Macro meteorology, electricity and micro-gravity of dry landscape in Spain

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Abstract. The study of the traditional and contemporary dry landscapes in Spain is divided in three categories: macro meteorology, electricity and micro-gravity. Traditional interventions in arid landscape are: fog catchers, crop hollows and salt evaporation ponds. The research is focused on analysing the normal scale (humans, animals, plants and machines), micro-scale (unicellular beings) and macro-scale (thermodynamic parameters). Contemporary landscape architecture is analysed through red, blue and green infrastructures. Firstly, red infrastructure (dehesa) is the large area of the fertile red soil with green meadow islands used in the park, gardens and green-roof of the Caja Badajoz new headquarters project in Western Spain. Isolated spots concentrate their energy resources providing sustainable landscape for humans, animals and plants and what we contemplate is an archipelago of holm oaks, cork oaks and olives trees over the extensive red humus-rich area underneath the entire unpaved surface, where the potential for vegetation growth depends on the weather conditions. Secondly, blue infrastructure (dry meadows) is the rainwater storage which is distributed under the squares and gardens of horticultural therapy of the Alzheimer Center Reina Sofía Foundation project in Central Spain. Landscape design has been carefully planned to separate plantation areas depending on the amount of water. It consists of rainwater harvesting storages such as an underground water tank (3x3x3 m3) under the public square and drainage cells (50x60x5 cm3) and under the private gardens of the care patient area. Thirdly, green infrastructure (dry-hot valley) is the concentration of plantations which is located in the urban parks, car parks and interior gardens of Córdoba Airport extension project in Southern Spain. The sort of invisibility of the infrastructure employed in the design of landscape airport takes as reference the other invisible world of micro-organisms, subtly insinuates on the free trade treaties and market forces. Despite the scientific classification that maintains apart the studies of electric fields and microbiology, the development of new infrastructures keeps those boundaries blurred. These systems translate the abstract world of electricity or microbiology to the concrete world of landscape architecture and infrastructure design using biological and economic knowledge to allow the subsistence of the arid Spanish landscapes.

Keywords: Landscape Architecture; Electricity; Meteorology; Sustainability: Green-blue infrastructure.

Introduction

The infrastructure supporting dry landscape architecture based on dehesa, dry meadow and dry-hot valley biomes has been broken down into a biological system (types, classes and orders) for the purpose of classifying the soil micro-organisms, water storage and power infrastructure of three landscape architecture projects in Spain.

The landscape interventions demand electricity to activate equipment; gravity to store water; and, finally, the right climatic conditions to ensure fertilisation through seeds transported by the wind. What we find as signs of life in the form of animals and plants (plug-in elements) would be unable to survive without the structural chain of micro-organisms (electricity), such as an electric system.

From the macro to the micro-scale of biological studies, Carl Wosse and George Fox [1] created the three-domain system, based on phylogenetic relationships rather than obvious morphological similarities, dividing life into 23 main divisions, incorporated within three domains: Bacteria, Archaea and Eucarya.

Furthermore, another micro reference has been found in the form of a new species of bacteria living in California's Mono Lake. This species is the first known life-form that uses arsenic to make its DNA and proteins; so it is possible to find potential life in dangerous and unexpected landscapes. Consequently, the definition of waste ground awaits a future use and could be a refuge for the Earth's biodiversity due to the absence of any human presence.

From the micro to the normal-scale of energy system, Pierre Verger [2] has written in the book Ewe, the Yoruba people's plant classification system which is different to that used by western botanical institutes and Carl von Linnaeus. The research for Ewe was undertaken in West Africa in a cultural universe established through oral traditions, where values differ from those of a civilisation based on written documents.

But knowing the scientific names of a plant is not enough, because each plant may have different attributes depending on the interchanges (seeds, minerals, microorganisms, etc.) with plants around it. It is therefore crucial that plants are not just catalogued taking into account their formal properties on a stand-alone basis. A plant may be compared to a letter of a word which is insignificant on its own, but when joined with other letters contributes to the meaning of the word; so the inter-connection of living species ensure survival landscapes can be maintained and sustained.

Fig. 1. Water Farms, El Hierro, Canary Islands, 2015
[Source: photo from Cristina Jorge private archive]

Fig. 2. La Geria, Timanfaya Natural Park,
Lanzarote, Canary Islands, 2015
[Source: photo from Cristina Jorge private archive]

From the normal to the macro-scale of thermodynamic parameters, Peter Sloterdijk [3] proposes a sphere metaphor which is a means of updating the topos and calls for a threefold inquiry – microspherological, macrospherological and pluripherological – into the three gradients of spherological reason (bubbles, globes and foam) which are used to explain human spaces. He also defines the creation of an "ontological constitution" that would incorporate all beings (humans, animals, plants and machines).

In the beginning, the shape of the topos was predetermined, but as times goes on, the contours of this form blur in the natural process and takes shape not only on a drawing plan, but on site; so a landscape project can generates a variety of atmospheres where wind can be moderated or increased.

Research and methodology

The study of these hidden structures in landscape science is divided into three categories: micro-gravity, electricity and macro meteorology. In the traditional dry landscapes of Spain we can see how the design follows the climate and topography in the following cases: fog catchers, crop hollows and salt evaporation ponds [4].

The research focuses on analysing the micro-scale (unicellular organisms), the normal scale (humans, animals, plants and machines), and the macro-scale (thermodynamic parameters).

The three-domain types at the micro-scale comprise a biological classification that divides cellular life forms into archaea, bacteria and eukaryote domains. Each of these types of micro-organisms has a different level of resistance to the environmental conditions found in the dehesa, dry meadow and dry-hot valley biomes.

The two normal-scale domain classes refer to endogenous and exogenous materials in each design project.

The four macro-scale domain orders take into account the action of climatic elements: wind, mist, rain and sunlight.

Traditional landscape architecture in arid landscape of Spain

The irregular nature of rainfall, the lack of the resources in the subsoil and the desire of generate water sustainably are the challenges of these traditional techniques in Spain, especially in Canary Islands.

1. Fog catchers. El Hierro, Canary Islands

Water farms are groups of NRP 3.0 fog collectors at three location on the island of El Hierro (Binto, Malpsa y Ajonce). They are used for the production of large volumes of high quality water, for forest uses such as reservoirs or dams supply to store water in periods of fire, reforestation and surveillance areas; for agro-livestock and even for isolated villages.

This will ensure the presence of water in the mountains which makes unnecessary the expense of other emergency cost, such as water pumping to the forest area. They are a system of meshes woven with strips of high-density polyethylene which are exposed to the prevailing direction of the fog. These mists are usually due to low clouds that are carried by ocean winds to landfall. In the Canary Islands, these clouds formations stratocumulus are called Sea of Clouds. It is an example of macro scale of meteorology linked with the use of the wind to generate water instead of electricity.

2. La Geria Crop Holes, Lanzarote, Canary Islands

The cultivation of grapes vines in Lanzarote takes place in large holes dug out of a volcanic substrate at the border of the Timanfaya National Park. Local farmers could sidestep the problem of Lanzarote's extremely low rainfall. These circular holes vary in size from three to eight meters in radius, and from one-half to two meters deep.

The lateral slopes are covered by 20-cm layer of volcanic sand in grains between two and seven mm large, which makes a continuous covering to prevent problems such as the appearance of weeds and to avoid soil erosion. In the upper part circular walls made of volcanic rocks are built perpendicular to the direction of the prevailing wind in order to stop the storm and protect the vines [5]. It is a sample of the normal scale of energy systems related with the use of endogenous and exogenous materials.

3. Bañaderos Salt Pans. Gran Canaria, Canary Islands

Salt evaporation ponds are shallow artificial ponds designed in circular shape to extract salt from sea water and other brines. The extraction process of double vessel has a place where the water is concentrated named "cocedero" and another site where the salt crystalizes called "maretas" (1-13 square meters). The ponds are separated by levees.

Bañaderos salt pans were built in the 17th century and are one of the last vestiges of salt evaporation ponds built on the model of primitive on rock salt evaporation pond. This process is linked with the extraction of waterproof materials: stone, mud and lime. In salt pans design, the circle of maretas follows topography, moving away from runoff. It is a case of micro-gravity as the need of water storage.

Due to variable algae concentration, the color of evaporation ponds, which indicates the salinity, varies from pale green to bright red. Microorganisms change their hues as the salinity of the ponds increases. In low-to-mid-salinity ponds, green algae such as *Dunaliella salina* are predominant; while in middle-to high-salinity ponds, *Halobacteria* in the group of halophilic *Archaea* shift the color to pink, red and orange.

Contemporary landscape architecture in arid landscape of Spain

1. Dehesa landscape architecture of park, gardens and roof of Caja Badajoz (Badajoz, Spain)

Dehesa. Red infrastructure (humus earth). The large area of fertile red soil with green meadow islands is used in the park, gardens and green roof of Caja Badajoz's new headquarters in Western Spain (outdoor area = 19,900 m^2 + built area = 33,500 m^2).

Energy resources are concentrated at isolated points, providing a sustainable landscape for humans, animals and plants and what we contemplate is an archipelago of holm oaks, cork oaks and olives trees over the extensive red humus-rich area underneath the entire unpaved surface, where the potential for vegetation growth depends on weather conditions. At the same time, some areas are designed with minimum defined spaces for activities, and do not offer anything other than necessary infrastructural conditions.

Micro-scale (gravity). Domain archaea reference (thermoacidophiles). These species thrive in extremely acidic, hot and moist regions, such as those in and near sulphur hot springs. Other archaea types are the halophiles which thrives in extreme salty environments in soil and in water; and the methanogens which can be found in swamps and marshy environments and are a vital part of sewage treatment and produce biogas. In response to these harsh conditions, rather than employing the usual solution of planting

Fig. 3. Salinas de Bañaderos. Gran Canaria. Canary Islands, 2015 [Source: photo from Cristina Jorge private archive]

Fig. 4. Dehesa landscape architecture of park, gardens and roof of Caja Badajoz (Badajoz, Spain) [Source: photo by Cristina Jorge]

Fig. 5. Dehesa landscape architecture of park, gardens and roof of Caja Badajoz (Badajoz, Spain) [Source: photo by Cristina Jorge]

the extensive green roof of Caja Badajoz with a sedum carpet, the roof is covered with humus earth and a limestone layer and the green areas are concentrated into islands of different sizes and scattered all over the roof.

Normal-scale (electricity). Endogenous and exogenous materials (green islands and red humus-earth stripes). Firstly, the endogenous materials comprise the semi-intensive islands on the green roof, on the park and on the gardens which can be set on small mountains of earth standing 600-800 mm tall for shrubs and 1000-1200 mm for trees. Secondly, the exogenous materials are the part of the

extensive limestone earth roof which can be laid on a growing medium layer of 100-150 mm. The ecosystems of a dehesa biome cannot exist within isolated areas, but must instead be part of a larger environmental framework; an interconnected pattern of natural areas that allows plant and animal species to migrate.

Macro-scale (meteorology). Thermodynamic parameters: Convection (wind). Due to its close proximity to the banks of the River Guadiana and the region's windy climate, many seeds are carried to and deposited on the green roof. Consequently, layers of humus-rich earth exist underneath the entire unpaved ground and not only under the green areas. The initial geometry of islands will change into great continents depending on the wind and the final configuration will be as complex and unpredictable as an original rural landscape.

Natural cooling features are the different types of trees which are distributed in the light of the river bank, the twilight of meadow land and the shadows of shrub land areas. In summer time, the deciduous trees have specific qualities for cooling the atmosphere, shrubs with white flowers in order to reflect the warm sun rays, and evergreen trees that produce considerable evaporation. During cold winters, holm oaks, cork oaks and olives trees have dense fronds that protect from the rain.

I. Dry landscape architecture of the Reina Sofía Foundation's Alzheimer Centre (Madrid, Spain)

Meadows_Blue infrastructure (water). Rainwater is stored under the squares and gardens of the horticultural therapy area of the Reina Sofía Foundation's Alzheimer Centre in Central Spain (outdoor area = 4,000 m^2 + built area = 8,500 m^2).

The landscape design of seventeen gardens including spaces for gardening therapy, growing fruit, vegetables, aromatic plants and fruit trees, a children's garden for visitors and an open-air exercise zone for residents has been carefully planned to separate plantation areas depending on the amount of water. Irrigation is supplied via several rainwater harvesting units such as an underground water tank (3x3x3 m^3) under the public square, and drainage cells (50x50x5 cm^3) under the private gardens of the private patient' area.

Micro-scale (gravity): Domain prokaryote reference (bacteria). They constitute a large domain of prokaryotic micro-organisms and have a number of shapes, ranging from spheres to rods and spirals, without a cell nucleus or any other membrane-bound organelles and provide the nutrients needed to sustain life by converting dissolved compounds such as hydrogen sulphide and methane into energy. From a biological perspective, the Alzheimer Centre was designed based on the recommendations and comments of biologists, doctors and patients, all

Fig. 6. Dehesa landscape architecture of park, gardens and roof of Caja Badajoz (Badajoz, Spain)
[Source: photo by Cristina Jorge]

Fig. 7. Dry landscape architecture of the Reina Sofia Foundation's Alzheimer Centre (Madrid, Spain)
[Source: photo by Cristina Jorge]

Fig. 8. Dry landscape architecture of the Reina Sofia Foundation's Alzheimer Centre (Madrid, Spain)
[Source: photo by Cristina Jorge]

Fig. 9. Dry landscape architecture of the Reina Sofia Foundation's Alzheimer Centre (Madrid, Spain)
[Source: photo by Cristina Jorge]

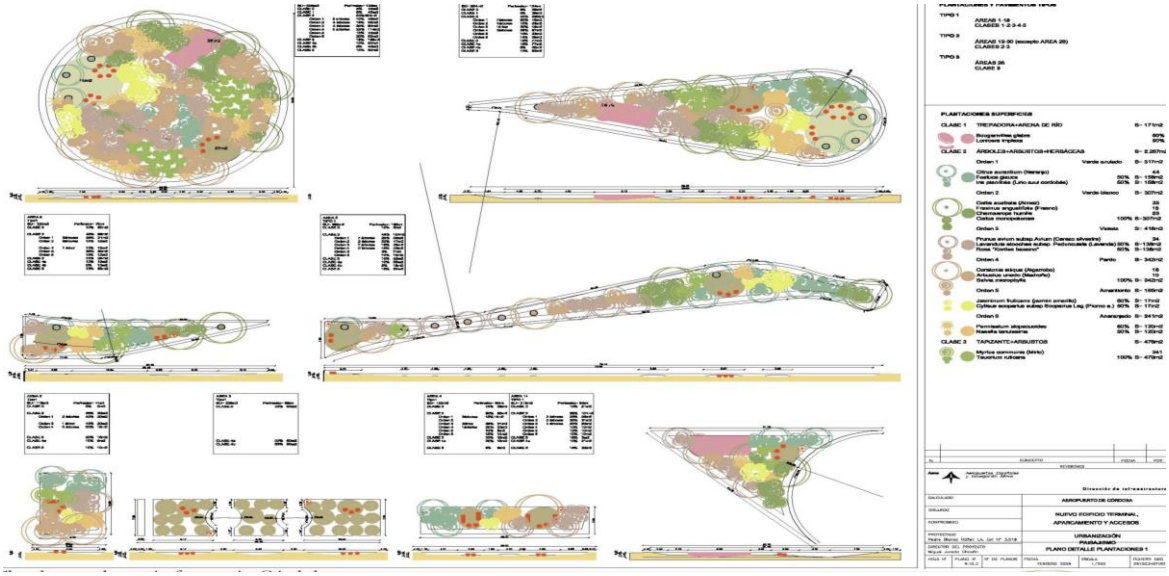

Fig. 10. Dry-hot valley landscape architecture of Cordoba Airport (Cordoba, Spain) [Source: drawings by Cristina Jorge]

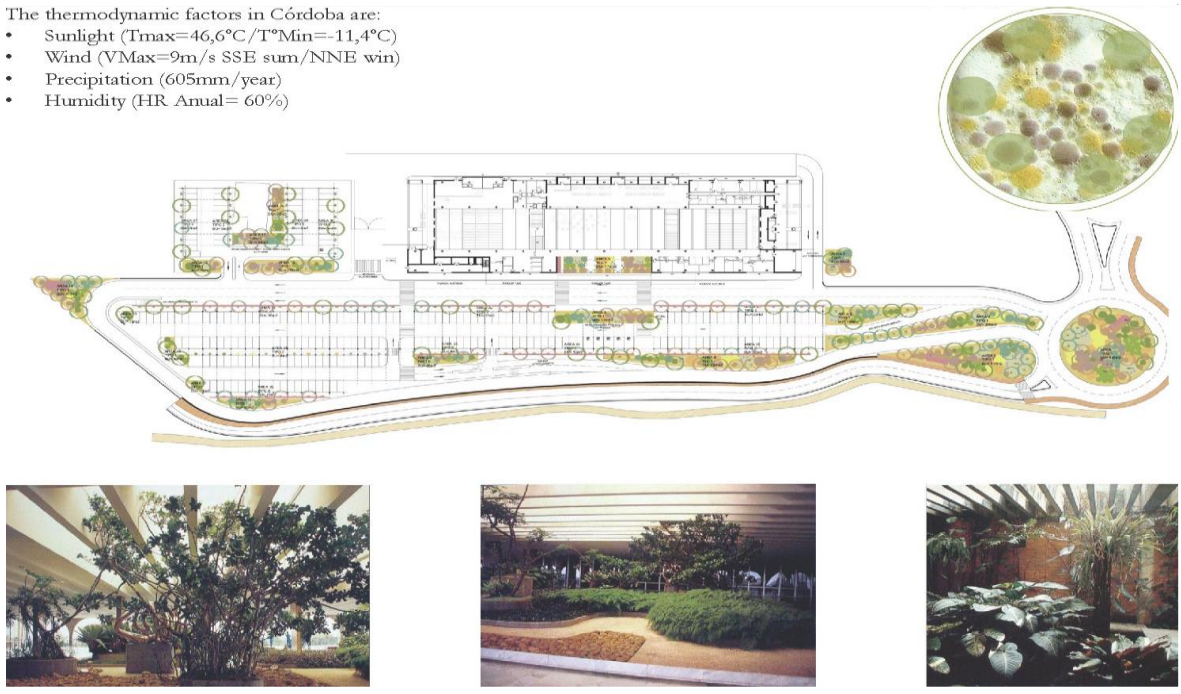

Fig. 11. Dry-hot valley landscape architecture of Cordoba Airport (Cordoba, Spain) [Source: drawings by Cristina Jorge]

Fig. 12. Dry-hot valley landscape architecture of Cordoba Airport (Cordoba, Spain)
[Source: photo by Cristina Jorge]

with the aim of making a positive contribution to patient therapy.

Normal-scale (electricity): Endogenous and exogenous reference (cell water storage in patios and tank water storage in squares).

As endogenous materials, the private patients' area with indirect lighting has six interior gardens for care area unit 1, three interior gardens for care area unit 2 and an interior garden for the day care centre where drainage cells (50x50x5 cm3) drain rainwater.

As exogenous material, the public visiting area with direct lighting has seven exterior gardens for a visitor's zone, an outdoor play area for children,

a horticultural therapy garden and outdoor exercise area where underground water tank (3x3x3 m3) store rainwater. Despite the project design's aim of keeping the hospital area, residential area, cultural centre area and garden area separate, the boundaries thereof merge into each other by way of the outdoor areas.

Macro-scale (meteorology). Thermodynamics parameters (rainfall and humidity/rain, mist, frost). From the meteorological macro-scale covering an area ranging from the size of a continent to the entire globe, to the micro-scale of atmospheric phenomena that range in size from a few centimetres to a few kilometres, the thermodynamic parameters taken into account in the Alzheimer Centre design are: net radiation, sensible heat flux, latent heat flux, ground heat storage, and fluxes of trace gases important to the atmosphere, biosphere and hydrosphere.

3. Dry-hot valley landscape architecture of Cordoba Airport (Cordoba, Spain)

Valley_Green infrastructure (lighting). The concentration of energy resources in plantations are located in the urban parks, car parks and interior gardens of the Cordoba Airport extension in Southern Spain (outdoor area = 25,000m^2 + built area = 8,000m^2).

The invisibility of the materials employed in the design of the airport landscape draws on the other invisible world of micro-organisms, where many protozoan species are symbiotes, some are parasites, others predators.

The lighting gradient varies depending on the proximity to the nearby river. From the diffused light (floodlights) in the interior gardens of the airport to the soft and medium highlight (bollards) of the car park to, finally, the direct and harsh light (streetlights) of the roundabout and highways. Unfortunately, this project to expand Cordoba Airport was cancelled for economic reasons.

Micro-scale (gravity). Domain eukaryote reference (protozoa)**.** They are usually single-celled and heterotrophic eukaryotes containing non-filamentous structures that belong to any of the major lineages of protist. In the natural spaces of the airport, an informal field of different shapes such as round borders, roundabouts and central reservations defines a catalogue of microorganisms shapes, translating the seven main components: cytoplasm, digestive vacuoles, shrink vacuoles, macronucleus, micronucleus, trichocyst and cilia.

Normal-scale (electricity): Endogenous and exogenous reference (3 green classes and 5 mineral classes). The endogenous green features are divided into three classes. Class 1: trees with climbing plants; Class 2: herbaceous with shrubs and trees; and Class 3: ground cover and barks. The exogenous mineral references are separated into five classes from soft to hard qualities: Class 0: hummus earth; Class 4a: gravel and mortar; Class 4b: rocks and mortar; Class 5: sandstone and curbstone; Class 6: concrete and rocks.

Like microorganisms, these features comprise a soft interior with a hard exterior membrane to protect themselves from the environmental conditions. In the Cordoba Airport project, the material transition goes from the riverbank to the concrete runway, and landscape architecture ensures a smooth transition from green areas to car parks.

Macro-scale (meteorology): Thermodynamic parameters (radiation/lightning and volcanic activity). Related to climatic elements, the lightning storm interchanges fluids and also oxidises nitrogen in the air into nitrates which are deposited by rain and can fertilise plant growth. Volcanic activity, meanwhile, is the principal factor controlling the lack of phosphorous in the sea and in the ocean depths. Micro-irrigation, and drip and sprinkler irrigation have an impact on water use efficiency by reducing local non-productive evaporation losses. Beginning with the existing climatic conditions as a point of departure in the airport landscape, the project has defined lighting gradation climatic maps according to the proximity to the river or to the airport building.

Conclusion

These systems translate the abstract world of microbiology. Electricity or macro meteorology to the concrete world of landscape architecture and infrastructure design using biological and economic knowledge to allow arid Spanish biome landscapes to be recreated in a sustainable manner.

In the traditional and contemporary works, the micro-scale is used to analyse the complex geometry in primitive organisms, the normal-scale is applied for the influence of foreign elements in the local landscapes, and the macro-scale is employed as new energy sources from thermodynamic parameters.

From the macro to the normal-scale energy system**,** the world of black boxes (irrigation and lighting equipment) as devices, systems or objects which can be viewed in terms of their inputs and outputs without any knowledge of their internal workings, has infinite cables which are connected to black buildings (power stations) that transform the energy generated by black platforms (solar, wind, biomass farms), also connected by cables. This system of cables creates relationships between all the elements that live and feed though them.

From the normal to the micro-scale of biological studies, the biomass of an ecosystem depends on how balanced and connected its food web is. In the case of a small biome, connected green islands reveal the possibility of using balanced

resources, which consist of the right qualities and proportions of water, drainage, minerals and electricity need to maintain growth: a state-of-the-art laboratory [6].

From the micro to the macro scale of thermodynamic parameters, the original geometry will be affected by the impacts of extreme weather events and the time of day or night; moving away from the desire to impose static order such as rigid geometric design on nature which is rare, and usually temporary. Landscapes are dynamic and the result of physical processes (such as erosion and sedimentation) and biological processes (involving growth, blossoming and decay).

At the different scales, the development of digital landscape architecture helps to make an hybrid of passive and active climatic conditioning which is made possible by advance control technology. This mixed system will promote the expansion of island configurations versus continent landscapes. The use of sophisticated software for climatic variations in normal scale that have been mapped by computational fluid dynamics simulation, in the same way as advanced microscopy and image processing software, is also a critical advance that allows the direct observation of interactions of individual protozoa in spatially complex environments at the micro-scale.

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Kopsavilkums. Pētījums veikts par trādicionālo un mūsdienu sauso Spānijas ainavu sadalot to trīs kategorijās: lielmēroga meteoroloģija, elektrība un mikrogravitācija (svarīgums). Fokuss pētījumā ir vērsts uz normālā mēroga (cilvēki, dzīvnieki, augi un mašīnas), mikromēroga (vienšūņu organismi), lielmērogā (termodinamiskie parametri) analizēšanu. Mūsdienu ainavu arhitektūra ir pētīta caur sarkano, zilo un zaļo infrastruktūru. Pirmkārt, sarkanā infrastruktūra (dehesa) ir liela teritorija sarkanas auglīgās augsnes ar zaļām pļavu salām, kuru izmanto parkos, dārzos un zaļajos jumtos rietumu Spānijas projektos. Otrkārt, zilā infrastruktūra (sausās pļavas) ir lietusūdens uzkrājēji novietoti zem zemes skvēros un dārzos kādā centrālās Spānijas projektā. Treškārt – zaļā infrastruktūra – (sausā,kārstā ieleja) ir urbānajos parkos, autostāvvietās un iekštelpu dārzos koncentrētie stādījumi dienvidu Spānijā, lidostas paplašinājuma projektā. Pētījums atspoguļo slēpto struktūru nozīmīgumu un to sadarbību starp dažādajiem mērogiem konkrētu projektu ietvaros dažādās Spānijas daļās.