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Agronomic design of a subway walipini-type greenhouse for the application of permaculture in high Andean moorlands

Diseño agronómico de un invernadero subterráneo tipo walipini para la aplicación de la permacultura en páramos altoandinos

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Abstract: This research proposes an agronomic design for a walipini, or subway greenhouse, in an Andean paramo zone; for which, the conditions for its implementation, agricultural and hydraulic operational indicators, including integrated pest and disease management, are analyzed. The proposed size is 20 x 5 x 2 m, with tomato, sweet potato, chard and bell pepper planting in the beds; and plantain, mint, chamomile, oregano, sweet grass, basil, aloe, passion fruit, and strawberries on the walls. The feasibility of its implementation is determined, with the subsequent application of the principles of permaculture and agroecology, to contribute to the food sovereignty of the communities of the high Andean zones.

Keywords: Agronomical design, subway greenhouse, walipini, permaculture

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Resumen: La presente investigación propone un diseño agronómico para un walipini, o invernadero subterráneo, en una zona de páramo andino; para lo cual, se analizan las condiciones para su implementación, los indicadores operacionales agrícolas e hidráulicos, que incluyen el manejo integrado de plagas y enfermedades. El tamaño propuesto es de 20 x 5 x 2 m, con siembra de tomate, camote, acelga y pimiento en camas; y de llantén, menta, manzanilla, orégano, hierba buena, albahaca, sábila, granadilla, y frutillas en las paredes. Se determina la factibilidad de su implementación, con la subsecuente aplicación de los principios de permacultura y agroecología, para contribuir a la soberanía alimentaria de las comunidades de las zonas altoandinas.

Palabras clave: Diseño agronómico, invernadero subterráneo, walipini, permacultura

Introduction

High Andean moorlands offer a number of ecosystem services; however, they are currently threatened by changes in land cover, expansion of the agricultural frontier and cattle ranching due to the population increase of rural communities who must build houses, crops and grazing activities in even higher areas for their survival (Chuncho-Morocho & Chuncho, 2019)..

In addition, climate change affects the páramos and also current agricultural systems, including reductions in food production of 10-15% (IPCC, 2022). (IPCC, 2022).. Given this reality, there is a need for research and action for the implementation of resilience strategies with a sustainable approach aligned with environmental governance; of these permaculture and agroecology recognize the social and cultural contribution of traditional farmers considering environmental care, social justice and economic viability (Armijos-Arcos et al., 2023; Cuadras-Berrelleza et al., 2021)..

As a viable alternative in the high Andean communities, subway greenhouses also known as walipinis, panqar huyu, sayaris or muya urkus are established as a viable alternative for agriculture because they generate a favorable microclimate and can implement irrigation and energy efficiency strategies in places that have extreme thermal amplitudes, strong winds and water scarcity. (Armijos-Arcos et al., 2023; FAO, 2012; Iturry, 2002)..

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Then, a walipini has the capacity to provide the population with food security and food sovereignty, i.e., that "people have at all times physical and economic access to sufficient, safe and nutritious food to meet dietary needs, in order to lead an active and healthy life." (Gordillo & Obed Méndez, 2013).

The objective of this research is to propose an agronomic design for a walipini, which implies defining the set of data and proposals related to the productive part of species of agricultural and economic interest to facilitate decision making in the planning of planting, rotation, association, management and irrigation to be implemented.

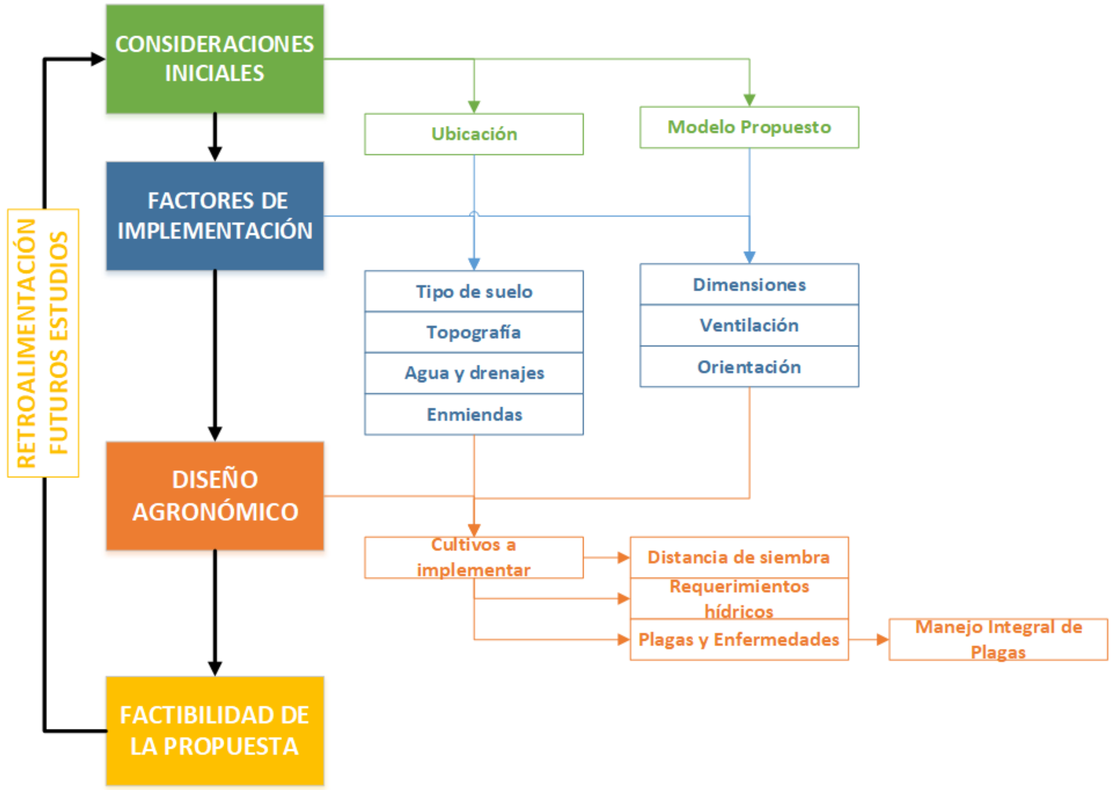
Materials and methods

The present research is applied, since it uses knowledge and know-how for the practical solution of the problem of agricultural production in high Andean zones; exploratory, since it generates the general image of the implementation of a walipini that will serve for future and more complex applications; qualitative, since it seeks to understand the reality of the agronomic design by determining the species to be planted and their respective problems; and field research, since the data collection is based on the characteristics of the Guamote canton (Editorial Etecé, 2021). (Editorial Etecé, 2021).

In turn, the techniques used, being a qualitative research are: direct and unstructured observation, to determine the feasibility of the implementation of the proposal and the collection of information from the site; and bibliographic research, which explores what is written about the crops to be analyzed and the support and support of the design for the walipinis (Montagud Rubio, 2020). (Montagud Rubio, 2020).

The research will take into account four steps, as shown in Figure 1, and detailed below.

Figure 1. Methodology for the proposed agronomic design of the



Walipini.

Source: Authors, 2023

The parishes of La Matriz and Palmira in the Guamote canton of the province of Chimborazo, which have high Andean climatic and geological characteristics, are considered as the implementation point.

According to (GADMG, 2019; GADPCh, 2018; Lara Vásconez, 2020; MAGAP, 2013) for the canton Guamote it is found that most of it is dedicated to Conservation and Production, mainly by the unaltered and altered herbaceous moorlands (52.5%); it is followed by Livestock use (16.In third place is the very altered humid herbaceous vegetation, which corresponds to a Conservation and Production use (13.5%), which has been affected by the introduction of livestock, and in fourth place is agricultural use (9.3%) with a predominance of barley, beans and potatoes; and the rest (8.6%) is for other uses.) The size of typical

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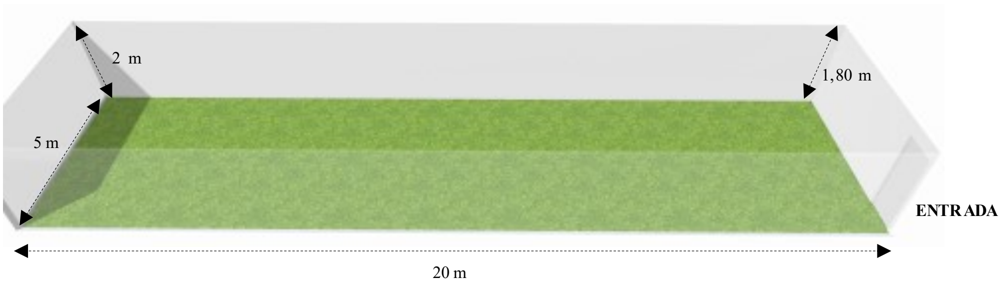
plots is small, up to 5 hectares, with a total area of 30002 ha, which corresponds to 78.7% of identifiable and applicable plots, with an average of 3.35 ha per Productive Unit. Regarding irrigation, only 28.9% of the identifiable units in the canton have been identified as irrigation systems. Additionally, according to in-situ observation and bibliographic compilation, it is established that the canton's production is maintained by the family nucleus, and each household seeks to produce different crops, and 39.5% of the production is destined for self-consumption with 60.5% destined for the market, with occasional salaried labor.

The initial model proposed for the agronomic and hydraulic design of walipini-type subway greenhouses is 20 m long and 5 m wide, with heights of 1.8 m to 2 m, i.e., a cultivation area of 100 m2, with use of the structure of the walls for vertical gardens, which will be used for family consumption. As shown in Figure 2.

Figure 2. Walipini model dimensions



Source: Authors, 2023

For the implementation of walipinis the (FAO, 2012) indicators should be considered as soil, topography, orientation, dimensions, water and drainage, ventilation, and amendments as detailed in Table 1.

Table 1. *Indicators of walipini implementation*

Indicator	Definition	Unit
Soil	The predominant factor is recommended in loam soils, which are more clayey than sandy. They should not be permeable soils	Type of soil
Topography	The slope of the land will define the orientation and should allow for excavation and construction of walls and berms if necessary. Flood zones should be avoided.	Pending

Orientation	Related to the use of sunlight so that the long section points from east to west. It must be protected from the wind, so the direction is analyzed, and it is not recommended that the lower part of the roof points towards the wind.	Address
Dimensions	Varies according to the type of production	Meters
Water	The amount of water will depend on the type of crop, plant development and production. Harvesting methods play a fundamental role in trapping and redirecting surface and rainwater.	Cubic meters
Drainage	Infrastructure to control and reduce the effects of soil salinity caused by continued irrigation.	Cubic meters
Ventilation	Opening of windows that allow the regulation of temperature and humidity inside the walipini, taking into account that sufficient heat must be stored to contrast the low temperatures at night.	Degrees Celsius
Amendments	Incorporation of a homogeneous mixture of soil with animal and vegetable manure to obtain a nutrient-rich soil.	Kilograms

Source: Based on. (FAO, 2012; Iturry, 2002).

The agronomic design is the first phase for the study of the potentialities and limitations of soil and water resources under the climatic conditions of a place, based on the interests and preferences of the farmers (Villafañe, 1998). (Villafañe, 1998).. Based on this and the agrometeorological conditions of the sector, drainage needs and irrigation management strategies are designed, with the objective of reducing costs and increasing the quality and quantity of irrigation (Olivares & Torrealba, 1998). (Olivares & Torrealba, 2011).. The indicators to be used are shown in Table 2.

Table 2. *Operational performance indicators for a walipini*

Indicator	Definition	Unit
Cultivation	Agricultural product or crop are plants that can be grown and harvested extensively for profit or subsistence.	Species and family
Altitude	It generates an arrangement of vegetation formations in tiers, since the higher the	a.s.l.m.

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	altitude, the higher the precipitation and the lower the temperature.	
Optimum temperature	It affects the rate of plant development through its various stages and the production of leaves, stems and other components.	Degrees Celsius
Energy efficiency	Sourced from the roof surface to capture solar energy and create a microclimate	W/m^2
Harvest time	Harvesting is the separation of the mother plant from the plant portion of interest at the appropriate time.	Days
Water requirements	Water supply is one of the determining factors for plant development and production. Which is different from the phases: germination, development, maturation and harvest.	Lt /plant/day
Sowing distance	Factor to determine the area to be occupied by the garden, where to place each crop and how many plants can be placed.	cm
Pests	Organisms that compete for cultivated food are a constant threat to crop development, but also include damage to health, property and resources for other living things.	-
Diseases	Processes that alter the metabolism of plants causing symptoms, thus affecting plant growth or development from sowing, transplanting or planting until after harvest.	-
Performance	The ratio of total production of a certain harvested crop per hectare of land used.	kg/ha

Source: Based on. (Deguine et al., 2021; López, 2003; Muñoz, 2019; Pereira et al., 2021; Rawson & Gómez, 2001; Rivera & Wright, 2020).

In addition, pest and disease control follows the precepts of Integrated Pest Management to consider available techniques and the subsequent integration of appropriate measures to reduce the development of pest populations and reduce diseases. (Oyarzún et al., 2002).

Feasibility is analyzed according to the parameters of technical analysis, environmental impact assessment and socio-economic impact assessment according to the top-down and down-top approaches of (Dey, 2001).

Result

Given that walipini is destined for family consumption (MAGAP, 2013) based on permaculture principles (Armijos-Arcos et al. (Armijos-Arcos et al., 2023) vegetables, fruit trees, edible plants, aromatic and medicinal plants should be integrated. Table 3 shows the proposed species and their requirements.

Table 3. *Selected Species and Requirements*

Cultivation	Temp (° C)	pH	Harvest (Days)	Water Req. Water (l/plant/day)	Sowing distance (cm)	References
Sweet potato	20 - 35	6-6,5	80 - 125	3,3	30 - 40	(Cobeña Ruiz et al., 2017).
Chard	15 - 25	7	60 - 80	0,56	25 - 30	(Rodriguez-Chiunti & Vidal-Gamboa, 2021)
Bell pepper	20 - 25	6,5-7	35 - 50	-	25 - 30	(Eguez Enriquez et al., 2022).
Tomato	18 - 27	5-6,8	90 - 100	1,8 - 2,7	40 - 60	(Tamayo-Ruiz et al., 2020).
Strawberry	10 - 20	6,5-7,5	150 - 180	0,25	20 - 30	(Morales et al., 2017)
Granadilla	14 - 24	6-6,5	365	3	400 x 400	(Gaona-Gonzaga et al., 2020).
Mint	20 - 25	5-7,5	-	-	20 - 30	(Barral Espejo, 2020)
Beets	8-25	6,2-7,5	70-80	0,88	18-22	(Rattin et al., 2022).

Carrot	16-18	5,5-7,0	115-120	0,125	10-15	(Forero Ulloa et al., 2015).
Chamomile	15 - 20	5,8-7,5	-	-	20 - 30	(Ramírez-Navarro et al., 2022).
Plantain	15 - 22	7	60	-	10 - 20	(Ramirez et al., 2018)
Aloe	17 - 27	6,5-7,5	360	-	60 - 100	(Khajeeyan et al., 2019)
Oregano	15 - 20	6,5-7,5	60 - 90	-	50	(National Forestry
Good Grass	15 - 30	6,5-7,6	30	-	20 - 25	(Quintero, Julian, 2016)
Basil	20 - 25	4,3-8,2	-	3	25 - 40	(Ojeda-Silvera et al., 2015).
Miramelinda	18	6.1-7	39-60	-	-	(Amaya-Santana & Martinez-Vanegas, 2022)

Source: Authors, based on the above references

Water supply is one of the limiting factors for the development and production of plants, since they must fulfill their entire vegetative cycle of germination, development, maturation and harvest. Therefore, to meet the needs, an irrigation lamina of 3 mm will be required in vegetable species, so as to cover the superficial roots, and that of fruit trees that exceed 60 cm in depth.

Drip irrigation is preferred, where for the specified area 175 drippers of 1.6 l/h at distances of 20 cm and an irrigation time of 23 minutes are required. This may vary according to the arrangement of the beds.

Based on Integrated Pest Management, the possible organisms that attack the plants must be identified, and thus propose an effective attack in harmony with socio-environmental responsibility and productivity. Tables 4 and 5 show the pests and diseases to which a wallipini can be subject.

Table 4. *Pests by species implemented in a* walipini

Common Name	Species	References
White Spider	Bell pepper Tomato Mint	(Chemonics International, 2008; Gallardo A., 1993; University of Puerto Rico, 2018).
Red Spider	Bell pepper Tomato Strawberry Strawberry Blueberry Beet Mint Aloe Oregano Basil Basil	(Chemonics International, 2008; National Forestry
Stem borer	Strawberry	(Quintana et al., 2022).
Blind Hen	Sweet Potato Strawberry	(Cobeña Ruiz et al., 2017; Perdomo, 2019).
Wireworm	Sweet potato Chard	(Cobeña Ruiz et al., 2017).
White worm	Chard	(Vallejo Amaya, 2013)
Budworm	Strawberry	(Perdomo, 2019; Quintana et al., 2022).
Fruit worm	Strawberry	(Morales et al., 2017; Perdomo, 2019).
Gray Worm	Chard	(Vallejo Amaya, 2013)
Heliothis	Bell pepper Tomato	(National Forestry Commission, 2006)
Leafminer	Tomato, Beetroot Basil	(Bernal Areces et al., 2012; Chemonics International, 2008; Demanet Filippi & Canales Cartes, 2020).
Whitefly	Sweet Potato Aloe Herb Buena Herba	(Cobeña Ruiz et al., 2017; Japón Quintero, 1985; Romero et al., 2010).
Beet fly	Chard, Beets	(Rattin et al., 2022; Vallejo Amaya, 2013).
Flower bud fly	Granadilla	(Gaona-Gonzaga et al., 2020).
Tomato moth	Tomato	(Chemonics International, 2008; Flores et al., 2012).

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Aphids	Sweet potato Chard Chard Pepper Tomato Strawberry Strawberry Mint Chamomile Chamomile Aloe Grass Basil	(Bernal Areces et al., 2012; Cobeña Ruiz et al., 2017; Flores et al., 2012; Gallardo A., 1993; Sádaba Díaz de Rada et al., 2004).
Flea	Chard	(Vallejo Amaya, 2013)
Green Doughnut	Bell pepper Beets	(National Forestry Commission, 2006; Demanet Filippi & Canales Cartes, 2020).
Trips	Bell pepper Strawberry Passionfruit Passionflower Mint Chamomile Basil	(AGEXPORT, 2017; Bernal Areces et al., 2012; Gaona-Gonzaga et al., 2020; UNIDO, 2015; University of Puerto Rico, 2018).

Source: Authors, based on the above references

Table 5. *Diseases of the species implemented in the* walipini.

Causal Agent	Species	Reference
Albugo ipomoeae	Sweet potato	(Cobeña Ruiz et al., 2017).
Alternaria solani /alternata	Granadilla Tomato	(Chemonics International, 2008; Flores et al., 2012; Gaona-Gonzaga et al., 2020).
Aphanomyces cochlioides	Beets	(Demanet Filippi & Canales Cartes, 2020; Morales et al., 2017).
Ascochyta pisi	Bell pepper Tomato	(Chemonics International, 2008; University of Puerto Rico, 2018).
Begomovirus CMV	Tomato	(Chemonics International, 2008; Flores et al., 2012).
Botritys cinerea	Bell pepper Tomato Strawberry Strawberry Passionfruit Oregano Basil	(Chemonics International, 2008; Gaona-Gonzaga et al., 2020; UNIDO, 2015; University of Puerto Rico, 2018).
Cercospora capcisi / beticola	Bell pepper Beet Basil	(Demanet Filippi & Canales Cartes, 2020; Morales et al.,

		2017; University of Puerto Rico, 2018).
Cilindrocarpon spp.	Strawberry	(Morales et al., 2017; UNIDO, 2015).
Cladosporium fulvum	Tomato	(Chemonics International, 2008; Flores et al., 2012).
Clavibacter michiganensis	Bell pepper Tomato	(Chemonics International, 2008; University of Puerto Rico, 2018).
Closterovirus	Tomato	(Chemonics International, 2008; Flores et al., 2012).
Colletotrichum spp	Bell pepper Tomato Strawberry Strawberry Passion fruit Oregano	(Flores et al., 2012; Gaona-Gonzaga et al., 2020; Rivera & Wright, 2020; University of Puerto Rico, 2018).
Erwinia chrizanthemi	Sweet potato Beet Aloe	(Cobeña Ruiz et al., 2017; Morales et al., 2017).
Erysiphe betae / cichoracearum/ galeopsidis /polygoni	Chard Beetroot Mint Oregano	(Barral Espejo, 2020; Morales et al., 2017).
F. oxysporum / lycopersici	Sweet potato Chard Chard Pepper Tomato Strawberry Strawberry Blueberry Beet Beet Chamomile Aloe Vera	(AGEXPORT, 2017; Cobeña Ruiz et al., 2017; Flores et al., 2012; Morales et al., 2017; University of Puerto Rico, 2018).
Glomerella singulata	Mint	(Gallardo A., 1993; Rivera & Wright, 2020)
Helminthosporium sp.	Basil	(Barral Espejo, 2020)
Meloidogyne sp.	Sweet potato Pepper Passionfruit Beet Mint Chamomile Oregano	(AGEXPORT, 2017; Cobeña Ruiz et al., 2017; Gaona-Gonzaga et al., 2020; Morales et al., 2017; University of Puerto Rico, 2018).

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Mycosphaerella fragariae	Strawberry	(Morales et al., 2017; UNIDO, 2015).
Oidium lycopersici	Tomato	(Chemonics International, 2008; Flores et al., 2012).
Peronospora farinosa/destructor	Beets	(Demanet Filippi & Canales Cartes, 2020)
Black Death (3 viruses)	Tomato	(Chemonics International, 2008; Flores et al., 2012).
Phoma betae	Beets	(Demanet Filippi & Canales Cartes, 2020)
Phomopsis obscurans	Strawberry Granadilla	(Gaona-Gonzaga et al., 2020).
Phytophthora capcisi / infestans	Bell pepper Tomato Strawberry Chamomile Chamomile Oregano	(AGEXPORT, 2017; UNIDO, 2015; University of Puerto Rico, 2018).
Pseudomonas solanacearum	Bell pepper Tomato Beet	(Chemonics International, 2008; Morales et al., 2017; University of Puerto Rico, 2018).
Pseudoperonospora cubensi	Basil	(Barral Espejo, 2020)
Puccinia menthae / rubsaameni	Peppermint Oregano Herba Buena	(National Forestry Commission, 2006)
Pythium spp.	Sweet potato Chard Chard Pepper Tomato Strawberry Beet Chamomile	(AGEXPORT, 2017; Chemonics International, 2008; Cobeña Ruiz et al., 2017; Morales et al., 2017; UNIDO, 2015; University of Puerto Rico, 2018).
Ralstonia solanacearum	Bell pepper Tomato	(Chemonics International, 2008; University of Puerto Rico, 2018).
Rhizoctonia spp./bataticola	Sweet potato Chard Chard Pepper Tomato Strawberry Beet Chamomile Aloe Vera	(AGEXPORT, 2017; Chemonics International, 2008; Cobeña Ruiz et al., 2017; Morales et al., 2017; UNIDO, 2015; University of Puerto Rico, 2018).
Sclerotinia sclerotiorum	Tomato	(Chemonics International, 2008; Flores et al., 2012).

Sclerotium rolfsii	Bell pepper Tomato Beet Mint	(Morales et al., 2017; Rivera & Wright, 2020; University of Puerto Rico, 2018).
SPCSV	Tomato	(Chemonics International, 2008; Flores et al., 2012).
SPFMV	Sweet potato Pepper Passionfruit Beet Mint Chamomile Oregano	(AGEXPORT, 2017; Cobeña Ruiz et al., 2017; Gaona-Gonzaga et al., 2020; Morales et al., 2017; University of Puerto Rico, 2018).
Sphaerotheca macularis	Strawberry	(UNIDO, 2015)
Stemphylium solani	Tomato	(Chemonics International, 2008; Flores et al., 2012).
Streptomyces	Sweet potato Beet Aloe	(Cobeña Ruiz et al., 2017; Morales et al., 2017).
Verticillium daliae	Tomato, Strawberry Mint	(Chemonics International, 2008; Rivera & Wright, 2020; UNIDO, 2015).
Xanthomonas campestris / fragariae	Bell pepper Tomato Strawberry Beet	(Chemonics International, 2008; Demanet Filippi & Canales Cartes, 2020; Morales et al., 2017; University of Puerto Rico, 2018).

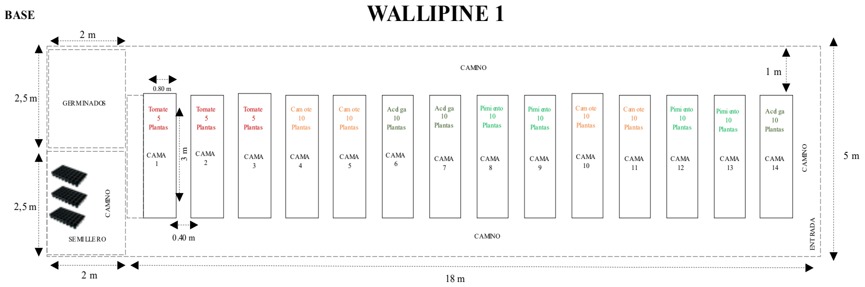
Source: Authors, based on the above references

The key to crop protection is early detection and combining preventive, mechanical, manual, physical, biological and chemical control methods. Methods of for agroecological management are the preparation of chili and onion tea and garlic against sucking insects and chewing worms, vegetable oils of tea and orange, natural pyrethrins from *Chrysanthemum cinerariaefolium*, copper compounds, sulfur, control by microorganisms such as *Ampelomices quisqualis, Bacillus amyloliquefaciens, Bacillus subtilis*, and chemical compounds such as laminarin, spinosad or azadirachtin. (Cabildo de Tenerife, 2019; National Center for Technology and Forestry, 2008)..

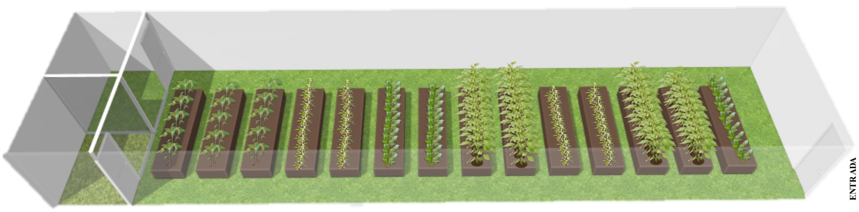
Figures 3a and 3b show the area and dimensions of the proposed walipini, considering three compartments: beds, seedbed and sprouts.

For the beds an area of 90 m2 is intended, and for the seedbed and sprouts an area of 5 m2 each, in these areas a vertical handling on shelves of the trays is expected, with the objective of taking advantage of the height of the walipini.

Figure 3: Distribution of walipini



3a) Top view *3b) 3D view*



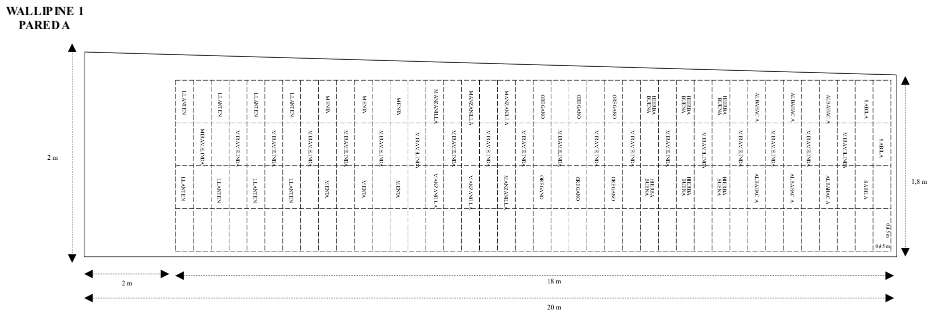
Source: Authors

As can be seen, it is proposed the formation of 14 beds of 3 m long by 0.80 m wide, in which 4 agricultural species could be distributed: tomato, sweet potato, chard and bell pepper.

Beds 1, 2 and 3 are for tomato cultivation, in this case, 5 seedlings will be placed in each bed. In beds 4, 5, 10 and 11 sweet potato plants, each with 12 tubers. Beds 6, 7 and 14 would have 10 chard plants per bed and finally, beds 8, 9, 12 and 13 would have 10 bell pepper seedlings per bed. This distribution is recommended on the basis of Tables 3, 4 and 5, in order to minimize future pest or disease attacks.

Wall A would have an area of 32.40 m2, in which the following species will be distributed: plantain, mint, chamomile, oregano, mint, good grass, basil and aloe vera, which are characterized by their allelopathic action at the agricultural level and their medicinal benefits at the social level. These species can be placed in holes of 10 cm in diameter directly in the wall with a substrate, you can use materials such as: geomembrane or a more homemade method such as sponges in the stem of the plants, the objective is basically to conserve moisture for root and leaf development. The recommended distance between plant and plant is 45 cm x 45 cm, taking into consideration the growth of foliage, the need for aeration and amount of light.

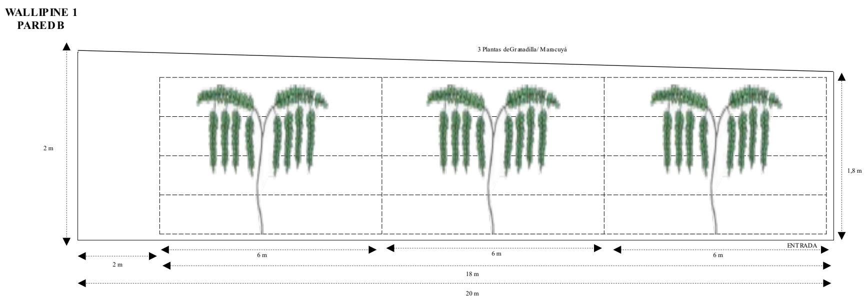
Figure 4: Distribution of Walipini Lateral Wall A



Source: Authors

Wall B of the walipini could be used for the implementation of vine type fruit trees such as the granadilla, with which trellis type trellising is managed, and benefits both the development of the plant and the fixation of the soil on the wall, avoiding its collapse, besides being visually striking and decorative.

Figure 5: Distribution of Walipini Lateral Wall B



Source: Authors

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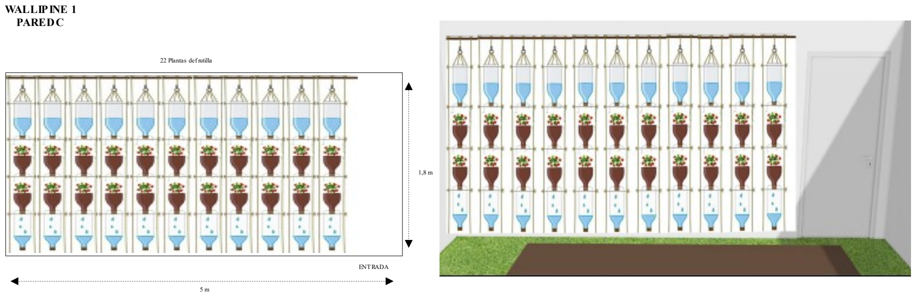
Finally, wall C and D, which corresponds to an area of 9 m2, it is recommended to place a vertical garden with easily accessible recycled materials, the system would consist of plastic bottles interconnected by means of a thread that also has an automatic home irrigation system. In this case the implementation of strawberries is suggested since their botanical and visual characteristics make them ideal for this type of system.

Figure 6. Distribution of Walipini Side Walls C and D.



Source: Authors

The technical feasibility of growing crops in subway greenhouses is supported by. (FAO, 2012; Iturry, 2002) and its practice regarding operability, maintenance, construction feasibility and temporal duration has been taken into account in the present article, coinciding with the experiences exposed by. (Gil Rosendo, 2018).

In the environmental aspect, the proposal follows permaculture principles (Armijos-Arcos et al. (Armijos-Arcos et al., 2023) with a sustainable agriculture approach to integrated pest management (Cabildo de Tenerife, 2019; Oyarzún et al. (Cabildo de Tenerife, 2019; Oyarzún et al., 2002).. It should be considered that high Andean areas are under anthropogenic pressure and their ecosystem services need to be maintained (Chuncho-Morocho & Chuncho, 2019; MAGAP, 2013). Therefore, the impact that the walipinis will have on the páramo ecosystems must be analyzed.

On the other hand, regarding the socioeconomic impact, 40% of the production is for self-consumption under the high Andean conditions of Ecuador (Lara Vásconez, 2020). (Lara Vásconez, 2020).In the case of Guamote, the average productive units are 3.5 hectares (MAGAP, 2013). (MAGAP, 2013)Therefore, the walipini proposal allows for a production alternative with a focus on food sovereignty, for commercialization and income generation with the aim of improving the quality of life (Vallejo Amaya, 2013).. However, specific studies are needed to further analyze the political, economic, social and legal aspects for its implementation, as well as the economic feasibility and investment or community credit.

Conclusions

This study concludes that there is technical feasibility for the implementation of a walipini of 20 m x 5 m x 2 m, defining in its agronomic design the planting in 14 beds of different species, including: tomato, sweet potato, chard and bell pepper; additionally the walls can be used with planting of plantain, mint, chamomile, oregano, good grass, basil and aloe, in the walls that require soil stabilization can be planted granadilla, and other walls can include hydroponic use with strawberries. In this combination of plants, rotation systems, association, management, and integrated pest and disease management with agroecological methods are considered.

Future studies are proposed to establish the economic feasibility of implementation in community areas and an environmental cost-benefit study if implemented in páramo ecosystems.

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