Biocultural calendars in southwestern South America

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Key points:

1. Biocultural calendars
2. "3H" model of biocultural ethics
3. In southwestern South America, cultural practices are combined in biocultural calendars marked by key biocultural species

Abstract. To integrate temporal and spatial dimensions of seasonal cycles, we combine two conceptual frameworks: ecological calendars and the “3Hs” model of the biocultural ethic. The latter values the vital links between human and other-than-human *co-inhabitants*, their life *habits* (e.g., cultural practices of human communities or life cycles of other-than-human species) and the structure, patterns and processes of their shared *habitats*. This integration enhances an understanding of core links between cultural practices and the life cycles of biocultural keystone species. As a synthesis, we use the term *biocultural calendars* to emphasize the co-constitutive nature of calendars that result from continuous interactions between dynamic biophysical and cultural processes. We apply biocultural calendars to examine cultural practices and socio-environmental changes in southwestern South America, specifically in Chile, spanning from (1) Cape Horn at the southern of the Americas in sub-Antarctic habitats inhabited by the Yagán indigenous community, (2) artisanal fisher communities in Chiloé archipelagoes, (3) coastal regions of central-southern Chile inhabited by Lafkenche and Williche indigenous communities, to (4) high Andean habitats in northern Chile co-inhabited by Aymara communities along with domesticated camelids and a rich biodiversity. To illustrate biocultural calendars, we designed *analemma* diagrams that show the position of the Sun in the sky as seen from a fixed time and location, and linked to continuous renewal of astronomical, biological and cultural, seasonal cycles that sustain life. These biocultural calendars enhance the integration of indigenous and scientific knowledge to confront complex challenges of climate change faced by local communities and global society.

Plain Language Summary. The "lens" of biocultural calendars allows us to understand the close seasonal relationships that exist between indigenous and local populations in southwestern South America, throughout Chile and its heterogeneous environments. This notion allows us to pay attention to the synchronizations between the life habits of human co-inhabitants and other-than-humans who share unique habitats. These culturally memorialized and ritualized relationships support life models that recognize the importance of maintaining balanced links with other species and the conservation of elements that are vital for all. Also, they allow local communities to understand and adapt to unforeseen changes in the environment, since in the past both humans and other-than-humans faced events that put them in check and forced them to react together. Today more than ever they are relevant in the face of global climate change but, paradoxically, they are in a situation of high vulnerability due to socio-environmental transformations imposed by a neoliberal development model that decouples the relationships between human beings and nature and tears apart ancestral biocultural interrelationships. The visibility of biocultural calendars generates opportunities that should encourage science, indigenous and local communities, and society as a whole, to revitalize connections with our environment.

Introduction

Since mid-20th century, the so-called Great Acceleration has amplified processes of ecosystem degradation and the extinction of a growing number of biological species on a global scale (McNeill & Engelke 2016). Concomitantly, local peoples and cultures have been displaced from their original habitats, replacing both their life habits and relationships of co-inhabitation with local ecosystems and biological species (Rozzi 2012). In less than 100 years modern civilization characterized by its *anthropocentrism* and *Eurocentrism* transmuted into a global society characterized by its high *anthropogenic* impact. However, it is not the whole human race that is equally responsible for its anthropogenic social-environmental footprint (Rozzi 2007, Figueroa 2011, Dunn 2017). Consequently, we need to better understand the social-environmental impacts of specific human groups (Rozzi 2015a). By more precisely identifying the diversity of cultures, their languages, values, and practices in heterogeneous habitats of the planet, we can find paths for more sustainable and just futures. To undertake this task, and more precisely understand the interrelations between biophysical and the cultural heterogeneity, in this article we use the perspective of the biocultural ethic that values the vital links between (i) the well-being and identity of the co-inhabitants (humans and other-than-humans),[1] (ii) their life habits, and (iii) the habitats where they take place (Fig 1).

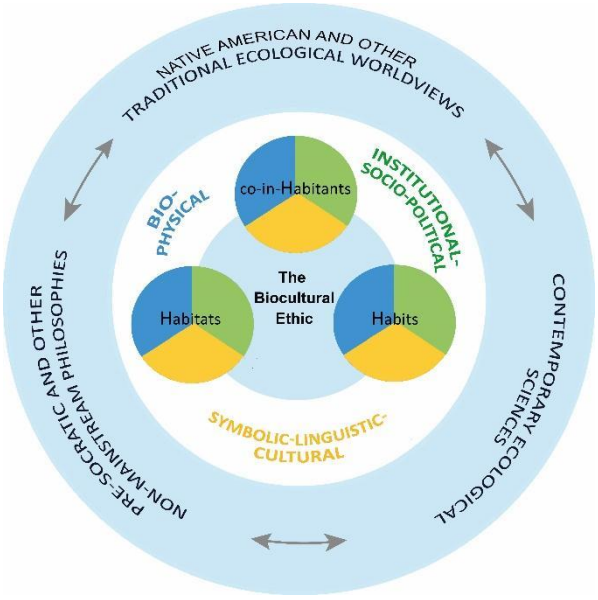

Figure 1. Representation of the "3Hs" model of the biocultural ethic that values the vital links between specific habitats and their co-inhabitants with their habits of life. The colors in each circle illustrate that each of the "3H" includes biophysical dimensions (blue), symbolic-linguistic-cultural dimensions (yellow) and

[1] The expression "other-than-humans" avoids the dichotomy derived from the more usual expression: "non-humans." It overcomes this dichotomy for two reasons. First, it alludes to the set of biotic and abiotic beings that form different levels of organization and interactions in the ecosystems they co-inhabit. Second, the expression "other-than-humans" allows us to understand that these beings inhabit not only biophysical nature but also the images, symbols and values of our cultures. Therefore, they are co-inhabitants in our biocultural communities, which encompass biophysical and linguistic domains of reality, and wakeful and oniric phases of our lives (see Rozzi 2018, Álvarez et al. 2022).

institutional-socio-political, infrastructural-technological dimensions (green). The green color (a mixture of blue and yellow) of this last dimension was chosen to indicate the need to carefully combine the biophysical and symbolic-linguistic-cultural dimensions in the design of policies, decision-making and infrastructure. The outer circle (in light blue color) indicates that biocultural ethics is informed not only by a diversity of ancient and contemporary forms of knowledge and worldviews of indigenous peoples, philosophies, and sciences, along with a plethora of social, political and cultural movements. The bidirectional arrows and the he circular shape of the figure indicate the multiple active exchanges that occur between worldviews and knowledge in the context of a global society that is, at the same time, dynamic and rapidly changing. Modified figure of Rozzi (2012)

The "3Hs" (co-inhabitants, habits and habitats) conceptual framework has a heuristic significance because it helps to visualize, understand, and value the interdependencies between the lives of diverse co-inhabitants. Understanding and valuing these interdependencies should guide decision-making and generate greater awareness of the consequences of decided actions, both for one's own individual well-being, as well as for the well-being of the community of human and other-than-human beings. Hence, the "3Hs" conceptual framework has also an ethical significance to foster an intercultural and inter-species solidarity and a socio-environmental justice. Conservation of the habitats and access to them is a matter of justice, because it is a necessary condition for the continuity of life habits linked to the well-being and identity of the broad community of co-inhabitants (Rozzi 2012).

The concept of co-inhabitants alludes to sharing the same habitat. It has a sense analogous to the concept of "companion" that, in its origin, referred to sharing bread (from Latin, *cum* = with; *panis* = bread). The understanding that we share habitats with vertebrates, invertebrates, and a multitude of other living and ecological beings (such as rivers, mountains, rocks, or oceans), has ontological, epistemological, and ethical implications. *Ontological*, because human and nonhuman beings do not exist as isolated individuals, but rather exist together in co-inhabitation interrelationships. *Epistemological*, because to understand human beings and other animals it is necessary to consider the co-inhabitation relationships that forge their identities and well-being. *Ethical*, because human beings share a common habitat, the biosphere, which we must take care of for the well-being of all animals by cultivating life habits that recover a sense of being co-inhabitants with myriads of living beings, most of which go unnoticed to citizens, but are critical for the health of humans and ecosystems (Rozzi 2019).

Biocultural ethics also demands overcoming epistemic injustice (*sensu* Fricker 2007) which may derive from an arrogance of hegemonic knowledge linked to Eurocentrism. Arrogance of hegemonic knowledge implies exclusion and oppression of forms of knowledge of indigenous and other local communities (Grosfoguel 2007). At the same time, this direct oppression of local communities also implies an indirect oppression of the biodiversity with which they co-inhabit. Epistemological arrogance "makes invisible" ways of knowing, which are intimately linked with forms of co-inhabitation with multiple biological species.

Ecological calendars offer us a concept that complements the "3Hs" model of the biocultural ethic to better appreciate how indigenous and other local communities have forms of knowledge, languages, and cultural practices linked to their environment (Dunn 2017). Across the world, these communities use environmental cues to establish their

patterns of cultural practices (Kassam et al 2011, Singh et al 2011, Ens et al. 2015). Ecological calendars (or "indigenous seasonal calendars") are particularly sensitive to climate change both in its biophysical expressions (for example, earlier flowering phenology of plants or arrival time of migratory birds) and its cultural expressions (for example, the loss of synchrony between fishing or agricultural practices with life cycles of fishes or plants).

In this article we use the conceptual frameworks of ecological calendars and the biocultural ethic to contribute understanding on how to reconnect global society with biocultural diversity and favor the dynamic synchronicity of material and symbolic cultures with rapidly changing biophysical patterns in the face of climate change. Toward this aim, we organize our article in three parts. First, we concisely introduce three types of barriers that have disconnected global society from biocultural diversity, with particularly severe impact in Latin America. Second, we describe the ecological calendars, in our terms biocultural calendars (see below), of indigenous and other local communities in Chile. Third, we concisely discuss the broader implications of the links (or disrupted links) between co-inhabitants, their life habits and their shared habitats found in contrasting regions of southwestern South America. This biocultural systemic, contextual, and co-evolutionary understanding could help to set social-environmental priorities, policies, and actions to conserve critical habitats and biocultural diversity not only in Chile but also in other heterogeneous regions of the planet. The biocultural ethic and ecological calendars introduce an understanding that transcends the purely descriptive plane, since it implies assuming an ethical responsibility.

1. Barriers hindering connections between global society and biocultural diversity

Why is it that authorities and other members of global society have so many difficulties perceiving, understanding, and appreciating biological and cultural diversity today? We distinguish three main types of barriers that drive the rapidly growing homogenization of life habits and habitats inhabited by people worldwide. Contemporary global society is characterized by an explosive growth of urban population, which leads to a drastic homogenization of the habitats inhabited by most humans. The urban enclosure of contemporary society generates a *physical barrier* that hinders the awareness and understanding of biocultural diversity. Second, *conceptual barriers* due to the losses of diversity of languages and forms of ecological knowledge and the concentration of information in digital media. Third, *institutional and educational barriers* associated with a concentration of economic and political power and homogenous educational programs that have displaced vernacular forms of knowledge These barriers synergistically foster biocultural homogenization (Rozzi 2018).

1.1 Physical Barriers

At the beginning of the twenty-first century, for the first time in the history of the human species, more than fifty percent of the world's human population lives in cities (Flavin 2007). This concentration of the population in cities has created physical barriers that distance global society from daily contact with biocultural diversity. The massive rural to urban migration is a recent event linked to the Great Acceleration, which has been

especially marked in Chile and Latin America where urban population has grown from 58% and 41 % in 1950 to 91% and 82 %, respectively, in 2020 (Fig. 2). This rural- urban migration has severe consequences for both the native habitats and the well-being of displaced human communities.

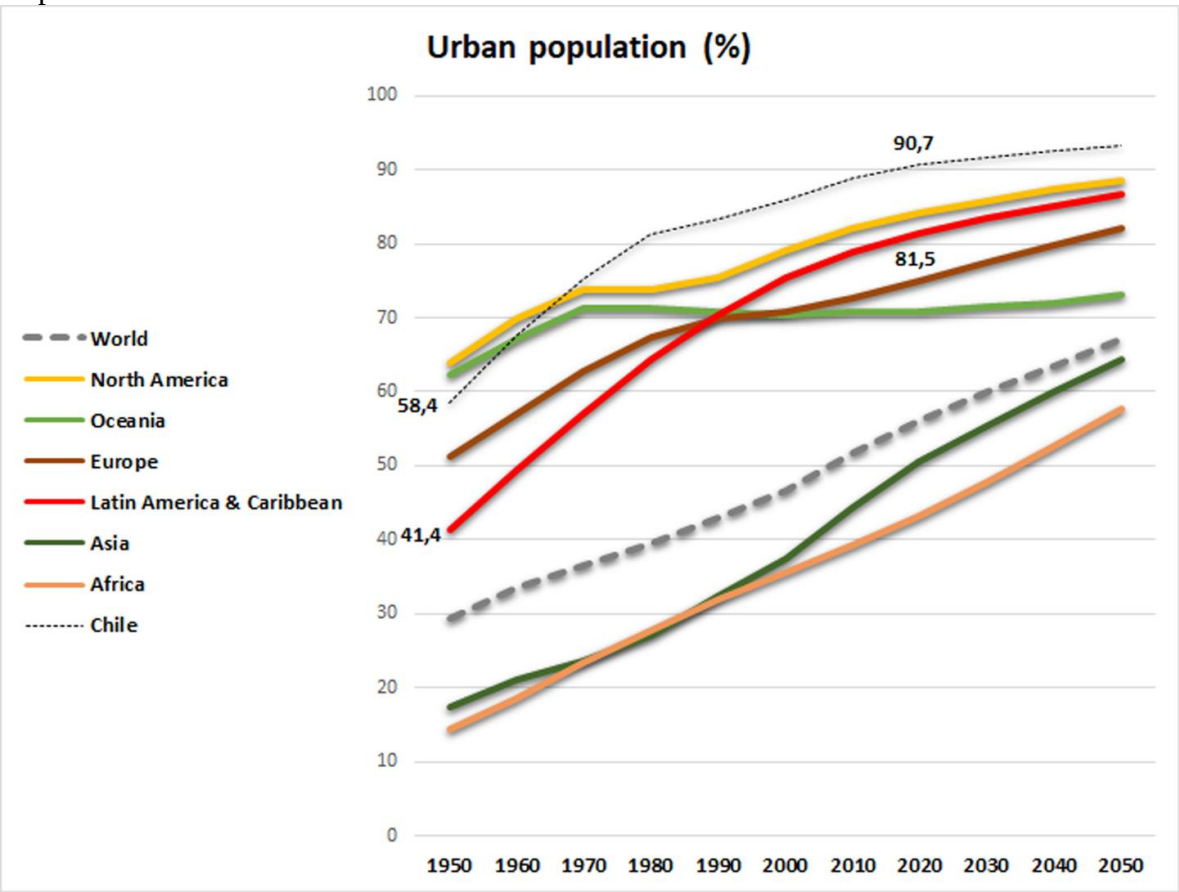

Figure 2. Figure 2. Relative percentages of urban populations since 1950, and estimated percentages until 2050, in Chile, Latin America and the Caribbean, North America, Europe, Oceania, Asia, Africa, and the world as a whole (Modified from Rozzi 2012; data from Heilig 2012).

Regarding the native habitats, the rural-urban migration generates a loss of the ancestral human stewards of the land. As indigenous people and other local communities are displaced to cities, native habitats are left open today to accelerated processes of land-use changes, including large-scale mining and expansion of monocultures associated with a concentration of the land property (Ceccon and Miramontes 1999, Tabasura 2006, Finer et al. 2008, Borras et al. 2011) During the last five decades, Latin American governments have been subject to an increasingly prevailing neoliberal economic, development model, which, driven by narrow technological and market parameters, has promoted the consolidation of land ownership in service of economies of scale. Both national and international development pressures act over regional habitats displacing and/or eliminating their native human populations. The explosive increment in the concentration of land ownership since the 1970s has had severe negative socio-ecological impacts (Borras et al. 2012). Indigenous and other local communities are keenly aware that well-being of human communities and other-than-human communities go hand in hand (Rozzi 2015b). In their territories, these populations frequently act as guardians of the land, protecting its

biological and cultural diversity. They attempt to resist their territorial displacements caused by development projects such as mining, dams, and monocultures, in order to conserve their autonomy, their traditional their habits and native habitats. Consequently, conservation should not be considered merely a luxury of rich people and rich nations. Instead, it is a vital need for the health of the local inhabitants and their culture (Rozzi 2001).

Regarding human habits and well-being, in the cities, displaced indigenous people, peasant and fishermen communities frequently lack access to basic services, such as food, water, shelter, and sanitary conditions; hence, they face extreme poverty conditions that are rapidly expanding in the marginal neighborhoods of metropolis areas in Latin America (Parentelli 1996; Gebara 1999; Rozzi 2001). Additionally, these populations lose their everyday contact with their regional biological diversity. The knowledge that most teachers, authorities, new generations of students, and the majority of citizens have about biological and cultural diversity is acquired in urban contexts, distanced physically, emotionally, and ethically from the regional habitats, their communities of co-inhabitants and diverse life habits (Leopold 2004, Poole 2018).

In summary, regional ecosystems become distant regarding the everyday experience, but they are heavily impacted by new urban lifestyles, with growing levels of energy and material consumption, and production of waste. Hence, losses of regional biological and cultural diversity are coupled with degradation of environmental and social sustainability. To counteract this trend, participatory conservation of habitats with the inclusion of local communities represents an ethical imperative that must be incorporated into development policies as a matter of eco-social justice (Rozzi 2013).

1.2 Conceptual Barriers

At the beginning of the twenty-first century, for the first time in the history of the human species, more than half of the world's population inhabits symbolic worlds that are defined by less than ten languages. According to the data of the Ethnologue (2010), today 52% of the world population speaks one of the seven of the dominant languages: Mandarin, English, Hindi, Spanish, Russian, Arabic, and Bengali (Figure 4). These seven dominant languages represent a minimal fraction (0.1 %) of the 6,909 languages that are still spoken around the globe. This linguistic homogenization drastically reduces the spectrum of concepts and worldviews with which biological and cultural diversity are perceived, understood, and valued. Today the extinction risks for languages exceed those for biological diversity worldwide and particularly in Latin America (Lizarralde 2001). In Chile, for example, over 50 % of the native languages are already extinct (Rozzi 2013).

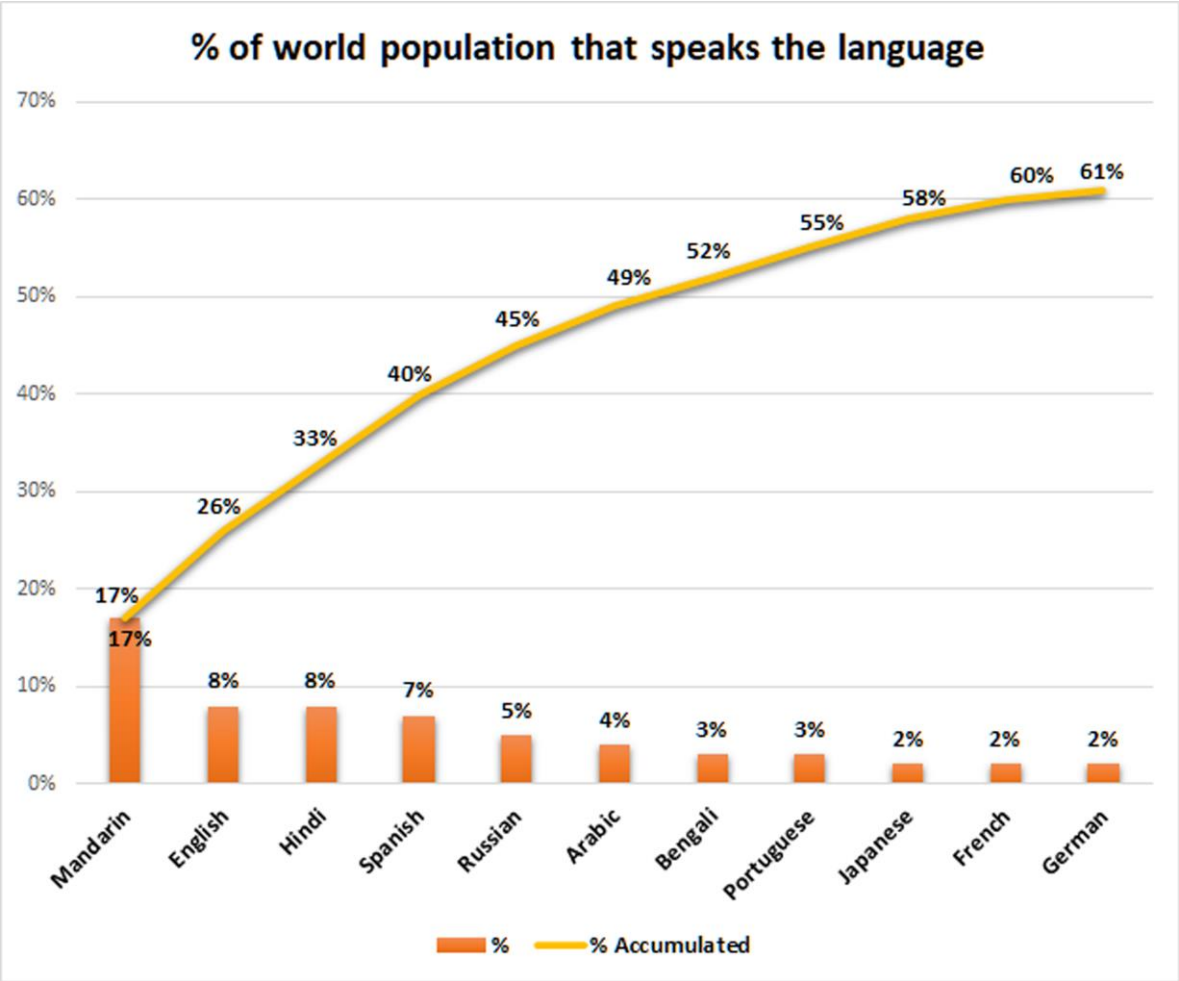

Figure 3. Dominant Languages Spoken in the World in 2000. Bars illustrate the relative percentage of the world population that speaks each of the dominant languages, and the line depicts the accumulated percentage of the world population that speaks one of these languages. (Modified from Rozzi 2012; data from Ethnologue 2010).

In summary, global society has forged *conceptual barriers* derived from the displacement of linguistic diversity and the widespread mediatization of perceptions about and experiences with biocultural diversity (Rozzi 2012). To counteract this trend, the conservation of vernacular forms of knowledge and life habits represents another pressing need to foster human well-being, autonomy of local communities and their complex and dynamic relationships with biodiversity (Rozzi 2013).

1.3 Institutional educational barriers

Global society has forged *institutional and educational barriers* derived from a concentration of economic and political power and educational programs that have displaced vernacular forms of knowledge (Escobar 1995). Since the 1970s, several Latin American countries are making efforts to recover indigenous languages and cultures. However, they are still ignored or only marginally incorporated into formal education, and Spanish continues to be taught as the unifying language of the nation-states (López 2007, Fajardo-Salinas 2011). In this region, and worldwide, monolingualism of the colonial

language has been imposed, and formal education represents a major driver of linguistic homogenization (Krauss 1992; Maffi 2001, 2005). Homogenous formal education programs hinder a plural understanding of human natures with cultural habits linked to particular local habitats and ensembles of co-inhabitants.

This biocultural homogenization conveys epistemic injustices because the knowledge of indigenous and local communities is systematically and arbitrarily ignored or oppressed. As mentioned above, numerous intercultural education programs have been initiated in different regions of Latin America (Albó 2018, Montoya-Greenheck 2018, Santafe-Troncoso & Loring 2021). To illustrate this point we begin by concisely presenting an intercultural education experience regarding the relationships between the indigenous Yagan language and the natural world in the archipelagoes of Cape Horn at the southern end of the Americas. In 2003, with elders, youngster, and children of the Yagan community we conducted a participatory workshop with Grandmother Cristina Calderón who was the only person who still fluently spoke the Yagan language at that time. She shared her memories and spoke the Yagan language to the young people, evoking landscapes, languages, tools and ways of inhabiting the seas and lands that ancestrally constituted their territories (Zárraga et al. 2006).

The children understood how the seasons of the year were indicated by the rhythm of nature (**Figure 4**). As such, *hanish lush*, the autumn, is associated with the color red (*lush*) acquired by the lenga tree (*hanish*) on the slopes of the mountains (*tulara*) in the fall. *Ina*, the winter, is marked by long nights and snow, associated with *lampia* (black) and *yakua* (white), respectively. *Iahakisi* (spring) the short (*iaha*) summer (*kisi*), is signaled by the shoots of leaves that color this season with *arlampia* (green). *Kisi,* the summer, arrives with its interminable days where *kurlampia* (blue) inundates the sea and sky.

Figure 4. Cover of the Yagan Dictionary *Hen larnanauti, hen maruti intien usi* ("Learning from and listgning to the Yagan world) that includes illustration made by children, and digital recordings of words in Yagan, Spanish, and English. The cover illustrates the four seasons of the year illustrated by boys and girls of the workshop who understood the meaning of words and cultural activities linked to the life cycles of plants and animals of the sea, coasts, wetlands and forests. The book is accompanied by a CD with the recordings of words were recorded in trilingual format, Yagan-Spanish-English to foster intercultural education. Cover image from Zárraga et al. (2006).

From this experience, the outlook of the boys and girls was prepared to recuperate the original names and feelings in their perceptions and illustrations of the seasons of the year, the sky, the sea, the fauna, the flora, the landscapes, the tools and the relationships in the ways the ancestral Yagan people coinhabited islands, fjords and channels of the Cape Horn archipelagoes. Their close forms of co-inhabitation with the natural world provide a biocultural orientation not only for the young people of the Yagan community, but also for the youngsters of the whole world.

2. Biocultural calendars in southwestern South America

In Latin America, the history of indigenous peoples and local communities has shown that most of the times their life habits foster a co-inhabitation with high levels of biodiversity (Toledo 2001, Toledo & Barrera-Bassols 2008). More broadly, worldwide, diverse communities cultivate forms of earth stewardship that involve multiple forms of co-inhabitation with other entities through close material (e.g., food) and symbolic (e.g., mythical actors of social life) ties (Rozzi 2015b, Dawson et al. 2021). These forms of co-inhabitation include cultural practices that are closely coordinated with the cycles of nature (solar, lunar, or by the seasonal behavior of species related to their subsistence) (Bulbulshoev et al. 2011, Cocharn et al. 2016). These calendars allow communities to better organize to meet their needs and collectively assume unexpected events, such as sudden periods of drought or torrential rains (Kassam et al. 2018). For example, it is possible to anticipate to unforeseen changes by observing the behavior of species (birds, fish, among others) or of the landscape (for example, changes in temperature in the sea) (Prober et al. 2011, Ryan 2013). Interestingly, natural scientists have also highlighted the value of not only using the Gregorian year calendar but to also observe and use ecological calendars (Balvay 1991).

These phenomena are imprinted in the biocultural oral memory of communities. These memories integrate both biophysical and cultural dimensions of reality (Rozzi 2015b). Hence, we propose that it is important to make explicit that ecological calendars have both biophysical and cultural dimensions to synchronize the rhythms of the natural world or cosmos with the rhythms of human daily activities and rituals. For this reason, in this article we use the term *biocultural calendars*. The term biocultural calendars was recently used by Mariana Landwehr (2019) on her Master thesis based on a study with the Zinancontec Maya community in Chiapas, Mexico. Maize (*Zea mays*) in Zinacantán is part of the cultural identity and is present in the social, political, religious, ceremonial, ritual and gastronomic organization during a well-defined biocultural calendar (Landwehr 2019). Complementarily, the term *ecocultural calendars* has been used in participatory biocultural

conservation projects (Belay 2012, Ali 2015, Flick 2021). As compared to ecological calendars, both biocultural calendars and ecocultural calendars have the strength of emphasizing the co-constitutive processes that generate these calendars in continuous interactions between dynamic biophysical processes and cultural imagination and tradition of local communities. We preferred to use biocultural calendars (instead of ecocultural) because it is broader insofar it also involves biological dimensions, and it is consistent with our work on biocultural stewardship (Rozzi 2015b). More importantly, the term biocultural calendars bring together concepts from ecological calendars and from biocultural ethics and biocultural conservation. This synthesis is relevant to integrate indigenous and scientific knowledge to confront complex challenges faced by local communities and global society in the face of climate change (see Dunn 2017).

In this section we use the concept of biocultural calendars to examine cultural practices and socio-environmental changes in southwestern South America, specifically in Chile (Figure 1). We organized the case studies from the south to the north of the country. We start with Cape Horn in the far south where sub-Antarctic habitats have been co-inhabited by native peoples for about 10,000 years (Borrero 2001) and more recently by artisanal fishing communities from Cape Horn to Chiloe (Alvarez et al. 2016, Pyne & Isabella 2021). Then, the coastal and forests habitats of central-southern Chile have been co-inhabited by Lafkenche (people [= *che*] of the ocean = *lafken*) and Williche (people of the south = *willi*) communities of the Mapuche (people of the land = *Mapu*) indigenous culture (Rozzi et al. 2003, Alvarez 2016). The extreme north of Chile, at the borders with Bolivia and Peru, is characterized by the high Andean habitats with salt flats and wetlands that have been co-inhabited by native peoples such as the Aymara along with domesticated camelids and a rich biodiversity (Castro & Romo 2006).

Figure 5. Map of Chile indicating the territories of the biocultural calendars examined in this article. From south to north: Cape Horn Biosphere Reserve; southwestern Patagonian channels and fjorrds that culminate in the Chiloé archipelago; in south- central Chile are the lafkenche-williche coastal territories; and in the extreme north the location of the two study sites, Salar de Huasco and Lirima wetlands, is indicated. Figure: own elaboration.

To illustrate biocultural calendars we have used *analemmas* (or *lemniscates*), a diagram showing the position of the Sun in the sky as seen from a fixed location on Earth at a fixed time (Figure 6). Our diagrams refer to a constant renewal of cycles (astronomical, seasonal, biological and cultural) that sustain biocultural calendars. This cyclicality has been observed by various native peoples who live in Chile where they have established biocultural calendars synchronized with the movement of the sun (and the moon) that influence the behavior of the tides and the seasonal cycles of the climate, plants and animals.

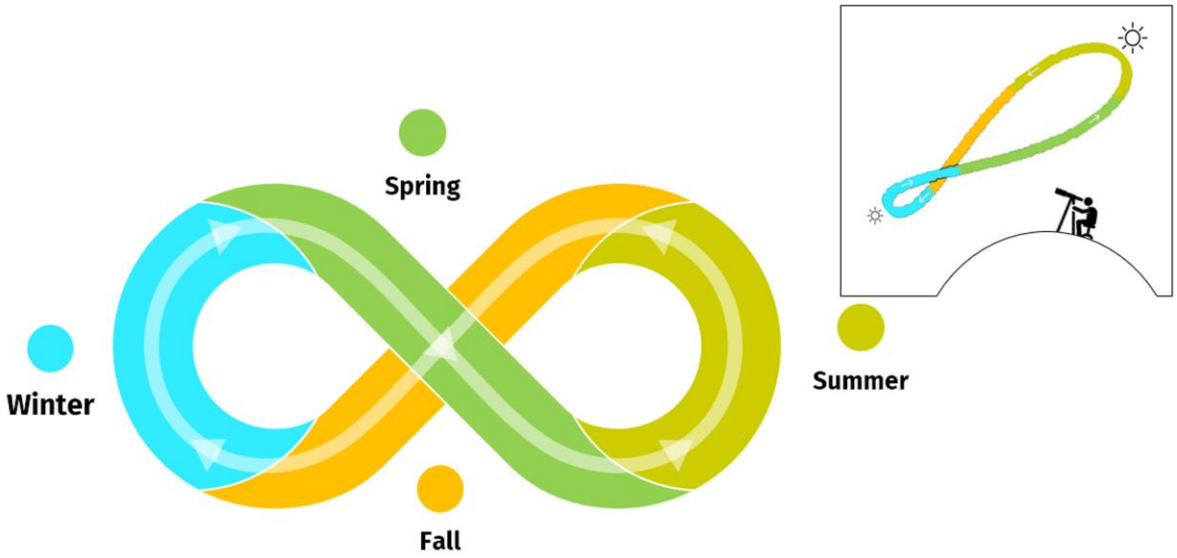

Figure 6. Diagram of the solar analemma in the southern hemisphere. The colors indicate each of the year's seasons, which are linked to cycles (astronomical, seasonal, biological and cultural) of continuous renewal that sustain biocultural calendars. Figure: own elaboration.

2.1 Biocultural Calendars at the southern end of the Americas

In the extreme austral region of southwestern South America, indigenous peoples have inhabited archipelagic landscapes rich in biodiversity for about 10,000 years (Vásquez & Borrero 2021). The Yagan, Selk'nam and Kawésqar peoples have worldviews integrated with this biodiversity (Falabella et al. 2017). In the 19th century, the State of Chile promoted the European colonization of these lands, arguing that they were hostile, inhospitable and unproductive landscapes, but that they offered natural resources for their exploitation (Álvarez et al. 2017). In the process, populations of indigenous peoples were

brutally treated, expelled from their territories and seas, and even distortedly declared extinct in national historiography. However, these communities are alive and during the last two decades there have been programs to revitalize and revalue their knowledge as well as the unique biodiversity of their archipelagic environments (Rozzi et al. 2003, 2006, Zárraga et al. 2006, González et al. 2017, Contador et al. 2018).

According to the cosmogonies of the Selknam and Yagan people, there was an ancient time in which the morphological differentiation between humans and other animals, plants, rocks or mountains was diffuse, if not null (Gusinde 1986). For the Selk'nam even the seasons did not originally exist. In that remote time the trees never lost their leaves and were always green. They only lost them when they died. But one of their ancestors, *Kamshoat*, (the *cachaña* parrot, *Enicognathus ferrugineus*) began to paint the leaves, giving rise to autumn. The trees revived months later, giving rise the spring. This was the beginning of the annual cycles in the southern world (Bridges 1952: 455).

In Selknam and Yagan cosmogonies and narratives humans and other species participate together conveying ethical-normative messages. Among the most recurrent themes, is the radical questioning of selfish attitudes of hoarding common goods, such as food or water. For example, in the Selk'nam case, the transgression of misappropriating water is represented through a spirit called *Taita* (Gusinde 2008), while in the Yagan case it is represented by the fox (*Lycalopex culpaeus lycoides*) called *Cilawáia* (Cristina Calderón, in Rozzi et al., 2003). In both cases the exemplary sanction for hoarding this vital element was death. In fact, when *Taita* or *Cilawáia* tried to monopolize it, they were selfishly trying to own a structuring part of the world. This indigenous worldview differs markedly from the way this essential element is currently governed and regulated in Chile, because the current constitution of the country allows the selfish capture of water by private parties. This regulation of water property has caused poverty, precarious migrations, and the ruin of numerous local ecosystems (Frene and Andrade 2014).

Today, indigenous communities resist the neoliberal model in Chile. They are revitalizing worldviews and cultural practices that maintain a correspondence with the behavior and life cycles of animals and plants and the dynamic processes of terrestrial, freshwater and marine ecosystems. For example, the marked seasonality in the sub-Antarctic region is expressed in the phenology of forests. The phenology of these broadleaf forests, with evergreen and deciduous species of *Nothofagus* (Veblen et al. 1996), influences the migrations and life cycles of birds, insects, fungi and lichens and distinctive cultural practices of each season. In the seascapes and landscapes of the Yagan people in the Cape Horn archipelagos, Spring marks the beginning of the reproductive season and arrival of migratory birds bringing wellness for the communities.

In spring, species of a group of epiphytic fungi begin to develop their fruiting bodies or stromas (Salazar-Vidal 2020). These fungi belong to the genus *Cyttaria* and have a long history of co-evolution with trees of the genus *Nothofagus* that dates back to the Gondwana continent about 100 million years ago (Swenson et al. 2001). This *Cyttaria- Nothofagus* co-evolution illustrates how ecological calendars have long-term inter-species relationships over broad temporal and spatial scales. In the Holocene, ecological calendars acquired human correlates and transmuted into biocultural calendars. For the Yagan people, fungi of

the genus *Cyttaria* constitute a staple food that provides carbohydrates and proteins essential for the family diet (Schmeda-Hirschmann et al. 1999, Salazar-Vidal 2019).

Nothofagus also provide essential materials that can only be harvested in spring. One of these is bark used to make canoes that enabled indigenous people to navigate and colonize the archipelagoes of Cape Horn. After the last maximum glacial, the archipelagoes emerged as the ice started to retreat approximately 13,000 years ago (Davies et al. 2020), and in the Cape Horn archipelagos humans arrived at least 8,000 years before the present (Orquera & Piana 2020). Since ancestral times, Yagan people have made their canoes with bark of the evergreen beech of "coigüe" (*Nothofagus betuloides*) (González et al. 2017). The bark can only be effectively removed during Hakuerum, "the time when the bark is loose," in late spring and early summer months when the bark is loose, revealing a deep understanding of how tree sap behaves seasonally (Vallejos 2009: 245). The bark extraction procedure is carried out on a single face of the trunk. In this way, the cutting of the sap flow by the phloem is avoided and the tree continues to live (González et al. 2017, Östlund et al. 2020). These culturally modified trees evoke similar practices in the Pacific Northwest (Morley & Eldridge 1992) and Scandinavia (Östlund et al 2020, Andersson et al. 2008).

In spring-summer, another biocultural keystone plant species for the Yagan people is the tall rush (*Marsippospermum grandiflorum*). Different types of baskets are made with its fibers: *steapa* with a tight weave and was used to collect berries, and *keichi* with a loose weave and that was used to collect shellfish (Massardo & Rozzi 2006). Rushes collection in wetlands, and basketry stimulate relational activities through collective practices that reinforce both social and inter-species bonds in relationships of co-inhabitation, which include humans, plants and birds, such as snipes (Figure 7).

Figure 7. In the Cape Horn Biosphere Reserve, wetland habitats provide fibers needed for basket weaving as well as nesting and feeding sites for snipes (*Gallinago paraguaiae magellanica*) and other birds that can be considered as co-inhabitants. Julia González, an artisan from the Yagan indigenous community, gathers *Marsipposerpum grandiflorum* rushes with which she weaves baskets. This image shows one of Julia's woven baskets, which is used for berry picking, among other traditional uses. Photographs of Jordi Plana (bird), Paola Vezzani (Julia weaving and gathering rushes) and Cristian Valle (basket). Figure modified from Rozzi et al. (2010).

Fall (*Hanihlush*) the season when the leaves of the high-deciduous beech (*hanis*) turn red (*lush*) marks also of abundance of sardines (Figure 8). The missionary Lucas Bridges (1952: 75) recalls that this phenomenon was called *Iacasi*: "(...) seals, penguins, albatrosses and other seabirds, and also deep-sea fish, which arrived in fall chasing the school of sardines. It was a time of superabundance for the Aborigines. The arrival of the Iacasi was celebrated with a harvest festival that could last up to two months". Fall is also the season when species such as guanacos (*Lama guanicoide*) and caiquenes (*Chloephaga picta*) are fat (Bridges 1952: 415).

In the Cape Horn archipelagos, some intertidal species, such as mussels (*Mytilus chilensis*), exhibit low seasonal variation in abundance (Ojeda et al. 2018). This constancy throughout the year was essential for human settlement in the extreme south (Figure 8). It provided a constant food source, which was supplemented with other species according to their temporary availability (Orquera & Piana 2009, Ojeda et al. 2018). Martin Gusinde (1986) highlighted the importance of the mussels, pointing out that: "(...) the molluscs are for the Fuegian aborigines what bread is for the European" (pp. 471). Mussels represent a risk-reducing factor that neutralized seasonal fluctuations in food supply (Orquera 2000), and were part of the diet in rituals (Koppers 1997). The banks of mussels were a determining

factor for the choice of settlement sites (Orquera 2000). These *molluscs* not only provided a food base, but their shells were essential for the construction of their rooms or *akar*, where they were intentionally deposited to generate permeable substrates in a very rainy area (Verdún 2010). The shell middens remain today as archaeological sites found in practically all the archipelagos of the Cape Horn Biosphere Reserve (Ocampo & Rivas 2000, 2004; Alvarez et al. 2004).

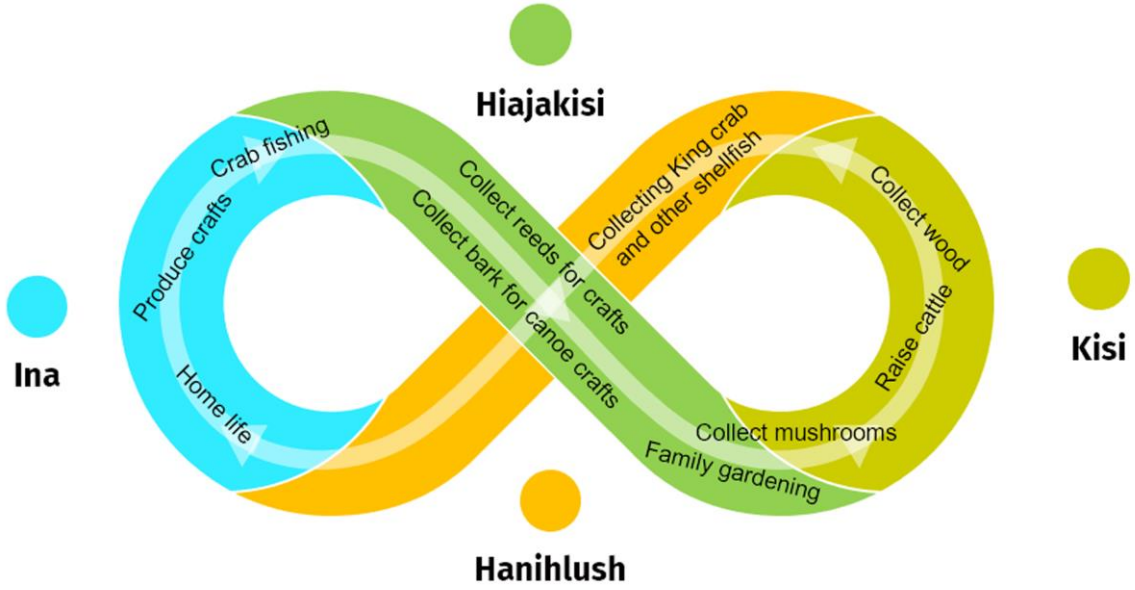

Figure 8. Yagan biocultural calendar. The colors indicate the seasons of the year -Spring (*Hiajakisi*), Summer (*Kisi*), Fall (*Hanihlush*) and Winter (*Ina*)-- and the main cultural practices in each of them. In different seasons of the year, these practices focus on specific *habitats* (eg, marine-coastal, wetlands or forests), characteristic life *habits* (eg, fishing or gathering) and *co-inhabitants* (eg, kingcrabs, mussels and other shellfish, rushes or fungi of the genus *Cyttaria* in *Nothofagus* forests) that are biocultural keystone species. Figure: own elaboration.

Throughout the year, both Yagans and Kawésqar used lunar cycles and their correspondence with tides as measures of time and reference to plan future actions; for example, to plan when a group should be back or when to meet somewhere. To fix meeting places over longer periods, some seasonal phenomenon was indicated; for example, the laying of eggs by wild geese (representing spring) or the emaciation of shellfish (representing winter) (Vallejos 2009). Regarding marine cycles, Kawésqar people organized their biocultural calendar in relation to seasonal conditions of the exposed ocean and the interior channels in their archipelagoes. During winter, Kawésqar activities were concentrated in the protected fjords and channels (toward the east, *jáutok*), where shellfish-based sustenance was essential. In spring they moved towards the west where the oceanic coasts (*Maltese*) exposed to the Pacific Ocean are rich in fish and breeding areas for birds and marine mammals (Aguilera 2011).

Biocultural calendars in artisanal fishing in the west-Patagonian channels

The growing prevalence of neoliberalism since mid-twenty century has instilled private property rights, economic efficiency, deregulation, economic growth, government cutbacks,

and devolution of responsibilities and risks to the private sector (Pinkerton 2017). This policy has drastically impacted artisanal fisheries in terms of access to coastal habitats and losses of traditional life habits. Regarding the latter ecological calendars have been replaced by calendars governed by markets. However, habits, knowledge, and local regulations of artisanal fishery are still present and maintain practices of community benefits and synchronization with seasonal calendars (Gajardo & Ther 2011).

Chilean anthropologists Carlos Gajardo and Francisco Ther (2011) described geolitoral calendars used by artisanal fishers in the archipelagoes of Chiloé. The geolitoral dimension highlights the high biocultural heterogeneity along the coast, where each bay is unique (FSP 2016, 2018). In these fisher harbors, economy is driven by a plurality of activities linked to customary life habits. For example, fishers alternate fishing activities with agricultural and forestry tasks, organized with calendars that integrate the life cycles of both marine and terrestrial species. This pluri-activity yields monetary dividends, but it yields higher social and environmental dividends. This pluri-activity is much more resilient in the long term, since customs provide normative restrictions that morally sanction the possibilities of hoarding, selfishness and other actions that are detrimental to the relationship between people and nature. In addition, multiple species and ecosystem elements are part of the material and symbolic culture, and can be considered as co-inhabitants beyond being just food, or materials to build something. In fact, in many beliefs with normative-ethical value, the central characters are other-than-human co-inhabitants (Alvarez and Ther 2016).

The relationship between cultural manifestations and natural cycles can be illustrated by the practice of fishing weir, stone or wood structures that serve to capture fish taking advantage of the dynamics of the tides (Figure 9). Today, fish weirs are also used as storage sites for algae and other functions. In Chiloé there are a thousand corrals that were used by island families until recent historical times (Alvarez et al. 2008, Alvarez 2016). Its use was synchronized with cycles in which species such as Chilean jack mackerels (*Trachurus murphyi*) and snoeks (*Thyrsites atun*) approached the coast chasing schools of sardines during the spawning period. In these fish weirs, fishing was also extended throughout the year with other species such as the Patagonian blennie (*Eleginops maclovinus*). The fish weirs also serve as a refuge for multiple intertidal species, such as rock fish, crustaceans and seaweeds that serve to support coastal families. Thus, fish weirs generate relationships of mutual reciprocity since these anthropic habitats stimulate greater biodiversity on the beaches (Sepúlveda 2017). This type of practice extends beyond fish weirs to subtidal micro-ecosystems that are protected by artisanal fishers who depend on carnivorous mollusks, such as Chilean abalones (*Concholepas concholepas*), and seed tunicates call “piures” (*Pyura chilensis*) to stimulate the proliferation of multiple species that support richer benthic harvesting. This point has been included in the Chilean law decree 18,892 on *Benthic Resources Management and Exploitation Areas*.

Figure 9. Above. A fishing weir on Caguach Island, Chiloé archipelago. This wall is used to catch fish taking advantage of the cycle of the tides, the moon and the seasonal migrations of fish. **Below**. Artisanal fisherman in his boat in the Guaitecas archipelago south of Chiloé (Photographs Ricardo Alvarez 2008).

The pluri-activity and geolitoral heterogeneity, combining fishing activities in fish weirs and small boats along the coasts (Figure 9), are in marked contrast with mono-species dependency driven by the market. The latter also imposes marked, discrete periods of fishing activity and the closed seasons. Market calendars foster an understanding and treatment of fishes, other species and marine ecosystems as mere natural resources. The establishment of industrial extractive methodologies and neoliberal fishing regulations have spoiled seasonal practices of fishing weirs. This cultural disruption has contributed to serious decrease in fish schools.

Coastal fishers' communities began to incorporate technologies and regulations that facilitated the deployment of the extractive model in the hands of the industries. Additionally, the aquaculture industry, especially salmon farming, has triggered a decoupling between productive activities and ecological and biocultural calendars. Since the 1980s, salmon farming has also precipitated the breakdown of relationships between humans and other marine species such as marine mammals (Bedriñana-Romano et al. 2021). These mammal species were part of the indigenous diet and worldviews, but today otariids and cetaceans are considered a threat to salmon farming cages (Osman et al. 2007). The complexity of the current context derives from the coexistence of industrial practices and views with indigenous habits and worldviews of artisanal fishers who still maintain a "mutual understanding" with marine mammals. This mutual understanding foster life habits of co-inhabitation habits where fishermen recognize high intelligence in sea lions (FSP 2018). Fishers understand how otariids learn quickly and vary their fishing practices to anticipate the actions of marine mammals. In this way, relationships become playful in everyday forms of co-inhabitation. In everyday life, while navigating in boats to set or collect fishing catches, fisher learn and sea lions and from each other establishing genuine inter-species relationships (FSP 2016).

Inter-species relations of co-inhabitation reveal a common language between human and other-than-human co-inhabitants, a language that is sensitive to annual cycles. Both sea lions and humans have times of abundance and cycles of scarcity. Today, artisanal fishers connect life habits and relational ecological and ethical values inherited from ancient times and competitive habits and values promoted by neoliberal policies where the activity is focused on a few species of commercial interest and any other species is designated as a threat. The complex process of adaptation between ancient customs and current tensions is illustrated by the artisanal hake fishery. Until the middle of the 20th century, in Chiloé, artisanal fishers did not consider hake as food, and it was even part of traditional taboos (Alvarez et al. 2008). Towards the end of the 20th century, international demand changed these customary considerations and thousands of local vessels and boats from other regions began an intense "exploitation" of hake in Chiloé.

In the Chiloé archipelagos, despite the strong effects of neoliberalism, an oral memory persists that maintains active biocultural calendars (Figure 10). This customary island model is especially visible on smaller islands (< 80 km2) where around 12,000 people live (Skewes et al. 2012, FSP 2018), which host intensely intertwined belief systems that represent historical miscegenation. For example, potatoes and other tubers are still planted with a waning moon (Urriola 2018) due to its cosmogonic equivalence with the underground; while species that grow towards the sun, such as wheat, should be planted with a crescent moon. These life habits and the lunar cycles are closely interrelated with the tides and the marine cycles. The full moon and new moon are associated with very intense tides or *pilcanes*, which are ideal for marine-coastal work, such as shore harvesting. In contrast, during the waning moon phase, agricultural work carried out by families in the interior habitats of the islands is privileged. However, the activities in these contrasting periods and habitats are interrelated. For example, the cultivation of potatoes and other crops requires seaweeds as a natural fertilizer (Cardenas et al 1991). Thus, during the Pilcanes, sea lettuces (*Ulva* sp.) and other seaweeds harvested during periods of the waning

moon (Alvarez et al. 2008). In short, in Chiloé, agriculture, fishing, and gathering practices have been interconnected in a complex lunar biocultural calendar (FSP 2016).

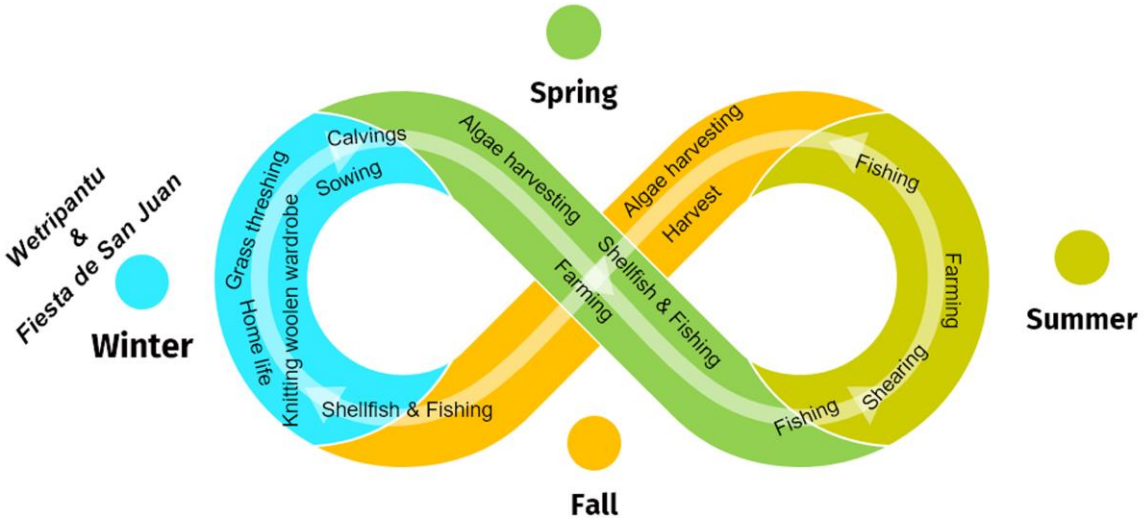

Figure 10. Biocultural calendar of fisher communities in the Chiloé archipelago. The colors indicate the seasons of the year and the main cultural practices in each of them. In different seasons of the year, these practices focus on specific *habitats* (eg, marine-coastal, pasturelands), characteristic life *habits* (eg, algae harvesting, fishing, potato planting or sheep shearing) and *co-inhabitants* (eg, red algae (*Gracilaria* spp. and *Sarcothalia crispata*), Patagonian blennie (*Eleginops maclovinus*) and other fish, potatoes, and sheep) which are biocultural keystone species year. Throughout the year, family work also includes the elaboration of handicrafts based on elements gathered in marine-coastal and forest habitats. Two festivities are celebrated during the winter solstice: *wetripantu*, of indigenous origin, and the *Fiesta de San Juan*, of hispanic origin. Figure: own elaboration.

Lafkenche-Williche biocultural calendar

From the northern region of the archipelagoes of western Patagonia to the coastal areas of central southern Chile are inhabited by Lafkenche and Williche indigenous communities. In These communities have a concept of poverty that is closely linked to the sanction of selfishness (Alvarez et al. 2016). Poverty is generated by acting selfishly; when actions unbalanced focus on your own benefit without consideration for others. First, whoever selfishly transgresses the possibilities of collective well-being is socially isolated. For this reason, there will come a time when the transgressors will be affected by illness, accidents or some unforeseen situations in which they will need the help of others, and when this happens they will realize that they are alone; that is, they are poor (Alvarez et al. 2016). This concept is maintained until today, where poverty connotes a lack of civic values that sustain customary life models (FSP 2016). In the Inland Sea of Chiloé, those who do not adhere to solidarity are marginalized from the benefits granted by the local community.

The accumulated experience in periods of seasonal scarcity, mainly between winter and spring, stimulates solidarity-type cultural practices. Food shortages are solved through joint work to establish food security thresholds that are common among families: no one will

have more or less. In this way, poverty is assumed as a transversal problem in the community. Those who are left behind (*kuñifal*) are immediately attended, because their precariousness causes imbalance. This same understanding of solidarity supports a biocultural ethic extended to all species with which human communities coinhabit. Humans and other-than-human beings are considered as co-inhabitants who strive for community well-being (Rozzi 2018), favoring the regeneration of life when it is altered (Skewes 2019).

The neoliberal development model has contributed to dismantling customary life habits and normative-ethical bodies of indigenous and other local communities in Chile. This development model was imposed with a military dictatorship (1973-1990) that fostered a notion of well-being based on selfishness, driven by individual competitiveness, hoarding and profit (Araos et al. 2019). Additionally, vast lands pf indigenous and other local communities were privatized. Consequently, this model changed both life habits and habitats. The neoliberal model disrupted customary cycles associated with the satisfiers most valued socially by these populations, including those that are linked to collective work, such as *mingas* (a peasant tradition that consists of the collaboration of neighbors and friends in a joint task). The satisfiers correspond to community life habits to satisfy elementary needs, such as subsistence, protection, understanding (Max-Neef et al. 1993), which constitute key cultural practices in the construction of biocultural calendars.

Central activities among the Lafkenche reinforce knowledge and customs from a collective dimension (Figure 11). Spring (*pewü*) implies flowing with the vitality of plants and animals through community activities linked to respectful use of forests (Skewes 2019), the cultivation of polyculture gardens (*tukun*) inserted in a matrix of forests and shrublands (Muñoz-Sáez et al 2019), and activities such as raising cattle on common lands and collecting seaweed and shellfish on beaches. Faced with unforeseen events, such as periods of drought, these families do not hesitate to exchange seeds that have been culturally modified for centuries and that they know will be able to germinate and grow under stressful conditions (Montalba et al. 2015). In summer (*walüng*) these activities are maintained, and harvesting of fruits and the birth of the bred are added, generating a season of opulence. In fall (*rimü*) collective exercises are reduced and conversations begin within the family nuclei, usually commenting on the experiences they had during the spring and summer. In winter (*pükem*), during the season of greatest deprivation, community practices include times for collective thought and reflection (Grebe 1987).

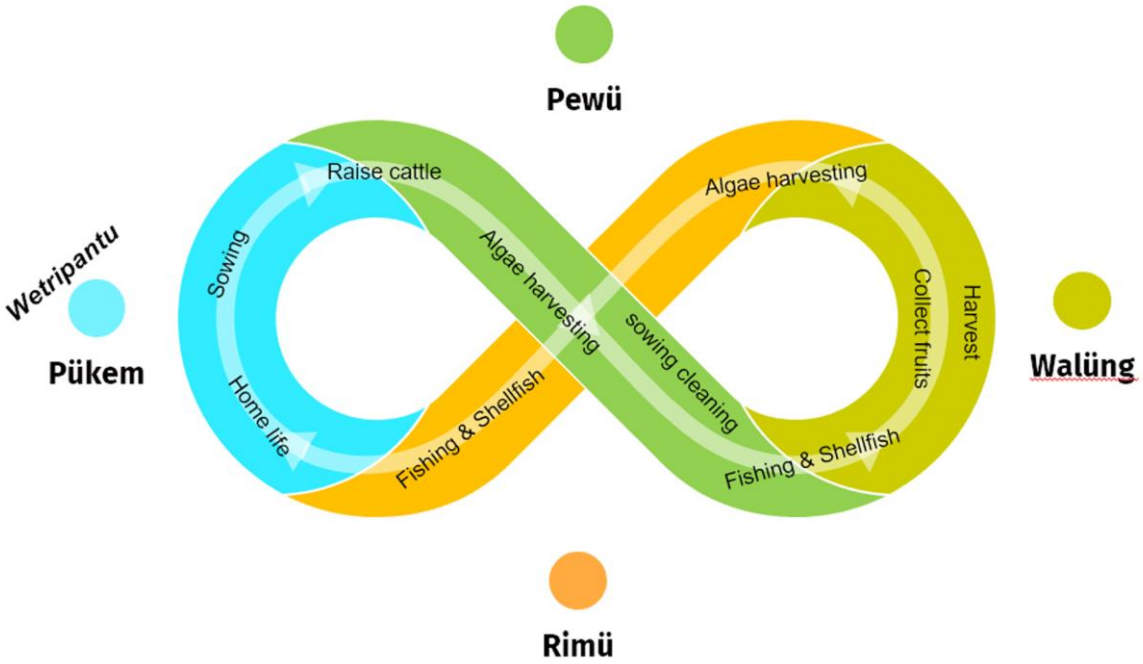

Figure 11. Lafkenche-Williche biocultural calendar. The colors indicate the seasons --Spring (*Pewü*), Summer (*Walüng*), Fall (*Rimü*) and Winter (*Pükem*)-- and the main cultural practices in each of them. In different seasons of the year, main cultural practices focus on specific *habitats* (marine-coastal, grasslands, or homes), involving characteristic life *habits* (eg, seaweed or shellfish harvesting, grazing, or handicraft making), and *co-inhabitants* (eg, seaweed, shellfish, or livestock) that represent biocultural keystone species. The *wetripantu* marks the beginning of a new year at the winter solstice, and involve several ritual activities. Figure: own elaboration.

Aymara biocultural calendar in northern Chile

Indigenous peoples in the high Andes of northern Chile have sustained models of life coupled with marked seasonal contrasts, which alternate rain and drought, heat and cold (Marsh 2015). For this coupling they have resorted built biocultural calendars that allow them to adapt to these cycles by closely observing the moon, the sun, and other stars. The sun is observed to interpret annual periods, while the moon is closely monitored to interpret shorter cycles (Lumbreras 2005). This type of observations is not restricted to communities inhabiting the mountains but they are also cultured by coastal communities. For example, facing the situation of the intensity of the tides on the coast, the moon is closely scrutinized to plan collection of shellfishes and seaweeds. These interpretations require spatial landmarks (such as rocks) and the behavior of species, such as flocks of seabirds ('pajaradas') that indicate the location of fish schools migrating close to the coast (Rubio and Castro 2019). This relationship between life, land, the sea and the cosmos dates back to the beginning of human settlement in South America. This knowledge still persists in indigenous and other local communities inhabiting coastal-marine habitats as well as with communities practicing agriculture in inland valleys or breeding camelids in high mountainous wetlands.

Today, increasing uncertainty is linked to climate instability. In the past there were also strong interannual oscillations in rainfall, no doubt on a different scale than currently (Squeo et al. 2006). However, they were multiannual patterns causing strong contrasts in productivity between very dry years and others that were very rainy, with a lower degree of predictability (Jara et al. 2022). The needs for calendars were essential, especially with agriculture, and the shamans played a fundamental role. Their accumulated knowledge and practices were intertwined with techniques and rituals to face unforeseen climatic changes. Biocultural calendars that covered long-term periods, beyond one year, acquired special relevance. These calendars were based on the knowledge shamans had about the differentiated movements between the sun and the stars. In its daily cycle, the sun moves from east to west. In its annual cycle, from winter to summer, the sun moves from north to south. Following solar time, each certain day there will be stars that will rise five minutes earlier, generating new constellations that are associated with changes in climate (Aveni 1991, in Lumbreras 2005).

The philosophy of the native peoples is foremost practical, a know-how. Andean worldviews entail social practices that involve human and other-than-human beings in the co-construction of biocultural landscapes as well as economic and religious practices (Mamani-Bernabé 2015, May 2015) (Figure 12). High Andean communities have inherited an ancestral way to understand their environment, where the world is alive and inhabited by positive and negative forces. For example, mountains (*achachila*), are ancestors and sacred sites (*mallku*). These sites make the reproduction of life possible and must be respected and remembered in rituals and offerings. Their seasonal changes are the changes of human time; this is how Aymara biocultural calendars have been forged.

Figure 12. "Floreo" or marking of llamas in the Lirima pampas. This ritual is a community practice to collectively mark the camelids (Photograph: Ximena Moreno 2008).

A notable case of a biocultural calendar is found in the Salar de Huasco and Pampas de Lirima (20°N, 69°W) on the northeast border of Chile with Bolivia at 4000 m altitude

(Figure 5). This area has large wetlands supported by underground saline aquifers that are home to a great diversity of native fauna such as flamingos and camelids (e.g., vicuñas, alpacas, and llamas) (Figure 13). Chilean anthropologist Ximena Moreno (2011) investigated ancestral cultural practices associated with high Andean wetlands that can be considered as "islands" within the desert region. These habitats have been used ancestrally for agropastoral uses related to changes in rainfall regimes. Combining ecological and ethnoecological methodologies, rainfall patterns have been identified at different altitudinal and ecological levels where pastoral activities are carried out allowing the conservation of biodiversity, phytomass, and functioning of ecosystems (Moreno 2011).

Figure 13. A. "Salar de Huasco," a salt flat dotted with ponds and salt marshes. It is seasonally covered providing habitat for a rich diversity of bacteria, small invertebrates, algae, and vertebrates that include camelids and one f the world's largest populations of the Andean flamingo (*Phoenicoparrus andinus*) as well as Chilean flamingo (*Phoenicopterus chilensis*). This habitat is particularly sensitive to changes in rainfall regimes that informed Aymara biocultural calendars (Photograph by Antonio Maldonado 2011). **B**. Pampas Lirima, a high Andean wetland that provides a key biocultural habitat for domestic camelids such as alpaca (*Lama pacos*) and llama (*L. glama*) two species of South American camelids domesticated in pre-Columbian

799 times. Alpaca and llama are kept in herds that graze on the high Andes and bred by Andean cultures for their
800 fiber, meat, and llama are also pack animals. (Photograph by Ximena Moreno 2010).
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The Huasco Lake Aymara Indigenous Association ("Asociación Indígena Aymara Laguna del Huasco", AIALH 2005) maintains Aymara pastoral practices as a grazing technique based on the seasonal transhumance of cattle which uses different ecological units in accordance with the concentration-abundance and dispersion-scarcity of fodder throughout the year. A synthesis of high Andean transhumance patterns attuned to local variations caused by the combination of ecological units that are particular in each basin was written by Johannes van Kessel (1992), a Dutch Catholic priest, sociologist and anthropologist, who investigated the Aymara cultural world for more than 45 years, especially in the high Andean Tarapaque region of Chile. Aymara transhumance patterns are organized in biocultural calendars that are adjusted to climatic variations from year to year. Their flexibility has enhanced practices of domestication and grazing of camelid herds that are compatible with the conservation of high Andean wetlands and a careful management of water (**Figure 14)**.

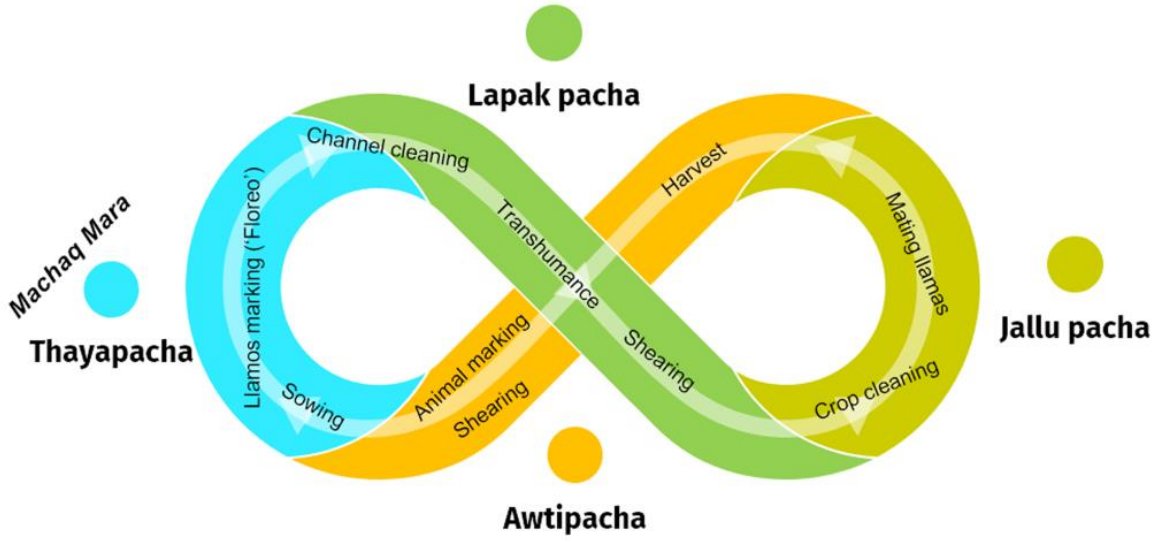

Figure 14. Aymara biocultural calendar. The colors indicate the seasons -Spring (*Lapak pacha*), Summer (*Jallu pacha*), Fall (*Awtipacha*) and Winter (*Thayapacha*)-- and the main cultural practices in each of them. In different seasons of the year, main cultural practices focus on specific *habitats* (high Andean wetlands), characteristic *habits* (e.g., transhumant grazing) and *co-inhabitants* (e.g, llamas, alpacas) that are biocultural keystone species. This calendar revolves around the breeding of camelids, but also integrates livestock of European origin, mainly sheep, always aiming for a balance calculated on the availability of water in the wetlands. Aymara festive cultural practices stand out, including the 'floreo' or marking of llamas in winter, and the *Machaq mara* celebration of the new year at the winter's solstice. Figure: own elaboration.

Pastoral management carried out in the Salar del Huasco has allowed to maintain an animal carrying capacity that has avoided overgrazing (Faúndez 2004). In contrast, in the Lirima pampas overgrazing is evident (Faúndez 2009). Is this degradation due to a loss of adaptability of biocultural calendars? Or is it due to other causes such as climate change or the introduction of cattle, goats and sheep? Regarding the first alternative, it is essential to evaluate the decline of biocultural calendars associated with losses of the Aymara language

by local populations. The disappearance of the language causes alterations in the synchronizations with nature (Faúndez 2009). The Chilean neoliberal model has precipitated the devaluation and oblivion of vernacular languages and knowledge, its economic and social model does not require peoples to have wisdom and to establish synchronies with the seasons and other species and elements of their environment (FSP 2019). Regarding the second alternative, the introduction of exotic domestic livestock has catalyzed processes of degradation and desertification. In recent decades, this degradation has been exacerbated by the negative impacts of decreased rainfall associated with climate change (González et al. 1991) and unregulated mining and tourism activities (Rocha and Sáez 2003).

Faced with multi-causal degradation processes, local ecological knowledge represents an alternative to confront climate change (Ricardo and Macedo 2004). The task of caring for water and biodiversity in the high Andean wetlands is urgent. This leads us to reassess the Andean philosophy with its community feelings and bonds, including experiences of co-inhabitation with other-than-human species. Current changes have altered customary high Andean cultural patterns or have directly expelled from their native habitats indigenous communities that had to migrate to cities (Gómez et al. 1997). To reverse this process, it is essential to stop land-grabbing and neo-extractivist waves in Latin America (Rozzi 2015a), and to recover the ability to learn from the elements of nature and that the stars, mountains, animals and plants recover their agency in human social life. In this way, biological diversity and cultural diversity will once again be intimately related and synchronized, and will open up opportunities to adapt to sudden and unforeseen changes that put at risk access to elements as essential as water.

Andean worldviews are based on respect, affection and gratitude for the land, water and all living beings that share their habitats (Gómez et al. 1997). The concept of diversity acquires a fundamental role in these cultures, as it is associated with socioeconomic and cultural diversity. This concept can be safeguarded with the programs of natural and cultural heritage initiated by the UNESCO World Cultural and Natural Heritage Convention in 1972 (Bridgewater & Rotherham 2019). UNESCO (1992) recognizes the exceptional value that diversity has in three dimensions for the identity and well-being of peoples: i) ecological, including genetic, species and ecosystem diversity; ii) socioeconomic including the diversity of individual organizations and social systems); and iii) cultural, including ethnic and human community diversities that are the basis for obtaining social equity (Romero 2001; Castro and Romo 2006). Heritage includes all those goods that represent for a human group its cultural heritage and the reinforcement of its identity. For the high Andean communities, rituals transmit, reinforce and deepen ancestral knowledge and practices that warn that the world is alive and inhabited by positive and negative forces (Castro 2021). These rites are significantly affective exercises, where the human desire is irrigated towards others, such as the mountains themselves (Gómez et al. 1998). In this way, native people of northern Chile have known how to adapt to climatic changes in the past and could do so today together with the other species with whom they co-inhabit the coast, the desert, and the mountains.

A brief synthesis of the four biocultural calendars: the vital links among co-inhabitants, their life habits and shared habitats

Cultural practices and socio-environmental changes in southwestern South America combine cycles of harvesting, fishing, agriculture, and grazing organized in biocultural calendars marked by keystone biocultural species. The relations of co-inhabitation are clearly exemplified by the links among co-inhabitants, their life habits and shared habitats illustrated in Table 1.

Table 1. Relationships among habitats, habits, and co-inhabitants in the four biocultural calendars examined in southwestern South America, Chile.

Local community /Territory	Habitats	Habits	Co-inhabitants
Yagan indigenous community / Cape Horn Biosphere Reserve	Marine coastal ecosystems	Collection of Chilean king crab and other species of shellfish	Chilean king crab (*Lithodes santolla*), mussels (*Mytilus chilensis*)
	Wetlands	Rushes gathering and basketry	Rushes (*Marsippospermum grandiflorum*), snipe (*Gallinago paraguaiae*).
	Forests	Collection of fungi and bark of Evergreen beech for the manufacture of artisanal canoes	Katran or LlaoLlao (*Cyttaria spp.*), "Coigüe de Magallanes" or Evergreen beech (*Nothofagus betuloides*), Magellanic woodpecker (*Campephilus magellanicum*)
Artisanal fishers / Chiloe archipelagoes	marine coastal ecosystems	Seaweed harvesting and fishing	Red seaweeds (*Agarophyton chilensis, Sarcothalia crispata*), Giant kelp (*Macrocystis pyrifera*), Chilean sea urchin (*Loxechinus albus*), Patagonian blennie (*Eleginops maclovinus*), Pink cusk-eel (*Genypterus blacodes*)
	Pasture lands	Potato farming and sheep shearing	Potatoes (*Solanum tuberosum*),Sheep (*Ovis aries*)
Lafkenche-Williche Indigenous communities / Coastal areas of central southern Chile	Marine coastal ecosystems	Shellfish and seaweed harvesting	Giant kelp (*Macrocystis pyrifera*), "cochayuyo" or southern bull kelp (*Durvillaea antarctica*), limpet (*Fissurella spp*).
	Pasture lands	Breeding of cattle, goats and sheep	Sheep (*Ovis aries* y goat (*Capra hircus*), cattle (*Bos taurus*)
	Family homes	Wool weaving using looms built with native laurel	Sheep (*Ovis aries*), *trihue* or "Chilean laurel" (*Laurelia sempervirens,*)
Aymara indigenous communities / High-Andes of northern Chile	High-Andean wetlands ("bofedales")	Breeding of native camelids and other livestock species of European origin	Llama (*Lama glama*), alpaca (*Vicugna pacos*), sheep (*Ovis aries*), cows (*Bos taurus*), Guayata (*Chloephaga melanoptera*), Andean flamingo (*Phoenicoparrus andinus*), Chilean flamingo (*Phoenicopterus chilensis*).

The four biocultural calendars examined in this article exhibit particular environmental characteristics in which different species have habits that are sensitive to seasonal cycles. In the extreme south, in the Yagan territory included in the Cape Horn Biosphere Reserve, cultural practices in the marine-coastal environments, forests and wetlands are respectively

organized based on the behavior of crustaceans (such as king crabs), the growth of rushes or the lightness that the sap acquires in the evergreen beech or "coigüe de Magallanes" during spring. The latter is vital because it allows extracting the bark of these trees –without damaging them- to make artisanal canoes today, and in the past canoes to navigate through the channels. Interspecies coordination involves numerous species that are co-inhabitants. However, the southernmost region of the Americas is undergoing important changes that put at risk the possibilities of synchronization with nature. A main threat is the possibility that the salmon industry settles in the pristine waters of the channels of the Cape Horn Biosphere Reserve. Exotic species are seriously impacting the forests and wetlands and the local biodiversity, both terrestrial and marine, of this reserve (Crego et al. 2015; Schüttler et al. 2019, Maldonado-Márquez et al. 2020). Added to this is a phenomenon of biocultural homogenization that is eroding the heterogeneity of knowledge and habits that are an essential part of the history of these southern archipelagos (Crego et al. 2018).

In the Chiloé archipelago, the habits of peasant-fishermen link marine and terrestrial habitats in co-inhabitation with multiple species. They synchronize their life habits with those of species that are of vital importance to their survival, such as shellfish in the sea or potatoes on land (Table 1). However, today this territory is seriously affected by salmon farming, which has had cultural, social and biophysical impacts such as harmful algal blooms that impact the economies of thousands of artisanal fishing families and affect native species (Armijo et al. 2020). Traditional life models are weakening due to these socio-economic transformations that have motivated the migration of young people from rural areas to cities, abandoning the knowledge and cultural practices of their ancestors. Those who have remained on the islands are elderly people who have limitations in transmitting their knowledge and traditional life habits (FSP 2016, 2018).

In the Lafkenche territory, cultural practices are developed that are synchronized with the coastal and terrestrial nature of common property. Harvesting seaweeds, such as "cochayuyo" or southern bull kelp (*Durvillaea antarctica*), involves synchronizing harvesting and drying habits with the periods in which the seaweeds grow (Table 1). In addition, the climate that allows them to be dried on the shore for storage and marketing is considered; otherwise it would rot. Shellfish that live attached to the rocks in the middle of large algae are also collected on the beach. On land, livestock and minor agriculture occurs in co-inhabitation with birds and other species that synchronize their habits to a greater or lesser extent. And at home, families transform the wool of their sheep into beautiful loom work in an environment where they also live interdependently with post-Columbian domestic animals such as cats, dogs and pigs. However, as is the case in the aforementioned territories, the habitats and species with which the Lafkenche and Williche have interwoven their habits of life are today being altered by numerous threats (Le Bonniec et al. 2017). For example, the grabbing of land ownership for the installation of forestry monocultures with exotic species, especially eucalyptus and *Pinus radiata* (Andrade 2019). The massive substitution of native forests by exotic monocultures causes severe losses of biodiversity, soil erosion, and compactness and is detrimental to the hydrological cycle, provoking floods during winter and droughts during summer (Salas et al. 2016). A strong migration of

rural population to urban centers is promoted because of the following: (1) Small owners have sold their lands to the tree companies; the consequent concentration of the land ownership has entailed displacement of local communities. (2) Forestry plantations require less labor than other agriculture, and labor is required only during intermittent years for planting, thinning, and cutting. (3) Most of the labor force comes with companies from other regions of Chile. (4) Other multiple uses and values of native forests are eliminated. Today, Mapuche resistance movements demand recovering access to the land, restoring native forest and its natural water cycles that have been disrupted significantly by the forestry plantations, and autonomy and opportunities for framing their own development strategies (Torres-Salinas et al. 2016). The Mapuche environmental justice movement offers an example to the world of how to defend biocultural conservation as an alternative to biocultural homogenization (Rozzi 2018).

Finally, in the extreme north, the delicate water balance of the Andean bofedales is carefully managed by the Aymara families through a system of transhumance cattle ranching of camelids (whose demand for water is low), but including cattle of European origin that put in tension the availability of this element (Table 1). The habits of human beings and other-than-humans are intertwined in a complex scenario where other uses, such as mining, put these wetlands and their biodiversity in check (Moreno 2011). On the other hand, the accelerated depopulation of Andean rural areas produces their aging and the precariousness of ancestral cultural practices (FSP 2019). These problems imply that these peoples are losing their biocultural calendars.

3 Conclusions

In this article we have combined conceptual frameworks of ecological calendars (Bulbulshoev et al. 2011) and of the biocultural ethic (Rozzi 2013). The first, also known as natural or phenological calendars or seasonal calendars, focuses on the temporal scale of life cycles and other ecological phenomena observed at a given place. Ecological calendars are “knowledge systems to measure and give meaning to time based on close observation of one’s habitat” (Kassam et al. 2018, p. 250). Through close observation, ecological calendars help to synchronize the rhythms of nature and the rhythms of cultures. This is particularly relevant in the context of climate change because by being locally attuned, ecological calendars enhance the capacity of local communities to accommodate their activities to climate trends and increasing variability. By combining the conceptual frameworks of ecological calendars with the 3Hs model of the biocultural ethic, we gain more resolution in three relevant dimensions.

First, we gain more resolution about the spatial dimensions. As shown in Table 1, the 3Hs model helps to link specific activities (*habits*) and species (*co-inhabitants*) to specific *habitats*. Hence, the combination of ecological calendars with the 3Hs model of the biocultural ethic enables an integration of space and time. This integration is especially relevant for patterns of transhumance of communities and fauna that move along latitudinal or altitudinal gradients, such as the pastoral life habits of Aymara people and their camelids in high Andean habitats (Table 1). This coupling of space and time may be particularly helpful to design and adapt local practices to climate change trends and variability.

Second, we gain more resolution regarding the links between different life habits and different habitats and season. Life habits are understood as a *modus vivendi* and it gives agency not only to humans but also to other-than-human species (Rozzi 2018, p. 27).For example, the life habits of gathering rushes and weaving baskets by handcrafters of the indigenous Yagan are attuned to the life cycle of the Tall Rush (*Marsippospermum grandiflorum*) (Table 1). In turn the time for gathering rushes is indicated by the observation arrival of migratory snipes and stories told about this bird in the Yagan cosmogony (Rozzi et al. 2003). The attention on life habits of human and other-than-human beings leads to a clearer understanding about the coupling between biological (or ecological) patterns and patterns of material and symbolic culture. This understanding motivated us to use the term biocultural calendars, which makes explicit the dialectical interrelationships between biological and cultural dimensions. We found this term used only in a Master thesis (Landwehr 2019), and we suggest that it would be valuable to further develop the concept of biocultural calendars.

Third, by paying attention to co-inhabitants we gain more resolution about biocultural keystone species. A clear identification of biocultural keystone species is helpful to design and adapt local practices to climate change and more broadly to social-environmental change. For example, the red alga *Sarcothalia crispata* has become the focus of novel management programs informed by ecological calendars designed by fishers and scientists (Avila et al. 1996). In the 1980s in the archipelagoes of Chile, this seaweed was initially harvested and exported as raw material for the production of carrageenan. By working with women of fisher communities, a culture based on this red alga was created and sustainable seaweed-harvesting programs were established with a precise but flexible calendar for repopulation, cultivation, harvesting, and commercial activities (IFOP 2013). Biocultural keystone species may also serve as ideal flagship species for conservation. Confronted with the complexities of climate change, the focus on certain species enhance the appeal and facilitates the design of management program. Finally, calling these species "co-inhabitants" stimulates an ethical appreciation in terms of their agency and the role local communities have, and we all should have, as earth stewards (Rozzi 2015a).

For the study of the causes of climate change we must forge both technological instruments and conceptual tools. In this article we have combined concepts associated with ecological calendars and biocultural ethics that have both theoretical and applied value. Theoretical to guide the investigation of biocultural systems in their complexity. Practical value to orient the design of habitat conservation programs that are essential for the continuity of life habits that contribute to the well-being and identity of the co-inhabitants.

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Conflict of interest (COI)

The authors have no conflicts of interest to declare.

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NATIVE AMERICAN AND OTHER
TRADITIONAL ECOLOGICAL WORLDVIEWS

BIO-
PHYSICAL

INSTITUTIONAL-
SOCIO-POLITICAL

co-in-Habitants

Habitats

Habits

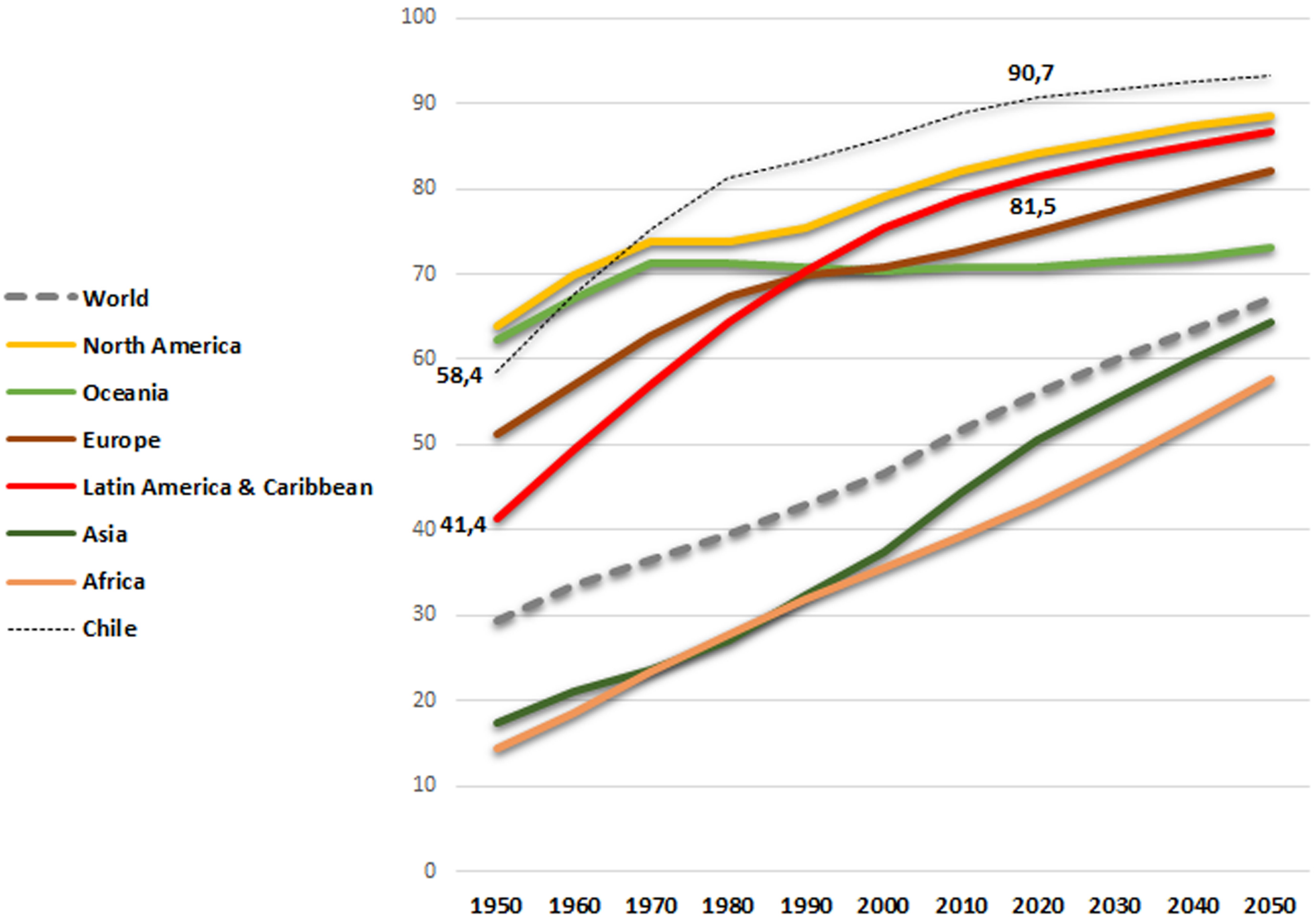
The
Biocultural
Ethic

SYMBOLIC-LINGUISTIC-
CULTURAL

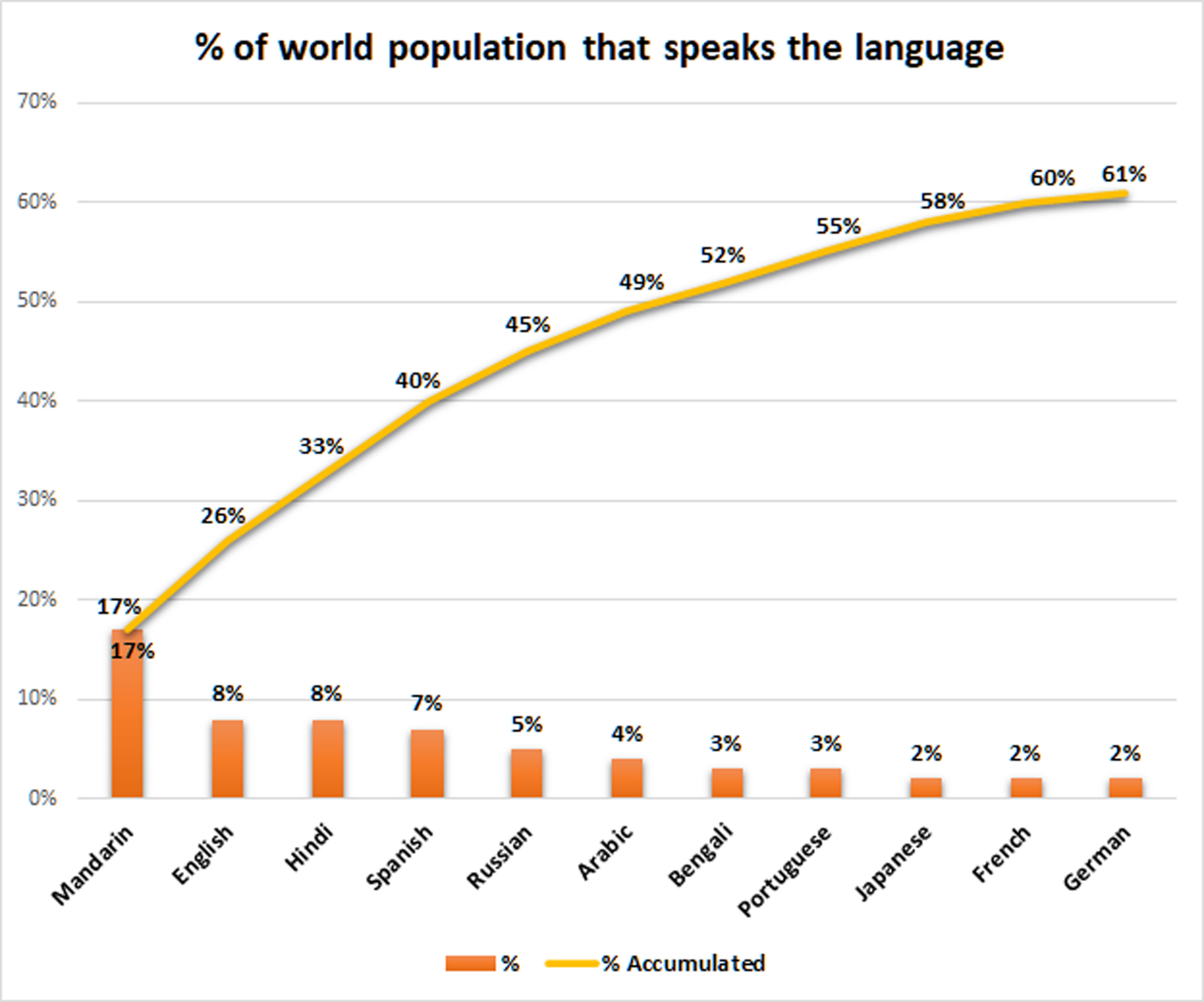
PRE-SOCRATIC AND OTHER
NON-MAINSTREAM PHILOSOPHIES

CONTEMPORARY ECOLOGICAL
SCIENCES

Urban population (%)



% of world population that speaks the language

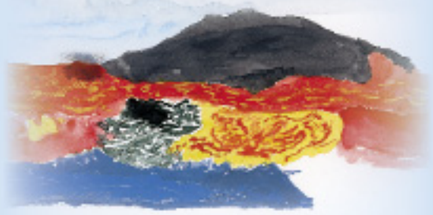


Iahakisi
Primavera

Spring

Kisi
Verano

Summer



Hanihlush
Otoño

Fall

Ina
Invierno

Winter

Ilustraciones niñas y niños Taller "Hen larnanauti, hen maruti, intien usi"
VILLA UKIKA, ISLA NAVARINO, Año 2003

Hen larnanauti, hen maruti, intien usi
Aprendamos, escuchemos el mundo yagán
Learning, listening the Yahgan world

Cristina Zárraga, Francisca Massardo & Ricardo Rozzi

EDICIONES DE LA UNIVERSIDAD DE MAGALLANES

N

Lirima salt flat
Huasco salt flat

Northern Chile

Chile

Lafkenche-Williche territory

Chiloé archipelago

Southwestern Patagonian fjords

Cape Horn Biosphere Reserve

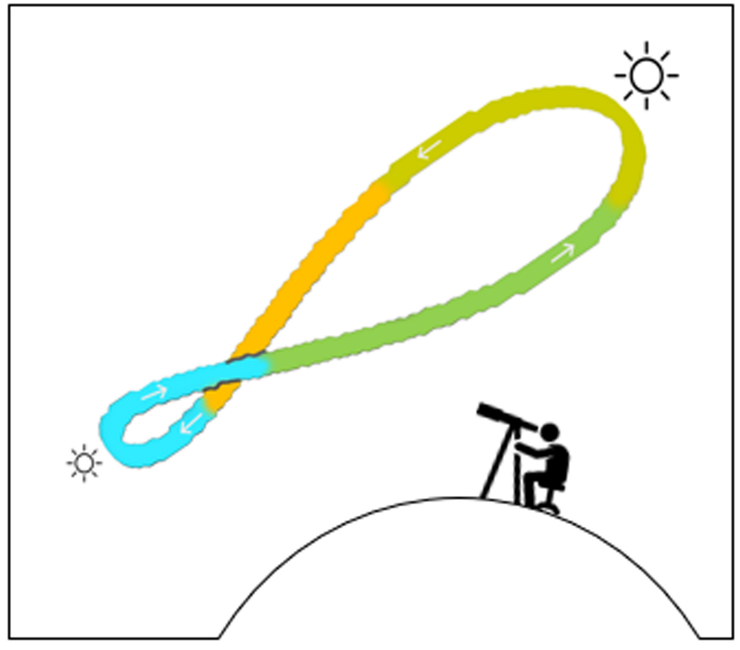
500 km

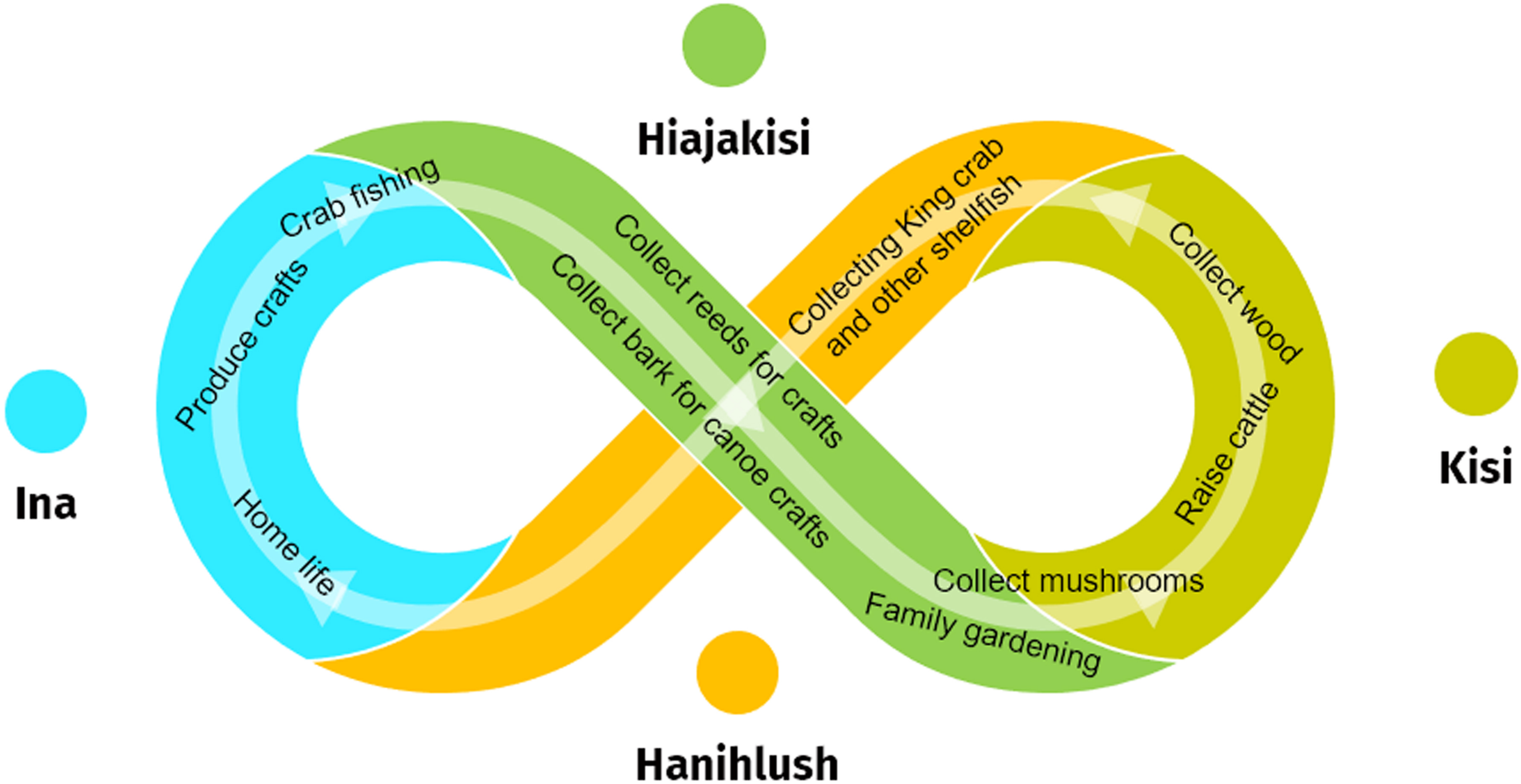
Spring

Winter

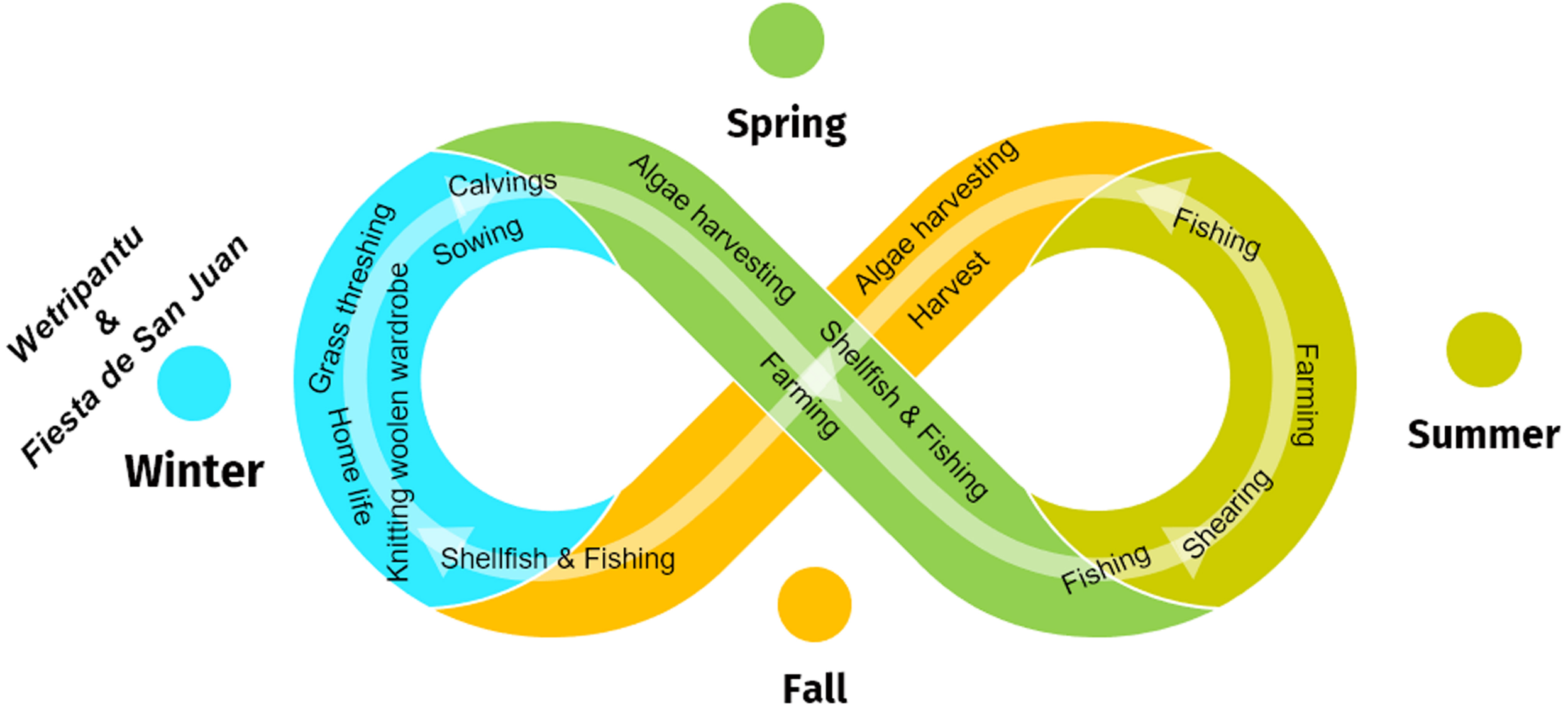
Summer

Fall




Hiajakisi
Ina
Kisi
Hanihlush
Crab fishing
Produce crafts
Home life
Collect reeds for crafts
Collect bark for canoe crafts
Collecting King crab and other shellfish
Collect wood
Raise cattle
Collect mushrooms
Family gardening

FUTALAFQUEN
MC 739


Spring
Wetripantu
&
Fiesta de San Juan
Winter
Summer
Fall
Calvings
Sowing
Grass threshing
Home life
Knitting woolen wardrobe
Shellfish & Fishing
Algae harvesting
Shellfish & Fishing
Farming
Algae harvesting
Harvest
Fishing
Farming
Shearing
Fishing

Pewü

Wetripantu

Raise cattle

Algae harvesting

Sowing

Home life

Fishing & Shellfish

Algae harvesting

sowing cleaning

Fishing & Shellfish

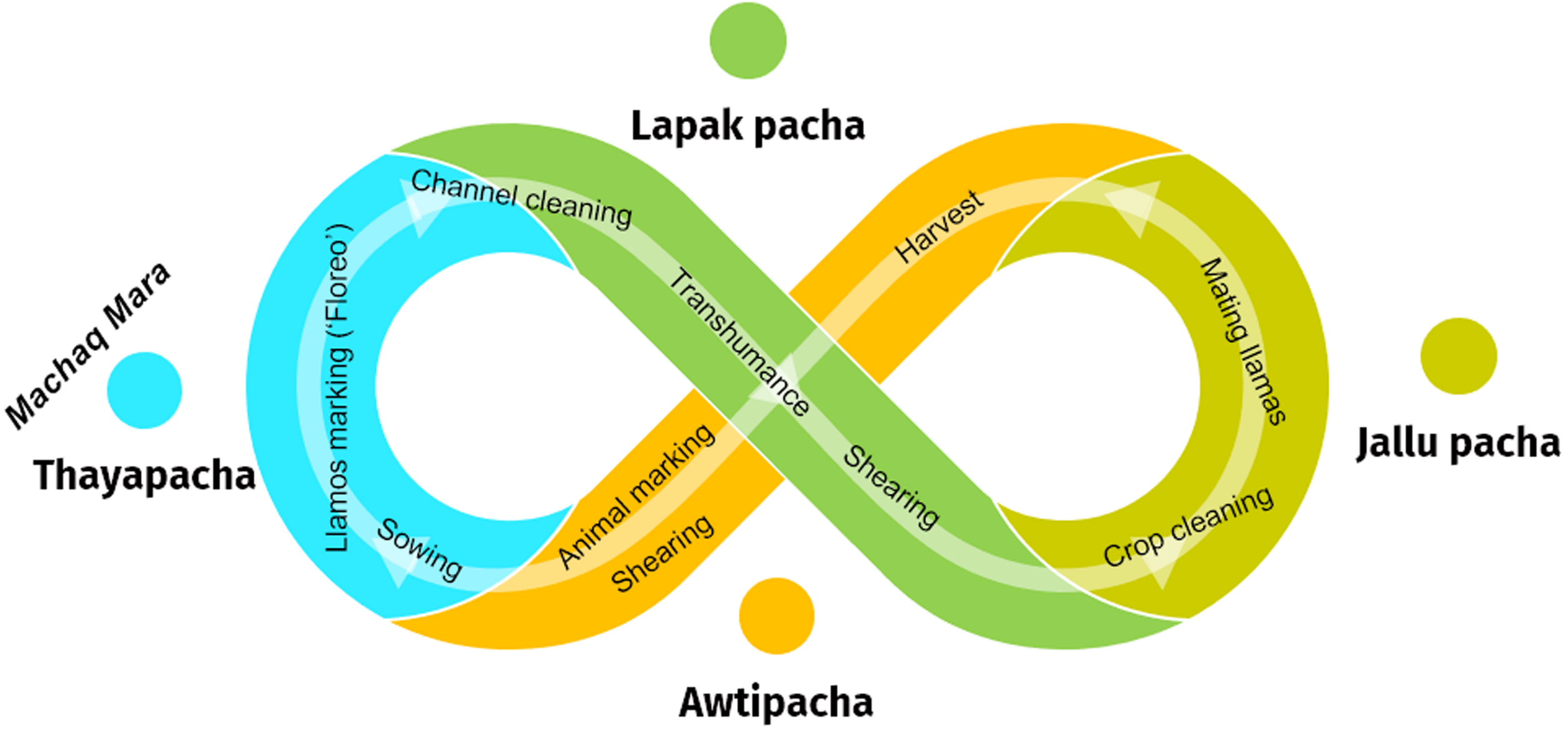
Collect fruits

Harvest

Pükem

Walüng

Rimü


Lapak pacha
Machaq Mara
Thayapacha
Jallu pacha
Awtipacha
Channel cleaning
Transhumance
Harvest
Mating llamas
Llamos marking ('Floreo')
Sowing
Animal marking
Shearing
Shearing
Crop cleaning