# -LANDSCAPE-Ecology and Agroecosystems

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## 20 Ecological Aspects of Production in the Canary Islands: Traditional Agrosystems

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Abstract: Three different areas representative of traditional agricultural systems in the Canary Islands were studied in order to find the ecological basis governing their productivity. Traditional agricultural techniques could bring solutions to problems of great importance in Mediterranean and mountain environments, such as desertification and pollution. These phenomena progress rapidly in island areas of volcanic origin that are fragile and under pressure from tourism, and where the complementary nature of agricultural systems has not been taken into account in land management.

Aridity and moisture were the basic factors for choosing the agricultural systems studied. Agrosystems in arid environments have been studied in southern Tenerife and Lanzarote. They can be distinguished by the volcanic material that is used to prevent aridity ("jable" and "lapilli", respectively). Agricultural systems in a humid environment are studied in northern Tenerife, which is under the influence of trade winds. The study was carried out by two coordinated teams. The first did the spatial analysis of the agricultural systems in order to find the key processes governing them and the second was concerned with the ecological basis for interpreting these processes. Results have enabled the identification of a series of cultural techniques which are the keys to environmental pest and disease control, combatting the wind, aridity, and erosion, and maintaining soil fertility without pollution. Such measures give rise to agricultural patterns with quality products, environmental conservation, and landscapes of great aesthetic value, as well as encouraging the maintenace of a cultural asset of great interest in searching for solutions to the struggle against aridity and desertification.

#### INTRODUCTION

The growing importance of research on the ecology of agricultural systems is no accident. Terms such as "limits of economic growth", "sustainable development", or "ecological economics" stress the management of natural resources from standpoints which go beyond those of the mechanics of utility and benefit (World Environmental & Development Commission, 1987). A new relationship between man and space is being generated, in which productivity is no longer the driving force and where land management is being undertaken from multiple disciplines (e.g., anthropology, sociology, biology, and economics).

"Agroecology can best be described as an approach that integrates the ideas and methods of several subjects, rather than as a specific discipline" (Hecht, 1987). Agroecology has introduced a new concept which may contribute to clarifying the man/environment relationships: the agrosystem. "The challenge for agroecology, then, is to find a research approach that consciously reflects the nature of agriculture as the coevolution between culture and environment, both in the past and the present. The concept of the agrosystem can (and should) be expanded, restricted or altered as a response to the dynamic relationship of human cultures and their physical, biological and social environments" (Gliessman, 1990).

This new discipline, agroecology, endeavors to give a scientific explanation to the traditional agricultural systems which have been self-sustained throughout the years without the use of excessive inputs.

A great variety of agrosystems exists in the Canary Islands, despite the limited area. These agrosystems are built around what is known as an internal or subsistence market agriculture, although crops for export outside the Islands are grown. Three representative models of the traditional farming systems in the Canary Islands have been studied with the purpose of establishing the ecological criteria governing their productivity.

The Canary Islands agricultural systems are of interest for the following reasons:

- The traditional farming techniques could contribute to solving important problems in Mediterranean environments, such as desertification, by combating aridness, erosion and wind, or pollution by crop rotation and using multicrops. It should be taken into account that these substrate are totally volcanic.
- Farming systems in the Canary Isles have given rise to quality agriculture, as well
  as conserving the environment and generating landscapes which, at present, constitute a valuable cultural asset.
- Intense land development is «taking place, because of tourist development and demographic pressure, which is causing destruction of traditional agricultural systems.

The interaction of the above three factors requires future solutions which will involve making agriculture and tourism complementary to each other.

### PHYSICAL VARIABLES: AN ADVERSE ENVIRONMENT FOR AGRICULTURE

Of volcanic origin, the Canary Island Archipelago is formed by eight inhabited islands and several islets, with a total area of 7511 km<sup>2</sup>. Its geographical location

determines two physical facts: a subtropical latitude (28° North) close to the Tropic of Cancer, and its proximity to the western face of the continent of Africa. There is scarcely 100 km between the most eastern island and the African coastline, where the most extensive desert in the world, the Sahara, begins (Figure 1).

Nevertheless, the Canary Isles have a climate which is not appropriate to their geographical location. This is due to the influence, on the one hand, of the Azores Depression which forms part of the what is known as a high-pressure, subtropical belt and, on the other hand, the Canary Island Cold Sea Current.

The geographical location, regional atmospheric circulation, and cold sea current explain the general Canary Islands climatic features: characterized by mild average temperatures with a low thermal range (20°C average annual temperature), high relative humidity, total precipitation between 200 and 400 mm/year, and cool NNE winds (the trade winds).

The climate's general characteristics have a high variety of local microclimates which noticeably influence agricultural systems. Such microclimates result from key factors such as the geographical situation of each island, insular orography and altitude, exposure, and arrangement of the relief. The following microclimate elements define the agrosystems studied (Figure 2).

Lanzarote — The island's maximum altitude is less than 700 m (670 m at Peñas del Chache) and therefore, its whole area is below the level of trade wind reversal. This physical fact restricts the important orographic rainfall in the western isles (Marzol Jaen, 1988). There is no mountainous obstacle that can stop the "sea of clouds" (stratocumulus bank of clouds caused by stratification of trade wind air masses). Moreover, together with Fuerteventura, Lanzarote is the nearest island to the continent of Africa. As a result, the annual average rainfall is around 160 mm and never exceeds 300 mm. Rainfall is irregular and does not exceed 47 days annually. Insolation is high (65%), with 130 clear days. The average temperature exceeds 20°C, with strong daylight sunshine (this is the island with the greatest daytime thermal range). The relative humidity is around 70%, but is reduced by the strong insolation. Winds are frequent but not violent (breezes and trade winds).

Tenerife — On the island of Tenerife (with a maximum altitude of 3717 m in the Teide composite volcano), masses of air change their behavior due to the orography. The orientation and thickness of the relief force the cloud masses from the NW and NE to collide along the island's north face, discharging part of their water content into the northern side and then falling with a föhn effect onto the south face (Marzol Jaen, 1988). These phenomena produce a marked differentiation between the island's north and south face. For example, in Las Mercedes — NE facing — 1000 mm of rain are collected per year on average, while at Punta de Rasca — south facing — it does not reach 100 mm per year. As a result, the northern face is characterized by an evenly spread system of rainfall ranging from autumn to spring (400–600 mm annual average), cool temperatures, high relative humidity, and abundant cloudiness. On the leeward

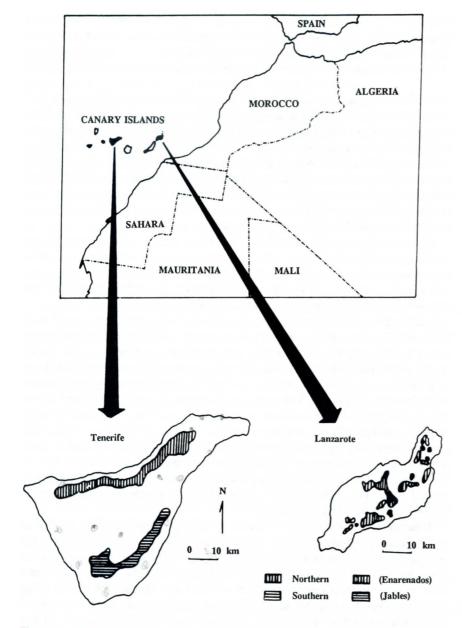


Figure 1. Geographical location of the agrosystems studied in Lanzarote and Tenerife.

face, with many hours of sunshine, there is little cloudiness and an average precipitation of between 100 and 300 mm.

The volcanic nature of the archipegalo, together with its climatic features, are the other physical factors affecting the traditional Canary Isles farming systems. In Lanzarote, a large part of the island is covered with recent volcanic materials,

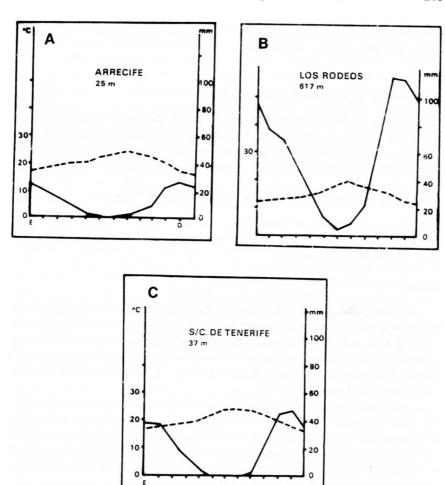


Figure 2. Gaussen's ombrothermal diagram of the three agrosystems in different seasons.

(A) Lanzarote; (B) Northern Tenerife; and (C) Southern Tenerife.

with eruptions dating from the 18th and 19th centuries. The result is that a major part of the island surface is covered by "malpais" and lapilli (volcanic cinders). "Jables" or calcareous sands of a marine origin are abundant on this island, formed by remains of shells and seaweed. Their origin lies in the Famara beach area to the north of the island. The predominant NE winds blow the organogenous sands, which the sea leaves on the beach, from Famara to the west coast.

On Tenerife's north face are found the most developed soils on the island (brown/fersialitic) gained for agriculture by felling the thermophilic forest (beech/heath and "laurisilva"). In the south part of Tenerife there are outcrops of a

group of pyroclastic materials of a salic nature, known as pumices, which give a certain homogeneity to the landscape.

#### MAN IN AN ADVERSE ENVIRONMENT

In the adverse environment described above, an agricultural culture has been developed which may be defined as man's struggle against the environment, without damaging the island ecosystem. The development of the man/environment relationship in the three agrosystems studied is described below.

#### Lanzarote — Modern Agriculture With Craft Techniques

There are two forms of cultivation as far as the nature of the agricultural substrata is concerned: the "jables" (organogenous sands) and the "enarendados" (lapilli of a basic origin).

#### Jables

Jables cover the argillaceous soil. After plowing the soil, holes are dug ( $^{1}$ /<sub>4</sub> m apart) until clay is reached, dung and chemical fertilizers are thrown in together with the seed, and all is finally covered with jable. Thus sweet potatoes and, to a lesser extent, marrows, sprouts, tomatoes, watermelons, and other crops are grown. Crops are rotated every three years (sweet potatoes/fallow) or two years (sweet potatoes/fallow).

In order to combat the constant NE winds blowing in the island, the crop plots are fenced in with "bardos": mud walls generally mixed with rye straw. The bardos are placed perpendicular and parallel to the predominant winds. Another of their functions is to stop wind-blown sand. Otherwise, the above-ground part of the plants would not only be knocked over but would be buried, since they act as an obstacle (Rodriguez Brito, 1986).

The evident aridity of Lanzarote is attenuated by using jables, since this sand of an organic origin preserves and condenses humidity. Likewise, it favors the growth and development of plants through acting as a heat insulator. An advantage of the jables is that it enables vegetables to be grown which demand water in a rain-fed system.

After passing through a peak period in the 1960s the jables were gradually abandoned. Nowadays, sweet potatoes and watermelons are sown over an area of less than 400 ha.

#### Enarenados

The enarenados are made up of soils covered with lapilli which have the effect of retaining and preserving subsoil moisture. They are used in two ways:

**Natural Enarenados** These are found in areas near recent volcanoes where lapilli covers the preexisting plant soil. The fact that lapilli thickness is highly variable makes farming difficult, as a thickness between 0.2 and 2 m is required.

Crops which can use these "enarenados" must have a deep root system enabling them to penetrate through the lapilli layer. The predominant crop, therefore, is usually the vine and, to a lesser extent, fig and other fruit trees.

Farmland is prepared by digging holes from 1 to 1.25 m deep, until the paleosoil is reached. A vine or fruit tree is planted at the bottom — 1 ha can take between 250 and 350 plants. The holes are protected with low stone walls which are placed perpendicular to the predominant wind direction. In this way, farming has been achieved in a highly xerophillous environment, with heavy evaporation and intense sunshine (these crops are located in the island's most arid sector).

Artificial Enarenados Their use is also to preserve soil moisture. The ground is cleared of stones for farming, and a 10- to 15-cm layer of lapilli is placed on it. The soil can keep moisture in even 12 months after the last rainfall, and agricultural yields are thus obtained comparable to those from irrigated land, though precipitation hardly exceeds 100 mm/year (Rodriguez Brito, 1986).

The onion is the predominant crop but melon, watermelon, sweet potatoes, pulses, potatoes, maize, and other cereals also occur. The variety of crops which have gradually adapted to Lanzarote's agrosystem must be related directly to the island's traditional isolation, which has caused the need for a certain self-sufficiency as far as food production is concerned. In addition, soil exhaustion caused by sweet potatoes, watermelon, or melon farming requires rotation with pulse crops and even fallow lands.

Lanzarote is shown as an area where varieties have been selected to adapt to the arid environment. Sweet potatoes, watermelons, and melons are all crops of a tropical origin (Central Africa and Monsoon India), highly thermophilic, and which absorb quite an amount of humidity. Adaptation to the island environment is also demonstrated in some varieties of potatoes and maize (dwarf maize, low in height with a single root system). The onion is the most widespread crop due, in part, to its high productivity, and in part to an exchange of seeds with other islands.

Artificial enarenados play an important role in the fight against erosion, as they allow rainwater to infiltrate, thus preventing runoff.

The problems of enarenados derive from their low average lifetime, from 15 to 20 years, at the end of which they must be renewed since they have mixed with the soil. There are also problems related to tillage, fertilization, and pest treatment.

In conclusion, Lanzarote's agriculture has an exceptional character due to the adverse environmental conditions. The existence of important agriculture is due to man's inventiveness which has solved the disadvantages of the situation. Farming in enarenados and jables enable yields per hectare to be similar to those

on irrigated land. This type of farming has proved to be a curb on erosion in an arid environment, where the scarce resources that exist for developing agriculture of quality and landscape creation have been optimized.

#### **Tenerife**

The two agrosystems studied are located in the "medianias" strip in the North (400–1000 m) and South (500–1200 m) on the island of Tenerife. Despite the different climate and edaphological characteristics, both systems are complementary on the level of seed exchanges, specialization of crops, or livestock activities. Nevertheless, nowadays this complementary nature is breaking down, constituting one further element in the agricultural crisis of the Canary Isles.

#### The North of Tenerife: Control of Inputs and Combatting Pollution

The medianias of the north part of Tenerife cannot be defined as a single agricultural system because there exists a great horizontal and vertical variation in the agrosystems, depending on the edaphic substratum and local microclimates. They do however offer the same ecological bases which enrich them: a diversity of crops (rotations and multicrops) for controlling pests and minimizing the consumption of inputs, and the importance of livestock in the struggle against the scarcity of soil and erosion.

The fight to maintain fertility has forced extensive rotation of crops in view of the scarcity of both natural and artificial fertilizers. On the other hand, an agricultural economy where livestock occupies a leading position (beef, and to a lesser extent, goats, pigs, mules, and asses) requires forage crops. In turn, this complementary nature between agriculture and livestock is demonstrated in the contribution of organic fertilizer (dung) from livestock. In one of the most interesting areas, a particular agricultural system in the north of Tenerife (La Esperanza), up to five-year rotations are undertaken. Thus, on the same plot, potatoes, fallow land (''manchón'') for two years, cereal (generally wheat), and lupin are the alternatives included in the rotation. During spring, a short-cycle crop, like maize, can be sown.

This long crop rotation system fulfills various functions whose main objective is to maintain fertility without pollution effects with a low input consumption and a complementary arrangement between agriculture and livestock practice. Combating pests in these long rotation systems has been shown in the control of nematodes in potato growing.

There exist other types of more simple rotations distributed throughout the mediania strip in the north of Tenerife: e.g., three-year rotation with tilled fallow land (fallow, wheat, and potatoes) and rotations without fallow land (wheat and potatoes) (Alvarez Alonso, 1976). On occasions when sufficient natural fertilizer is available, the crop can be intensified and three crops of potatoes on the run can be obtained, but afterwards the rotation system is reintroduced.

Another ecological base which contributes towards enriching the organization of the northern agrosystem is multiple cropping, e.g., vines/potatoes, potatoes/

maize/leguminous plants, potatoes/sprouts, beans/maize, potatoes/fruit trees and vines/maize/sprouts. The location of the mixed crops within the area under study varies as a function of the edaphic substratum and microclimates. For example, the vine does not appear in the long La Esperanza rotations which were discussed earlier, because this area is exposed to wind and is excessively wet and rainy. However, farming happens in areas of low medianias (Acentejo District) and in others where the soil is less developed, as is the case of lapilli or the volcanic conglomerates of an intermediate or salic nature (Icod District). Vines may appear as the only crop when conditions are favorable.

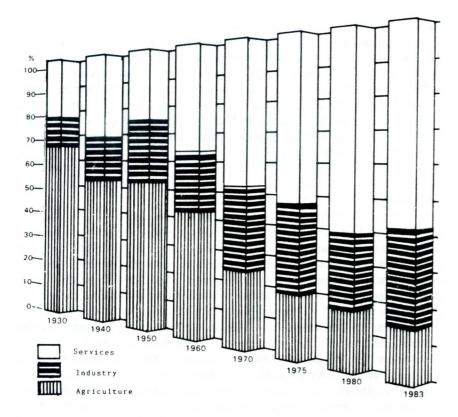
The beans/maize association is located in the low medianias (rarely above 700 m) in the whole of the north but mainly in the northwest end (La Culata depression) where there is less cloud and temperatures are mild.

One of the most interesting mixture of crops is the potato/fruit tree, with the latter represented by the chestnut tree. This is a tree suited to the wet conditions of the north of the island, mostly located in the Acentejo District. The importance of this crop association lies, amongst other features, in its providing shade and environmental moisture in the last maturing stage of the potato. These phenomena have been seen when warm air masses arrive from the neighboring continent of Africa.

The exchange of seeds between farmers of both zones and adaptation of different plant varieties are other elements distinguishes this agrosystem. This is shown by the traditional seed exchange between areas in the north of Tenerife itself (both vertically and horizontally) or from the north with the south and vice versa. The adaptation of varieties is demonstrated in potato growing, with local varieties like "bonita", "negra", "colorada", "rosada", "melonera", venezolana", "liria" and others of a British origin, e.g., "King Edward", "Up-to-date", and "Cara".

Erosion, wind and scarcity of soil are the adverse elements for farming in this area. To reclaim agricultural land it has been necessary to create a system of terracing in steeply sloping hill sides. At the same time, the terrace system involves an obvious curb on erosion processes (particularly those due to water erosion). Growing quickset hedges like the "tagasaste" (Citisus proliferus) on the edge of the plots has not only acted as fodder for livestock but has also turned out to be an effective means of attenuating erosion (their roots act as a soil fixer), combating the wind, and giving the soil fertility. Quickset hedges are of a variety of plants, e.g., trees, agaves, prickly pear, broom, and heather.

The main problems currently within this agricultural system are both internal and external. The former include the agricultural crisis of the Canarian domestic market, where only the vine and potatoes generate sufficient profit for the farmer. The latter is caused by land development taking place throughout this mediania strip (Santa Cruz/La Laguna metropolitan area stretching from the Puerto de la Cruz tourist center) and the growing drift of population towards the service sector. Both phenomena are generating part-time farming around potato and vine growing (Burriel de Orueta, 1981), (Figure 3).



**Figure 3.** Evolution of the working population in the three largest Canary Island sectors (1930–1983).

## South Tenerife: Adaptation of an Undiversified Agricultural Systems to an Arid Environment

The agricultural systems in southern Tenerife contrast strongly to those in the north. In the north, the rotation system and the associated crop are most important, but in the south it is the adaptation to an arid environment where livestock was possibly traditionally of greater importance than farming. The absence of rotation systems and associated crops is therefore one of the main problems to be solved in the southern agrosystem.

The major environmental elements that have been developed in the agriculture of this area are the pumice "enarenados", "gavias", and "nateros" systems.

*Pumice Cultivation* Two subtypes are distinguished: direct growing on pumice and argillaceous soil covered with pumice (here also called jables).

The first subtype is characterized by growing on disturbed pumice (fallen acidorigin pyroclasts). Their abundance and facility for working them have facilitated a very peculiar landscape since both the habitat and the growing soils are located in the places of greatest abundance of these volcanic materials. The scarcity of developed soils in this part of the island restricted settlement until the 19th century, when pumice began to be used in agriculture. Therefore, it became, in the 30s and 40s of the present century the most prosperous district in the south of the island. The pumice allowed it to be possible to create a rain-fed agricultural economy in an area in which it was rare for 300 mm of annual rainfall absent irregular to be collected.

Direct growing on pumice has created a quality agricultural landscape. Man's struggle against the scarcity of soil, aridity, and erosion has generated an agricultural area where thousands of plots are arranged in steps on the steep slopes of the area. There has also been a need to build retaining walls to modify the adverse conditions (also of pumice: stones worked by man from pyroclastic) from soil.

Farming on argillaceous soils covered with substratum of pumice is of more recent extension, although no less important from the socioeconomic point of view.

There are some sectors in the south, not covered with pumice, with argillaceous soils of a better quality which are like islets among those materials. The water-absorbing quality of pumice enables a layer of jable some 20 cm thick to make the soil preserve humidity for a long time. As a result, water consumption is noticeably reduced (1500 to 300 m³/ha. This type of enarenado spread by reason of the water transfers taking place in the 1950s.

This system achieves a work saving: there is no need to eliminate weeds as they hardly emerge, and seeding and raking work is simple due to the low compaction of the jables. The moderating action the jable exercises on the soil because of its white color and porous nature is worthy of note.

Pumice growing on argillaceous soil currently covers more than 90% of the land farmed between 400 and 1500 m high in this area (Rodriguez Brito, 1986). Water for irrigation and the special conditions of the foreign potato market have caused the jable enarenados to become specialized in this kind of tuber. The potato monocrop is currently one of the main problems for maintaining efficiency in these agricultural systems. Pests (particularly nematodes) are causing a substantial reduction in crop productivity (this area bore two crops a year for more than a decade). Productivity can only be maintained currently on the basis of a high consumption of fertilizers and pesticides. Further, there is the high cost of water (in competition with the coastline's tourist consumption), the loss of traditional markets, and population drift towards the service sector. These are phenomena causing a large number of jable estates to be abandoned. This was not the traditional situation of the southern jables since the exchange of seeds with the north of Tenerife and between different areas in the south of varieties of local potatoes, the organic fertilizing systems, and fallow lands provided for a certain diversification of the agrosystem.

Enarenados were not the only way to improve farming. "Gavias" and "nateros" constituted — since nowadays they are practically abandoned — a way

of occasional irrigation in the extensive gully network extending over the south of the island.

The most elemental form of gavia consists of building terraces at the bottom of small ravines, perpendicular to the direction of the current, so that the terraces themselves intercept runoff water. The most evolved gavias are dike built, diverting water towards land prepared on terraces on both sides of the ravine bed.

The difference between gavias and nateros lies in the fact that in the former the growing soil existed previously, while in the latter, it is necessary to build the area to be farmed (Quirantes Gonzalez, 1981).

The importance of the gavias and nateros is not due solely to using runoff water, but also because mixed with the water comes a considerable amount of sludge which is deposited on the growing area, thus contributing towards improving soil fertility.

Nateros and gavias in the south of Tenerife have been traditionally occupied by cereal and potato crops, but fruit trees are also important, e.g., fig, almond, prickly pears, and even highly water-demanding fruit trees like chestnut, pear, or apple.

#### **CONCLUSIONS**

The variety of Canary Island agrosystems is explained by the soil and climate characteristics, and in the development of a close relationship in the adaptation of agriculture to the adverse environment. The Canary island farmer has created a singular landscape of undoubted aesthetic value at the present time, but also until recently with an outstanding socioeconomic importance.

The need to protect these agricultural areas is not only because of their value as a cultural and scientific asset, but also because of the economic feasibility of the crops which have been developed here. Tourist interest in a cultural asset, scientific interest in the fight against arid land erosion, the wind and pollution, and socioeconomic interest are the result of a quality agriculture. There is also a necessary complementary relationship between agriculture and tourism.

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