (**a**) Agustina Saquisilí in the agriculture system; (**b**) María Tenesaca in the horticulture system; (**c**) María Mendoza in the management system; (**d**) María Morocho in the cultural control system.

3.1.3. *Agroecological Practices*

Regarding agroecological practices, 36 types of these were recorded according to the agricultural techniques used in the cropping systems of the Nizag community. We highlight the techniques for soil conservation (organic fertilization and erosion control), agrobiodiversity conservation (massive selection of seeds and propagules, crop reproduction, seed exchange, weed control, pest and disease control), water supply (water collection, retention, and storage) and climate resilience (climate calendar management, agroforestry, and territorial zoning) (Table 4).

Table 4. Agroecological practices and modern macroremains assemblages recorded in the cropping systems of the Nizag community.

Agricultural Techniques	Agroecological Practices	Discarded Modern Macroremains
Organic fertilization	*Cavia porcellus* production of organic fertilizer.	√
	Direct fertilization with *C. porcellus* manure for the crops of *Zea mays*, *Solanum tuberosum* and fruit trees.	√
	Ovis aries post-harvest manure storage by grazing.	
	Green manures production: *Phaseolus vulgaris*, *Lupinus mutabilis*, Cucurbitas and/or *Calandrinia ciliata* for *Z. mays* crops; *Amaranthus quitensis* and *Phenax rugosus* for *S. tuberosum*.	√
	Incorporation of stubbles: *Tropaeolum tuberosum*, *Oxalis tuberosa*, *Ullucus tuberosus* and/or *S. tuberosum*, in *Z. mays* and *S. tuberosum* crops.	√
Erosion control	Conservation tillage	
	Crop rotation: *Z. mays* with *S. tuberosum*.	√
	Crop association: (*Z. mays–Phaseolus vulgaris* or *Lupinus mutabilis–Cucurbitaceas*), (*U. tuberosus–O. tuberosa–T. tuberosum*) and (*S. tuberosum–Dysphania ambrosioides–Amaranthus quitensis*).	√
	Intercropping: in rows between *Z. mays* and *L. mutabilis*.	√
	Crop diversification: *Z. mays* and *S. tuberosum*. Intensive in orchards and extensive in chacras with polycultures.	√
	Mixed cropping: *Z. mays* or *S. tuberosum*. One or several plots of tubers and vegetable roots within the crops fields.	√
	Use of terraces for the production of *Z. mays* crops in hillside plots.	√
	Crop fallow.	
Mass selection of seeds and propagules	Chaleo: Collective selection of seeds (*Z. mays*, *P. vulgaris* and *L. mutabilis*) and propagules (*S. tuberosum*).	√
	Pseudocereals and fruits through the individual mass selection of seeds, and vegetable roots and tubers through the selection of propagules.	
Crops reproduction	Sowing by seeds: by holes (*Z. mays*, *P. vulgaris*, *L. mutabilis* and fruits) and by air methods (*A. quitensis*).	
	Sowing by propagules: using stakes in fruit trees (*Schinus molle* and *Carica pubescens*), tubers and vegetable roots.	
Seeds exchange	Intra-community exchange with the cultural practice of Chaleo for seeds of *Z. mays*, *P. vulgaris* and *L. mutabilis*.	
	Intercommunity exchange for the acquisition of propagules of tubers from the agroecological zone of the Páramo.	
Weeds control	Live cucurbitaceaes covers for the cultivation of *Z. mays*, and *A. quitensis* and *Phenax rugosus* for the cropping of *S. tuberosum*.	√
	Weeding in chacras and orchards.	√
Pests and diseases control	Burning of infected plants at the edges of the yungas and quechuas chacras, for crops of *Z. mays* and *L. mutabilis.*	√
	Application of biopesticides, made with fruits and seeds of *Capsicum baccatum*, *Ambrosia arborescens* and *S. molle*.	√
	Application of ashes from *Baccharis latifolia* and *Z. mays*, for the control of phytopathogenic diseases in crops.	
	Cultivation of insect repellent plants, such as: *Nicotiana glauca*, *P. rugosus*, *Brugmansia arborea* and *S. molle*.	√
	Cultivation of trap plants, sown to attract harmful insects, such as *Nicandra physalodes* in *Z. mays* crops.	√
	Use of the branches of *S. molle* in the covers and floors of storage structures for the control of phytopathogenic diseases.	
Collection of water sources	Use of slopes (pucyu) for the cultivation of vegetable roots and channels (Larqay) for the irrigation of orchards and chacras yunga.	
Water retention	Use of terraces (patas) for the production of crops in the chacras quechua.	
Storage	Use of seasonal reservoirs (cochas) for irrigation in the fields.	

Table 4. *Cont.*

Agricultural Techniques	Agroecological Practices	Discarded Modern Macroremains
Management of the climate calendar	Use of the lunar calendar for vegetative cycles of plant management. Distinction of the types of mist for the forecast of rains. Distinction of mists on Mount Puñay for the forecast of periods of drought or rain.	
Agroforestry	Forest agroecological barriers for the protection of crops from climatic risks (solar radiation, droughts, winds and excessive rains): *Prunus serotina*, *Juglans neotropica*, *Persea americana*, *Inga insignis*, *Caesalpinia spinosa*, *Alnus acuminata*, *Delostoma integrifolium*, *Phytolacca rivinoides* and *Tecoma stans*), and agroecological bush barriers: *Agave americana*, *Echinopsis pachanoi* and *Armatocereus laetus*. Intracultive barriers of *L. mutabilis* for the protection of *Z. mays* crops against frosting.	√
Territory zoning	Territory delimitation for intensive and extensive agricultural use and conservation of forest ecosystems, through a network of roads (chaquiñan).	

3.1.4. Cropping Catchment Area

Of the 1320 ha that make up the Nizag territory, 609 ha form the productive area, representing 46.14% of the territory; 1001 ha are steep slopes (26–50%) where agriculture would be unsuccessful. The crop yields by zone are presented in Table 5, which gives the number of plots, the total area cultivated, and the number of cultivated species. Despite the high number of parcels distributed in the kinray (N = 882) and pampa (N = 855) zones, it is in the orchards (N = 50) that the highest diversity of cultivated species is observed. Specific information about the cultivation area is shown in Table 6. The extent, range elevation, and number of fields for each crop are detailed. It highlights that the *Zea mays* fields always include *Phaseolus vulgaris*, Lupinus mutabilis (cultivated from 2500 masl), *Cucurbita ficifolia*, and *Cucurbita maxima*.

The Andean crops are between 2000 and 2950 masl, and the surface area available for crop production is between 18 and 784 m^2. The crops with the largest planted areas during the three years of this ethnographic study were *Zea mays*, with 629 plots for a total of 250.39 ha, and *Solanum tuberosum* in 85 plots spanning 11.12 ha. The crops in smaller areas are *Manihot esculenta* within seven plots of only 0.17 ha, and *Carica pentagona* registered only in 0.15 ha. The crop with the highest altitudinal range is *Zea mays* (2096 to 2950 masl), while the crops with the most restricted range are *Manihot esculenta* (2000 to 2027 masl) and *Tropaeolum tuberosum* (2715 to 2781 masl). Figure 8 shows that the agricultural catchment reaches a range of 4 km, with the nearest crops being vegetables and fruit trees, and the most distant highland tubers.

Table 5. Crop fields of the Nizag community.

Crop Fields	Agroecological Zones	#	Cultivation Area (has)	No. Cultivated Species		
				Native	Introduced	Total
Chacra kinray	Quechua	882	449.76	8	7	15
Chacra pampa	Yunga	855	158.61	14	10	24
Orchard	Ecotone	50	0.87	38	46	84
Total		1787	609.24	60	63	123

Table 6. Extension, elevation range, and number of crop fields.

Crops	Extent (ha)			Range Elevation (masl)			# Crop Fields
	Total	**Max.**	**Min.**	**X**	**Max.**	**Min.**	
Zea mays	250.39	2.27	0.01	2468	2950	2096	629
Triticum aestivum	50.65	1.83	0.03	2576	2921	2301	116
Hordeum vulgare	76.69	2.08	0.05	2577	2949	2300	175
Pisum sativum	4.73	1.45	0.05	2800	2845	2629	18
Lens culinaris	7.68	0.51	0.03	2800	2957	2391	37
Vicia sativa	1.62	0.44	0.08	2765	2875	2432	8
Solanum tuberosum	11.12	0.45	0.18	2173	2276	2013	85
Ullucus tuberosus	0.80	0.17	0.02	2533	2712	2419	9
Oxalis tuberosa	0.36	0.05	0.02	2607	2748	2442	11
Tropaeolum tuberosum	0.37	0.06	0.02	2741	2781	2715	11
Canna indica	0.26	0.02	0.004	2090	2128	2048	32
Smallanthus sonchifolius	0.25	0.02	0.002	2097	2266	2047	26
Arracacia xanthorrhiza	0.48	0.04	0.005	2097	2168	2049	31
Manihot esculenta	0.17	0.05	0.01	2009	2027	2000	7
Ipomoea batatas	0.42	0.03	0.003	2090	2150	2045	27
Solanum betaceum	0.62	0.32	0.30	2263	2277	2249	2
Carica pentagona	0.15			2199			1
Introduced grasses	6.75	0.35	0.02	2125	2255	2000	56
Medicago sativa	41.13	1.43	0.02	2238	2541	2012	196
Introduced vegetables	9.89	0.55	0.005	2171	2289	2013	140
Eucalyptus globulus	2.62	1.12	0.20	2799	2969	2584	4
Saccharum officinarum	4.20	0.32	0.02	2120	2252	2008	45
Weeds	137.03	11.72	0.04	2598	2985	2242	71
Total	**608.39**						**1737**

3.2. Archeobotanical Research

Botanical Spectrum and Representation of Ecological Groups

A total of 923 charred botanical macroremains were recovered from the site, corresponding to 54 botanical taxa, of which 29 are presented in samples from both the RDP and IP periods (Table 7 and Figure 9). The relative frequency of some of the taxa is high. According to this parameter, the most dominant taxa for the RDP is *Zea mays* (20%). Subsequently, other taxa are reflected with much lower percentages, such as *Calandrinia ciliata* (5%), *Verbena litoralis*, *Amaranthus spinosus*, *Arenaria lanuginosa*, and *Vicia andicola,* each comprising 3%, as well as *Phytolacca rivinoides* (2%). For the IP, the dominant taxa are: *C. ciliata* (28%), *P. rivinoides* (17%), *V. andicola* (9%), and *V. litoralis* (4%). All other taxa found occupy meager relative proportions, especially those that comprise ecological groups of wild plants. In addition, indeterminate taxa comprise proportions of 31% in the RDP and 12% in the IP.

As for ubiquity, the most ubiquitous taxa from the RDP are *Z. mays* (25%), *V. litoralis* (19%), *A. spinosus* (17%), and *P. rivinoides* (14%). Deficient levels of ubiquity were recorded for all plants grown other than maize, such as in the taxa *Phaseolus vulgaris* (3%). On the other hand, in the IP, the most ubiquitous taxa are *C. ciliata* (55%), *P. rivinoides* (55%), and *V. andicola* (29%). In contrast, the plants cultivated during this period with very low ubiquities are *Z. mays* (10%), *Lupinus mutabilis* (10%), and *P. Vulgaris* (3%).

Concerning the ecological groups, adventitious plants are most conspicuous among the RDP taxa, evincing the greatest number of macroremains (N = 78, or 24% of the total). Cultivated and wild plants likewise proved relatively conspicuous (totaling 65 specimens per group, or 20% each of the absolute count for the period). In contrast, ruderal plants comprised 6% (N = 18) of the RDP's archeobotanical assemblage. Finally, indeterminate taxa comprised 30% (N = 99) of the total specimens. In the IP assemblage, the adventitious plants' group was again the most conspicuous, totaling 291 specimens or 49% of the tally for the period, followed by ruderal plants with 21% (N = 124), wild plants with 17% (N = 102), and finally cultivated plants with 2% (N = 9). Indeterminate taxa comprised 11% (N = 72) of the IP plant assemblage.

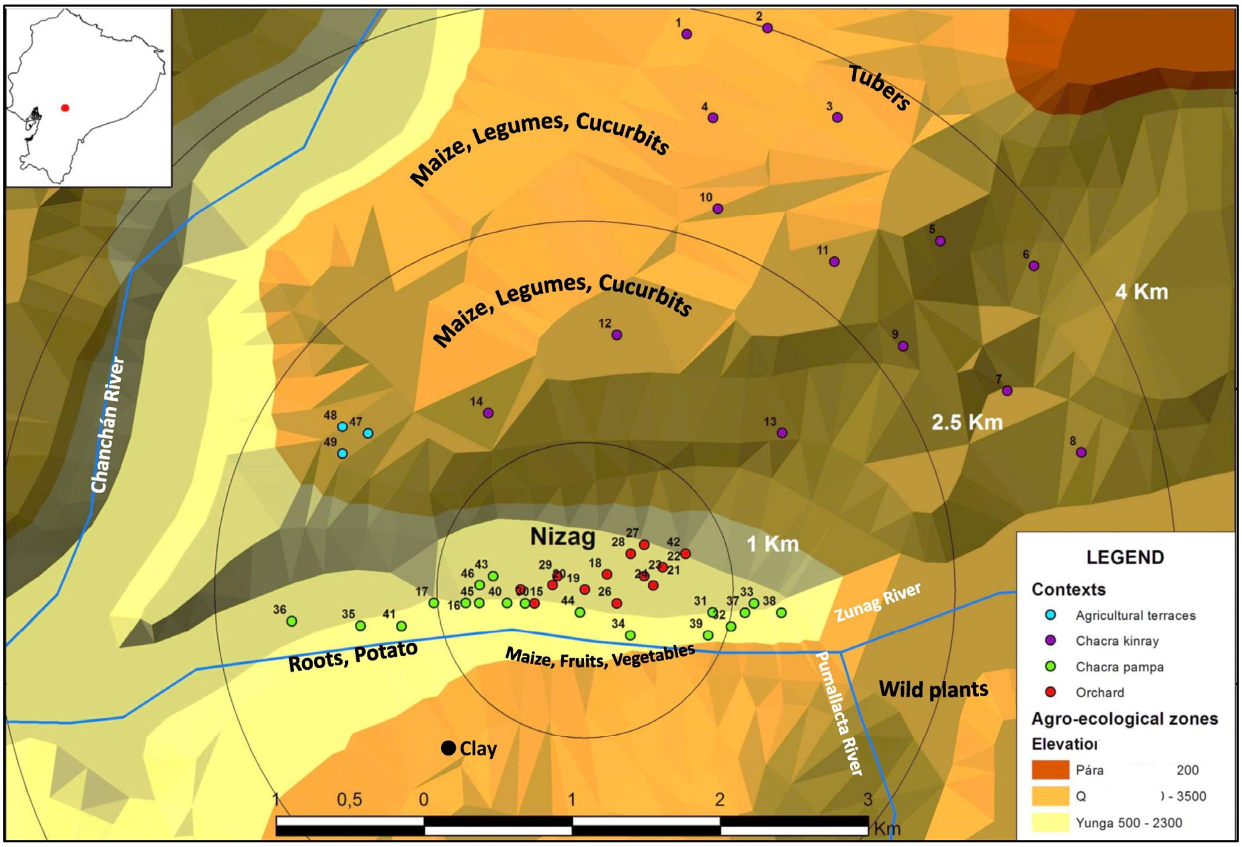

Figure 8. The agricultural catchment area of the Nizag community. (1–14) Interview sites in the Chacras Kinray; (15–30); Interview sites in the Chacras pampa; (31–46); Interview sites in the Orchards; (47–49) Interview sites in the Agricultural terraces.

Figure 9. Botanical macroremains recorded in the archeological terraces of Joyagzhí (Scale: 1 mm). Cultivated taxa: (**a**) *Zea mays*, (**b**) *Phaseolus vulgaris*, (**c**) *Lupinus mutabilis*. Adventitious taxa: (**d**) *Amaranthus* sp., (**e**) *Amaranthus spinosus*, (**f**) *Calandrinia ciliata*, (**g**) *Dysphania ambrosioides*, (**h**) *Chenopodium petiolare*, (**i**) *Nicandra physalodes*, (**j**) *Oxalis latifolia*, (**k**) *Plantago linearis*, (**l**) *Rumex andinus*, (**m**) *Trifolium Amabile*, (**n**) *Urtica leptophylla*, (**o**) *Verbena litoralis*, (**p**) *Vicia andicola*. Ruderal taxa: (**q**) *Arenaria lanuginosa*, (**r**) *Armatocereus godingianus*, (**s**) *Cavendishia bracteate*, (**t**) *Cyperus aggregatus*, (**u**) *Passiflora ampullacea*, (**v**) *Passiflora* sp., (**w**) *Phytolacca rivinoides*, (**x**) *Rubus roseus*, (**y**) *Vaccinium* sp.

Table 7. Archeobotanical analysis of the charred macrobotanical assemblages of the Joyagzhí terraces. The results were merged by chronological period (RDP: Regional Development Period; IP: Integration Period; NR: number of remains; FR: relative frequencies; Ub.: ubiquity).

	RDP			IP			
Taxa	**NR**	**FR (%)**	**Ub. (%)**	**NR**	**FR (%)**	**Ub. (%)**	**Total NR**
Cultivated							
Zea mays *	63	20	25	3	1	10	66
Lupinus mutabilis *				5	1	10	5
Phaseolus vulgaris *	2	1	3	1		3	3
	65	**20**		**9**	**2**		**74**
Adventitious							
Amaranthus spinosus *	11	3	17	15	3	13	26
Arenaria lanuginosa *	11	3	14	2		19	13
Calandrinia ciliata *	17	5	25	170	28	55	187
Dysphania ambrosioides *	3	1	3	7	1	13	10
Chenopodium petiolare *				1		3	1
Nicandra physalodes *	3	1	6	2		7	5
Oxalis latifolia *				1		3	1
Plantago linearis *	2	1	6	7	1	16	9
Rumex andinus *	4	1	8	3	1	10	7
Trifolium amabile *				3	1	7	3
Urtica leptophylla *	7	2	11	7	1	7	14
Verbena litoralis *	11	3	19	21	4	19	32
Vicia andicola	9	3	8	52	9	29	61
	78	**24**		**291**	**49**		**369**
Ruderal							
Armatocereus godingianus	3	1	3				3
Cavendishia bracteata				2		7	2
Cyperus aggregatus				7	1	7	7
Passiflora ampullacea	3	1	6	5	1	16	8
Passiflora sp. *	1		3	2		7	3
Phytolacca rivinoides *	7	2	14	104	17	55	111
Rubus roseus *	2	1	6	1		3	3
Vaccinium sp.	2	1	6	3	1	7	5

Table 7. *Cont.*

Taxa	RDP			IP			
	NR	FR (%)	Ub. (%)	NR	FR (%)	Ub. (%)	Total NR
	18	**6**		**124**	**21**		**142**
Wild							
Apium sp.	2	1	6	1		3	3
Asteraceae Type 1	1		3	16	3	10	17
Asteraceae Type 2	1		3				1
Asteraceae Type 3	7	2	6				7
Asteraceae Type 4				1		3	1
Brassicaceae				1		3	1
Callisia sp.				2		7	2
Carex sp.	2	1	3				2
Epilobium denticulatum				3	1	7	3
Eupatorium sp.	2	1	6	2		7	4
Euphorbiaceae	1		3				1
Fabaceae Type 1	3	1	8	3	1	3	6
Galinsoga sp.				1		3	1
Galium sp.	3	1	8				3
Ipomoea sp.				5	1	7	5
Isolepis sp.				1		3	1
Lathyrus sp.	1		3	7	1	10	8
Lupinus pubescens				2		3	2
Malva sp.	11	3	19	3	1	3	14
Mimosa sp.	1		3				1
Oenothera sp.	1		3				1
Papaveraceae				1		3	1
Poaceae Type 1	2	1	6	1		3	3
Poaceae Type 2	1		3				1
Poaceae Type 3	2	1	6	10	2	13	12
Poaceae Type 4	2	1	6	2		3	4
Polygonaceae	1		3	2		7	3
Polygonum sp.	1		3	4	1	10	5
Salvia sp.	17	5	8	34	6	3	51
Solanum sp.	2	1	6				2
Thalictrum sp.	1		3				1

Table 7. *Cont.*

Taxa		RDP			IP		
	NR	**FR (%)**	**Ub. (%)**	**NR**	**FR (%)**	**Ub. (%)**	**Total NR**
	65	**20**		**102**	**17**		**167**
Indeterminate	99	30	67	72	11	58	171
	99	**30**		**72**	**11**		**171**
NR		325			598		923
No. of samples (+)		36			31		67
Volume (l)		1950			1950		3900
Density r/l		0.17			0.31		
No. of taxa		40			44		

* Taxas registered in the ethnobotanical context of the Nizag community.

4. Discussion

4.1. Agroecological Legacies of Cropping Systems

The cropping systems registered in the landscape of the Chanchán basin are agriculture, horticulture, management, and cultural control. This corroborates that the cropping systems go beyond agriculture and the domestication of plants, because agriculturists appropriate, use and transform the landscape according to their co-evolutionary dynamics [57].

Agriculture is the set of economic and technical activities related to soil treatment and the cultivation of plants for food production [48,57]. This refers to all forms of the management of crops that may or may not be completely domesticated [49,51]. The diversity of plant ecotypes in the Andean Neotropics requires the incorporation of other agroecological cropping systems, which respond to and regulate the materialization of various contingencies (ecological and social) at all levels of agrobiodiversity (microorganisms, genes, species, ecosystems, and landscapes).

4.1.1. Horticulture

In the case of horticulture, this cropping system was only evidenced in the current historical context of the landscape of the Chanchán basin. The ecological legacy of this cropping system lies in the conservation of all the ecological groups that constitute agrobiodiversity, through the cultivation of a high diversity of domesticated, semi-domesticated, and wild plants in their orchards. It perpetuates processes of domestication through the selective conservation of certain plants [14,55].

This taxonomic diversity confirms that horticulture sustains and diversifies the ethnobiological richness in the western foothills of the Andes. This is a generalized pattern in humanity, because orchards are implemented by 75% of the 1.5 million small-scale farmers worldwide, occupying less than 30% of arable land and preserving the agricultural diversity that contributes at least 50% of the products used for global consumption [75]. This type of highly biodiverse agriculture is recognized as one of the solutions to the countless uncertainties facing humanity today, such as climate change, financial crises, and loss of food security [114].

4.1.2. Management

For its part, the crop system of management, similar to horticulture, was also recorded in the contemporary historical context. The ecological legacy of this system is the use of certain techniques for the production of food crops, without this representing the transformation of the same into agroecosystems. In the case of the Andean landscape of the Chanchán basin, this is extended towards cultivated plants (food roots and tubers), since in other tropical regions, management consists solely of the manipulation and control of wild species without cultivation or morphological changes [57].

We emphasize that although management is similar to vegeculture, in terms of the vegetative propagation of plants through propagules (roots, rhizomes, tubers, and stakes) and not seeds [115,116], it differs because the cultural work does not include soil preparation, tillage, irrigation and/or pruning for the production of crops. By conceiving the habitat as an ideal space for the survival and biological reproduction of a domesticated plant species, this approach allows its cultivation under the regimen of the natural processes of a given ecosystem. The agroecological strategy, at the landscape scale, would allow for regulating the composition and structure of ecosystems with minimal anthropic disturbance.

4.1.3. Cultural Control

The cultural control cropping system was registered in the historical archeological and current context. The legacy of this approach is the agroecological strategy applied for the conservation of the landscape as a single crop plot, where cultural practices extend from domesticated species to biotic communities. This is intended to increase the availability of agrobiodiversity in the long term [58,59], allowing the agricultural production of species of economic value such as *Zea mays*, and at the same time the ecological conservation of agroecosystems.

We highlight that cultural control differs from plant collection, due to the selective conditioning of plant species for their preservation, abundance, distribution, and function in an agricultural landscape. This is in contrast to hunter–gatherer societies that access wild plants in ecosystems by following the plants' natural processes in terms of abundance, distribution, and the timing of resource availability [117], or through finding plant resources that were involuntarily created, as in abandoned camps [118,119].

The taxa linked to the cultural control system represent 29% of the RDP and 69% of the IP (Table 7). According to ethnobotanical research, these taxa are represented by adventitious and ruderal species. These plants are part of a functional agrobiodiversity system consciously selected by Kichwa agriculturists in Nizag to regulate various ecological processes for the benefit of economically important crops (e.g., soil erosion, biodiversity loss, climate resilience, etc.). Cultural control practices enable the expansion of their crop systems from agroecosystems to the entire agricultural landscape, facilitating cultural work to achieve the desired agrobiodiversity. These plant species' existence, abundance, function, and distribution depend not only on natural processes, but also on cultural regularities and social decisions.

Through this study, cultural control practices have been identified as having arisen when pre-Hispanic Kañaris farmers intentionally introduced a range of adventitious (N = 13) and ruderal (N = 8) plants with different agroecological uses for the production of maize in the terraces of Joyagzhí. In the RDP, there are remarkably high ubiquities of taxa such as *Calandrinia ciliata* (25%), *Verbena litoralis* (19%), *Amaranthus spinosus* (17%), *Arenaria lanuginosa* (14%), and *Phytolacca rivinoides* (14%). During the IP, the prominent taxa were *C. ciliata* (55%), *P. rivinoides* (55%), *V. andicola* (29%), *A. lanuginosa* (19%), and *V. litoralis* (19%). Among the total taxa identified and recorded in the archeobotanical contexts, 64% (N = 14) of them are inherent to the community (Table 7).

4.1.4. Agriculture

Agriculture is culturally materialized in extensive and intensive systems for the cultivation of food species such as cereals (*Zea mays*) and legumes (*Phaseolus vulgaris* and *Lupinus mutabilis*). Although the percentages are low, they represent 20% in the PDR and 2% in the PI (Table 7). This low level of representation is confirmed by the fact that all the cobs were transferred immediately after harvest to their domestic units, through family or community work (mingas). These are still carried out in the Nizag community, except when pests or phytopathogenic diseases have infected the maize crop. This minimizes the frequency of archeobotanical contexts arising for recording in archeological sites.

Z. mays is identified in all periods, and is represented by 66 charred grains from 240–384 cal AD to 1293–1393 cal AD, showing a long historical trajectory in agricultural production lasting almost 1200 years. These periods are determined by a series of radiocarbon dates of several charred grains from different units (Table 3). Additionally, carbonized wood was dated in the artificial levels, where maize grains were also recorded, and this was used to correlate our evidence with radiocarbon dates. The radiocarbon dates of *Zea mays* are the first to be obtained in the terraces located in the Andes of Ecuador.

Legume crops, *L. mutabilis*, and *P. Vulgaris* have low frequencies and ubiquities (Table 7). Therefore, a conclusion cannot be drawn about the distribution and economic importance of legumes in pre-Hispanic contexts, given their low number of remains. However, in the current historical context of the Nizag community, these two taxa are produced as a polyculture among other crops, such as *Z. mays*. This production occurs because *L. mutabilis* is highly tolerant to frosts occurring in the Andean lands, while *Phaseolus vulgaris* is advantageous via fixing nitrogen and thus optimizing maize growth. According to the archeobotanical assemblages found in Unit J9 (Table 3), *L. mutabilis* were identified to derive from the final phase of the IP (1293–1393 cal AD). In comparison, *P. Vulgaris* was identified from the middle phase of the RDP (240–384 cal AD) through an associated date in Unit J6 (Table 3).

One of the agroecological legacies of this cropping system was that agricultural intensification through the construction of agricultural terraces did not cause a natural setback in the dynamic sequence of its ecosystem processes. Despite the search for high production levels to ensure the nutritional satisfaction of their populations, which is an essential condition for the reproduction of a regional social structure, as was maintained from 240–384 cal AD until 1293–1393 cal AD, the elasticity of the paleo-agroecosystem was sustained over a long trajectory of approximately 1200 years.

Cultivated lands slowly absorb nutrients and are more exposed to soil loss, offering less resistance to water and wind erosion due to tillage [120]. Faced with these soil degradation processes, pre-Hispanic Kañari farmers for more than a millennium had the technological capacity to cycle nutrients, conserve the soil, preserve agrobiodiversity and regulate the amount of water. All this was achieved through agroecological practices such as "soil redeposition" plus "zero tillage", which established a fluctuating degree of stability between agricultural production and ecosystem processes. Replenishing the lost soil and cultivating without plowing preclude the permanent disturbance and erosion of the soil, favoring its health, fertility, and agricultural productivity [121].

All the excavation units located on the Joyagzhí terraces evidenced organic paleosols suitable for agriculture, sequentially redeposited with an arable layer between 50 and 151 cm, and without signs of erosion, waterlogging, compaction or desertification. This redeposition of organic soil can be seen in the Joyagzhí terraces through a stratigraphic sequence of cultural levels that contain evidence of macrobotanical assemblages with carbonized remains of *Zea mays* grains. This condition is corroborated by the absence of investments in radiocarbon dating, plus the stability and formation of agricultural soils in "Horizon A" of units J4, J6, J7, and J9 (Table 3).

It is clear, then, that the incorporation of the terraces increased the agricultural production of maize. Apart from the vital record of a total of 66 *Zea mays* paleocarporrests, the chronological sequences of five radiocarbon dates on charred grains of this plant (574–656 cal AD; 626–684 cal AD; 672–789 cal AD; 757–879 cal AD; and 1044–1214 cal AD) allow us to affirm this condition (Table 3). Although extensive and intensive agriculture systems are different productive strategies, instead of stages of an evolutionary sequence, the archeological records show that the agriculturalization process of the pre-Hispanic archeological landscape of the Chanchán basin followed a trajectory of intensive progression [122,123], in which agriculture emerged extensively and then over time became increasingly intensive.

4.2. Legacies of Agroecological Practices

Regarding agroecological practices, the archeobotanical assemblages composed of botanical macroremains of cultivated plants plus macroremains of weeds are the most promising source for establishing agricultural system regimes [48,51,112,124]. In the case of this research, these assemblages show a broad spectrum of dynamic interrelations that pre-Hispanic societies maintained with their ecosystems and plants. Some interrelationships are related to the conservation of agroecosystems for the cultivation of food plants (agriculture), and others are linked to the conservation of all agricultural landscapes for the integral cultivation of agrobiodiversity (cultural control).

The archeobotanical records of the Joyagzhí terraces compared with the ethnobotanical contexts of the Nizag community show the emergence of various agroecological practices in the Chanchán basin (Supplementary Material Table S2), which materialized primarily for the intensive agroecological production of *Zea mays* crops from 240–384 cal AD to 1386–1438 cal AD.

- The production of green manures is related to taxa such as *Phaseolus vulgaris*, *Lupinus mutabilis*, *Vicia andicola*, and *Trifolium Amabile*. These Fabaceae are used in Andean crops to incorporate extra atmospheric nitrogen into the soil to aid in producing food of productive value, such as *Zea mays*. This process can occur as a result of legumes fixing nutrients in their roots through a symbiotic association with bacteria of the genus *Rhizobium* [125]. Comprehensively, these species have been documented at notable levels in both the RDP and the IP.

- Cover crops are primarily visible in the taxa *Calandrinia ciliata*. *C. ciliata* shows the highest ubiquity of 25% (RDP) and 55% (IP) in archeobotanical records, and is referred to as Yuyusara (Yuyu: grass; sara: maize) by Nizag people (Table 7). This linguistic meaning relates directly to the agroecological use of the crop. This adventitious species is used today as a plant cover crop for the agricultural production of *Zea mays*. This agroecological relationship is also perceived in the Central Andes, where this plant is integrated into the local agricultural farming systems [126].
- Crop diversification is recognized in two types of archeobotanical macrobotanical assemblage records. One record is linked to the association of *Phaseolus vulgaris* with *Zea mays* cultures from 240–384 cal AD (RDP), while the second record is related to the association of *Lupinus mutabilis* with *Z. mays* from 1293–1393 cal AD (IP). These polycultures host a diverse range of domesticated and wild plants that use soil resources and photo-synthetic radiation, and assist in reducing the impacts of climate change, pests, and phytopathogenic diseases [127]. Therefore, wildlife diversity is essential to traditional risk management practices in the terraces of Joyagzhí. A particular case this can be observed in is with Amaranthaceae (*Amaranthus spinosus*)—wild relatives of quinoa that are characterized as being highly tolerant to climate stress and that provide food during difficult periods for Andean populations [78].
- The construction of monumental engineering systems, such as the terraces of Joyagzhí in the Quechua agroecological zone, intensified the agricultural production of maize. The archeological record shows a clear cultural preference for the cultivation of this plant in this type of agroecosystem, possessing a ubiquity of 25% (RDP) and 10% (IP) (Table 7). Maize's values are high in comparison to other species with lower ubiquity values, such as *Phaseolus vulgaris* with 3% (RDP) and 3% (IP), and *Lupinus mutabilis* with 10% (IP). This artificialization of ecosystems for the intensive production of maize is a recurrent agroecological strategy throughout the Andean region [11], primarily intended to reduce soil erosion and increase water infiltration [70,72,78].
- The redeposition of organic soil can be identified by the stratigraphic sequence of sedimentary levels of Horizon A, which includes evidence of macrobotanical assemblages with charred grains of *Zea mays*. For example, these levels reach a thickness of 81 cm and 151 cm, respectively, in the adjacent units J5 and J6 (Figure 10). This continuous line of organic soil redeposition can be perceived in the cultural sediments, and is corroborated by the radiocarbon dates obtained from Unit J4 (Table 3).
- The burning of infected crops is related to the recorded evidence of charred macrobotanical assemblages in different sedimentary levels of excavated units. In the ethnobotanical context of Nizag crop systems, this cultural practice eradicates infected food crops' pests and/or phytopathogenic diseases. In the case of *Zea mays* and *Lupinus mutabilis*, all parts of the plants, including their fruits and seeds, are burned in cultivated fields to avoid possible contamination from the infected fruits in their domestic units. The latter factor is a determinant used to identify this type of cultural practice in archeobotanical contexts; this is related to other types of agricultural combustion practices, such as those of slash-and-burn systems, which do not include the carbonization of the fruits and seeds of cultivated plants.
- Trap crops are found in the *Nicandra physalodes* record, referred to as Mamasara (mother of maize) in the Kichwa language. The name derives from its agroecological function of protecting *Zea mays* from harmful insects. In the current historical context of the river basin, this symbiotic interrelationship between *Nicandra physalodes* and *Zea mays* is still active between these two botanical species, with Nizag farmers allowing the vegetative growth of this adventitious plant next to maize. Nalbandov et al. identified *N. physalodes* as an insect repellent because of the toxic properties of its leaves [128].

- Vegetal barriers are evident in macrobotanical assemblages that possess the taxa of ruderal shrub species. There are two types of barriers, the incorporation of fences and intra-crops, that are implemented when using various taxa. For instance, the first species used as barriers were *Armatocereus godingianus*, *Cavendishia bracteata*, *Passiflora ampullacea*, *Phytolacca rivinoides*, *Rubus roseus*, and *Vaccinium* sp. *Phytolacca rivinoides*, also called Kantusara (Kantu: fence; sara: maize), was used, and shows the highest ubiquity values of 14% (RDP) and 55% (IP) (Table 7). *Phytolacca* is a shrub species characterized by its ability to colonize places where man has destroyed the natural plant cover [129]. It stabilizes the earth in the initial stages of landslide succession, as it accumulates nutrients in the soil necessary for the subsequent colonization of woody tree species [130]. In contrast, intra-crop barriers for crops of *Zea mays* involved the use of *Lupinus mutabilis*.

4.3. Agroecological Diversification Model

Based on the analysis of the agricultural catchment area and the composition of the agrobiodiversity of the Nizag indigenous community in the Chanchán basin, it is suggested that the societies located in the western foothills of the Ecuadorian Andes have structured the agroecological systems for the production of their crops based on a model of "Agroecological Diversification". This has been registered in the present ethnobotanical investigation and contrasted with the ethnohistorical references of the towns of Alausi and Chunchi from the time of contact between the Spanish conquest and the Andean societies of the 16th century [102,103].

Martín de Gaviria and Hernando Italiano, parish priests from the towns of Chunchi and Alausi, stated that these societies, organized into chiefdoms and located in the Chanchán basin, cultivated the following species for their livelihood until 1582: maize (*Zea mays*), bean (*Phaseolus vulgaris*), quinoa (*Chenopodium quinoa*), potato (*Solanum tuberosum*), racacha (*Arracacia xanthorrhiza*), oca (*Oxalis tuberosa*), mashua (*Tropaeolum tuberosum*), olluco (*Ullucus tuberosus*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), achira (*Canna indica*), coca (*Erythroxylum coca*), chili (*Capsicum baccatum*), cotton (*Gossypium barbadense*) in small quantities, cabuya (*Furcraea andina*), pumpkins (*Cucurbita ficifolia* and *Cucurbita maxima*), cucumber (*Solanum muricatum*), guava (*Inga insignis*), walnut (*Juglans neotropica*), and some seeds of herbs.

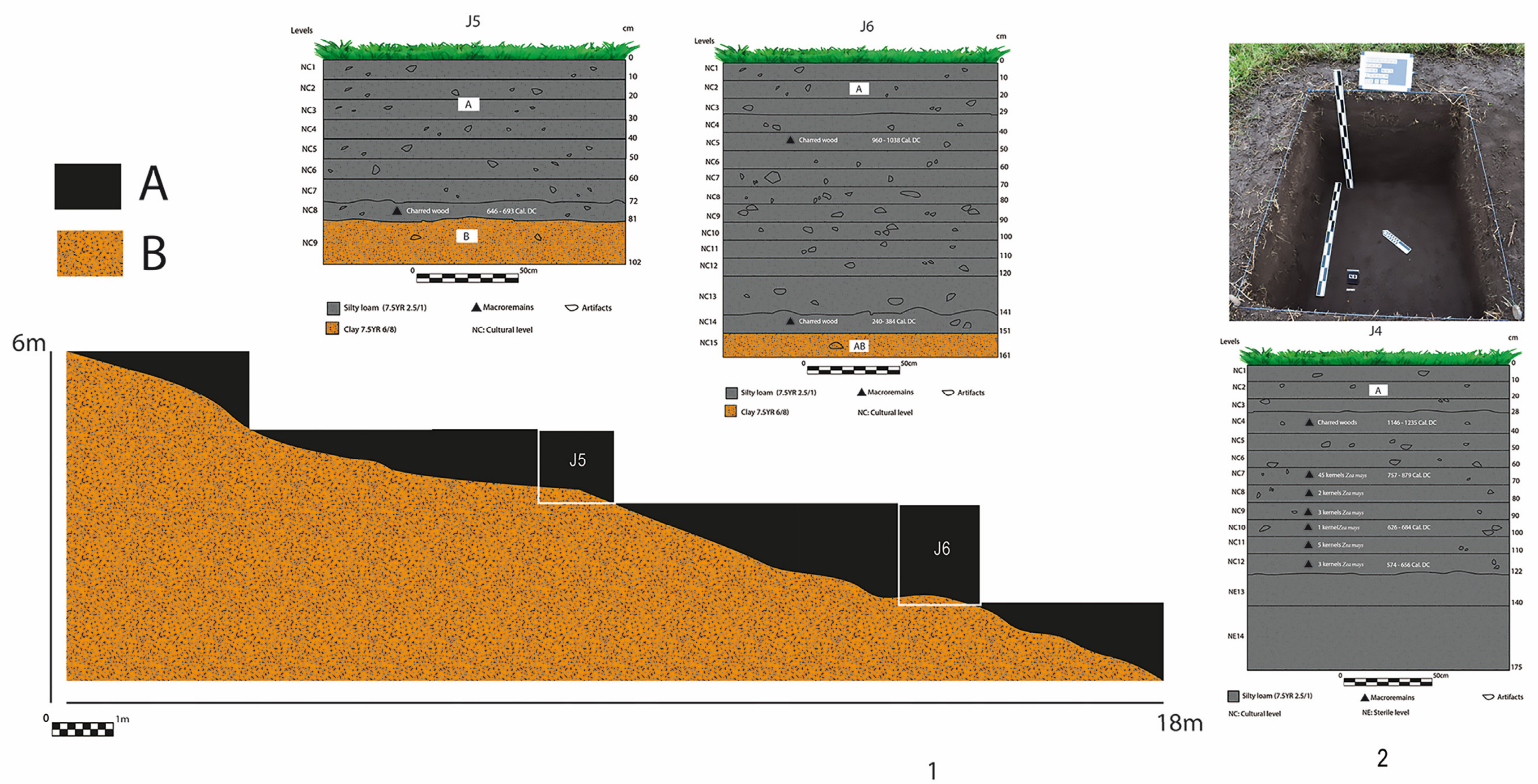

Figure 10. Stratigraphic profiles of units J4, J5, and J6 of the Joyagzhí terraces. (1) Sedimentary sections of units J5 and J6. (2) Profile and photograph of unit J4. (A) Organic sediment horizon. (B) Alluvial horizon.

In this way, the "agroecological diversification" model proposes that access to plant resources in indigenous societies located in the western foothills of the Ecuadorian Andes occurred and occurs through the diversified production of crops, the establishment of agroecological zones of occupation (Yunga and Quechua), plus the adaptation of crops from other zones (Páramo and Chala) that have adapted to their crop fields in ecotones of agroecological transition (Figure 11). We have identified the following most relevant socio-ecological characteristics:

(1) Nucleated population households are located on plateaus in the ecotones of the Yunga and Quechua agroecological zones, in an altitudinal range of 2200 to 2400 masl;
(2) Diversification of crops by incorporating multiple agroecological systems: agriculture, horticulture, management, and cultural control;
(3) Andean crop production occurs within a radius of 4 km, with the maximum extent being *Zea mays* up to 4 km from the community, and with concentrations of the other crops at the following distances—fruit trees and vegetables (0–1 km), root crops and *Solanum tuberosum* (1–2.5 km), legumes and cucurbits (1–4 km) and highland tubers (limit of 4 km) (Figure 8).
(4) Diversified production of Andean crops in different agroecological zones:
    - The lower limit of the Yunga zone—production of lowland roots originating from the Chala zone (*Canna indica*, *Ipomoea batatas*, and *Manihot esculenta*), tubers such as *Smallanthus sonchifolius*, and *Arracacia xanthorrhiza*;
    - In the Yunga area—production of vegetables (*Chenopodium ambrosioides*, *Peperomia peltigera*, *Phenax rugosus*, and *Rumex andinus*), fruit trees (*Annona cherimola*, *Capsicum baccatum*, *Carica papaya*, *Carica pentagona*, *Carica pubescens*, *Inga insignis*, *Juglans neotropica*, *Lycopersicum esculentum*, *Opuntia aequatoralis*, *Passiflora ampullacea*, *Passiflora ligularis*, *Persea Americana*, *Physalis peruviana*, *Pouteria lucuma*, *Prunus serotina*, *Psidium guajava*, *Rubus glaucus*, *Solanum betaceum*, and *Solanum muricatum*), and tubers such as *Solanum tuberosum*;
    - In the Quechua area—production of cereals (*Zea mays*), legumes (*Phaseolus vulgaris* and *Lupinus mutabilis*), and cucurbits (*Cucurbita ficifolia*, *Cucurbita maxima*, and *Cyclanthera pedata*);
    - Upper limit of the Quechua area—production of highland tubers originating in the Páramo area (*Oxalis tuberosa, Tropaeolum tuberosum,* and *Ullucus tuberosus*);
(5) Redistributive management in the agrarian economy, based on agroecological practices that promote intra-ethnic reciprocity to achieve food security, such as the cultural practice of "Chaleo", which consists in the collective harvesting of the best seeds through "mingas" (voluntary non-remunerated work of a reciprocal character, whose purpose is the social welfare of the whole community), carried out before the owners of the chacras begin with the harvest of their crops (Table 4). This guarantees self-sufficient and equal production among all inhabitants, and the spatial distribution of genetic richness throughout the agricultural landscape.

The model presents an alternative means of understanding how Andean societies organized their territories for the management of their agricultural economy in the western foothills of the Ecuadorian Andes. It follows the model of the "Vertical Archipelago" proposed by John Murra [131], which adheres to the principle of verticality or vertical control of the ecological floors, based on the theory that each aillu or group of communities in a territory moves to a different ecological floor for the production of specific crops.

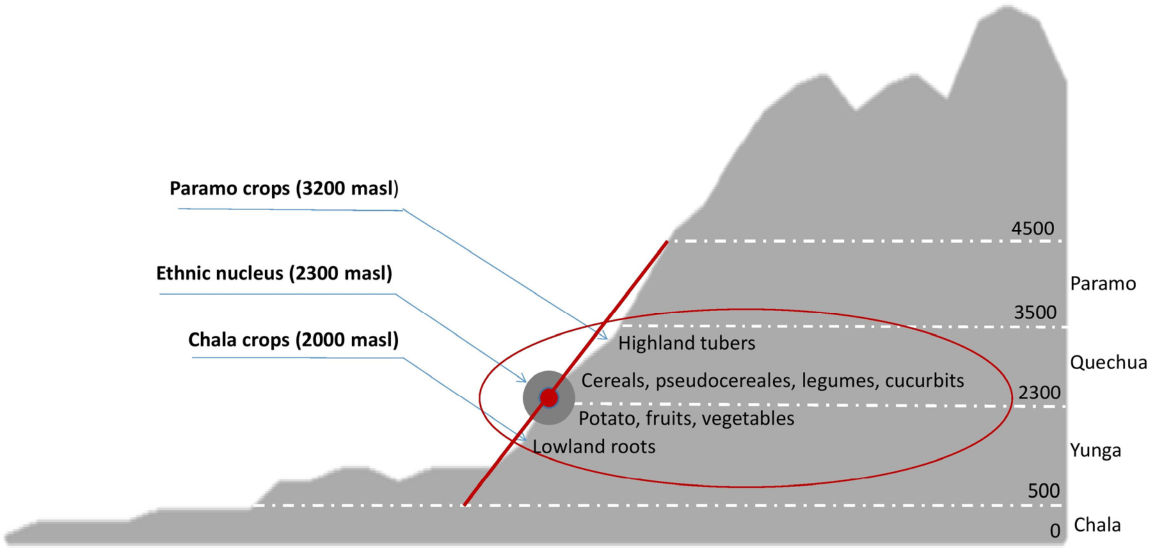

Figure 11. Agroecological diversification model of the Chanchán basin.

5. Conclusions

Pre-Hispanic archeological landscapes, such as that of the Chanchán river basin, can transfer their agroecological legacies to ensure the conservation of agrobiodiversity in the western foothills of the Ecuadorian Andes. These legacies serve as cognitive vehicles that are perpetuated in indigenous societies for the purposes of constant readaptation, resistance, and resilience to the socio-environmental changes of the 21st century.

The agroecological cropping systems used by the pre-Hispanic Kañaris societies allowed the intensive agricultural production of *Zea mays* for approximately 1200 years, without causing irreversible environmental deterioration in the cloudy montane forests of the western Andean. The existence, abundance, function, use, and distribution of plants in the Chanchán landscape show the conscious selection of the desired agrobiodiversity, intended for the regulation of the various socio-ecological impacts that arise at all levels of biological interrelationships (microorganisms, genes, species, ecosystems, and landscapes).

Certain interrelationships configured the Chanchán landscape as a great cultural artifact, where the non-human agency of plants (cultivated and wild) occurred as more than a mere adaptation to the niches culturally constructed by human populations. Non-humans are active agents in recovering the functional and structural integrity of agroecosystems after a social or ecological disturbance. The high levels of cloudiness, precipitation, atmospheric humidity, and soil erosion, typical of the western foothills of the Ecuadorian Andes, are regulated and/or mitigated through the use of certain stable agroecological practices that balance the resilience thresholds of the soil, ecosystem, and landscapes. Agroecological legacies place people and plants in the same co-evolutionary position, since these two agents, according to Andean ontologies, are an integral part of the habitus, and not only of habitats.

Archeobotanical and ethnobotanical data have shown that the management techniques of the agricultural landscape in the Chanchán basin were developed by the Kañaris cacical societies a millennium before the arrival of the Incas. This corroborates that agroecological practices in the Ecuadorian Andes emerged in response to the regulation of their socio-ecological contingencies, under the "Model of Ecological Diversification", over and above such influences as ecological imperialism. The plant species have adapted to the ecotones and ecological floors of the western Andean foothills, enabling them to diversify and thus increase the availability of food crops that are bioculturally appropriate for the agrobiodiversity.

Finally, the agroecological management of landscapes promotes not only egalitarian and self-sufficient agricultural production for human populations, but also maintains the flow and genetic richness of species with the highest biocultural value in all agroecosystems, through redistributive socio-ecological practices such as "Chaleo".

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land12010192/s1, Table S1: Ethnobotanical inventory of the Nizag community, Table S2: Archaeological and modern macrobotanical assemblages derived from agroecological practices in the Joyagzhí terraces and Nizag community.

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