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Geotechnical Properties of Soils

The Analysis of Green Environment

Highlights

Core City Slums and Vulnerability

Trends and Variations in Tropical

Discovering Thoughts, Inventing Future

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The Convents of Mexico City in the Colonial Biological Exchange: Notes for Colonial Environmental History from the Sixteenth to the Eighteenth Centuries

By Gonzalo Tlacxani Segura
El Colegio de México

Abstract- Employing travel writings and juridical documentation created during the colonial period in Mexico, this article offers an analysis of the transfer of plants and animals from the Old World to North America and their effects, with a particular focus on Mexico City from the sixteenth to eighteenth centuries. The aim of this paper is to highlight the role of the orchards and gardens associated with the Discalced Carlemite Order's convents as a key site that allowed for the adaptability of different European and Asiatic plants in Mexican lands.

Keywords: environmental history, new spain, religious orders, order of discalced carmelites, old world plants and animals, spanish conquest.

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I. Introduction

The Spanish conquest of the powerful Mesoamerican cities located in Mexico's central highlands launched a period of unprecedented biological exchange in the region. Beginning with the conquest of the Aztec city of Tenochtitlan in 1521, New Spain became a place where Old World and New World pathogens could transfer freely through trade, human-to-human contact, and agricultural introductions that radically shaped the construction of the new Hispanic baroque society.[1] The Europeanization of the New World set into motion a long process that attempted to recreate the political, economic, cultural, and natural environments of the Iberian Peninsula in the territory of New Spain. The native environment was not only transformed by novel crops and livestock imported from the conquistadors' homeland, but was also transfigured by plants and animals which had been moved from the Antilles to the continent. The creation of Spanish harbors modified the original ecosystem which had existed before the arrival of Spanish.

In the particular case of Mexico City and its surrounding lands and populations inside the basin of Mexico, the insertion of non-native animals – including the European bearded man – in the early sixteenth century brought about significant changes that are difficult to perceive today. The plants and animals that the Spanish introduced in the fertile soils of Lake Texcoco, Chalco and Ecatepec modified the previous ecosystem. Thus, in the decades following the conquest of Mexico-Tenochtitlan large farms of wheat, barley, corn, and other seeds were established and developed in the region, which together with the raising of steadily growing numbers of livestock altered the natural lacustrine environment of the lake region.

The cultivation of fruit trees of Eurasian origin was a relevant concern during this first century of Hispanic life in the Americas. The Church played a significant role in the process of adaptation of these species, with convent orchards serving as a primary site for their cultivation. In addition to this participation, the regular clergy have left us testimony in their provincial chronicles of two crucial cultural phenomena that were developing in the territory: firstly, the promotion of some particular devotions and the existence of certain hagiographical figures who exalted the spirituality of a religious corporation within a providential historical reality; and, secondly, at the level of earthly historical reality. The chronicles expressed the vision that some clergy had of the future of the human communities that interacted politically, economically and culturally in the cities of Hispano-American, placing special attention on their concern for knowing the geography and nature of the New World through the lens of the philosophical relationship of Providentialism with Pantheism and Neo-Platonism.

It is within this cultural context contained in the local historiography produced at the time that the present work aims to address the importance of the convents of Mexico City within the Hispanic biological transference in the colonial period through two primary areas of focus. Based on the presentation of some of the first moments of colonization led by Hernán Cortés in the 1520s, the first section will study the relevance of the region where Mexico City was founded within this biological process. An additional aim was that of reconstructing the process of the introduction of different plant species into the territory through some of the most important chronicles and writings of the Indies, an objective for which the consultation of documents related to the subject from the General Archive of the

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Nation of Mexico and in the Historical Archive of Mexico City was fundamental.

The sociocultural repercussions brought about by the introduction of non-American species into the territory through gastronomy and the economy will be briefly discussed in this section. In the second part of this work, two case studies will be analyzed on the role of the convent gardens in this process of biological transference: the gardens of the Discalced Carmelites and their convents located in Santo Desier to de Santa Fe (Holy Desert of Santa Fe) and San Ángel.

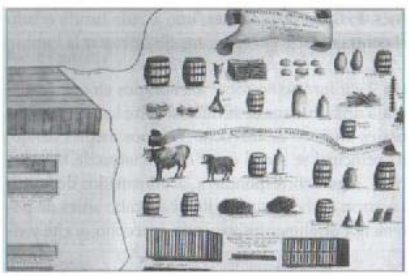
II. Colonial Biological Exchange: The Case of Mexico City and its Surroundings

> Aquí, Señora, el cielo, de su mano,/ parece que escogió huertos pensiles/ y quiso él mismo ser el hortelano;/ todo el año es aquí mayo y abriles,/ temple agradable, frío comedido,/ cielo sereno y claro, aires sutiles/ […] Bellísimo sin duda es este llano,/ y aunque lo es mucho, es cifra, es suma, es tilde,/ del florido contorno mexicano;/ ya esa fama de hoy más se borre y tilde,/ que, comparada a esta inmortal frescura,/ su grandeza será grandeza humilde. […] Al fin, ninfas, jardines y vergeles,/ cristales, palmas, yedra, olmos, nogales,/ almendros, pinos, álamos, laureles,/ hayas, parras, ciprés, cedros, morales,/ abeto, boj, taray, robles, encinas,/ vides, madroños, nísperos, serbales,/ azahar, amapolas, clavellinas,/ rosas, claveles, lirios, azucenas,/ romeros, alhelís, mosqueta, endrinas,/ sándalos, trébol, toronjil, verdenas,/ jazmines, girasol, murta, retama,/ arrayán, manzanillas de oro llenas,/ tomillo, heno, mastuerzo que se enrama,/ albahacas, junquillos y helechos,/ y cuantas flores más abril derrama,/ aquí, con mil bellezas y provechos,/ las dio todas la mano Soberana:/ este es su sitio y estos sus barbechos/ y esta la primavera mexicana.
>
> *Bernando de Balbuena, Grandeza Mexicana (1604)*

This was the allegorical immortal springtime that Bernardo de Balbuena wrote about Mexico City in the early seventeenth century. His work had been conceived with the intention of exalting the political, economic and social importance of the capital of the viceroyalty of New Spain[2] and serves as a testimony of the modification that the natural landscape of the Valley of Mexico basin suffered as a result of the Hispanic biological exchange that began between August and September 1521 with the Spanish conquest of Mexico-Tenochtitlan.

As Alfred W. Crosby wrote, the process of "Europeanization" that the American territory suffered as a result of the Columbian contact of 1492 was gradual.[3] In 1519 the soldiers who accompanied Captain Hernán Cortés on the expedition left the island of Cuba for terra firma on the shores of the Yucatan Peninsula, with the expedition culminating in the conquest of the powerful Mesoamerican empires of the central highlands between 1521 and 1523. Naturally, they required food, fibers and skins for their subsistence both before and after formally establishing themselves in the territory. From where and how did they obtain these provisions to resist the warfare against the Indians and the inclemency of the climate of the New World? From his departure from the Antillean island, Cortes had transported on his ships domesticated fruits, vegetables, and animals that would not be consumed by his crew during the sea voyage but would be of benefit when they reached the mainland.

Following the logic of conquest established by Christopher Columbus almost two decades earlier, the Antilles became a laboratory of experimentation for the adaptation of plant and animal species from the Iberian Peninsula to transfer and adapt the modus vivendi of the Spanish society who would populate the Caribbean islands. The history of Hispaniola in 1493 is an example of this situation; during Columbus' second trip, the Genoese admiral established European horticulture through the settling of twelve hundred men who travelled on seventeen ships as well as the cultivation of wheat seeds, chickpeas, melons, onions, radishes, green vegetables, grapevines, sugar cane, and fruit trees.[4] As Alfred Crosby points out, the results were initially encouraging according to the admiral's testimony, although crops such as wheat, olive trees, and grapevines failed because of the island's hot, humid climate.



Source: Antonio Rubial Garcia (cord) Historia de la vida Cotidiana en Mexico II.La ciudad barroca Mexico Colmex, FCE 2012

Fig.1: Provisions that are Shipped to give the daily rations to the passengers of the ship in the *Album* of the marquisof victory

Hispaniola – the so-called "foyer of the Americas" – was the place where European horticulture began (naturally, with some failures) and, by 1500, the transformation initiated by the Spaniards was successful. Thus, following the conquer of Mexico-Tenochtitlan, they aimed to initiate the same process in

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New Spain. When Hernán Cortés and his army arrived in the territory of Mexico, in addition to bringing smallpox and other viral diseases previously unknown to the region, they rode their road to the capital of Mexica empire "on horses fed in the Antilles and accompanied by guard dogs coming from the same islands."[5]

Once the conquest of Mexico-Tenochtitlán was successful, Hernán Cortés ordered that the new Spanish city to be built on top of the old Mesoamerican city. The construction process was more protracted and demanding than the Spaniard had anticipated, continuing into the mid-sixteenth century. Wheat bread was the most appreciated foodstuff for the Spaniards; cereals and other seeds reached the Valley of Mexico before 1530 for the benefit of the new city's population.[6]

In 1524, Cortés wrote and ordered the proclamation of the *Ordenanzas de buen gobierno para los Vecinos y moradores de la Nueva España* (*Ordenances for the Good Governance of the Residents and Inhabitants of New Spain*). In the text, Cortés wrote that the Spaniards would arm and Christianize the Indians who were distributed to them, and that "any resident [*vezino*] who has Indians at his disposal [*indios de repartimiento*] is obligated to give them, for each hundred Indians that he has at his disposal, one thousand grapevine shoots…these grapevine shoots can be planted wherever he sees fit, without harming any third parties, and that he plants them each year in the seasons in which it is advisable to plant them, until he arrives at the quantity of one hundred to one thousand vines for each hundred Indians whom he has at his disposition."[7] Further on, in the eighth point of this *ordenanza*, Cortés ordered that "there being other tree plants from Spain and wheat or barley and any legumes, [the residents] likewise are obligated to plant and sow them in the towns of the Indians that they have, with the aforementioned punishments."[8]

As for the production of wine – the second most important dietary element in Iberian gastronomy – the shoots that prospered as a result of this courtly policy gave some bunches of grapes from which low-quality wine was produced;[9] the grapes did not ripen perfectly due to Mexico's temperate climate.

A crop that followed a similar path to that of the grapevine in the center of the New Spanish Viceroyalty, particularly in Mexico City, was that of sugar cane, which had been remarkably successful in adapting to various regions of the New World since the end of the fifteenth century. The sugar plant was able to prosper in Hispaniola as it had in the Canary Islands and the Azores due to its weather conditions. This crop of Asian origin had been cultivated practically without any problem in the lands of Andalusia and Granada with the Muslim expansion in North Africa and the Iberian Peninsula. In the case of North America, Crosby postulates that sugar became a common crop in the lowlands and deeper valleys of these regions that had a hot climate.[10] In the case of Mexico City, the sugar farms that were established (such as the one Cortés had in Coyoacán) did not prosper for several reasons, as Alexander von Humboldt conjectured. It was Baron von Humboldt who suggested that this crop had to disappear from the landscape of the valley of Mexico because the tree felling of forests over the next three centuries "cooled the climate";[11] this erroneous judgement by the Prussian geographer and naturalist on the decrease in temperature of this region of Anahuac can only be explained by the ravages caused by the climatic phenomenon now termed the "Little Ice Age" (1600-1850).[12]

During the remaining years of the sixteenth century, different modifications to the landscape of the Anahuac region were made by the Spaniards as the introducers of European and Asian animals, fruit and vegetable species. These changes were also provoked by the indigenous peoples of the territory in their roles of personal service to the *encomendero* or as farmers within their communities. We will now highlight some cases recorded in the chronicles and writings of the natives. Despite the fact that in North America few olive trees grew and produced oil – to the extent that their production was insignificant during this and the following two centuries – different travelers who passed through New Spain, such as the aforementioned Humboldt, reported that the olive tree was successfully cultivated in the valley of Mexico. The areas where this Mediterranean crop is known to have flourished included the village of Tacubaya,[13] the village of Milpa Alta,[14]the town of San Joaquin, the neighborhood of Necaltitlan (belonging to the town of San Juan Moyotlan, a neighborhood of Indians within the Republic of San Juan Tenochtitlan),[15] and Xochimilco.[16]

Sugarcane prospered in different communities near the capital of the viceroyalty, such as the jurisdictions of Chilapa and Cuauhnáhuac, the latter belonging to the Marquesado del Valle.[17] A testimony of the importance of this crop in the territory can be found in the *Ordenanza para que no siembren las tierras de caña de azúcar* (*Ordenance to not plant lands with sugarcane*)which was issued in 1599 by the viceroy Don Gaspar de Zúñiga, Count of Monterrey, in consideration of the fact of many lands of Mexico were good for sugar production but should be used for more practical crops. He wrote, "the production of wheat and maize and other seeds is more important and necessary for the Republic than sugar, that there has been a great deal more than what is required for forced uses and that the land for the production of wheat and maize has been lacking and is being reduced to a smaller size than that required for such production".[18]

In regards to wheat, the most popular and interesting crop in New Spain, there are several testimonies about its presence in the territory of Anahuac. Within the historiography of the Indies that

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took place at this time, it is possible to observe how Augustine Vetancurt, a Franciscan clergy member of the province of del Santo Evangelio de México, observed that in Cuautitlán, Tlalnepantla, Chalco, Tultitlán, Tepepan, Texcoco, y San Jerónimo Aculco there were farms dedicated to the cultivation of wheat.[19] Friar Antonio de Ciudad Real, a Franciscan clergy member, reported that wheat was abundant in the Valley of Mexico.[20]

One aspect that is impossible to deny is the footprint was left by wheat and barley production on the economy of the Kingdom of New Spain, particularly in our region of this study. In the Colonial Institutions branch of the General Archive of the Nation of Mexico, it is possible to observe a number of files, distributed in different sub-branches, that show that this agricultural activity closely linked to colonialsocietyand its most important product – wheat –had to be sent to Mexico City in order to satisfy the population's demand.[21] The archival documents highlight the importance of certain populations, such as Texcoco, in the supply of grain;[22] the sale of wheat and, once processed, flour by the natives of their crops;[23] the need for different plantations to be supplied with Indians for wheat cutting and bread making;[24] permissions to the local authority for some Spanish neighbors to grow wheat and barley on the outskirts of the city;[25] and permissions for the production of common bread by mixing fine and ordinary wheat so that its cost would be accessible to the poor,[26] among other socioeconomic issues.

As noted above, the importation and raising of livestock in these lands was essential for the survival of the new settlers who established themselves in the different Spanish towns, villages, and cities, among which Mexico City was the most important political and administrative center. Which livestock animals were introduced to the Mexico Valley basin between the sixteenth and eighteenth centuries? Alexander von Humboldt's later testimony reveals that in Mexico City and its surroundings oxen, horses, sheep and pigs abounded, a list of animals to which we would add dogs and chickens.[27]

A peculiar case in this work is that of the roosters and hens from the Old World who were raised in the area of the Archbishopric of Mexico, a subject little known in colonial environmental studies. In the 1617 *Ordenanza sobre que cada indio tributario críe 12 gallinas de Castilla y un gallo y seis de la tierra en cada un año* (*Ordenance concerning that each tribute-contributing Indian raises 12 hens from Castile and a rooster and six from the land per year*), the natives of each of the towns of New Spain had the obligation to raise six American and twelve European hens each year, plus one rooster, due to the following reasons: "there is a great lack of them and with this their increase in price [*encarecerse*], it is practical as a remedy, so as the republics are provided with this genus."[28]



Fig. 2: The Capital before the great Flood of 1629 Map of Ciudad de Mexico Painted of juan Gomez de Trasmonte

It is not known from the documentation produced at the time if the introduction of this domestic bird caused any effect on the natural environment of the villages and towns of New Spain in addition to being used for reproductive purposes and cockfights.

From this brief study of the fruit and vegetable species that were introduced in Mexico City between the sixteenth and eighteenth centuries, we can observe how the capital of the viceroyalty of New Spain was shaping the natural physiognomy that Bernardo de Balbuena described in 1604 when the process of Europeanization of flora and fauna of the New World was already irreversible. In the same period that Balbuena wrote his Grandeza Mexicana, the friar Antonio de Ciudad de Real noted the process of Hispanic biological exchange that Mexico City was

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experiencing: oranges, limes, lemons, ciders, walnut trees, apple trees, pomegranates, peaches, apricots, quince jellies, pear trees, fig trees, plums, cherries, grapes ,and olives were transplanted from Spain,[29] fruits to which he added the list of flowers and herbs: "Castilian roses, carnations, wallflowers, lemon balm, rue, pennyroyal, chess, oregano, cumin, caraway, Our Lady's herb and fennel, among others not mentioned, have been brought from Spain".[30]

A century and a half later, José Antonio de Villaseñor y Sánchez, a cosmographer and royal accountant, published the first volume of his *Theatro Americano. Descripción general de los reinos y provincias de la Nueva España* (*American Theater. General Description of the Kingdoms and Provinces of New Spain*). In this work, in addition to a detailed description of the territorial political organization of the Viceroyalty of New Spain, he recorded the modifications that the natural ecosystem of North America had undergone as a result of the Hispanic biological exchange that began in 1521. In the specific case of Mexico City, Villaseñor points out that in its surroundings, wheat, chickpeas, lentils, rice, flax, grapevines, olives, peas, corn, beans, and barley can be harvested, as well as the raising of bulls, steers, cows, and pigs.[31] The capacity of these fertile lands of the Valley of Mexico basin at the time had three important lakes that fertilized the wetlands: Texcoco, Chalco, and San Cristobal and facilitated the existence of wheat and barley farms in areas like Tacubaya. Additionally, they provided precious water for the orchards in convents and country houses where pears, peaches, prunes, apples, plums, apricots, pomegranates, quince jelly, and some citrus fruits such as oranges and lemons were grown.[32]

Every one of these fruits, plants, and animals were brought from the islands of Hispaniola and/or from the ports of Seville and Cadiz to the port of Veracruz using a trip of little more than three months made by the fleets that had sailed from the Old World. Their arrival had an important impact on the daily life not only of the inhabitants of Mexico City but also of the American viceroyalty. Juan de Viera refers to this biological impact in 1777 in two areas: commercial and cultural. In the commercial sector, he wrote that Mexico City sells salted and cured meats, hens, wreaths of roses from Castile, 124,895 annual loads of wheat flour, pomegranates from China and watermelons, almonds, walnuts, hazelnuts, coconuts, pine nuts, figs, pears, limes, oranges from China, and loads of barley, straw, and oranges.[33] This variety of products had an impact on the New Spanish cuisine, which, since very early times acquired a strong mestizo character. This is why, in addition to the sale of these fruits and animals, tamales with pork meat, goat and cow cheeses, butter, pineapple, guava, prickly pear fruit, almond pulp, and liqueurs were also offered in the city's *tianguis* and markets which survive today. In addition, Viera offered a list of nearly ninety-four fruits, both American and European, that entered the twenty-four squares of Mexico, as well as the meats that supplied the forty-two butcher's shop and wheat flour to the forty-six bakeries, gave us a fact about the place where they grew some of these fruits that were for sale in the city: "Here[in the vicinity of the lake town] you can see the mountains of fruit, where the number of fruit trees abounds all year round, and the number of which exceeds 90, as will be seen in the memoir that I will attach to this story: in the same way the vegetable gardens are seen and recorded, so that not even in the fields themselves is there so much abundance, as is seen together in this theatre of wonders".[34]

A little more than three decades later in the nineteenth century, Alexander von Humboldt witnessed the result of the transformation of the Valley of Mexico's ecosystem during the colonial period, writing "To the south of the valley are orange, peach, apple, cherry and other fruit trees from Europe"[35] and later adding that "[there is] a large crop of cherries, plums, peaches, apricots, figs, grapes, melons, apples and pears on the Central Table. They are especially found in San Agustín de las Cuevas, Tacubaya, in Carmelo de San Ángel and in the garden of Fogoaga in Tlalnepantla."[36] The participation of the Church in the biological conquest of New Spain will be discussed later.

Other travelers of European origin who visited New Spain between the end of the seventeenth and beginning of the eighteenth centuries provide us with other relevant data on the impact of the biological transfer from the Old World to the New World. In the case of Giovanni Francesco Gemelli Careri, a Neapolitan traveler who passed through North America in 1697 from the Philippines, we find some interesting data that coincides with the descriptions of other travelers and chroniclers who described the territory at that time. Gemelli Careri was surprised by the exuberance and fertility of the New Spanish lands since He arrived in Acapulco; his first comment was that "on the road from Acapulco to Mexico, there are wild lemons and oranges."[37] Once he arrived in the capital of the viceroyalty, the Neapolitan man recorded in his diary some aspects of the flora and fauna that caught his attention: "in the orchard of the convent of Tepotzotlán there is fruit like that of Europe,"[38] and not only there, but elsewhere: "there are all the European fruits[in the region], except hazelnuts, cherries, medlars and sorbs."[39] This last comment leads us to ask the ships a kind of Noah's Ark for transporting animals and fruits of all kinds, also possessing contagious diseases that, once landed on land, could generate epidemics among plants?[40]

The last traveler we will examine in this study is the French captain Jean de Monségur, who arrived in New Spain in 1707 after having suffered misfortunes in

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the waters of the Caribbean Sea after having faced two Dutch sloops. The French navigator was also interested in the urban composition of Mexico City, in addition to referring in his memoirs to matters of geopolitical and economic interest to the Spanish Crown with regard to commercial contact with the American kingdoms. He held a particular fascination for the volcanic rock tezontle with which some buildings were built, including the aqueducts that provided water to the city. The Alameda, a plaza which was built by the orders of Viceroy Luis de Velasco "The Young" between 1590 and 1592, he saw that some poplars were sown in early days.[41] The fact that this tree species caught his attention is not by chance, as this species is of Eurasian origin and must have been introduced into American territory at some point in the sixteenth century.

So far, some comments have been provided on the transformation of the landscape. But who brought certain plants to certain places during three centuries of Hispanic presence in the American territory? And what role did the natives play in the Hispanic biological exchange that the region of the Valley of Mexico experienced?

Alfred Crosby said that at the beginning of the sixteenth century, the Jesuit José de Acosta asked who had planted the "forests and whole forests of orange trees" in the Andean area of the viceroyalty of Peru that he visited and somebody replied to him that "oranges fell to the ground and rotted and their seeds germinated, and that those that the water drags to various parts grew these very thick forests".[42] In this sense, in regards to the first question, it is likely impossible to know who in particular took certain seeds, trees, and plants from Spanish ports to the Americas to be placed in different parts of the continent, as the passenger books of the Indies neither inform us in detail about the objects that the travelers carried with them nor assure us that the people on the register were those who actually crossed the ocean. Since they lack this precise data, this work proposes three actors who were able to bring seeds, plants, and livestock with them to the New World and particularly to Mexico City: the conquistadors, the Spaniards who were to settle in the city, and the clergy of different religious orders.

In the case of the conquistadors, as mentioned above, it was these men-of-arms who were responsible - once they became *encomenderos* - for introducing the first cattle in the lake region of the Valley of Mexico. They also introduced other species into other regions of Mesoamerican territory such as the Oaxaca Valley, where Hernán Cortés, after having introduced Merino sheep into the Toluca Valley and sowed sugar cane, was responsible for the introduction of the first cattle into the lake region of the Valley of Mexico.[43] There is a significant possibility that the Spaniards who arrived after the fall of Mexico-Tenochtitlan to approach the new Spanish city intentionally transported seeds for human consumption in the folds of textiles, in clods of soil, in manure, or in many other possible ways, as Crosby points out in the case of clovers and some forages.[44]

And the clergy? Independently of their evangelizing project in the Indies, the members of some of the different religious orders, seeing their work in the regions with high density of Indians strengthened and seeing that church and convent were built for Christian activities, created their gardens to plant olive trees, flowers (such as the rose of Castile), and some fruit trees such as apple trees, pears, and other European fruits. These include the olive orchards that were planted in the Carmelite convents of San Ángel and San Joaquín, the Santo Desierto of Santa Fe, of the same religious order, where roses from Castile and apples were sown; the convent of San Diego in whose small square in front of the convent poplars and willows were planted; and the college of Saint Francisco Javier Tepotzotlán of the Society of Jesus in its the orchard bore European fruits, according to Gemelli Careri. For these and other reasons, it is proposed in the following section of study to see the convent garden as the main laboratory of botanical adaptation – next to the gardens of the Spanish country houses – of the process of Hispanic biological transference between the sixteenth and eighteenth centuries.[45]

Up until this point, I have explained the biological historical changes that the ecosystem and landscape of Mexico City and its surroundings had during the colonial period as a result of the Hispanic biological exchange. Here, I would like to introduce the case study that motivated the realization of this work, which is the participation of the convents of the capital of New Spain in the biological transference from their orchard. I propose that it was the basis for the expansion of European horticulture into Indian communities and other newly discovered points on the American map. In this section I analyze the biological experience of the Carmelite convents of San Angel and the Santo Desierto de Santa Fe, both located to the west of Mexico City.

III. Colonial Biological Garden: A Place of Spiritual Contemplation and Botanical Experimentation

- The Holy Desert of Santa Fe

The Order of Discalced Carmelites was characterized, in comparison with other religious orders in New Spain during the sixteenth and seventeenth centuries, by its active contact with the natural and spiritual environment through the concept of the "desert."The desert, conceived in 1592 by Friar Thomas of Jesus,[46] was a large convent house accompanied by some hermitages or chapels that in its surroundings had lush gardens and free fauna that was limited by a perimeter fence under the protection of the Carmelite

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friars. The creation of this special convent away from all human contact had the purpose of connecting the clergy with the roots of their religion; that is to say, the primitive organization of the order on Mount Carmel in present-day Israel and Palestine with biblical figures such as the prophet Elijah and his hermits.[47]



Source: Manuel Ramos median El Carmelonovosipano, Mexico CEHM 2008.

Fig. 3: Remains of an olivemill in the convent of san Joaquin

The allegorical reconstruction of this contemplative past of the Order in New Spain was an important element for the Carmelite to develop his life in solitude within the particular setting of the natural world. This element was based on the ideal of finding paradise on Earth in the discovered lands of the New World.[48] The deserts founded since 1593 in the Spanish congregation of San José were a kind of "Edenic shelter"[49] inside it where the human spirit could return - in its contact with nature - to the paradise from which the divine creation came and thus be able to reach communication with God through prayer and penance. This mythical longing for the past materialized in the very figure of deserts, regardless of whether it was real or not; the desert integrated[50] a space isolated from the outside that included the reality where impossible dreams could come to fruition.

The formal foundation on January 1, 1605 of the first and only desert of the Province of San Alberto in the mountains of Santa Fe was the work of Friar Juan de Jesús María "el Indiano" and the sponsorship of the assayer Melchor de Cuéllar. The space that made up the prayer hall was a truly mystical garden that dazzled with its beauty and colorfulness as described by the chronicler brother Agustín de la Madre de Dios:

> They lie towards the part that falls between the west and north of Mexico City, some robust and thick mountains whose entrance is through a valley that begins with a small entrance and slowly gets wider and wider as one walks through. (…) Witness that place dressed in so much green that no other color is seen and since its creation this vestment has never moved, as not even the winter strips [the valley] of it nor does time wizen it. The woods are so dense that they form closed forests and almost on the entire mountain one walks beneath the pavilions that weave the *guayemeles*, pines, and other plants that create so much variety and abundance that one's feet barely fit. There the branches embrace each other, the beeches with the ashes, the strawberry trees with the oaks, the cedars with the white pines, the alders with the laurels, and they are so interwoven that even with rays the sun can barely penetrate them in order to illuminate the valleys.[51]

The desert thus represented a paradisiacal place that might well remind us of its description in the book of Genesis about the Divine Creation and the Garden of Eden, but which, in spite of the various adversities of time, is currently maintained with the same magnificence under the legal classification of National Park of the Desierto de los Leones since 1917. Now, the Discalced Carmelites have been replaced by the hundreds of tourists who visit it every weekend to enjoy its rich vegetation and history.[52]

The relationship that the Santo Desierto de Santa Fe had with the process of Spanish biological transference during the seventeenth century was evidenced in its garden. Of the ten species of trees present in the mountains that housed the perimeter fence of the convent complex, at least three species were present (the strawberry, the oak, and the laurel) were introduced by the clergy, by the native peoples who illegally crossed into the sacred area, or by Spaniards prior to the settlement of the Carmelites in the hills of Santa Fe.

Some of the observations and descriptions on the nature of this area of the Valley of Mexico made by Fray Agustín de la Madre de Dios and contained in his chronicle *Tesoro Escondido en el Monte Carmelo Mexicano. Mina rica de ejemplos y virtudes en la historia de los carmelitas descalzos de la Provincial de la Nueva España (Hidden Treasure in the Mexican Mount Carmel. Rich Mine of Examples and Virtues in the History of the Discalced Carmelites of the Province of New Spain*), the author refers to other observations on the modification of the natural ecosystem following the introduction of European plant and animal species into the territories of the New World by the Spaniards.

> Authors have said much of the fecundity of these countries; there are valleys in these parts that produce so much wheat that in a single eat one thousand and sometimes two thousand grains can be counted, as the highly knowledgeable Solórzano said of the wheat of this earth (…) Two and three

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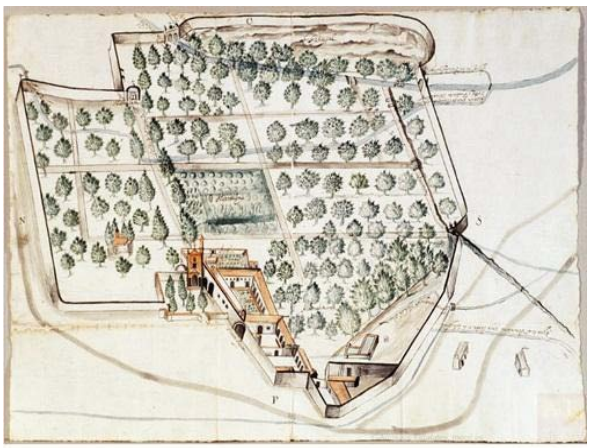
> times a year the wheat is harvested, like in the valley of Atlixco currently is experienced, after one hundred years without a single harvest. The trees are continually dressed with the adornment of their leaves and in a single one in any season there can be seen flowers, ripe fruit, and unripe fruit, always serving as a tribute to the ungrateful man without interruption. (…) There is a great deal of diversity among the animals, because when together those from Europe and those that America fill mountains and valleys and make many wealthy Spaniards. One named Camargo (referring to Antonio de Herrera [y Tordesillas]) multiplied over ten years in a valley by Mexico from only two sheep that he raised, forty thousand heads of livestock.[53]

This description written by the Carmelite chronicler Fray Agustín de la Madre de Dios took up other native writers, such as Antonio de Herrera and Tordesillas, and is illustrative and unique as a provincial chronicle of religious orders whose purpose was to exalt the miracles of portentous images and the prodigious lives of the clergy who formed part of the Carmelite family in New Spain. There exists the possibility that Father Agustín exaggerated in his account the effects that the biological transference originated in the valleys of Mexico, Atlixco, and Toluca, but the virtues and properties that the lands of the New World had at that time were not diminished by the chroniclers and travelers who travelled through North America. For this reason, we must give a vote of confidence to the Carmelite chronicler on the information that is to be found here.

The modification of the ecosystems of these three valleys is important. As Father Agustín suggested in the case of Mexico, the cultivation of wheat gave strong results due to the fertility and the temperance of the land; in Atlixco, fruit tree crops prospered in the last hundred years with three harvests per year. These statistics indicate that, if we take into account that the chronicler is writing this passage between 1646 and 1653, the cultivation of fruit in the region of Puebla must have been introduced between the decades of 1520 and 1550 as well as in Toluca, a place which is inferred by the chronicler's reference to the fact that in a valley next to Mexico sheep farming reached 40,000 head within ten years of the introduction of two animals of this species.

- The Convent of San Ángel

The Convent of San Ángel is located in the town of San Jacinto Tenanitla next to the town of Coyoacán, which served as the administrative headquarters of the Marquesado del Valle. The convent school and church of San Ángel was founded by the Discalced Carmelites between 1614 and 1615. The complex that was built was of large dimensions, had an extension of more than a league and a half of circumference, and was bordered by a wall of five rods high.[54] Inside it housed the theological college, the church under the title of San Angelo Mártir (later under the title of Santa Ana), and a convent that had cells, a domestic chapel, and a library, among other services. According to Manuel Ramos Medina, the convent's orchard was exceptional in its time because of its size; it was because of its extension that the Carmelites, under the help of the Indians of the town of Tenanitla, prepared the land for cultivation and thus take advantage of fertile soil.[55]



Source: Archivo General de Indias, MP MEXICO, 762

Fig. 4: Map of the School of santa Ana of the town of San Jacinto jurisdiction of Coyoacan of the Discalced Carmelites

In order to favor the cultivation of crops in the orchards, the Carmelites formed dams to take advantage of the water of nearby rivers. These constructions allowed the clergy to plant fruit trees of plums, peaches, figs, grapes, apples, and pears, according to Alexander von Humboldt.[56]

On the other hand, within the family of the Carmelites there were prominent clergy who were characterized by their specialization in one or more areas of scientific and/or technological knowledge, as was the case of Andrés de San Miguel. This friar who lived in New Spain during the first half of the seventeenth century and who was an architect, hydrologist, and mathematician wrote a handwritten a series of treatises on carpentry, geometry, the manufacture of sundials, astronomy, glasswork, nature and the site of the waters, and - in particular - on the breeding of peaches in the orchard of the convent of San Ángel, a Carmelite foundation that was built under his instructions.[57]

The treatise on the breeding of peaches acquires a unique and incomparable value within his work, demonstrating the importance of the convent garden as a "laboratory" for adapting the species brought from the Iberian Peninsula to the warm and fertile lands of North America. This historical fact allows us to see religious orders not only as spiritual agents

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dedicated to the conversion of souls at the crossroads of the so-called Spiritual Conquest, but also as transformers of the urban and rural environment from the introduction of rams and plants like the rose of Castile and orange and peach trees that in a short- to medium-term period impacted not only on the modification of the ecosystem at the local but also at the regional level. We can see how did work the convent garden – independently of its purpose of religious recreation – as a platform in the process of adaptation of new plant species. In the words of Friar Andrés de San Miguel:

All these genuses want template breezes, neither cold nor vigorous (…) The tree is raised easily and quickly grows old, although they can be planted with a branch and from the offspring that are born at its foot the good and most beneficial are those that are planted from their seeds (…) The time in which they should be planted in this garden, so that they are sprouted and grown well, are fifteen or twenty days pass after having eaten them, having dried in the shade. The entire seeds, unbroken and spaced by a fourth or a third, four fingers deep, and in the nipple of the seed turned downwards, which becomes the root (…) the first weeding may be done with a hoe, cutting the plans between two soils, as the seeds do not grow here until the peaches start to grow their leaves (…).[58]

The fruit mentioned in this fragment of the description about the cultivation of peaches in the orchard of the convent of San Ángel was surely not only used in the diet of the clergy of El Carmen, but also must have been sold among the Spanish and Indian neighbors of the town of Tenanitla with the intention of obtaining income for the sustenance of convent life.This fact is proven by the lawsuit filed by the colonial authorities in 1681 against the Carmelites to force them to pay the corresponding tithes for the production of the fruit trees in their orchards.[59]

This text has studied the production of the convent orchards of the Discalced Carmelites in Mexico City, work that could later be incorporated into the impact that peaches had on the diet of the New Spanish settlers, a situation that could be understood if some handwritten recipes of the time were found. Other sources where the role of the regular clergy in the Hispanic biological transference could be understood would be the accounts of the convents and estates they were in charge, in these texts, which included information about the type of cattle they raised and the seeds they grew, as well as their quantity, could be better understood.

IV. Concluding Considerations

The study of American nature in its continuities and transformations could not be understood within the colonial period without the reading of the Jesuit José de Acosta's *Natural History of the Indies*. He structured his work with the intention of following the tradition of the medieval rhetorical writers, dividing history into two main aspects: natural history, which included the geographical descriptions (mountains, rivers, valleys) and the animals, plants and mineral products of a region; and moral history, which narrated the facts of men and the descriptions of warrior feats by kings and nobles were exalted.[60]

This division allowed not only the Jesuit, but also the various civil and ecclesiastical writers of the sixteenth and seventeenth centuries, to analyze the geography and nature of the Indies within a historical narrative with providential tones.Their religious association did not deny them the possibility to discuss the proposals of Pliny the Elder and Aristotle on the points of terrestrial space with the intention of refuting the ancestral lies about the existence of the antipodes and the impossibility of inhabiting the torrid zone.[61] These misunderstandings were empirically possible to refute based on the discovery and conquest of the Mesoamerican and Andean civilizations by Hernán Cortés and Francisco Pizarro, respectively.

For these and other reasons offered by the writers of the Indies, the American continent was reconfigured as a place full of natural wealth and a temperate and friendly climate that allowed it to be inhabited and biologically adapted to the needs of the subjects of the kings of Spain and Portugal. In the particular case of the Valley of Mexico basin, and Mexico City, then-capital of the viceroyalty of New Spain and a commercial meeting point for goods from Europe and Asia, the Hispanic biological transfer left a solid mark on the modification of the Mexican ecosystem that persists today. Livestock both large and small modified the areas where there were large pastures where cattle, sheep, goats and other grazing animals altered the soils of the neighboring valleys including Toluca and Ixmiquilpan. The temperate climate of the lake region of Mexico allowed the fruits and vegetables of European and Asian origin to flourish in the vegetable gardens of Spaniards, Indians, and members of the clergy, which had a significant impact on the cuisine and diet of the people of New Spain.

Possibly one of the most singular and important cases that epitomizes the biological transference in Mexico City was that of the Virgin of Guadalupe, in whose maguey fiber ayate the portentous image "must have been painted with rose juice because of its tone," according to Juan de Viera, who follows the official version of the Guadalupan apparitions.[62] The American maguey and the rose of Castile, by means of a mystical or fictitious mixture, gave rise to a virgin, image and identity of the Mexican people and symbol of the legacy of the Hispanic biological conquest that began in 1521 and continues to this day.

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[2] Bernardo de Balbuena, *Grandeza Mexicana*, edition, introduction, and notes by Luis Íñigo-Madrigal, preface by José Pascual Buxó, Mexico, AML, pp. 197-201, 222-223, 228-238.
[3] Alfred W. Crosby, "Gran historia como historia ambiental," in *Relaciones Estudios de historia y sociedad*, El colegio de Michoacán, Zamora, Michoacán, num.135, v. 34, Fall 2013, pp. 33-35.
[4] Alfred W. Crosby, *El intercambio transoceánico*, op. *cit*., pp. 72-73
[5] "en caballos alimentados en las Antillas y trotaban a su vera perros guardianes provenientes de las mismas islas." *Ibidem*, pp. 84-85. Translation by the author.
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[9] *Ibidem*, pp. 77-78. The Mediterranean diet of that time was based on wheat, grapes, and olives.
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[18] "…para labores de trigo y maíz y otras semillas más importantes y necesarias para la república, que no la azúcar, de que ha venido a haber cantidad muy sobrada de la que es menester para usos forzosos y faltar y estrecharse por otra parte las tierras para las dichas labores de trigo y maíz." Translation by the author. *Ordenanzas del trabajo. Siglos XVI y XVII*, selection and notes by Silvio Zavala, Mexico, Editorial Elede, UNAM-IH, 1947. p. 39.
[19] Antonio de Ciudad de Real, *Tratado docto y curioso de las grandezas de la Nueva España*, edition, studies, appendixes, glossaries, maps, and indexes by Josefina García Quintana and Víctor M. Castillo Farreras, Mexico, UNAM-IIH, 1993. p. 65
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[21] *Vid*. "Expediente 21", Mexico, April 4 1679, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, Reales Cédulas Originales y Duplicados, item 21, box 100, vol. 233, 2 f; "Expediente 727", Mexico, May 9, 1607, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, Reales Cédulas Originales y Duplicados, file 727, box 100, vol. 05, f. 179v; "Expediente 35", Mexico, November 18 1587, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, Reales Cédulas Originales y Duplicados, file 35, box 100, vol. 03, f. 17v; "Expediente 81", Mexico, 1786, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, General de Parte file 81, box 051, vol. 65, 41 f; "Expediente 117", Mexico, May 4, 1677, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, General de Parte, file. 117, box 051, vol. 15, f. 121v; "Expediente 161", Mexico, September 23 1677, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, General de Parte, file 161, box 051, vol. 15, f. 1r; y "Expediente 16", Mexico, April 24 1674, AGNM, Mexico City, *Instituciones coloniales*, Real Audiencia, Indios, file 16, box 15, vol. 25, 16 f.

[22] Expediente 195", Mexico, 1693, AGNM, Mexico City, *Instituciones coloniales*, Real Audiencia, Indios, file 195, box 18, vol. 31, f. 150v.

[23] Expediente 328", Mexico, November 20 1579, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, General de Parte, file 328, box 051, vol. 02, f. 1r.

[24] "Expediente 007", Mexico, 1609, AGNM, Mexico City, *Instituciones coloniales*, Indiferente Virreinal, file 007, box 1986, f. 1r-1v;

[25] "Expediente 130", Mexico, June 5 1706, AGNM, Mexico City, *Instituciones coloniales*, Gobierno virreinal, Reales Cédulas Originales y Duplicados, file 130, box 100, vol. 037, f. 433r.

[26] "Expediente 1", Mexico, 1792-1793, AGNM, Mexico City, *Instituciones coloniales*, Ayuntamiento, Abasto y Panaderías, file 1, box 001, vol. 4, f. 1-157v.

[27] Alejandro von Humboldt, *op. cit*., p. 299. The introduction of European livestock into the Valley of Mexico region was a topic of interest in colonial public life, a situation that is evidenced within the different documents of medium and lesser interest concerning judicial disputes and prices and restrictions concerning the livestock that are contained within the Historic Archive of Mexico City in branches such as: Abasto de Carne, Potreros de la Ciudad and Alcabalas y Almacenes.

[28] "haber mucha falta de ellas y con esto encarecerse, a que conviene por remedio, por tanto y para que la tenga y las repúblicas estén proveídas de este género" Translation by the author. *Ordenanzas del trabajo. Siglos XVI y XVII, op. cit.*, p. 58.

[29] Antonio de Ciudad Real, *op. cit*., p. 60.

[30]*Ibidem*, p.66. "se han traído de España rosas castellanas, claveles, clavellinas, alhelíes, toronjil, ruda, poleo, ajedra, orégano, comino, alcaravea, yerba de Nuestra Señora e hinojo, entre otras no mencionadas" Translation by the author.

[31] José Antonio de Villaseñor y Sánchez, *op. cit*. pp. 145 y 154.

[32] *Ibidem*, pp. 178 y 183.

[33] Juan de Viera, *Breve y compendiosa narración de la Mexico City*, trans. Beatriz Montes, presentation by Jorge Silva Riquer, Mexico, Instituto Mora, 1992, pp. 29, 30, 110, 132, 136, 137 y 141.

[34] Juan de Viera, *op. cit*., p. 28. Translation by the author.

[35] Alejandro von Humboldt, *op. cit*., p. 120.

[36] *Ibidem*, p. 275.

[37] Giovanni Francesco Gemelli Careri, *Las cosas más considerables vistas en la Nueva España*, trans. José María de Agreda y Sánchez, prologue by Alberto María Carreño, Mexico, Ediciones Xóchitl, 1946, p. 33.

[38] *Ibidem*, p. 90.

[39] *Ibidem*, p. 151.

[40] *Cfr.* Flora Trejo, "El barco como una ciudad flotante", in Antonio Rubial García (coord.), *Historia de la vida cotidiana. La ciudad barroca*, t. II, Mexico, Colmex, FCE, 2012, pp. 160-161.

[41] Jean de Monségur, *Las nuevas memorias del capitán Jean de Monségur*, trans. Florence Olivier, Blanca Pulido and Isabelle Véricat, edition, prologue, and instroduction by Jean-Pierre Berthe, Mexico, UNAM-IIH, IFAL, CEMyC, 1994. pp. 28-29

[42] José de Acosta, *Natural and Moral History*, cited in Alfred W. Crosby, *El intercambio transoceánico*, *op. cit*., p. 72.

[43] Alejandro von Humboldt, *op. cit.*, p. 302.

[44] Alfred W. Crosby, *El intercambio transoceánico*, *op. cit*., p. 80.

[45] *Cfr*. Paulina Machuca, "El arribo de plantas a las Indias Occidentales: el caso del Balsas-Jalisco a través de las Relaciones geográficas del siglo XVI", in *Relaciones. Estudios de historia y sociedad*, El Colegio de Michoacán, Zamora, Michoacán, num. 136, v. 34, Fall 2013, pp. 83-91.

[46] Serafín Puerta, *El Carmelo teresiano. Compendio histórico*, trans. Ildefonso Moriones, Roma, Carmelo Teresiano de Antequera, 2011, p. 221.

[47] *Cfr.* Daniel Rops, *La Iglesia de los apóstoles y de los mártires*, Barcelona, Luis de Caralt, 1954, p. 529-531.

[48] Manuel Ramos Medina, *El Carmelo novohispano*, Mexico, CEHM Carso, 2008, p. 119

[49] *Idem*. This element of the Edenic garden present in the "desert", *vid*. Eduardo Báez Macías, *El Santo Desierto. Jardín de contemplación de los carmelitas descalzos,* photography by Pedro Cuevas, UNAM, 1981, p. 35-42.

[50] Nowadays, the Santo Desierto de Tenancingo in the State of Mexico remains in operation.

[51] "Yacen pues, hacia la parte que cae entre poniente y mediodía de la ciudad de México, unos membrudos y pesados montes cuya entrada es por un valle que empieza en pequeña boca y se ensancha poco a poco, al paso que se encumbra. (…) Mírase todo aquel sitio vestido tan de verde que no se ve otro color y desde que le criaron jamás mudó el vestido, pues ni el invierno le despoja de él ni el tiempo le envejece. Están por todas partes tan densas las arboledas que forman bosques cerrados y casi por todo el monte se camina debajo de los pabellones que tejen los guayameles, los pinos y otras plantas de que hay tanta variedad y muchedumbre que apenas caben de pies. Allí se abrazan las ramas de las unas con las otras, las hayas con los fresnos, los madroños con las encinas, los cedros con los ayacahuites, los alisos con los laureles, y quedan tan enlazados que aún con rayos el sol apenas puede romperlos para dar luz a los valles." Translation by the author. Agustín de la Madre de Dios, *Tesoro Escondido en el Monte Carmelo Mexicano. Mina rica de exemplos y virtudes en la historia de los Carmelitas Descalzos de la Provincia de la Nueva España*, book 4, chap. V, n. 2, p. 512. Translation by the author.

[52] *Vid*. Agustín Tornel Olvera, *Desierto de los Leones*, Mexico, Secretaría de Agricultura y Fomento, Dirección Forestal y de Caza y Pesca, 1922.

[53] "(…) Mucho han dicho los autores de la fecundidad de estos países; valles hay en estas partes que producen tanto trigo que en una espiga sola se pueden contar mil granos y algunas veces dos mil, como dice el doctísimo Solórzano del trigo de la tierra (...) Dos y tres veces al año se recogen las cosechas, como en el valle de Atlixco hoy día se experimenta, después de cien años que se cultiva sin descansar uno solo. Los árboles están vestidos continuamente del adorno de sus hojas y en uno mismo se ven en cualquier tiempo flores, fruta maduray fruta verde, estando siempre tributando a la ingratitud del hombre sin tener interrupción. (…) Hay en los animales tanta copia cuanta hermosa diferencia, porque juntos en uno los de Europa y los que engendra la América llenan montes y valles y enriquecen a muchos españoles. Uno llamado Camargo (refiere Antonio de Herrera [y Tordesillas]) multiplicó por espacio de diez años, en un valle junto a México, de dos ovejuelas solas que metió, cuarenta mil cabezas de ganado." Agustín de la Madre de Dios, *Tesoro Escondido en el Monte Carmelo Mexicano. Mina rica de exemplos y virtudes en la historia de los Carmelitas Descalzos de la Provincia de la Nueva España*, book 1, chap. VIII, n. 2 y 3, p. 46-47. Translation by the author.

[54] Francisco Fernández del Castillo, *Historia de San Ángel*, en Manuel Ramos Medina*, op.cit*, p.133.

[55] *Ibidem*, pp. 133-134.

[56] Alejandro von Humboldt, *op. cit*., p. 275.

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[57] Andrés de San Miguel, *Obras de fray Andrés de San Migue*l, 2nd ed., introduction, notes, and paleographic version by Eduardo Báez Macías, Mexico, UNAM-IIE, 2007, p. 25-30.
[58] "Todos estos géneros quieren aires templados, no fríos ni recios (…) Este árbol que con facilidad se cría y en breve se envejece, y aunque se pueden plantar de rama y de los hijos que le nacen al pie, pero los buenos y más provechosos son los que se plantan de sus huesos (…) El tiempo en que se deben sembrar en esta huerta, para que nazcan y se críen bien, es quince o veinte días después de haberlos comido, habiéndose enjugado a la sombra. Siémbranse los huesos enteros y sin quebrar y una cuarta o tercia desviados, hondos cuatro dedos, y en la parte del pezón abajo, que es la raíz (…) la primera escarda se puede hacer con azadón, cortando la yerba entre dos tierras, porque los huesos no nacen aquí hasta que los duraznos comienzan a brotar sus hojas (…). Translation by tha author. *Ibidem*., p. 342-343.
[59] Manuel Ramos Medina, *op. cit.*, p. 134.
[60] *Vid*. Joseph de Acosta, *Historia natural y moral de las Indias,* 3rd ed.,edition, prologue, and appendixes by Edmundo O'Gorman, Mexico, FCE, 2006, p. 73-142.
[61] *Ibidem.*, p. 30-45.
[62] Juan de Viera, *op. cit*., p. 127.

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Rainfall Irregularities, Trends and Variations Intropical Semi-Arid River Catchment

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Abstract- Irregularities in rainfall behaviour has been characteristically visible in semi-arid climate particularly in the tropics. Trends and variations have been used as proxies in detecting the presence of irregularities in climatic variables such as rainfall. Thirty six years (1980-2015) of data obtained from Nigerian Meteorological Agency (NIMET) were used for the present study. Multivariate statistics such as ANOVA and Cluster Analysis were used for assessing variations between and within the data mean. However, Mann-Kendall trend test was applied for trend detection. The ANOVA results showed significant variation in rainfall [$F(3, 140) = 67.012$, $P < .05$], between the stations. The cluster analysis produces two classes for rainfall indicating that rainfall is less variable spatially. Mann-Kendall trend test result shows an insignificant annual increasing trend in rainfall. However, the monthly series showed varied trend results consisting of significantand insignificant increasing and decreasing trends.

Keywords: rainfall, climate variability, mann-kendall, cluster analysis, semi-arid, Nigeria.

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Rainfall Irregularities, Trends and Variations Intropical Semi-Arid River Catchment

Da'u Abba Umar [α], Mohammad Firuz Ramli [σ], Ahmad Zaharin Aris [ρ], Wan Nor Azmin Sulaiman [ω], Danladi Yusif Gumel [¥] & Hamisu Alhaji Basiru [§]

Abstract- Irregularities in rainfall behaviour has been characteristically visible in semi-arid climate particularly in the tropics. Trends and variations have been used as proxies in detecting the presence of irregularities in climatic variables such as rainfall. Thirty six years (1980-2015) of data obtained from Nigerian Meteorological Agency (NIMET) were used for the present study. Multivariate statistics such as ANOVA and Cluster Analysis were used for assessing variations between and within the data mean. However, Mann-Kendall trend test was applied for trend detection. The ANOVA results showed significant variation in rainfall [F (3, 140) = 67.012, P < .05], between the stations. The cluster analysis produces two classes for rainfall indicating that rainfall is less variable spatially. Mann-Kendall trend test result shows an insignificant annual increasing trend in rainfall. However, the monthly series showed varied trend results consisting of significantand insignificant increasing and decreasing trends. The trend results was spatially interpolated using inverse distance weightage (IDW) for easy comprehension of the spatial distribution of rainfall across the river catchment Even though the annual trend results was statistically insignificant, the fact that the area is fragile and sensitive to minor climatic changes, the result is still crucial for the planning and management of rainfall related activities especially water supply and agriculture, and for the preparation against weather extreme events such as floods and droughts in the area. Finally, it is suspected that other factors temperature and land use changes may aggravates the impacts of rainfall irregularities and are thus recommended for future climate variability studies.

Keywords: rainfall, climate variability, mann-kendall, cluster analysis, semi-arid, Nigeria.

I. Introduction

There have been reported studies and some are currently ongoing on impact of climate variability on hydrology and water resources worldwide (Pachauri et al., 2014; Pervez and Henebry 2015; Hoque et al., 2016; Li et al 2016). The variability in climate system is basically investigated using rainfall and temperature fluctuations. However, in arid and semi-arid areas the inter-annual and intra-annual rainfall variability has been more important in the study of climatic changes. This is due to the sensitivity of these areas to minor climatic fluctuation, especially the rainfall irregularities. Although climate variability in the form of rainfall irregularity occur at all spatial scales (Elsanabary and Gan 2015), currently interest have been shifted to regional and basin scales studies, that provide suitable location for details hydro climatic studies which will provide crucial information for planning and management of regional and local activities such as farming and water supply (Pervez and Henebry 2015), and for the preparation against extreme events such as floods and drought (sangaya et al., 2014).

Rainfall dynamics have been used as representative in the study of climate change and variability (Kusangaya et al., 2014; Mohammed et al., 2015), particularly in drier areas. Besides rainfall variability, temperature fluctuation and increased manifestation of extreme weather events such as heavy storms, droughts and floods were mentioned as basic features of climate variability (Ogungbenro and Morakinyo 2014; Suleiman and Ifabiyi 2015).

Although variability is an inherent behaviour of climate, the increase fluctuation of climatic variables particularly rainfall is becoming a major concern and is associated to motivated rise in greenhouse gas (GHG) concentrations and the changes in land uses (Warburton et al., 2005; Reason 2007), which consequently intensified global warming and the hydrological cycle (Huntington 2006; Pachauri et al., 2014).

In the semi-arid region of Nigeria due to its sensitivity to minor climatic changes, rainfall irregularities was found to aggravate the already existing environmental deprivation and water scarcity (Ogungbenro and Morakinyo 2014; Balogun et al., 2016). Consequently, there is increasing fear of food insecurity, human health challenges and slowing down of environmental flow (Balogun et al., 2016) and of course conflict over available natural resources particularly the water(Roma 2008; Audu 2013; Umar and Ankidawa 2016)

Thus, the study area is prone to extreme weather events largely due to rainfall variability, and therefore farming and water supply in the area is

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subjected to the tyranny of climate variability, particularly the rainfall irregularities. Considering the importance of rainfall to agriculture and water supply in particular and to all aspects of human existence in Hadejia River Catchment (HRC), the need to understand the nature and pattern of rainfall irregularities from trends and variations of the rainfall series has arisen.

II. Materials and Method

a) Study area

Hadejia River Basin is sub-catchment of the Lake Chad Basin. This sub-catchment has an area of 24,680 km^2 (Adakayi 2012). The basin is climatically control by two air masses, the south west and the north east trade winds. The south west trade wind is rainfall bearing from the Gulf of Genue, thus, precipitation over a particular location is in the area is by the dominance of the south west air masses. This south west air masses usually stayed between May to September (summer). The north east trade wind, however come along with dryness and coldness from the Sahara Desert between Octobers to April (winter). The interphase of these air masses is known as the Inter-tropical convergence zone (ITCZ) and its pendulum north to south of the region in particular control the onset and cessation of rainfall in the entire basin perimeter (Ebele and Emodi 2016).Precipitation is very variable with time temporal and with space spatial, however temporal variability is more discernible. Mean annual rainfall varies from 987 mm in the south of the basin (Tiga station) to less than 400 mm in the extreme north east of the basin (Hadejia station) (fig 2). Temperature reaches as high as 35°C before the onset of the rains (April/May) and drop as low as 18° C in December/January (Abdul Kadir et al 2015). Mean annual maximum temperature varies from 33°C at the north-eastern part of the basin (Hadejia station) to 31°C at the southern part of the basin (Tiga stations). Similarly, mean annual minimum temperature varies from 20°C at the north-eastern part of the basin (Hadejia station) to 19°C at the southern part of the basin (Tiga stations). Temperature increases north to south, unlike rainfall which decreases with increasing altitude.

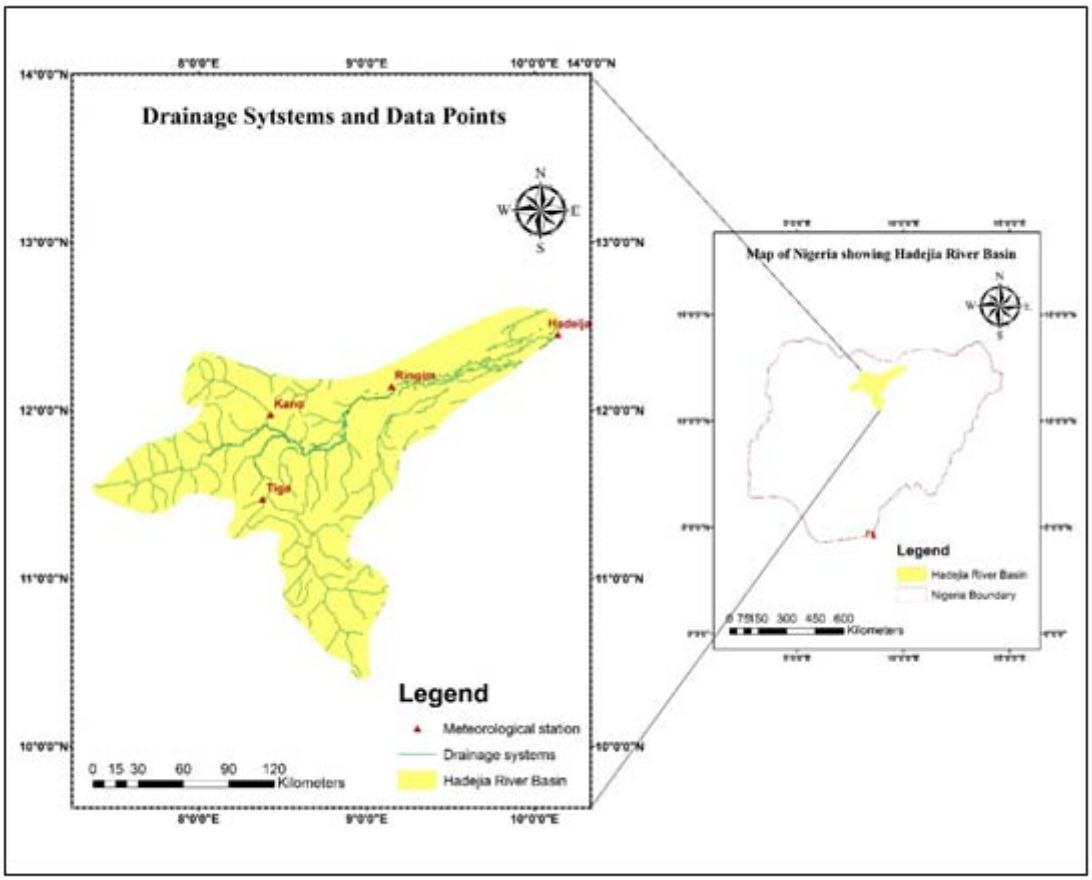

Figure 1: Drainage and meteorological stations within the basin. *Modified after IUCN 2003*

b) Data for the study

Rainfall data for thirty six years were obtained from Nigerian Meteorological Agency (NIMET). The data contained monthly records, which was used in depicted rainfall irregularities in Hadejia River.

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The first data treatment applied to the data was the quality assurance and quality control (QA/QC) as prerequisite to the application of suitable statistics (Duhan and Pandey 2013). The data were crisscross for anomalies such as missing data and outliers. The result of QA/QC analysis revealed that the data were statistically clean except for few missing data which is found less than 10% of the whole dataset. They were supplanted with the means of the last two recorded observations that bound the missing observations (Chatterjee and Hadi 2015)

c) Data analysis

Rainfall and river discharge variations were analysed analysis of variance (ANOVA), cluster analysis (CA) and Mann-Kendall trend test. Cluster analysis was also conducted to strengthen the ANOVA and Tukey HSD Test results. However, the relationship between rainfall and river discharge was quantified using correlation statistics and hydrograph analysis. Prior to the application multivariate statistic the data was subjected to descriptive analysis to understand the nature of the dataset. The mean, SD and CV as well as the trend results were interpolated via inverse distance weight age (IDW) technique within the GIS environment.

d) Descriptive statistics

Descriptive statistics are used to label the basic features of the data in a study. They offer simple summaries about the sample and the measures. They are brief coefficients that summarize a given data set. Descriptive statistics discloses the measures of central tendency, and variation/spread in data (Bluman 2008). They are the underpinning procedures for quantitative analysis of a dataset.

e) Analysis of Variance (ANOVA)

Aanalysis of variance (ANOVA) is one of the most renowned statistical tool used in determining the existence of variation between two or more groups of observations. It is used to test whether the means of two or more independent groups are equal. This statistical tool tests the null hypothesis that samples in two or more groups were drawn from the same population (Chatterjee and Hadi 2015).

The null hypothesis (Ho) stated that; all sample means are equal (Ho: $\mu_1 = \mu_2 = \mu_3$)
The alternative hypothesis (Ha) stated that; at least one mean is different

So if the decision is to reject the null hypothesis base on the outcome of the analysis, then at least one of the means is different. However, the omnibus one-way ANOVA does not shows where the difference are, thus you may need to conduct a post-hoc tests for pairwise analysis (Chatterjee and Hadi 2015). The reliability of this statistical tool is tied to some basic assumptions; assumption of normality, homogeneity and independence.

f) Mann-Kendall Trend Test and Sen Slope Estimator

The nonparametric tests have been the most widely used tests for establishing the temporal variations in hydro meteorological variables (Zhang et al., 2014; Li et al 2016). Mann–Kendall (MK) trend test is the most encouraged approach (Jaagus 2006; Yürekli 2015), perhaps for its ability to accommodates missing values and outliers, and data with skewed distributions (AbRazak et al., 2016)

The null hypothesis (Ho) of the MK test is that, *time series values have no trend* while alternative hypothesis (H1) states that, *there is trend in the data set*. In this study 95% confidence level is used, thus a significant trend is indicated in the test when *P* value is less than 0.05.
The test is establish on the statistic that;

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign(xj - xk). \quad (1)$$

Where S is the Man-Kendall test values, xj and xk are the sequential data values, j, k and n are the length of the data.
Sign $(xj - xk)$ is a pointer function which assumes any of the values 1, 0, and -1, subject to the sign of $(xj - xk)$; *i.e.*

$$sgn\ (xj - xk) = 1 \text{ if } xj - xk > 0 \quad (2)$$

$$= 0 \text{ if } xj - xk = 0 \quad (3)$$

$$= -1 \text{ if } xj - xk < 0 \quad (4)$$

The Sen Slope estimator is used to estimate the true slope of Man-Kendall's trend analysis. It is a simple nonparametric test developed by Sen. (Sen 1968) and later presented by Gilbert (Gilbert 1987; Dorigo et al., 2012). This test calculates the magnitude of any significant trend detected in the Mann-Kendall test. Sen. (Karpouzos et al., 2010; Gocic and Trajkovic 2013). The Sen Slope estimator can be calculated using this equation

$$Q = \frac{xj}{j} - \frac{xk}{k} \quad (5)$$

where Q is the value of Sen Slope estimator, xj and xk are data values at time j and k.

III. Results and Discussion

a) Descriptive statistics

The result of normality statistics chosen (Skewness and kurtosis) were found to be within the range of -2 to +2 and -3 to +3 respectively, indicating that the data were from normal population distribution (George and Mallery 2003) (figure 2 a and b). Rainfall mean was slightly higher in Kano than Tiga stations and the least rainfall mean was at Hadejia station (Figure 3a). Furthermore, rainfall variability is much higher than that of temperature and the highest coefficient of variation (CV) and standard deviation (SD) of rainfall was at Tiga station. It is also the station with higher rainfall range (Figure 3b and sc).

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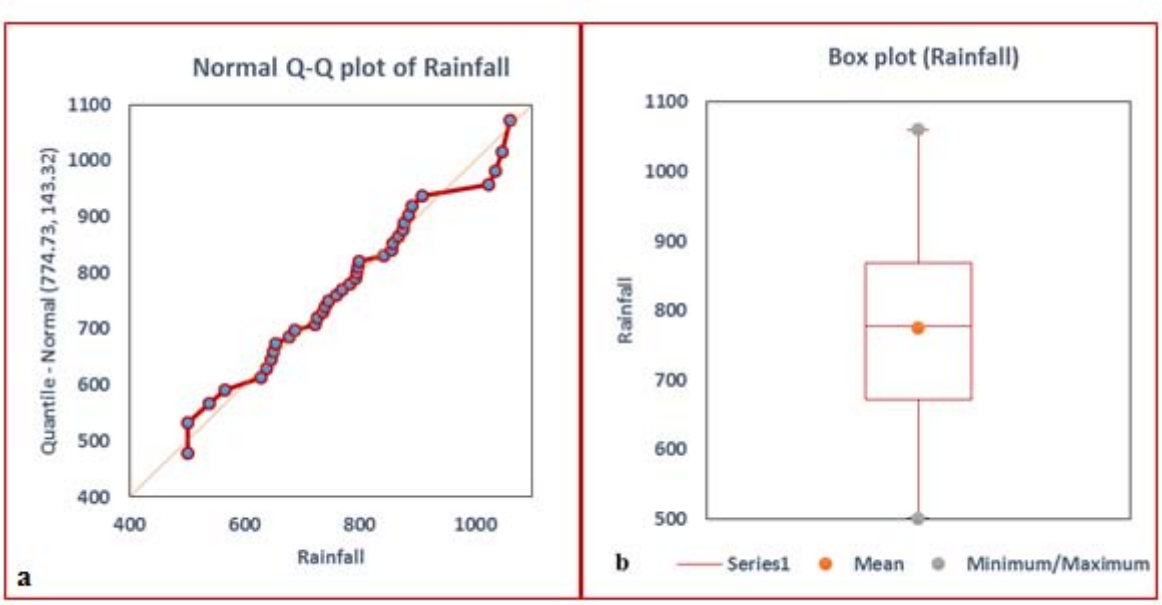

Figure 2: Rainfaoo normality (a)and box plot rainfall centrality(b)

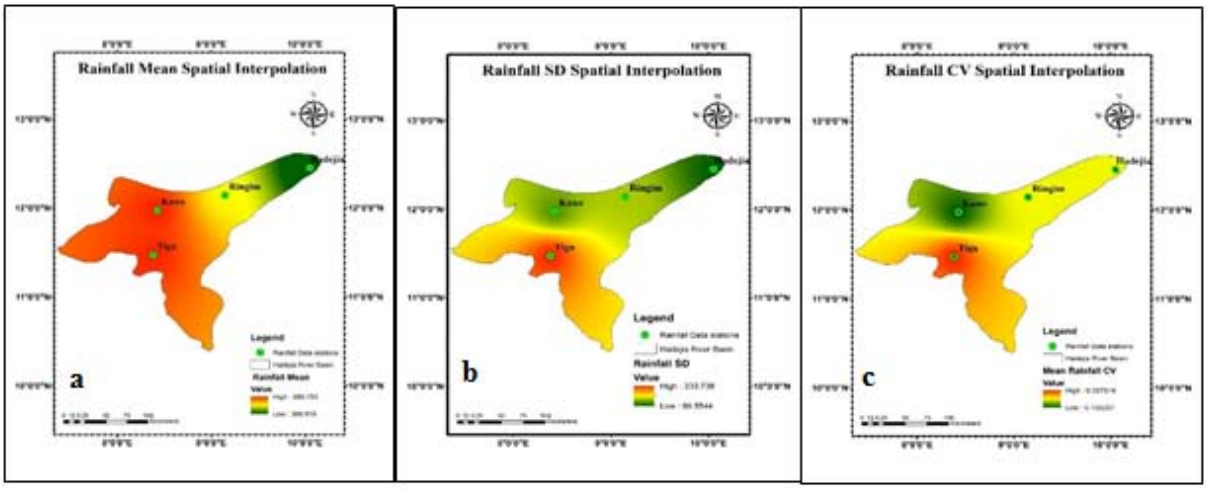

Figure 3: Spatial interpolation of rainfall (a)mean (b) SD and (c)CV

b) One way Analysis of Variance (ANOVA)

A one way analysis of variance (ANOVA) was conducted to compare the difference between six meteorological stations on annual mean rainfall. The result shows significant difference in annual mean rainfall based on meteorological stations computed [F (3, 140) = 67.012, $P < .05$] (Table 1).

Multiple comparisons test using Tukey HSD further revealed that, there was a significant difference between all the stations except between Tiga and Kano (Table 1).

Table 1: ANOVA Test of Meteorological stations on Mean Annual Rainfall

Variable	*n*	Mean ± SD	*df*	F	*P*
Rainfall			3	67.012	.000
Tiga	36	987.64 ± 338.48			
Kano	36	989.77 ± 135.70			
Ringim	36	743.36 ± 183.11	140		
Hadejia	36	383.74 ± 96.34			

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The overall rainfall spatial behaviour via ANOVA and Tukey HSD statistics has unveiled the spatial changes in rainfall mean in the area. The highest rainfall mean was in Kano (989.77 mm) and the least was in Hadejia stations (383.74 mm), probably due to their locational disparity (Figure 1). Thus, there was significant difference between all the stations except between Kano and Tiga, meanwhile Kano station has the highest rainfall mean though the difference with Tiga station was very slight likely natural rainfall variability. It is thus indicated as previously established (Adakayi 2012) that rainfall is higher in the southern locations and low in the northern part of the basin (Figure 3a).

Table 2: Turkey HSD Test of Mean Annual Rainfall between stations

Significant Difference Between stations	Mean Difference (Md)	*P*-value.	Std. Erro
Tiga station			Std. Error = 49.41
Kano	-2.12222 (NSD)	1.000	
Ringim	244.27778*	.000	
Hadejia	603.90000*	.000	
Kano station			
Ringim	246.40000*	.000	
Hadejia	606.02222*	.000	
Ringimstation			
Hadejia	359.62222*	.000	
Hadejia station			
See above			

The mean difference is significant at the 0.05 level; NSD= no significant difference

The movement of these two air masses is regulated by the migration of the ITCZ or ITD north to south and vice versa (Oyekale et al 2010). Thus, the seasonal characteristics of the basin and the country at large was dictated and shared by the ITD's migration north to south and vice versa (Thelma 2015). This might be one of the reason for high rainfall mean in Kano and Tiga stations relative to Hadejia station. Moreover, the altitudinal/topographic differences is also another reason for this visible disparity. For instance, Tiga and Kano stations were located in the higher elevation topography relative to Hadejia. This, may occasionally influence the formation of orographic precipitation (Odjugo 2010).

c) *Spatial pattern of rainfall and temperature using cluster analysis (CA)*

Agglomerated hierarchical clustering (AHC) using XLSTART was used to find out the homogeneity between the studied stations based on their dissimilarities characteristics. In respect of rainfall characteristics, the stations were grouped into three classes; class 1(Tiga, and Kano stations), class 2 (Ringim) and class 3 Hadejia stations (Figure 8).

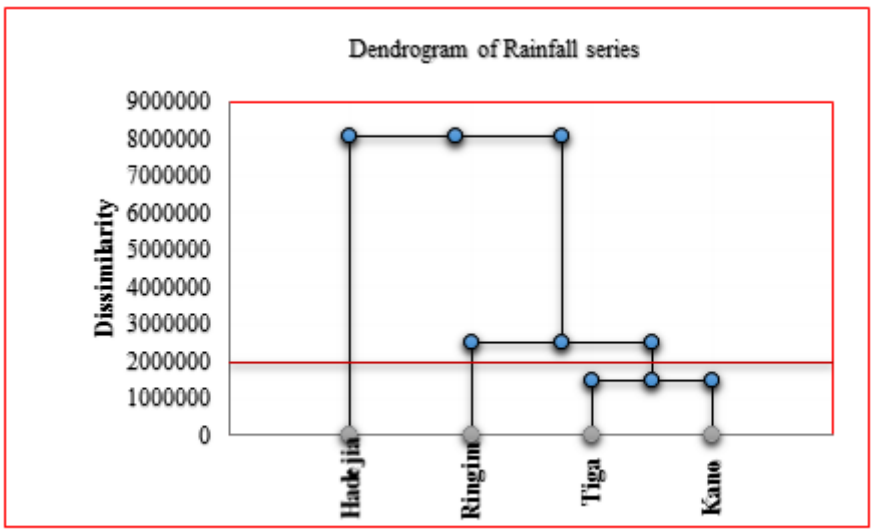

Figure 4: Rainfall clusters across the catchment

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Hadejia was independent of all other stations, probably because of its location in the extreme north eastern part of the catchment. The pattern of rainfall clustering seems incline more to the temporal dynamics than to spatial fluctuations. Moreover, there is marked differences in topographical alignment between the locations, reflected by differences in elevation, vegetation and other physiographic factors which contributesto the spatial disparities in the occurrence and distribution of rainfall in the area (Medugu et al 2011; Adewole and Serifat 2015; Balogun et al., 2016).

d) Trend analysis

Man-Kendall trend test was conducted to detect temporal behaviour of rainfall and temperature in the area (Table 8). The monthly rainfall trend test result in all the stations shows an increasing trend except for some few months (e.g. in August at Tiga; in April, May and July at Kano; in April, May, August and October at Ringim station), there is no decreasing trend observe at Hadejia station. However, the only statistically significant increasing trends was in October atTiga; June and September at Ringim and lastly in October at Hadejia stations respectively (see table 8; Figure 11 a, b, c and d). The statistically significant increasing trend in June, September and October, especially the October increased at Hadejia station is an indication of increasing rainfall/climate variability in the area.

Table 3: Mann–Kendall test statistic for monthly precipitation by stations (1980-2015)

Month	Tiga			Kano			Ringim			Hadejia		
	Z	*Q*	*P*	*Z*	*Q*	*P*	*Z*	*Q*	*P*	*Z*	*Q*	*P*
April	0.19	0.000	0.846	-0.01	-0.020	0.989	-1.39	-0.077	0.163	0.0 0	0.000	0.970
May	0.90	0.644	0.369	-0.50	-0.225	0.617	-1.09	-0.413	0.276	1.3 6	0.221	0.173
Jun	0.10	0.220	0.925	1.59	0.903	0.112	2.33	2.279	**0.019**	1.2 5	0.757	0.210
Jul	1.74	3.917	0.081	-0.18	-0.131	0.861	1.59	2.243	0.112	0.1 5	1.058	0.882
Aug	-0.04	-0.130	0.968	0.56	0.800	0.579	-0.44	-1.298	0.663	0.3 0	1.782	0.764
Sept.	1.78	2.180	0.074	1.02	1.312	0.310	2.56	2.342	**0.010**	1.5 3	0.870	0.127
Oct.	2.51	0.660	**0.012**	-0.49	-0.208	0.623	-0.54	0.000	0.589	1.0 1	0.213	**0.044***
Annual	1.51	0.746	0.130	0.67	1.637	0.507	1.48	4.436	0.139	1.6 5	0.175	0.099

**The bold values are mean difference significant at 0.05 level*

Meanwhile, the overall annual trend was increasing from all stations, but were not statistically significant (Table 3). However, spatial interpolation showed that rainfall increasing trends was higher around Hadejia station (Figure 5 and 6a) even though it is the station with lower rainfall mean. Similar findings was previously established in the area (e.g. Mohammed et al., 2015; Suleiman and Ifabiyi 2016), where a noticeable increase in rainfall condition was reported.

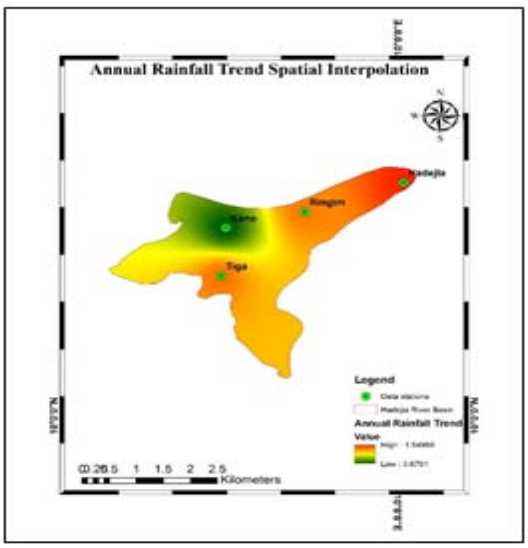

Figure 5: Interpolated annual rainfall trend

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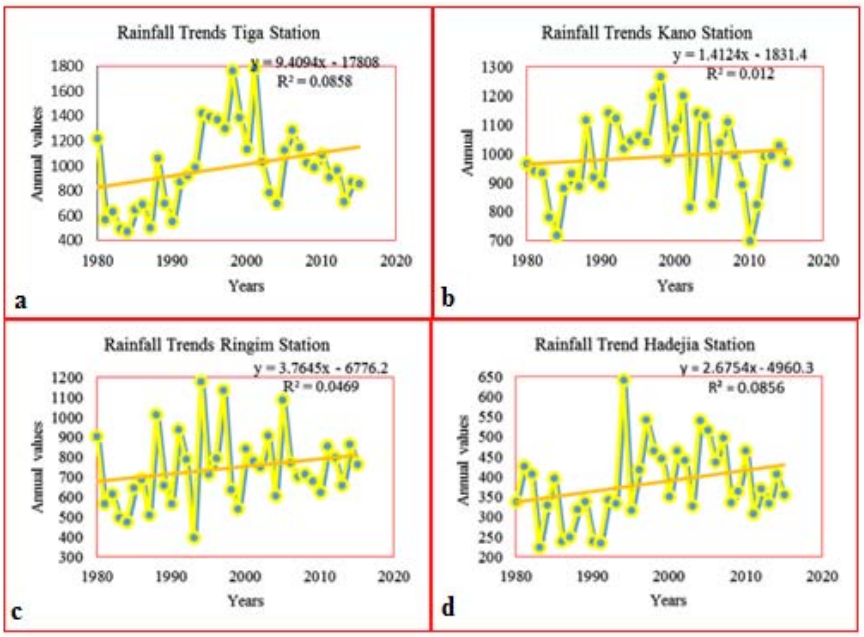

Figure 6: Trend for Individual Stations (a) Tiga (b) Kano (c) Ringim (d) Hadejia

e) Occurrence of extreme weather events

The occurrence of extreme weather events such as floods and droughts are considered important evidences of climate variability in the area. Of all the climatic parameters, rainfall is the most variable parameter in the region (Medugu 2011; Ekpoh and Nsa 2010). The pattern of rainfall behaviour and the increased inter-annual rainfall variability has long been associated to climate change and variability (Medugu et al 2011; Adakayi 2012; Muhammad et al 2015) as demonstrated by the current study. Although rainfall and do vary with time and space, however the temporal variabilityis more visible than the spatial changes. Thus, rainfall extreme (high and low) values were given precedence in the discussion of weather related extremes in this study. In terms of drought disasters, the downstream areas of the basin are the most affected, perhaps due to low rainfall and high temperature north-eastward. Whereas, the severity of flood disaster was more pronounced in upstream areas, this is not surprising because rainfall increases southwest ward and temperature decreases in the similar direction(Figure Table 12). Furthermore, all the representative stations in the area shows corresponding coincidence between some years of high and low rainfall records and some years of floods and drought occurrences (Table 12).Some of these recurrent climatic events have been reported to cause untold consequences to over 15 million inhabitants living and depending on Hadejia river catchment for their livelihoods (Sobawole et al 2010; Medugu et al 2011).

Table 4: Rainfall extremes and corresponding year of floods/droughts in the studied stations

Stations	Parameter	Extremes		Historical Records		Droughts Magnitude	Floods Magnitude	Source
		High Years	Low Years	Droughts Years	Floods Years			
Tiga Kano	*Rainfall*	1999 2009 2010	1983 1985 1987	1983/84 1986/87	1999/ 2010	Moderate Moderate	Moderate Severe	(Adefolalu 1985) *(Olagunju 2015)* (Olaniran, and Summer 1989)
Ringim	*Rainfall*	1998 2001 2003	1983 1984 1987	1983/84 1986/87	2001 2003	Severe Moderate	Severe Severe	*(Olagunju 2015)* (Olaniran, 1991)
Hadejia	*Rainfall*	1994 2005 2010	1983 1986 1991	1983/84 1986/87 1991/92	1994 2005 2010	Severe Severe Severe	Severe Severe Moderate	(Ekpoh and Nsa 2010) *(Medugu et al 2011)*

Source of the extreme values are from the data

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IV. Discussion

The overall findings was that, rainfall varied significantly between stations and that the temporal variation is more discernible than spatial variation. The statistically significant annual increasing trend in rainfall at 50% of the stations, have suggested the presence of increasing climate variability, considering thatthe variations were reversible within few years to few decades shorter than the climatic averaging period. Thus, we cannot yet conclude the full existence of climate change, as the time span of the data is not enough to draw such a critical conclusion. Since climate change connotes variations longer than the standard climatic averaging period with significant impacts on man and the general ecosystem. (Ayeode 2003).

The spatial variability of rainfall and temperature was assessed using one way ANOVA, Tukey HSD test and cluster analysis. ANOVA results showed that there was a statistically significant difference between the meteorological stations on mean annual rainfall [F (3, 140) = 67.012, $P < .05$]. The multiple comparison test using Tukey HSD has confirmed the ANOVA results, that there was significant variation between the studied stations.

Both results (ANOVA and Turkey test) have sustained the earlier findings that, the southern part of the basin has higher rainfall and lower temperatures compared to the northern frontier of the basin (Adakayi 2012 and Mohammed et al 2015) and that, rainfall is less variable spatially (Thelma 2015). Cluster analysis have further distinguished the spatial characteristics between the stations. These stations were grouped based on their associated attributes.

The apparent spatial variations between the stations were attributed to many factors such as the influence of topographical alignment, the movement and how longITDZ stayedin given location.

The result of temporal evaluation via Mann-Kendall trend test have shown a general increasing annual trends for all stations. Although the annual result was statistically insignificant, it is still crucial for the understanding of climatic behaviour of the region particularly that the region is fragile and very sensitive to minor climatic changes. Moreover, the increasing and decreasing trends in monthly series have further confirmed the variability in climate of the region. In this area, the annual and monthly increased in precipitation significant or insignificant possessed the potential incur serious impacts on the activities (rain-fed and irrigation agriculture) and programmes (water supply) of the region as well as other socio-economic activities such as fishing and recreation. The findings obtained is consistent with the proceeding studies, which have confirmed the uncertainty and irregularities of rainfall behaviour and is associated to increased climate variability (Ekpoh and Nsa 2011; Ifabiyi and Ojoye 2013; Suleiman and Ifabiyi 2015).

Additionally, Adakayi (2012) used 36 years of meteorological data to assess the extent of climate change and variability in the region and part of his findings was that rainfall and temperature does not deviate from the climatic normal and that rainfall was the most variable parameter in the area. Similarly, Mohammed et al (2015) used 100 years of rainfall data to assess rainfall dynamics over the region, found that there was a noticeable improvement in rainfall/moisture condition in the area. Thus, their major conclusion was that the climate of the area have not significantly deviate from the normal trend. Therefore, the observed changes were just an increasing climate variability.

The spatial and temporal fluctuations and the presence of extreme observations in climatic parameters and the corresponding occurrences of extreme climatic events (floods and droughts) are some of the major evidences of increased rainfall irregularities linked to climate variability in the area (Sawa et al 2015) Moreover, besides increased rainfall irregularities and its potential impacts in the area, it is feared that the effects of other factors such as increased temperature, land use changes and increased human and livestock population expansion may perhaps aggravates the effects of rainfall irregularities. These other factors are liable to increase the sensitivity of the region and thus the vulnerability of inhabitants and their societal resources, particularly water resources and agriculture will be amplified.

V. Conclusion

Generally, rainfall annual trend displayed an insignificant increasing trends, suggesting gradual rainfall recovery in the area as reported by Adakayi (2012) and Muhammad et al (2015). However, the monthly trends showed varied results consisting of statistically significant increasing and decreasing trends portrayingintra-annual rainfall variability and has further accentuate the temporal behaviour of rainfall in the catchment.

It is concluded that, the semi-arid region of northern Nigeria within which Hadejia River Catchment is located faces challenges of increased rainfall irregularities associated to increased climate variability. Evidences were manifested from the statistically significant spatial variations in the rainfall series and in the increasing and decreasing trends depicted from the annual and monthly rainfall trend results. Even though theannual trends was not statistically significant, the results is still crucial for the understanding of rainfall behaviour in the area and for planning and management of activities and program related to water resources in the area such as agriculture and water supply. In the whole, the results displayed the magnitude of spatial

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and temporal inclination of rainfall, thus temporal variability is more discernible than the spatial changes, but that does not suggest overlooking the spatial variations, since spatial variations will accordingly affect the distribution of water related activities spatially across the river catchment. This suggest careful consideration in the apportionment of priorities to these variations in the area. For instance the spatial variability might constraints the water resource planning and management across the spatial extent of the catchment as more water will be where it is not even needed the most.

Furthermore, the study presented the ability and robustness of the used statistical and envirometric techniques; ANOVA, cluster analysis and the Mann-Kendall trend test. The findings will also assist the local climate and river basin management authorities with valuable information crucial for proper planning and management of climate related events (floods and droughts) and activities (agriculture and water supply). Finally, the study will hopefully assist the scientific research community in stimulating further research efforts on simulations and predictions of future climate behaviour.

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"Conflict of interest-None"

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The Analysis of Green Environment Movement Campaign in Supporting National Food Security of Indonesia

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Abstract- This study aims to analyze and describe the implementation process of green environmental movement campaign in supporting national food security through hydroponic farming campaign conducted by Military District Command (KODIM) 0503 West Jakarta. The concepts used are the public relations, public relations campaigns, and environmental communication. The method used in this research is qualitative research with single case study design. This research revealed that the green environment movement campaign, in supporting national food security through cultivation activity with hydroponics technique, covers three stages:1) Problem identification, which is to review and identify the problem prior to campaign program implementation, 2) Campaign management, which is to identify the characteristics of target audiences in order to formulate messages, campaign actors, campaign channels, and technical campaign implementation, 3) Evaluation stage, which is to see how many people have started this green environmental movement campaign program at their home.. The results of this study suggested the following: 1) to add more varied campaign media, 2) a brand ambassador for the campaign program, 3) to strengthen media relations activities for campaign publicity purposes, 4) to add quantitative methods in conducting surveys on the success of the campaign program.

Keywords: *campaign, environment, hydroponics.*

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The Analysis of Green Environment Movement Campaign in Supporting National Food Security of Indonesia

Yuliawati [α] and Enjang Pera Irawan [σ]

Abstract- This study aims to analyze and describe the implementation process of green environmental movement campaign in supporting national food security through hydroponic farming campaign conducted by Military District Command (KODIM) 0503 West Jakarta. The concepts used are the public relations, public relations campaigns, and environmental communication. The method used in this research is qualitative research with single case study design. This research revealed that the green environment movement campaign, in supporting national food security through cultivation activity with hydroponics technique, covers three stages:1) Problem identification, which is to review and identify the problem prior to campaign program implementation, 2) Campaign management, which is to identify the characteristics of target audiences in order to formulate messages, campaign actors, campaign channels, and technical campaign implementation, 3) Evaluation stage, which is to see how many people have started this green environmental movement campaign program at their home.. The results of this study suggested the following: 1) to add more varied campaign media, 2) a brand ambassador for the campaign program, 3) to strengthen media relations activities for campaign publicity purposes, 4) to add quantitative methods in conducting surveys on the success of the campaign program.

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I. Preface

The vast-growing development of cities in Indonesia, particularly in DKI Jakarta has an impact on the wide change of land use, including green open space (RTH). Such conditions affect the physical condition and burden the environmental quality. One of the drivers of increasing development is the increasing socio-economic demands due to population growth. This has implications for the increasingly crowded and densely populated housing environment. The implications from low green open space certainly leads to lower health quality.

The low environment quality is influenced by various factors such as rapidly rising world population, unplanned industrialization, pesticides, chemical use, and the subconscious damage of people (Konur & Akyol, 2017:2109). This is also in accordance with McHarg (1971) notion that the densely-populated urban areas relatively susceptible to physical, social and mental illness. Increased density also correlates to social stress, which also increases the risk of heart and kidney disease. Panjaitan et. al. (2011) states that other health problems that also arise due to air pollution are respiratory problems, irritation, and even cancer (Syahadat, 2017:180).

Besides causing the disease, the urban population density also causes the lack of cultivation activity for the people living in, especially in Jakarta. At least 275 tons of vegetables are supplied to Jakarta per day. These supplies of vegetables generally come from Java and some provinces on Sumatra. Only a small portion of vegetable products are produced by farmers in DKI Jakarta. The small vegetable production in DKI Jakarta is mainly caused by the narrowing agricultural lands due to land conversion to fulfill the need for housing and non-agricultural services (Sastro & Rokhman, 2016: 1).

Considering such condition, the Government of DKI Jakarta has launched various policies to develop clean and environmentally friendly vegetables production, such as using hydroponic technology approach as its achievement. The advantages of hydroponic crop cultivation is space-saving. The above-mentioned pattern of approaches is expected to meet the specific criteria of urban agriculture with limited land, yet effective, productive, has high quality, high added value, and can increase the availability of sufficient food and nutrition at affordable prices (Sastro & Rokhman, 2016: 2).

Under President Jokowi administration, Indonesia invites all elements to be actively involved in the handling of environmental problems. As quoted by kompas.com on Wednesday, August 2, 2017, at least the president Jokowi provided four types of awards to individuals, groups, heads of regions, and schools that participated in preserving the environment. There were four awards given, namely Kalpataru, Adipura, Adiwi-yata and Nirwasita Tantra. In addition, the Indonesian National Army (TNI) have been increasingly active in implementing various campaign programs and environ-mental sustainability movements. Dandim 0503 West Jakarta Lieutenant Colonel Inf Wahyu Yudhayana said that all TNI soldiers must participate in developing plantations and agriculture as commanded by TNI Commander General, Gatot Nurmantyo.

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TNI involvement in the green environment movement to support national food security through cultivation activities using hydroponics techniques aims to create a green environment, as well as to improve the movement of national food security in urban environments that have limited land or green space. This is as conveyed by Yudo Husodo (2003) that Indonesia became one of the countries with mediocre food security level. This is because of substantial amount of Indonesia's dependence on foreign food supplies (Armawi, 2009: 78).

Maintaining environmental sustainability is not a seasonal trend that is only highlighted as short or medium-term initiatives. Environmental sustainability is a long-term goal, requiring direction, champions, financial supports, and stakeholder supports over a period of time (Hamid et.al., 2016:484). Therefore, it requires a campaign design and strategy that can reach people's sensitivity in order to cooperate and provide support and real participation. Thus, it is necessary to identify audiences, compile a campaign message, choose a campaign method, and choose the right media for delivering campaign messages.

Based on the explanation, the researcher is interested to research and focus on how the implementation of green environmental movement campaign supports national food security conducted by Military District Command (KODIM) 0503 West Jakarta. The purpose of this study is to analyze and describe the implementation process of green environmental movement campaign in supporting national food security. Thus, this research can provide various recommendations related to communication innovation, on how to implement the environment-based campaign program among urban community.

II. Literature Review

a) Public Relations

Public relations can refer to a management tool designed to build various support both from internal and external. In addition, public relations is also needed to build a positive image for the company through various publicity and communication activities with various stakeholders (Rivero & Theodore, 2014:21). In addition, public relations is generally associated with communication activities designed to create and maintain the image and good relationship of the organization with its public space (Prindle, 2011:32).

In the campaign context, PR must be able to build communication activities to build understanding and cooperation, in order to understand the problems and overcome them together. Therefore, the role of public relations is very important in this context. The role of public relations that can be explained are:

1. Technical Communication. In this role, PR is considered as the technical communications implementer. Therefore, PR should be able to write and edit newsletters of campaign activities, write news releases and campaign features, develop web content about campaign information, create media campaign communications, and handle media contacts.
2. Expert Prescriber Communication. PR is regarded as an expert. PR should be able to provide feedback to leaders how the campaign process can be done well. Their relationship is the doctor-patient relationship.
3. Communication Facilitator. PR should be able to communicate campaign messages to the public. Both to external and internal public.
4. Problem Solving Process Facilitator. PR should be able to be a facilitator in a problem-solving process. PR involves and is involved in crisis management (Yuliawati and Irawan, 211: 2016).

b) Public Relations Campaign

Ruslan explains public relations campaign is an activity which aimed at raising awareness and knowledge of target audience, growing perception or positive opinion towards an activity of a institution or organization (corporate activities) in order to create a good trust and image from society through intensive message delivery over a period of time continually, achieving understanding and motivating the community towards a particular activity or program through continuous and planned communication process and techniques to achieve positive publicity and image (Libertine, 3:2014).

Johnson-Cartee and Copeland (1997) state that campaign activities include: 1) Pre-campaign, which is aimed at problem identification and setting campaign goals. According to Ostergaard (2002), there are "3A" that needs to be achieved, awareness, attitude, and actions. These three aspects are interrelated and serve as the target of influence. 2) Campaign management, starting from design, implementation, to evaluation. At this stage, the campaign program contents are directed to equip and influence the aspects of knowledge, attitudes, and skills of target audiences. These three aspects become a prerequisite for behavior change. 3) Evaluation process, which is a systematic effort to assess various aspects related to implementation process and campaign goals achievement (Tyas, et.al., 2017:59-61). Another opinion conveyed that in general, there are three goals of public relations campaigns: (1) information, (2) motivation, and (3) behavior. Furthermore, the three stages are sequential activities and the process allows feedback as a benchmark that can serve as a successful parameter of a campaign activity. (Michaelson, Wright, Stacks, 2012:6).

c) Environmental Communication

Scientific evidence about global warming suggests that were are now in dire situation and very

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close, or already exceeded, irreversible critical climate thresholds for over 1,000 years. This situation requires various parties to take steps to deal with global warming. To solve this problem, one of the solutions is to design and conduct environmental communication that can build the collective consciousness of the people around the world in overcoming this problem (Brulle, 2010:83).

Oepen and Hamacher explain that environmental communication is a planned and strategic communication process used by media products to support effective policy-making, community participation, and project implementation directed at environmental sustainability. An environmental communication involves a two-way interaction of the social process that enables the person concerned to understand certain environmental factors and interdependencies. They also respond to problems in a better way with the use of this method (Puji Lestari et.al: 56:2016). Environmental communications can be actualized with campaign activities aimed at educating the public by expanding knowledge which often depends on the asymmetric tactics of public relations. The tactics can be utilized through the use of controlled media (in form of advertisements, websites, direct mail, newsletters, and public service announcements) and uncontrolled media (media releases, opinion pieces, and publicity of events). (Henderson, 2005:122).

Furthermore, Robert (2010) argues that environmental communication is a pragmatic and constructive medium to provide understanding to the society about the environment. Therefore, it is necessary to have a strategy in composing messages in certain communication media, so that the awareness and society participation will improve in environmental management. The main communicators in environmental communication are government and non-governmental organizations committed to environmental management (Herutomo, 41: 2013).

Fatonah (2008) argues that environmental communication is a part of sustainable development communications which uses various efforts and techniques, including techniques of conveying ideas and skills from initiators of development aimed at the wider community so that people can understand, accept, and participate (Herutomo, 40:2013).

III. Research Methods

This research uses qualitative method with single case study design. A single case study has three rationalizations: first, once the case states an important case in testing a well-constructed theory; secondly, the case presents an extreme or unique case, and third, it is a disclosure case (Yin, 2011: 46). The uniqueness of this campaign program is the implementation of environmental campaigns integrated with efforts to strengthen national food security programs. From that case, the researcher wanted to understand how KODIM 0503 West Jakarta implements the campaign program.

The data is collected collecting data through interviews with relevant sources and involved in the implementation process of the campaign. In addition, the researcher will also collect data through field observation. This research is supported by secondary data obtained from offices, books, literature or reports, media coverage, campaign activity documentations, websites, photos, etc.

The interviewees in this research are chosen using purposive sampling technique. Purposive sampling is a technique of determining the sample with certain considerations, one of which is by the involvement in the case under research, or understanding the conditions under study. The selected interviewee is a member of Dandim 0503 West Jakarta, Sertu Rasyidi who serves as a Field Coordinator for the management of hydroponic and aquaponics at KODIM 0503 West Jakarta, while the second interviewee is Lt. Col. Kav Andre Henry Masengi who currently serves as Commander of Dandim 0503 West Jakarta.

The data analysis techniques according to Miles and Huberman include three concurrent activities: data reduction, data presentation, and conclusion (verification). To determine the validity of the data, the researcher runs a triangulation technique on the source. Moleong (330: 2013) explains that in this technique the researcher compare and review the degree of information confidence obtained by: (1) comparing the observation data with the interview result data (2) comparing the consistency of the interviewees' replies by comparing what they say in public for example, by what they say personally (3) comparing one's perspective, with others in the team.

IV. Results and Discussions

a) Problem Identification

The increasing number of population in urban areas has direct implications on the narrow and limited land, as well as green environment in urban settlements. This condition makes urban societies difficult to implement green environment. This population problem directly impacts the level of public health. This is as stated by McHarg (1971) which mentions that in urban areas, the poor are concentrated in relatively small areas surrounding commercial centers. This area is relatively present in diseased cities, but it cannot claim that poverty is the main cause of physical, social and mental illness. Health in urban areas is generally affected by to population density. The uncontrolled population density leads to sprawl, causing an impact on some diseases such as stress. Increased density also correlates to social stress, which also increases the risk of heart and kidney disease.

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Various health problems have the potentials to affect Jakarta citizens, given that, based on data from Jakarta Parks and Cemetery Agency, the number of Green Open Space (RTH) in Jakarta reached 33,131. These green open spaces are form of city parks, environmental parks, interactive parks and also the path of green road. Central Jakarta is the region with the most green space, reaching 913 RTHs. Although the number has been widely spread throughout the DKI Jakarta, yen the green open space areas in Jakarta is only 9.98% of the total area. This figure is still far from the target of 30% by DKI Jakarta government. During this time, the land acquisition and land purchases processes are still on the way.

In addition to leaving environmental problems, population density also causes limited land that can be utilized by urban communities to grow crops. This has implications of low cultivation activities for urban society, especially in Jakarta. At least 275 tons of vegetables are supplied to Jakarta per day. These supplies of vegetables generally come from Java and some provinces on Sumatra. Only a small portion of vegetable products are produced by farmers in DKI Jakarta. The small vegetable production in DKI Jakarta is mainly caused by the narrowing agricultural lands due to land conversion to fulfill the need for housing and non-agricultural services (Sastro & Rokhman, 2016: 1).

Environmental issues are also in the eye of all parties, including TNI, that seek to contribute in minimizing the issues. It is as ordered by TNI Commander, General Gatot Nurmantyo, in which TNI soldiers in West Jakarta should participate in developing agriculture in West Jakarta. Responding to this case, West Jakarta District Commander Lieutenant Colonel Wahyu Yudhayana informed one of the interviewees stated the Military District Command (KODIM) 0503 West Jakarta sent its members to attend basic agriculture training in Bogor for one week around July 2017. The event was carried out by The Army in cooperation with the Ministry of Agriculture. After returning to training, Dandim ordered to make hydroponic land at KODIM Headquarters and all the Koramil in West Jakarta.

Based on the Ostergaard model, the first stage in the model is the problem, which is the stage to find out what problems occur before deciding to implement the campaign. Venus states that the first stage serves as a preliminary stage or problem identification. In this stage, the decision maker or campaigner refers at the facts that occur in the environment as a problem (Venus, 2009: 15). Referring to this stage, KODIM 0503 West Jakarta previously had done a study on the conditions and situation in West Jakarta, and aligned it with instructions from the TNI Commander General Gatot Nurmantyo that TNI soldiers in West Jakarta should participate in developing agriculture in West Jakarta. Based on this study, a campaign of green environmental movement was initiated in supporting national food security through cultivation activities with hydroponics techniques as an environmental reforestation campaign and to encourage the spirit of national food security.

Lieutenant Colonel Inf Wahyu Yudhayana said that the program is designed for all members of KODIM 0503 West Jakarta together with the society to disseminate the spirit of farming with hydroponics technique, especially in West Jakarta. Therefore, this environmental campaign is expected to change the old paradigm that cultivating and greening the environment can only be done if it has adequate green open space. But in principle, many ways that people can do to create green open spaces by farming a space efficiently yet really easy to do, one of which is by farming through hydroponics techniques.

By further analyzing, KODIM 0503 West Jakarta measure described above is a part of efforts to study the situation and conditions before conducting the campaign activities is part of the problem identification stage. Once the facts later revealed, then subsequently compiled a campaign program. According to Ostergaard, the social change campaign program draft without being supported by scientific findings is not feasible. Therefore, a campaign program should always start from a clear identification of the problem. At the problem identification stage, a cause and effect relationship with the existing facts is being identified (Tyas, et.al, 2017:59-61).

b) Campaign Management

After understanding the various problems and situations in West Jakarta environment, the next step is the stage of campaign management, starting from design, implementation, and evaluation. In designing the campaign, a research is necessary to identify the characteristics of target audiences in order to formulate messages, campaign actors, channels, and the appropriate campaign technical implementation. (Venus, 2009:16).

The target segmentation identification step was done so that the green environment movement campaign program is well targeted at supporting national food security through cultivation activity with hydroponic technique. The determination of audiences through the identification was aimed to let us know who should know the campaign activities and care about issues raised in the campaign. The segmentation of campaign target conducted by KODIM 0503 West Jakarta targeted all Bintara Pembina Desa (BABINSA) in West Jakarta. BABINSA then socialized and coached the community in their respective regions.

After identifying the audience and the situation, then the next step was composing a message, which determined the theme and material. Many factors are related to the content of the message, ranging from supporting material, message visualization, negative

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messages content, emotional approach, fear approach, creativity, humor, and reference group approach (Venus, 2009:71). Given the campaign message is very important, KODIM 0503 West Jakarta formulated a message so that the purpose to be conveyed can be well received. Campaign messages are the environmental-based food security movement.

To strengthen the campaign message, KODIM 0503 West Jakarta added the visualization of the message by establishing Sustainable Food House in a number of flats in West Jakarta. In addition to providing an example of how hydroponic techniques are managed in sustainable food house, BABINSA also intensely socialized this program by providing explanations supported by media such as banners to provide an explanation related to stages and steps in implementing hydroponics techniques in their respective environments. The existence of Sustainable Food House is very illustrative on how easy the planting is done with hydroponic techniques, and to illustrate how to plant properly and correctly to the community. The message approach through visualization becomes a more effective message processing strategy to generate behavioral and motivational changes to conduct cultivation activities with hydroponics techniques.

First Sergeant Rasyidi explained that the message to be conveyed to the public was done through the campaign of green environment movement in supporting national food security through cultivation activity with hydroponic technique that is about the importance of creativity of society in exploiting the yard which is not wide as a means to cultivate with hydroponic technique. The lack of land is not a reason not to be able to manage the green environment which can be utilized for everyday purposes as well. The result is a greener, cleaner and healthier environment, as well as the rise of public awareness to help the government in helping national food security.

In conveying and disseminating campaign message, KODIM 0503 West Jakarta was also supported by the society, one of which is the students who upload the hydroponic activities techniques to social media and Youtube, so that the community then quite a lot of who came to this location. After the activity has been published, slowly but surely various media will make news coverage on the green environment movement campaign program in supporting national food security through cultivation activity with hydroponics. The researcher saw that KODIM 0503 West Jakarta needs to pack the message better and disseminate it by using various media, as well as gaining support from public figures both from TNI and the general public, so the message will motivate and attract more audiences.

As expressed by Venus (2012) in general, the main factor that must be considered in selecting the campaign is the suitability of the character with the object of campaign, media used, and credibility in the public. Campaign objects are generally used as the first basis of the consideration in setting campaign message conveyor (Tyas, et.al, 2017:59-61).

With regard to publications through electronic, printed and online media, it should be admitted that KODIM 0503 West Jakarta was still undergoing a development process. So far KODIM had not created a website, social media, or Youtube channel which are specifically used as a medium of publication and communication of this campaign activity. In the future, there needs a communication media that can reach all public audiences, especially those in West Jakarta. The existence of online media is certainly an opportunity for KODIM to be able to utilize as a publication media, given the characteristics of online media is likely to be easier, cheaper, and is currently preferred by all levels of society. This is very relevant, considering that West Jakarta residents are relatively easy to access the internet. In addition, in the context of this message, KODIM had not had time to test the message to be delivered to the public. In the future, this process is expected to invite and involve universities in West Jakarta area, so that the campaign program can run in accordance with the target.

The campaign activities are always implemented within a certain period of time. According to Gregory (2000), there are two interrelated major factors that must be observed when considering the time scale (Tyas, et.al, 2017:59-61). The green environmental movement campaign program to support national food security through cultivation with hydroponics techniques is currently still running until further notice. In principle, this program will be implemented sustainably, in which KODIM 0503 West Jakarta assists BABINSA will continue to campaign this program until each area under BABINSA managements implements this program. In practice, this program is supported by various stakeholders such as Agriculture and Livestock Sub-Office of West Jakarta and West Jakarta Sub-dept. of Fisheries and Food Security, as well as schools in West Jakarta. In the future, KODIM 0503 West Jakarta will involve more related stakeholders.

To ensure that this campaign program runs smoothly, KODIM 0503 West Jakarta Lieutenant Colonel Inf Wahyu Yudhayana sent his members to attend basic agriculture training in Bogor for one week. The submitted members were prepared to be a communicator in the campaign. After returning to training, the Dandim ordered to open hydroponic lands at KODIM headquarters and all the Koramil in West Jakarta. In the future, this program campaign will not only be done by KODIM 0503 West Jakarta members, but also SKPD who have competence in the field of cultivation through hydroponic technique. With many parties involved in this program, it is expected to

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accelerate the expansion and dissemination of this campaign program in West Jakarta.

Considering the green environment movement campaign in supporting national food security through cultivation activity with hydroponic technique is dominant with practical activities, hence a complete set equipment (props) is worth considered. So far, the props used is the Sustainable Food House which is equipped with a banner that informs stages and steps in implementing hydroponic techniques. Channels or communication media are important to note. According to Schramm (1973), channels are any intermediary that allows messages to the recipient (Venus, 2009:84). Therefore, these channels or media need to be considered and selected based on the audience characteristics and messages of the campaign. Things that need to be developed by KODIM 0503 West Jakarta is to increase the variety of media campaigns, so that more audience can be reached. In addition to creating their own campaign media, KODIM 0503 should strengthen media relations activities as part of its policies and tactics in gaining publicity from the media.

The final stage in the campaign implementation was an evaluation on the effectiveness of the program that has been implemented. As a planned and programmed activity, all actions in the campaign must be monitored so that various issues and constraints can be addressed appropriately. Therefore, it should be understood that a campaign is not a rigid and partial act (Venus, 2009:205). Therefore, the green environment movement campaign program in supporting national food security through cultivation activity with hydroponic technique should be evaluated on a regular basis. This stage is the last component of a series of campaign management processes. The form of campaign management evaluation conducted by KODIM 0503 West Jakarta was survey and interview to the community involved in the program. The evaluation measure is done through a two-weekly regular meeting with Babinsa of West Jakarta. The various obstacles encountered by Babinsa during the campaign were described and analyzed to seek the solutions, as well as various problems during hydroponic engineering practices undertaken by the society.

c) Evaluation Stage

The last stage in the campaign management is the campaign evaluation stage. This stage is the final step that must be done in a campaign. Campaign evaluation is a systematic effort to assess various aspects related to the implementation process and campaign goals achievement. Briefly, the assessment of the campaign drafting implementation process can be done by analyzing campaign daily report containing various data and facts as a result of the monitoring process, field observations, and interviews conducted to obtain feedback (Tyas, et.al, 2017:59-61).

The evaluation process conducted by KODIM 0503 West Jakarta was aimed to see how many people have started to implement this green environmental movement campaign program at their home. The weekly evaluation are done on every Friday for the Danramil (Koramil Commanders), to see what has been done and what has not been done. For Babinsa, the evaluation will be done every 2 weeks or every month.

One of the things that needs to be developed in this evaluation process is the need to add more comprehensive evaluation methods. One of the evaluation activities that needs to be done is through surveys and interviews by visiting residents directly by independent teams. In every survey and interview, it is necessary to measure and understand how the development of the society knowledge, attitude, and practice in the campaign program.

Basically, the evaluation of the campaign program can be used as a parameter of success or failure, either in the short term or long term. Through the evaluation activities, we can map out weaknesses in the campaign program implementation, whether it's on the campaign communicator, messages, media, or methods. According to Frank Jefkins (2004:129), the evaluation results can be divided into qualitative results and quantitative results. The first is the qualitative results. Generally the results of a PR activity are qualitative. That is, these results cannot be measured statistically, but measured through real experience and comparison instead.

Referring to Frank Jefkins evaluation concept, KODIM 0503 West Jakarta so far can still conduct qualitative evaluation, in which they only see how far the campaign message goes and can be accepted by target audience only by interviewing and observing. Thus, KODIM 0503 West Jakarta is only limited to look qualitatively the public understanding on the message and behavior as well as their actions in the campaign activities. To find out the effectiveness of this campaign program, KODIM 0503 West Jakarta should also make quantitative measurements by conducting surveys.

Evaluation activities are very important, which according to Gregory, a campaign expert from the UK, there are five main reasons for evaluation: 1) The evaluation can focus efforts on the priority to achieve the objectives, 2) The evaluation shows the effectiveness of the campaigners, 3) Ensure cost efficiency, where all campaign activities are audited so that there are no unused funds, 4) Realistic, clear and directed. Irrelevant issues will be quickly identified and immediately excluded, 5) The evaluation assists accountability of campaign implementation (Siahaan, 2011: 235).

Through these evaluation activities, KODIM 0503 West Jakarta can restore the focus on the objectives of this campaign: 1) to create a green environment, as a movement to improve the national food security movement in urban environment; 2) to see

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whether the campaign program has been effective or not, 3) to ensure that all budgets used in campaigns are efficiently allocated, 4) to make campaign programs more realistic, clear and directed. If there are irrelevant activities in the campaign activity it will be immediately removed, 5) to assist the accountability of campaign implementation, in which the campaigners can be accountable and be transparent to public.

V. Conclusions and Suggestions

a) Conclusions

This research reveals that the green environment movement campaign, in supporting national food security through cultivation activity with hydroponics technique, covers three stages: first, to identify issues. At this stage, KODIM 0503 West Jakarta performs studies and problem identification first. Then, the solutions to be taken are first studied in accordance with government instructions, in this case the TNI Commander. Based on the identification, the green environmental movement campaign program to support national food security through cultivation activities with hydroponics techniques emerged. The second stage is the campaign management. This stage identifies the characteristics of target audiences in order to formulate messages, campaign actors, campaign channels, and technical campaign implementation. The third, and the last stage, is the evaluation. This activity is intended to see how many people who have started the green environmental movement campaign program at their home.

b) Suggestions

Based on the results of the research, the researcher suggests that KODIM 0503 West Jakarta to conduct campaign activities using mode varied media, both printed and digital media To accelerate the process of receiving campaign messages, this campaign program should have a Brand Ambassador from the TNI or public figures from general public, so the message will motivate and attract public interest to hear and follow the invitation according to the contents of the message to be conveyed. To increase the publicity of the campaign program, it is suggested to strengthen media relations activities as part of its policies and tactics in gaining publicity from the media. To find out the effectiveness of this campaign program, KODIM 0503 West Jakarta should also make quantitative measurements by conducting surveys.

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Core City Slums and Vulnerability: A Theoretical and Analytical Approach

By Oyeniyi, S. O., Adekiya A. S. & Kolawole A.S.
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Abstract- Cities,'the magnet of hope' are pulling people into themselves without preparing for them, this influx leads to overconcentration of people in the already blighted cities centers, this creates new problems or aggravates the existing ones which makes the residents vulnerable to various dangers. This work reviews a few urban planning theories, triangulated them and introduces a modified version. It also analysis vulnerability in the slums of core city centers and suggested strategies that can reduce it. The work will be of tremendous use to policy makers, urban planners, academic community and the general public.

Keywords: cities, environment, slums and vulnerability.

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I. Introduction

The crisis of human settlement has become a topical issue and debate on it has been on for many years now. There are both intellectual and professional viewpoints on the need for controlling human settlements to enhance their growth and sustainability. The study of settlements occupied an important position in the historical development of geography. Geographers and sociologists have over the years tried to explain variations in spatial pattern and their consequences Atser (2006). To find a compatible multiple theories therefore, (a sort of divergence) directed at presenting scientific explanations of the result of the researchers and then look for a convergence of evidences in other to draw overall conclusions in the social sciences Afolabi (2012). Against this background has the researchers engaged in a critical reflection on the rationale behind formulation of some urban planning theories, triangulate, modify and used them as spring board for the formulation of another model, since models form an integral and accepted part of present-day geographical thinking and teaching as opined by Waugh (1995).

a) The Synthesis

Urban Growth Theories; Concentric Growth Zone, Multiple Nuclei Theory, Regional Land use Model, Sector Theories were triangulated with a view to discovering zones of convergence, test their validity and use them as spring board for the formulation of a new theory/model or at least modify the existing ones. Basically, all the theories were formulated upon the fundamental premise of the desire to understand better man-environment interaction, all the four theories embrace in the concept of Central Locations; a place where population and activities concentrate, for instance to Von Thunen in Regional land Use Model, it is 'Markets; the city center, around which all other activities take place with specific reference to agricultural practices, to Earnest Burgess in Concentric Growth Zone, it is 'Central Business District' (CBD), so it is to Homer Hoyt in Sector Theory with additional observations, Chauncy and Edward (1945) in Multiple Nuclei Theory opined that cities grow in wedge shape or sector starting from 'Central Place' called (CBD).In the same vain, they also unanimously agreed that from the central location the expansion starts and grows to all directions e.g. Regional Land Use Theory says activities of agriculture surround the 'market' (Central Place), Concentric Growth Zone says 'the city expands in rings', while Sector Theory expresses the view of 'outward progression of growth' starting from a center, to buttress this stand, Multiple Nuclei Theory talks of 'outskirt growth of city' from a center. Beside these, both concentric growth zone and sector theory described settlement of immigrants along the second ring and along the roads, identifying areas of likely over population and overconcentration of human activities and its attendant problems that include slum development.

IPAT Theory of Ehrlich (1971) comes in at this stage; Impact = Population X Affluence X Technology. According to this formula, the impact of a population on the environment is the product of the size of the population (**P**), its level of affluence (**A**), and the impact of the technologies (**T**) that sustain the level of affluence. The implication of this formula is straightforward – the more people are, the more they consume, and the more technology they use, the greater the damage to the environment. Ehrlich (1971) pioneered the approach which presented environmental degradation as the consequence of too many people. 'Too many cars, too many factories, too much pesticide, too little water, too much carbon dioxide – all can be traced easily to too many people'. It explained the impact of overpopulation on the environment at the core or central place of the city and its impact on the people.

Theory of Slumification – A Modified Version

Sequel to this background therefore, authors proposed the model below CSC = PC= AC = EP = HH;

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Where: CSC = Core City Centers, PC = Population Concentration,
AC = Activity Centers, EP = Environmental Problems, HH = Health Hazards.

The hypothesis stands on the following assumptions with reference to Africa cities.

CSC = Are places of earliest settlers, places around Kings palaces / first administrative centers with daily market places, worship centers or shrines, the places came before the introduction of modern urban planning so they were not planned, those places have highest concentration of human population and their activities in these cities, That the place is characterized by old dilapidated buildings, That these areas has worst environment due to poor sanitation, environmental pollution of various sources e.g. automobile, domestic, noise and others, therefore, it can be concluded that Central Places in Africa cities possesses all the characteristics of slum most especially, about 1km radius to Kings palaces Abumere (1985).

Both physical evidences and literature support this line of though, especially, when scholars have independently identified and unanimously agreed that (CBD) is characterised by old buildings because it is the oldest part of the cities, limited access to space due to high value placed on it, high traffic congestion that resulted from converging transport routs and its associated urban stress, highly populated day and depopulated night, high crime rate, pollution of different forms etc. Mabogunje (1962),(1968),Abumere (1987), Agboola (1987), Laurent (2002), Morife (2010), Obayomi (2012), Owoeye (2013),Oyeniyi *et al*.(2015) etc.

Massive immigration into cities, skyrocketing urban population, rapid growth of informal settlements including slums and squatter, increasing environmental, social and economic problems are clearly the trend of events in African societies, even developed world has its own share. Ola in (2011) opened that since the creation of man and the effects of cohabitation, there have been the consequences of population explosion and concentration underlying nearly all environmental problems is the rapidly increasing human population. Simplify but highly influential formula of Frank (1973) states that population growth contributes to the destruction of the environment, thereby endangering all forms of life.

The word slum is thought to be the Irish phrase *'slome'* meaning 'it is *a bleak or destitute place'*. An (1812) English dictionary define slum to mean *'a room with low going ones in life'* Piece Egan in (1935) define slum as *low, un-frequent part of the town*. It is a heavily populated urban area characterised by substandard housing and squalor Owoeye and Omole (2012). Corecityslumsare the slum communities described by Agboola (1987) as traditional slums, Abumere (1985) as slum within one kilometer radius from the city center and Laurent (2002) as the oldest and largest slum is the core area of the city, which covers the entire pre-colonial towns; a large part of the ancient walled city can be seen as a slumhe concluded.

Core city slums are blighted communities characterised by high population densities per unit area of land, precarious housing condition, poor and unhygienic environmental situation, physical layouts are relatively haphazard, urban services are minimal or not-existing decayed infrastructure, more than three persons share a room, majority of the residents are low-income earners, they are tenants who outnumbered owner residents at a ratio of 9 to1, morbidity and mortality rates caused by diseases stemming from poor environmental conditions are significantly higher than what is obtainable in planned areas of towns, tenure in the informal settlement is largely lacking, poor and costly safe drinking water situation, extremely poor sanitary situation and breeding ground for all forms of anti-social vices, just to mention a few.

II. Vulnerability in Core City Slums

Pelling (2003) defines vulnerability as the exposure to risk and an inability to avoid or absorb potential harm, he defines physical vulnerability as the vulnerability of the physical environment; social vulnerability as experienced by people and their social, economic, and political systems; and human vulnerability as the combination of physical and social vulnerability. Cardona (2003) and (2004a) opined that vulnerability originates as a consequence of three factors: (a)Physical fragility or exposure, linked to the susceptibility of human settlements to be affected by natural or social phenomena due to its location in a hazard-prone area, (b)Socio-economic fragility, linked with the predisposition to suffer harm due to marginalization, social segregation in human settlements, and due to poverty and similar factors; and (c)Lack of resilience, related to the limitations of access and mobilization of resources, and incapacity to respond when it comes to absorbing the impact of a disaster. It can be linked with under-development and the lack of risk-management strategies.

These descriptions fit the condition of core city slums and the residents there of, the people living in slum environment are exposed to risks and they do not have ability and capacity to absorb or resist potential harm, they are vulnerable to physical, social, and most often economic environment. The people are largely poor; their economic lives are unstable and fragile, they eke out there lives on daily paid and energy sapping jobs, the conditions that did not only forced them into residing in slum environment but make them more vulnerable and unable to resist, respond and cope effectively associated dangers that goes with such live style.

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Chambers (2006) stated that the main asset of most poor people is their bodies. These include the plain facts that the poorer people are, the more it matters to be able to work and earn, the more they depend on physical work, and the higher are the personal costs of physical disability. At the same time, the bodies of the poorer are more vulnerable than those of the less poor: they are more exposed to sickness from insanitary, polluted and disease-ridden environments both at work and at home, and to accidents in their work; they are weaker, with malnourishment and previous sickness tending to reduce resistance to disease and to slow recovery; and the poorer have less access to prophylaxis or to timely and effective treatment.

Housing quality, condition or habitability is a serious concern in slum environment because it is usually generally precarious, exposing the residents to extreme danger of insufficient protection against extreme climatic elements, such as rainfall, wind, and temperature. The lives of slum dwellers are also exposed to danger of collapse building especially in core city centers in Africa, where we have the first set and oldest buildings, most of which were built over one hundred years agowith inferior materials and are dilapidated; roofs are rusted and linking, windows and doors are neither in poor condition or not in place the walls are not plastered, the floors not paved rather they are moist. Clark (2009) notes that damp housing affects physical health because it has the potential to increase dust mites and moulds, both of which are allergenic. The rooms are small so are the windows, hence rooms/houses are not well ventilated.

Poor health results in increased hospital admissions and more absences from school and work, with implications on the economy. Basic facilities are generally lacking; no motor able roads within the core city slum communities in case of emergency, most city center slums do experience seasonal flooding due to lack of planning and poor waste management practices which pollutes underground water, bathrooms and toilets are situated outside the houses denying the residents of the expected privacy and exposing them to possible harassment by opposite sex.

Slum dwellers are undoubtedly exposed to dangers of overcrowding and insufficient living space. Since the slum communities seem to be the only affordable to poor migrants, more people are clogged in an unhealthy environment that allows diseases to strive and spread quickly especially when there is an outbreak of diseases. Ant ova *et al* (2008) demonstrated a relationship between crowded living conditions and asthma.

People residing in slum environment are also vulnerable to inadequate sanitation which remains a leading cause of diarrheal disease and mortality among children in developing countries and particularly in urban slums. The Global Burden of Disease Study undertaken by the World Bank (2006) indicates that 15% of all the deaths in children fewer than 5 years in low and middle-income countries are directly attributable to diarrheal disease, 88% percent of the diarrheal disease burden is caused by unsafe sanitation, water, and hygiene. NISER (2011) asserted that water and sanitation disease are responsible for 60 per cent of environmental health. Among water borne diseases, diarrhea dispropo-rtionately affects children under the age of five poor health among children adversely affects the attendance rate at schools.

Children safety is always an issue in slum environment, issues arises from poor child spacing practices, low rate of immunization, poor health seeking practices, poor antenatal care and low rate of life birth Sarah *et al* (2002). Many children in the slums start work at a very early age with no prospect of getting any education. They make money by rag picking trawling through rubbish dumps to retrieve anything that can be sold, all these make them vulnerable to many more disease and injury, researches have sown that people that handle waste or live around dump sites are infected with gastrointestinal parasites, warms and related organisms. Vector insect and rodents can also transmit various pathogenic agents(amoebic and bacillary dysenteries, typhoid fever, salmonellosis, herpes, pneumonia, various parasites, cholera, yellow fever and others). Similarly, children sell newspapers in traffic jams; they peddle drugs or beg on the streets making them and other residents' alike more vulnerable to severe accidents, and cyclic poverty.

Omotoso and Oyeniyi (2015)reported that overwhelming majority ofcore city centers slum inhabitants depend on hand-dug wells for their water needs, most of these wells are too shallow, poorly covered, or not covered at all, these results in polluted surface water from the surrounding area gaining direct entrance into them, raw sewage do find their ways in to wells through seepage, run-off and flood enters directly during heavy rains especially when some wells are just one foot higher than the earth surface. Free ranged animals like goat sheep and fowls pass nights on wells and their dungs equally enter the wells directly, other negative consequences of poor sanitation on water drinking water safety in the core city slums includes citing of wells close to septic tanks, burial sites of dead family members buried within the compounds and dump sites located within the living space, these are repository of filth through which many contaminants pollutes the well waters. Water is drawn manually from the wells and the drawers are left on the wells or beside the wells on a bear floor, these drawers serve as piggy-back for germs and dirt getting into the well waters especially when many wells are not covered, poorly covered or poorly constructed Oyeniyi et al (2015).

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As reported by Agbola (2007) slum residents don't usually have legal right to the property they occupy. The situation that justifies forced eviction especially in blighted core city centers. There is substantial empirical evidence showing that urban development, commercial interests, city beautification projects and public interest are popular reasons advanced by the authorities when forced eviction is done Thomas(2014). Residents of blighted city centers are highly vulnerable to forced eviction as the communities usually face demolition when government reclaims the illegally occupied land for other usages Ramash (2010). As a matter of facts, many of them live with perpetual perturbation of forced eviction, because they know that when it happens, people don't just lose their homes, they lose their hard earned but meager properties especially their means and places of livelihood, family and kinship are separated, pupils change school or drop out of school, forced to seek newjob, new home, and start live afresh into a new and uncertain future in the new environment.

The slum environment is the perfect breeding ground for a wide range of social problems. High unemployment often causes men to stay around the home growing increasingly frustrated with their pathetic situation and the worsening poverty this thereby making them to be vulnerable to committing crimes and engage in anti-social vices. Slum and squatter settlements create a zone of terror and dread for the city people where almost all evils are found, the residents are therefore vulnerable to social stigma from the rest of the society and harassment by security agents; indiscriminate arrests, suspicion and lack of trust.

III. Conclusion

Our immediate environment is as important as the dresses on us. It plays crucial roles on our wellbeing but unfortunately, majority of uson planet earth today congregate and live in blighted or core city centers that fall below the expected standard. We are therefore vulnerable to all forms of dangers that resulted from overconcentration of man on blighted core city centers. This exposes human lives to all forms of dangers that resulted in poor man-environment relationship. No responsible government should allow this precarious situation to continue. Policy Implication

It is time for policy makers and urban planners to seek workable, acceptable and practicable ways of controlling influx of population into cities. To reduce pathetic and life threatening situation in the extremely vulnerable slums of our core city centers government should frantically seek ways of tackling poverty; create jobs, adopt educational policies that is not only theoretical but informal, semiformal and practical. Housing policy that combines affordability, improved technology, the use of local materials and guarantees quality should be introduced. Satellite towns could be of help in reducing overcrowding and its associated vulnerability in our city centers. Public enlightenment on personal safety, security and cleanliness can go a long way in alleviating live threatening conditions and perturbation. Provision of infrastructural facilities within range, slum re-development strategies better waste management methods togetherwith economic empowerment for the dwellers may reduce vulnerability in our core city slums

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Geotechnical Properties of Problem Soils in Greece

By John Christodoulias
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Abstract- This is a ten years research programme and it was sponsored by the Geek Ministry of Public Works, in order to prevent damage in public road services. This research program might serve as an information database for geotechnical properties of swelling soils in Greece. The purpose of this laboratory investigation firstly was to examine the engineering properties and secondly to test the geotechnical behavioras many as possible active soils throughout the Greek mainland and islands. For this, grain size analyses, Atterberg limits, x-ray analyses, shrinkage limits tests,, swell pressure in the oedometer, cation exchange capacity and pH in disturbed and undisturbed soil samples have been investigated. Also an attempt has made to correlate swell pressure and shrinkage limit, with the variables which are water dependable (liquid limit, plasticity index, moisture content), in order to determine ones well potential index and the results were very promising.

Keywords: geotechnical properties, swelling soil, shrinkage limit.

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Keywords: geotechnical properties, swelling soil, shrinkage limit.

Resume- Il s'agit d'un programme de recherche scientifique d'une durée de dix ans réalisé pour le compte du Ministère Grec des Travaux Publics.

Son objectif est de contribuer à la prévention des dégradations du réseau routier public.

Dans le cadre de ce programme une base de données a été créée concernant les propriétés géotechniques des sols gonflants en Grèce.

Les essais réalisés en laboratoire avaient comme but dans un premier temps d'examiner les propriétés mécaniques et ensuite de tester le comportement géotechnique des sols actifs pour le plus grand nombre des cas couvrant la Grèce continentale et ses îles.

Pour cela un grand nombre d'analyses et d'essais a été réalisé sur des échantillons de sol perturbés et non perturbés, comme p.ex. analyses granulométriques, essais de limites d' Atterberg, analyses par rayon X, essais de limites de rétrécissement, de pression de gonflement dans l'oedometer, de la capacité d'échange cationique, de pH etc.

Un effort a été également mené pour tester la corrélation entre la pression de gonflement et la limite de retrait, avec des variables qui dépendent de l'eau (p.exlimite de liquidité, index de plasticité, teneur en eau), afin de déterminer un seul indice de gonflement. Les résultats étaient très prometteurs.

I. Introduction

Expansive soils are found extensively in tropical areas. The presence of expansive soil affects the construction activities and all civil engineering work. In many parts of S.W. United States, S. America, Africa, Canada, India, and Middle East.

Extensive areas around the world are covered by clay soils of high swelling potential. These clays are now well known as active clays due to their behaviour with volume changes according to their moisture content. In arid and seem-arid regions such as Greece or other Mediterranean countries, the clay material exists in an unsaturated condition due to deep water table. With seasonal climatic changes, the clay tends to change moisture content. The more water they absorb the more their volume increases. Expansive soils also shrink when they dry out. Fissures in the soil can also develop. These fissures help water to penetrate to deeper layers when water is present. This produces a cycle of shrinkage and swelling that causes the soil to undergo great amount of volume changes. Of course no one method of soil analysis can estimate shrink – swell potential accurately for all soils. We can recognize shrink – swell behavior by examining all physical, chemical and mineralogical soil properties.

Soil properties measured were LL, PI, and particle size distribution, clay mineralogy with x-ray diffraction, CEC, swelling pressure, linear shrinkage, and shrinkage limit. Also one expansive soil Index (Is) was developed through the shrinkage limit results in comparison with swell pressure.The existence of specific expansive minerals in the clay soil related to the climatological conditions (drought and heavy rain) in Greece, have resulted to induce unexpected shrinkage and swelling movements with all the unfavourable consequences to light structures, to new road construction and to industry buildings, founded on clay. During the last ten years it became apparent that surface soils in many places are subject to swelling, were structural damages had been appeared in the form of wide cracks in the wall, distortion of floor, heaving of beds in canal, rutting of roads etc. The concern of this laboratory investigation, sponsored by the Ministry of Public Works, first was to examine the engineering properties and the geotechnical behavior as many as possible active soils throughout the Greek mainland and islands. This research work must consider as one inventory that would serve as an information database for geotechnical properties of swelling clay soils in Greece.

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Map 1. Sampling areas all over Greece.

II. Geology of sampling areas.

From the engineering geology point of view, the question was to identify which swelling clay minerals could cause the most severe damage. Terra Rosa, alluvial clay deposits or the volcanic originated clay.

The second question which had to be answered was, to measure in the lab the swelling pressure of each clay soil sample and to determine the numerical damage of swell which could cause to any construction.

a) Lesvos Island.

Sampling area No 36 in the city of the Island.

Quaternary, The Holocene era mainly consists of undivided deposits consisted of red and gray clays,

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and sand. Deeper we have talus and conglomerates with gravel of serpentinite, ofiolites, basalt or phyllites. The Pleistocene contains talus and conglomerates with gravel, mainly of serpentinite, ignimbrite and rhyolotic tuffs. Also we had one volcanic eruption. The Pliocene contains deposits of marls, soft sandstone, clay and several shell beds. Total thickness more than 60m. (IGME,1990).

a) Egina Island

sampling area No 26

Egina is a small island located in a distance of 20 nautical miles SW of the capital city Athens. The island has one heavy geological past and has suffered two volcanic eruptions. First eruption occurred during Miocene and second eruption in Pliocene era. Most of the island is covered by andesitic rock with pyroxenites and Dacite with biotite, also with pyroclastic fragments (conglomeretes), tuffs and pumice.

In the North part of the island (town of Souvala) damages were reported to the local road network and in many light farmer houses. The first laboratory investigation revealed the presence of smectite as the cause of trouble. The whole area is basin containing Neocene sentiments mix with swelling clay minerals. Smectites produce by degradation of rich in silica glass material and are formed by alteration of basic rocks or other silicates low in K, under alkaline conditions, providing Ca and Mg are present. (IGME, 1990).

b) Evros. District

Sampling area No 13, 14, 15

The area is mainly covered by clay, clayey silt, sand mainly from river Evros fluvial deposits a. (age Holocene). A bit deeper there is sand and clayey silt red to yellow in alternating deposits. Continental formations without fossils, mainly terrestrial fluvial terraces, partly deposits of sallow basins. Usually loose, rarely slightly cemented, unbedded or weekly bedded. Pebbles of various size from the Pre-Tertiary basement (schist, serpentinite, quartz, limestone, volcanic), fine grained material from Tertiary sediments. Age Plio- Pleistocene. Thickness over 100m.

Also, clays, grey to yellow, compact, locally imperfectly schistose, with frequent intercalations of fine grained sandstone. They overlie the lower members of Oligocene series (marls and clay alternations), but their contact is covered by alluvial deposits. Additional lower series of clay and marls. grey –yellow or grey clays, thin schistose, in alteration withmarls of green – grey color, they occur in a limited area overlay the Upper-Eocene limestone. (IGME, 1980).

c) Tripolis Plateau.

Sampling Area No 25
Quaternary – Holocene age.

The whole plain is covered by alluvial Pleistocene deposits such as clayey silt, clayey sandy material silty-clay and terra-rossa, having thichess approximate 250m.

The surround mountain area consists of Upper Palaocene flysch formation containing alternations of sandstone and sandy siltstone. Also rounded pebbles of serpentinized igneous rocks are locally observed.

Upper Cretaceous limestone. White to reddish, often clayey, compacted with chert, marl and calcitic sandstone. They are multifold and fractured.

Upper Cretaceous dolomitic limestone. Gray to black, thikbeded to massive. In the upper beds have very cohesive breccias with sandy cement.

Upper Jurassic siltstone. Alteration of radiolarites siltstone and limestone. They are mainly green jaspers, thin bedded with siltstone intercalations.
The geotechnical problem with this plain is that there is no way to the sea, and the only way to drain the rain water after a strong precipitation is same well known sink-holes in Nestani village. Thus the plain suffers flads every two or three years and by the time where the flady water procceds in a low speed movement underground in a limestone country, houses, farms, roads and all public network are damaged. (IGME, 1990).

d) *Plain of Viotia*.

Sampling areas 1 to 12

Foundation conditions on the plain north to north-east of Thebes city, about 100 km north west of capital city, Athens, have attracted attention because of the new motorway construction and steady influx of industry. A few years ago it became apparent that the surface soils is the large area are subject to swelling. Light structures are observed to suffer from heaving and in summer the soil surface develops shrinkage cracks. The evidence of swelling is strengthened by the water table lying deeper than 10m and by the regular climatic cycles of dry summers followed by substantial rains in the autumn. The plains are underlain by Holocene terra rossa but there are also lacustrine deposits with intercalations of peat bed, of torrential or river origin at the edges. Deeper, there are Pleistocene deposits of torrential and river origin with variable degree of cohesiveness. The material consists of conglomerates, sandstone, sand, silt, red clay. In the surrounding mountain area there are formations of undivided flysch, (Palaocene-Eocene), consisted of red-cherry clay – marl beds fine and coarse conglomerates, fine sandstone. Also upper Cretaceus limestone is present, microcrystalline, gray to light gray. The upper horizons consist of deep sea (pelagic) hard, white-gray, thin bedded limestone. (IGME, 1980).

e) Sampling

In order to study the physical characteristics, the engineering properties and the mineralogical

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composition of the swelling soils, a large scale sampling was initiated in 38 deferent regions of 20 Provinces in the Greek territory, collecting 911 disturbed and undisturbed soil samples (Map 1), in different time periods. Sampling included disturbed and undisturbed soil samples collected from 202 shafts and 99 boreholes. In the laboratory the undisturbed samples were wrapped up with paraffin and canvas cloth, in order to prevent them keeping their natural moisture content.

f) Identification tests

The laboratory based evidence of swelling potential was given by grainsize analyses (table 1) and Atterberg limits, (histogram 1 and 2).

The material passing the US sieve No 200 varied between 70% and 100%, having a clay fraction between 20-70% average 34,6% and stdev=9,3. For the grain size analysis of the clay fraction smaller than 2 μm, sodium phosphate solution was used as dispersant. From the Liquid Limit (LL)results (ASTM D4318) the samples yield liquid limit values between25-91% mean value 51,8and stdev=14,76. From the plasticity index test (PI) resultsthe samples revealed PI values varying between 24-70%, stdev=3,66and average 30.1. Such clays belong to the CL and CH groups of the unified classification system.

Further indications of swelling potential came from x-ray analyses, linear shrinkage, shrinkage limits tests using the mercury apparatus suggested by the Transport and Road Research Laboratory (TRRL,1974){32}. Also free swell tests in suspension (Holltz& Gibbs, 1957){16}, were extensively used in order to measure the volume change capacity between air dry and wet conditions. Swell pressure in the oedometer and free swell in the oedometer under an external pressure of 7 kPa (approximately 1 psi) were measured on undisturbed soil samples taken out by Shelby. Finally the cation exchange capacity (C.E.C.) measurement of representative soil samples in comparison with x-ray analyses and the activity charts supported the investigation in order to classify areas having high, medium and low swell potential.

Table.1. Sieving analyses of soil samples.

Sampling area	n	Sand %	Silt %	Clay %
Area 1	25	5-30	30-40	20-55
Area 2	28	2-24	24-40	20-74
Area 3	30	2-20	48-50	20-48
Area 4	20	10-23	34-45	25-56
Area 5	10	16-26	20-30	28-56
Area 6	25	2-20	30-44	22-60
Area 7	8	2-22	40-50	20-58
Area 8	10	4-18	36-50	20-60
Area 9	36	4-28	28-46	20-50
Area 10	35	10-15	40-45	30-50
Area 11	21	2-10	38-54	30-60
Area 12	33	2-16	20-30	42-68
Area 13	20	2-26	30-43	30-55
Area 14	21	4-42	26-41	25-70
Area 15	27	4-28	22-46	20-50
Area 16	26	10-40	15-45	25-45
Area 17	20	4-26	40-46	24-56
Area 18	27	4-20	42-58	20-54
Area 19	22	2-10	22-48	42-76
Area 20	13	18-34	26-40	20-42
Area 21	17	14-36	28-45	20-40
Area 22	17	18-30	26-31	22-50
Area 23	12	8-18	26-32	34-60
Area 24	21	26-40	18-34	14-40
Area 25	51	14-30	10-18	20-48
Area 26	34	4-40	11-51	24-46
Area 27	32	2-46	25-44	15-52
Area 28	33	2-36	21-26	25-78
Area 29	19	2-26	34-38	24-54
Area 30	22	8-32	28-48	22-44
Area 31	27	6-24	31-38	24-64
Area 32	19	2-36	22-38	20-53
Area 33	19	8-15	22-33	20-68
Area 34	21	2-18	42-50	28-44
Area 35	30	8-30	34-44	18-46
Area 36	24	2-14	28-60	20-70
Area 37	30	2-22	36-48	20-60
Area 38	28	10-36	22-32	24-52

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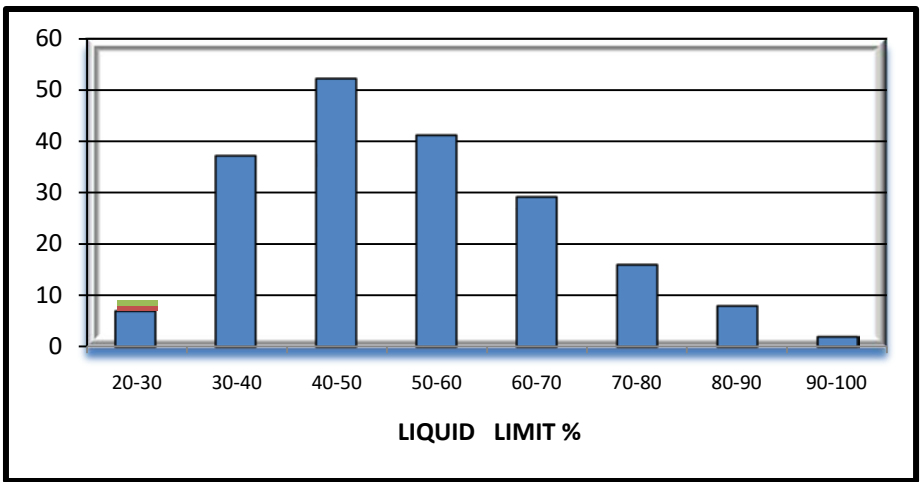

Figure 1: Histogram of the liquid limit results for thetotal number of soil samples

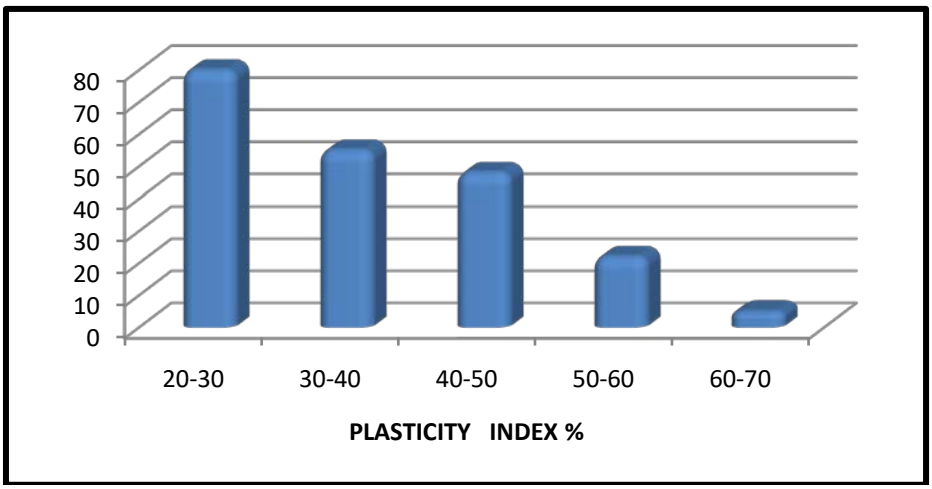

Figure 2: Histogram of plasticity index for the total number of soil samples

III. Cation Exchange Capacity (C.E.C.).

The precise definition of cation exchange capacity of the soil samples, was measured with the method of ammonium acetate (Schofield, 1949) and the determination of exchange able ionswas measured with a cornflame photometer. Finally 52 soil samples were tested, collected out of 38 districts For comparison two extra samples were tested, one of pure industrial bentonite as clay material with a high swelling capacity revealing C.E.C. 72 meq/ 100gr and one of pure industrial kaolinite as a material with a low swelling capacity, revealing C.E.C. 6 meq/ 100gr. As it was identified, the cation exchange capacity (CEC) for the Greek swelling soils varies between 20 meq/ 100gr to 70 meq/ 100gr. One soil sample from Viotia province (Area 8) revealed CEC 70 meq/ 100gr, similar to that of industrial bentonite.

Since Schofield (1949), Rich and Thomas (1960, have reported that soils having pH values higher than 7, reveal high C.E.C. values, is was important to measure the pH in the vicinity of each of the above mention soil samples. For these, from thesurrounded soil and in a distance of about 100 cm, different samples were collected and tested with a pH meter. Additionally one samples of pure industrial bentonite revealed pH value 10.5 and one sample of pure industrial kaolinite revealed pH value equal to 5.2. The results of the measurements from 300 soil samples of the Greek territory are reported on Table 2and the recorded values varies between
pH = 7.50 and pH = 9.46.

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Table 2: C.E.C. and pH values of soil samples

Sampling Area	C.E.C. meq/100 gr	N	PH.	N
Area.1	55.3	1	8.08-8.82	6
Area.2	58.9	1	7.72-9.46	4
Area.2	55.1	1	7.70-9.10	4
Area.2	57.6	1	7.50-8.50	3
Area.2	56.2	1	8.20-8.30	3
Area.3	35.1	1	7.52-7.98	5
Area.4	49.8	1	7.78-8.30	5
Area.5	36.0	1	7.97-8.59	6
Area.5	27.8	1	7.52-8.35	4
Area.6	17.2	1	7.80-8.11	4
Area.7	36.7	1	7.82-8.52	4
Area.8	70.0	1	7.50-8.30	5
Area.9	48.6	1	7.94-9.22	8
Area.10	51.3	1	8.13-8.93	8
Area.11	50.1	1	7.00-8.30	5
Area.12	37.6	1	8.07-8.53	1
Area.13	37.4	1	7.63-8.20	5
Area.13	41.2	1	7.71-8.34	3
Area.13	43.4	1	7.90-8.60	3
Area.14	37.0	1	7.00-8.60	3
Area.15	35.6	1	8.03-8.44	5
Area.15	26.0	1	7.98-8.33	2
Area.15	15.6	1	7.66-8.15	2
Area15	22.7	1	7.30-8.24	2
Area.16	50.2	1	8.58-8.88	2
Area.17	39.6	1	7.50-8.43	3
Area.18	34.0	1	8.20-8.68	3
Area.19	36.4	1	8.55-8.82	6
Area.20	23.3	1	7.60-7.90	3
Area.21	25.3	1	7.90-8.11	5
Area.22	18.2	1	7.68-8.20	3
Area.23	42.4	1	7.90-8.50	3
Area.23	25.1	1	7.65-8.13	3
Area.24	17.4	1	8.00-8.51	6
Area.25	16.8	1	7.84-8.13	4
Area.25	18.1	1	7.97-8.21	4
Area.25	53.7	1	7.85-8.66	3
Area.26	57.2	1	8.42-8.64	4
Area.27	32.4	1	7.68-8.40	3
Area.28	27.4	1	7.50-8.15	3
Area.28	56.9	1	8.20-9.10	3
Area.28	24.4	1	7.40-8.23	5
Area.29	50.4	1	7.45-8.36	4
Area.30	34.0	1	7.70-8.90	4
Area.31	17.9	1	7.45-7.95	5
Area.32	14.4	1	8.09-8.70	9
Area.33	23.6	1	8.10-8.60	5
Area.34	30.5	1	8.34-8.56	6
Area.35	26.0	1	7.20-8.27	9
Area.36	56.1	1	8.00-8.96	9
Area.37	17.6	1	7.52-8.00	3
Area.38	25.2	1	7.50-8.20	3

IV. The Mineralogical Analysis of Clay Fraction

The crystalline mineralogical components of a clay soil were identified by the powder method of x ray diffraction analysis. The clay samples were tested with a Philips diffractometer, using copper radiation with nikel filter (CuKa), working with power of 40 KV and 20 mA. Before testing a U.S. No 40 sieve was used to remove the non-clay minerals, the hydrometer method (B.S. 1377) was also used to isolate the silt and clay fraction. The oxygen peroxide method (BS 1377) was used to purify each sample from organic content. In some clay samples was noticed that the three main clay minerals, montmorillonite, Kaolinite, chlorite, were giving not clear peaks. In that case, Wilson's 1987 suggestions was used and the samples were special treated with glycerin and heated up to 120° C, in order to distinguish the montmorillonitic peak.

The mineralogical composition in 57 clay samples (Map. 1), including one sample of each area and one sample of pure industrial bentonite, was determined by x ray diffraction analyses (Table 3), by the method described by Brindley and Brown (1980), and the quantitative analyses was obtained by the method described by Bayliss (1986).

Finally from the quantitative x ray analysis was revealed that:

- Quartz participated in 57 clay samples
- Calcite was revealed in 54 samples
- Plagioclase were present in 29 samples
- Feldspar was identified in 31 samples
- Dolomite was also present in 13 sample
- Montmorillonite participated in 57 samples with high percentages
- Illite was identified in 57 samples
- Kaolinite participated in 39 samples but in small percentages
- Halloysite was also present in 6 samples in well crystallized shape

Quartz percentage varies from 10% to 38%, Calcite percent was between 10% and 33%, Plagioclase only in 15 x-ray samples with percent from 5% and 9%, Feldspar in 20 x-ray samples having from 5% to 15% percent, Dolomite only in 6 x-ray samples with one percent between 3% and 6%.The less of 100 percent, is due to organic matter, which was burned during heating.

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Picture 1: SEM photo from area 26. Quartz crystal having suffered a shear stress, surrounded by flakes of montmorillonite. Magnification x 2000.

Table 3: Results of x-ray analysis.

Area	Mont Moril lonite	Illite	Clorite	Kaoli-nite
Area.1	40	06	04	03
Area.2	45	05	10	--
Area.3	12	11	20	05
Area.4	31	10	08	--
Area.5	24	18	04	04
Area.6	40	--	--	--
Area.7	17	28	02	--
Area.8	40	20	04	06
Area.9	20	--	--	--
Area.10	33	08	06	13
Area.11	10	08	08	04
Area.12	19	12	08	04
Area.13	40	04	12	04
Area.14	25	05	05	--
Area.15	21	17	08	06
Area.16	25	05	10	--
Area.17	31	07	--	06
Area.18	11	06	04	04
Area.19	20	05	05	--
Area.20	23	12	04	--
Area.21	13	08	06	--
Area.22	14	13	12	10
Area.23	14	17	--	--
Area.24	25	05	05	--
Area.25	19	12	07	10
Area.26	33	07	07	07
Area.27	28	21	06	06
Area.28	23	28	06	06
Area.29	53	08	04	04
Area.30	15	06	05	05
Area.31	50	09	07	07
Area.32	28	27	05	05
Area.33	34	05	04	04
Area.34	21	12	---	---
Area.35	26	07	04	04
Area.36	25	10	---	---
Area.37	26	10	05	05
Area.38	10	08	07	07
	40	12	---	---
Industrial Bentonite	72	08	05	---

V. Linear Shrinkage Determination

The determination of bar-linear shrinkage was made according to BS1377, in 15x15x140 mm semi spherical moulds, using 406 remoulded clay soil samples from liquid limit test. As it was determined, the samples revealed linear shrinkage larger than 8. The statistics elaboration revealed minimum value 5.9, maximum 31.1, the average value was 15.28 and standard deviation S=3.348. According to Altmeyer's (1956) list, were classified as having critical swelling potential. Several soil samples gave values higher than 20 (Table 4). Also from the correlation graphbetween bar-linear shrinkage and free swelling index it was concluded that there is one good relation having the type of exponential curve oftype $Y=ax^{\beta}$ and coefficient $R^2=0.8008$.

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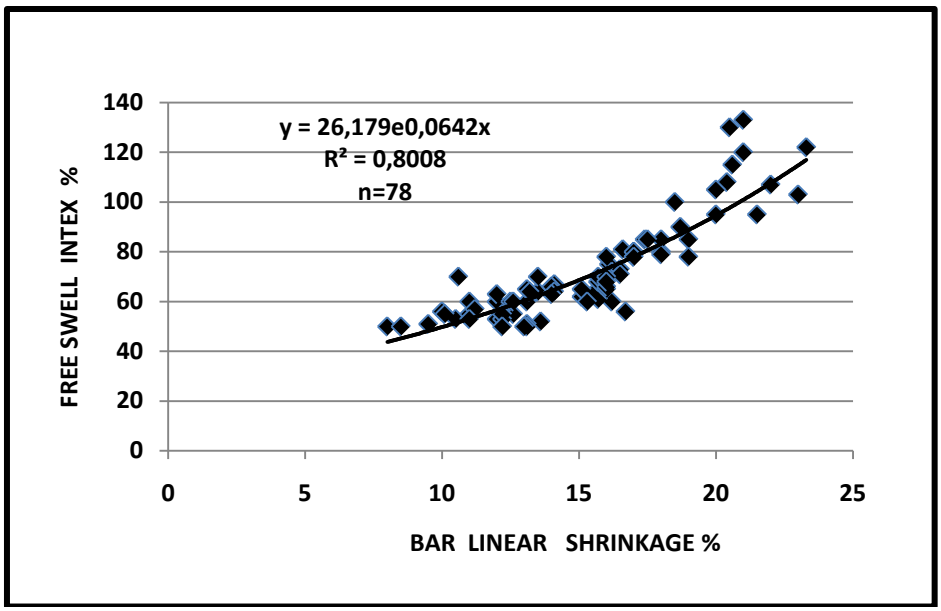

Figure 3: Correlation between free swell index and linear shrinkage%

VI. Determination of the Shrinkage Limit

The shrinkage limit has been used in soil classification as considered in relation to the natural moisture content of soil in the field, indicated whether or not further shrinkage will occur if the soil is allowed to dry out. The method, which has been used for finding the shrinkage limit of the Greek soil samples, was that suggested by TRRL (1974) mercury device test method and involved the measurement of the total volume of each specimen as it was dried out. For correlation purposes three special samples of pure industrial bentonite were prepared and the shrinkage limit was determined in the same manner as the soil samples. The obtained values were 6.8, 6.5 and 7.4 per cent. A total number of 280 disturbed soil samples were tested as was mentioned above and the results are reported on Table 4 with the number of the tested samples per area. In some areas the shrinkage limit results of five samples were similar to those obtained for bentonite. The statistical elaboration revealed minimum value 5.5, maximum value 17, average value 11.4 and standard deviation S=2.37.

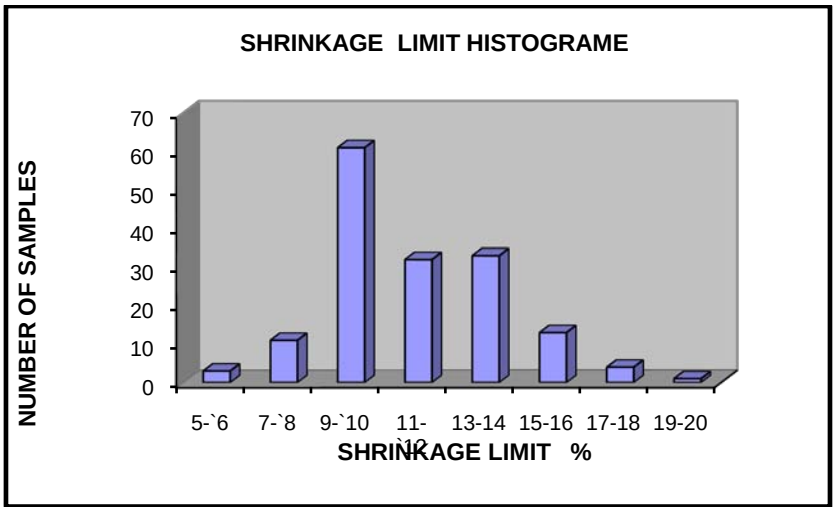

Figure 4: Total shrinkage limits histogram.

VII. Free Swell Determination

Free swell tests were performed according to the Holtz and Gibbs (1956) test method. For this, 373 disturbed soil samples were tested by slowly pouring 10 cm^3 of dry soil passing the U.S. sieve No 40 into a 100 cc^3 graduated cylinder filled with distilled water, and it was found that free swell values vary between 50% and 142%, with mean value 98%, standard deviation 19.52, minimum value 50 and max value 142. (Table 4)

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Table 4: Summary of laboratory results for free swell index %, bar linear shrinkage %, shrinkage limit.%

Sampling area	n	Free Swell%	n	Linear. Shrinkage%	n	Shrinkage. Limit%.
Area.1	14	52 - 90	23	9.6 -27.0	9	6.7 - 20.0
Area.2	20	50 - 106	20	9.6- 23.0	7	9.5- 13.4
Area.3	9	50 - 78	14	8.6- 18.0-	7	8.0- 17.0
Area.4	9	85 - 130	28	10.7 - 21.8	4	9.0 - 10.5
Area.5	10	54 - 67	10	13.2- 18.2	5	9.4 - 14.1
Area.6	6	50 - 72	5	11.4- 17.7	3	11.2 - 12.5
Area.7	4	51 - 72	6	10.3- 19.5	3	10.5 - 11.5
Area.8	10	70 - 115	10	16.9- 17.9	6	8.5- 11.5
Area.9	3	63 - 85	3	15.0 - 19.0	3	10.4 - 12.0
Area.10	9	50 - 133	9	15.5 - 29.8	3	9.5 - 10.0
Area.11	5	55 - 66	5	11.4- 17.7	5	8.5 - 12.5
Area.12	12	51 - 73	12	13.6 - 19.0	12	9.0- 11.6
Area.13	21	70 - 130	18	11.6 - 31.1	6	7.0 - 12.0
Area.14	9	50 - 75	9	10.0 - 21.0	8	9.0- 12.5
Area.15	9	52 - 88	24	8.0- 21.0	8	5.5- 12.9
Area.16	26	50 - 87	4	10.3 - 19.5	3	10.0- 14.0
Area.17	7	55 - 70	7	11.4 - 18.4	7	8.5- 14.0
Area.18	6	55 - 80	6	11.0 - 17.1	6	9.5 - 13.5
Area.19	6	56 - 83	7	12.1- 18.4	6	9.0- 13.0
Area.20	13	50 - 76	11	7.3 - 13.2	4	9.1- 13.0
Area.21	4	53 - 66	4	10.3 - 13.9	2	10.5 - 13.0
Area.22	4	50 - 68	6	10.3 - 14.2	3	10.0 - 11.5
Area.23	8	55 - 75	11	11.7- 22.2	7	8.5 - 15.0
Area.24	7	50 - 65	10	9.8 - 11.7	7	9.5 - 12.5
Area.25	16	50 - 93	25	10.7- 18.7	30	7.0 - 14.0
Area.26	11	60 - 140	5	15.3 - 21.7	8	10.0 - 15.0
Area.27	5	50 - 65	6	10.7- 17.7	5	9.0- 13.0
Area.28	11	54 - 85	15	12.5 - 21.5	14	10.3 - 15.0
Area.29	9	65 - 130	10	16.0 - 23.6	7	9.0 - 13.5
Area.30	22	51 - 110	22	5.9 - 19.3	10	8.0 - 15.2
Area.31	4	58 - 70	10	7.0 - 12.9	18	7.0 - 14.6
Area.32	11	50 - 87	7	8.9 - 14.0	10	9.0 - 11.6
Area.33	12	50 - 142	10	11.4 - 20.0	20	8.0- 14.0
Area.34	5	50 - 65	4	10.0 - 12.5	5	13.2- 17.6
Area.35	9	50 - 72	5	9.6 - 15.6	4	10.0 - 15.6
Area.36	4	87 - 108	4	18.7 - 24.0	5	8.5 - 11.9
Area.37	14	52 - 81	13	10.0- 26.2	4	9.0 - 12.0
Area.38	8	52 - 65	8	15.7 - 23.2	5	11.0 - 13.0

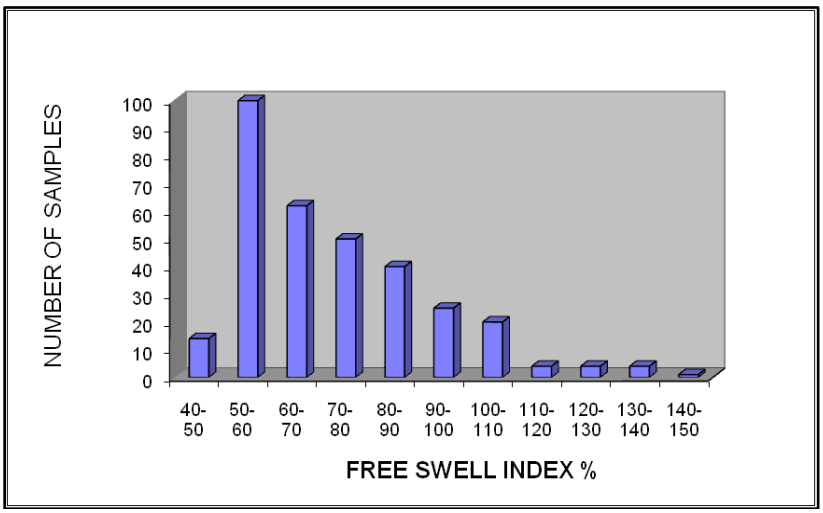

Figure 5: Histogram of free swell index for total sample

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VIII. Plasticity Chart and Activity

The heave to be expected under any light structure may be estimated using the plasticity or activity chart, based on the results of Atterberg limits and particle size determination Van der Merve,{33} The simple classification chart using the relationship of plasticity index of the whole sample (weighting plasticity) and the percentage clay fraction, has been used in order to classify the Greek swelling soil into the four categories of potential expansiveness, (Figure 6).From the plotting of 285 soil samples on activity chart, was apparent that Merve"s chart applied for the Greek swelling soils and from the statics was reported that 54% of samples are enlisted invery high activity area. 42% of samples are classified in high activity area. Finally only the rest 14% percent is enlisted to medium activity area.

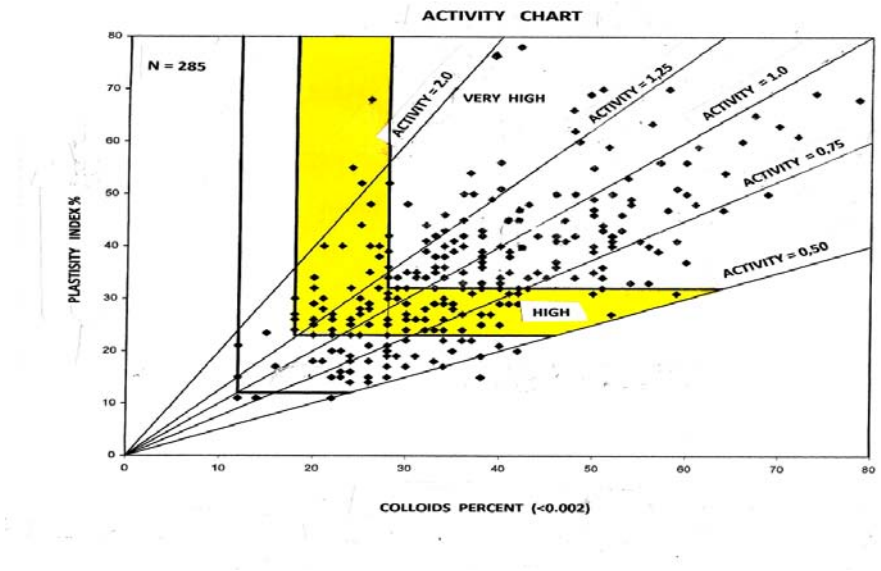

Figure 6. Activity chart for the Greek swelling soils after Van der Merve, (1984)

a) Consistency index (Ic)

The term consistency index generally refers to the firmness of one cohesive clay that varies from soft to hard, so the determination of consistency index for cohesive clay soils is important for engineering applications due to the strength of clay soil. Since water has a significant effect on it, if the clay has high moisture content, is soft. If the moisture is low, the same clay has high strength.

Since the consistency index depends on the moisture content of the soil and the swelling pressure increases proportional to the reduction of the initial moisture content, became apparent to examine if there is any relation between swelling pressure and consistency index. The consistency index value was calculated according the soil mechanics text books, taking in account from the same soil sample, the liquid limit, the plasticity index and the natural moisture content of the undisturbed soil sample. The graph was plotted having the swelling pressure and the equivalent Ic for each specific pressure. From figure 7 it is apparent that there is a strong relation having the type $Y = ax^{\beta}$of exponential curve and correlation factor R^2 equal to 0.8239 for sampling areas 8, 23 and 34. From this graph we can conclude that the drier the soil sample, which means high consistency index, it is able to absorb more water so, if the mineralogy permits it, will give higher swelling pressure. This property depends on the chemical composition, the physicochemical characteristics and the individual moisture conditions of each area.

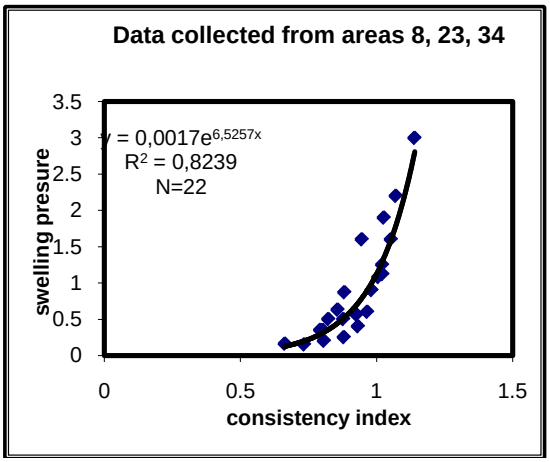

Figure 7: Correlation plot between swell pressure and consistency index.

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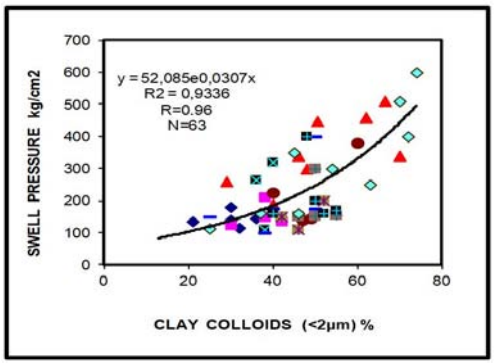

Figure 8: Good correlation of type Y=ax+b and R2=0,9336 between swell pressure and colloids.

b) Swelling Characteristics

The swelling characteristics of Greek clays were studied in the laboratory of Central Public Works, (KEDE), quantitatively by carrying out swell consolidation tests of ASTM type (D-4546-1993) and also free swell tests in consolidometer.

Swell consolidation test in oedometer were conducted on 224 specimens prepared of equal undisturbed samples collected with Shelby. The majority of samples were tested havingthe initial density and water content as expected in the field. For these, undisturbed soil samples, half inch thick, were placed in the consolidometer ring of the fixed-ring type and the size of container ring was 3.5in. diameter by 3/4in. deep. The initial dial reading was recorded after applying a seating load of 6.25 kPa. The load was increased gradually as required to hold the sample at the original height, up to the maximum load, which represents the maximum swelling pressure. The successive loads were maintained for 48 h to obtain constant values of height. In order to identify the influence of moisture content changes on swelling pressure, samples from the same undisturbed sample (Shelby), were prepared but tested, in the initial moisture content, and after being desiccated for a few days using one silica gel laboratory desiccators. (Figure 9).

Additionally, from random shelby 50 extra soil specimens were collected and the values of vertical swell pressure were measured under a seating load of 7 kPa

- Mean value = 5.1
- Standard deviation = 3.68.
- One percentage 17% of samples revealed swelling = 2.5%
- Second percent 12% of samples appeared swelling = 1.5%.
- Also 10% of samples presented swelling between 5.5% and 8% ..(freeswelloedometertestinFigure 10).

For some sampling areas there are exceptional swelling percentages.

Sampling area 29= swell 11%
Sampling area 15= swell 10,5%
Sampling area 4= swell 13%
Sampling area 2= swell 13.4%

The histogram which was plotted from the obtained values of the 224 soil samples, revealed a mean value of 1.55 kg/cm2 with a standard deviation of S=1.63. Of these values, a percentage 29% of the samples revealed swelling pressure of 0.5kg/cm2. Another percentage of 22% fluctuates to a swell pressure of 1kg/cm2. A third percentage of 13% reached pressure values of 1.5 kg/cm2. A smaller percentage of 7% revealed pressure of 2kg/cm2. 10% of the undisturbed soil samples gave high values of swelling pressure between 2.5kg/cm2 and 4kg/cm2. Higher swell pressure values were also obtained, a small proportion (2.6%) was found having swell pressure between 5kg/cm2 and 6.5kg/cm2. Of course, in some districts the swell pressure (after 72 h desiccation) was exceptionally high:

Sampling area25 (town of Tripolis) a swell pressure 11.0 to 12.5kg/cm^2
Sampling area11… (town of Shimatari) a swelling pressure 6kg/cm^2
Sampling area 6… (town of Thiba) a swelling pressure 6kg/cm^2

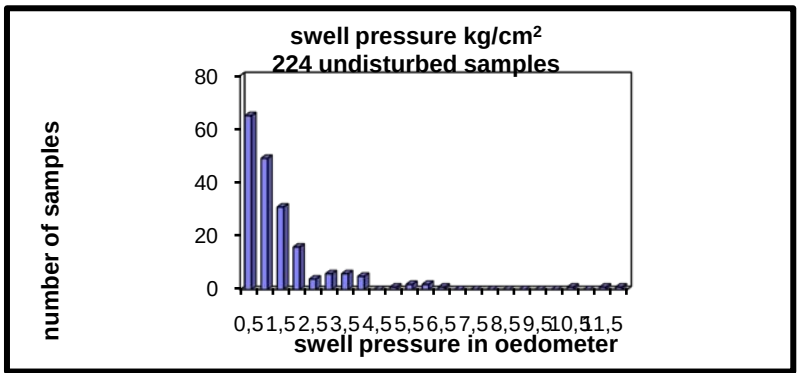

Figure 9: Swelling pressure test in oedometer conducted on 224 specimens prepared of equal undisturbed samples collected with Shelby

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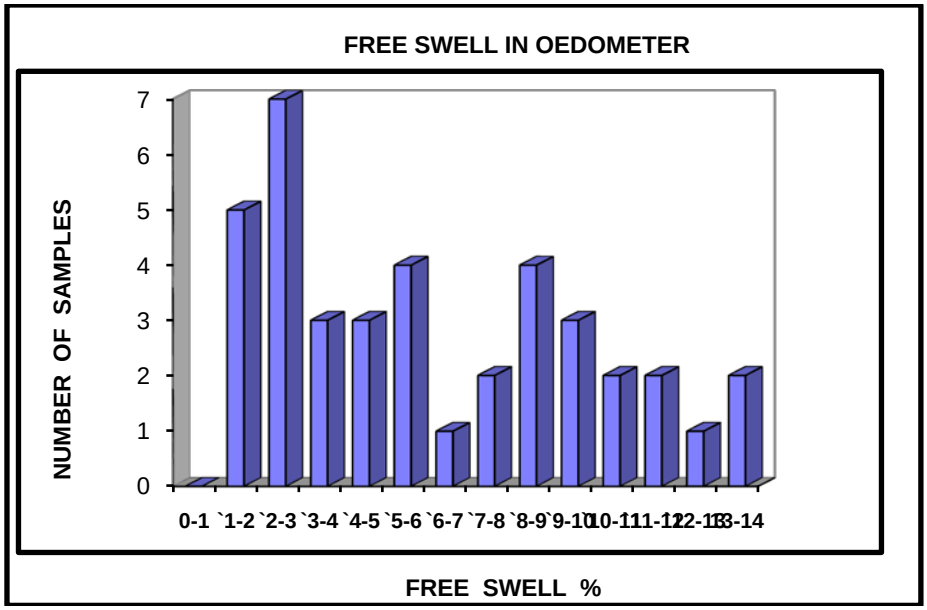

Figure 10: Histogram of free swell test in oedometer

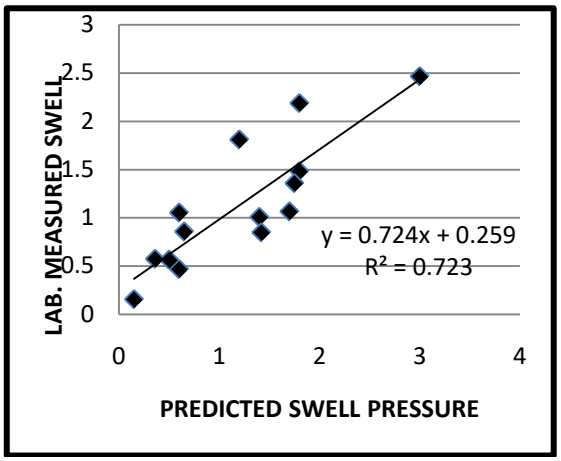

Figure 11: Good correlation of type Y=ax+b and R2=0,7239 between laboratory and predicted swell pressure.

c) *Swelling pressure and shrinkage limit*

Chen [11] reported that there was no conclusive evidence of correlation between swelling potential and shrinkage limit, also Sridhar an [6] said that shrinkage limit is not satisfactory used to predict swell potential. Since there is no empirical expression utilizing shrinkage limit and swelling pressure to predict swelling potential, an effort was made to correlate swelling pressure (SP) and shrinkage limit results from the tested locations, but the coefficient of correlation was not acceptable. After a second attempt, the correlation between swelling pressure, liquid limit(LL), moisture content (mc), shrinkage limit (sl), indicated that if we compare the quotient of liquid limit minus moisture content divided by liquid limit minus shrinkage limit (MC-SL / LL-SL) and plot it with the swelling pressure, from soil samples from the same Shelby, we have one strong coefficient of correlation. In Figures 12, 13 and 14 from three different sampling areas, we obtain coefficient of correlation R^2=0.9147 for sampling area 8, R^2=0.879 for sampling area 29, R^2=0.8083 for sampling area 15. We have named this fraction, *shrinkage limit ratio (ls)* and as we can see from the three following graphs between swelling pressure and shrinkage limit ratio there is a strong exponential relation.

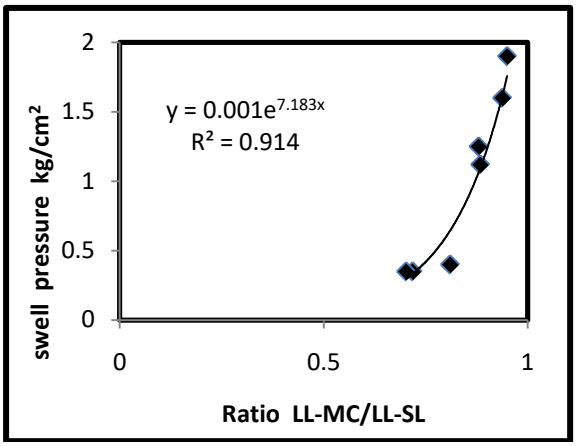

Figure 12: Shrinkage Limit Ratio for sampling area 8

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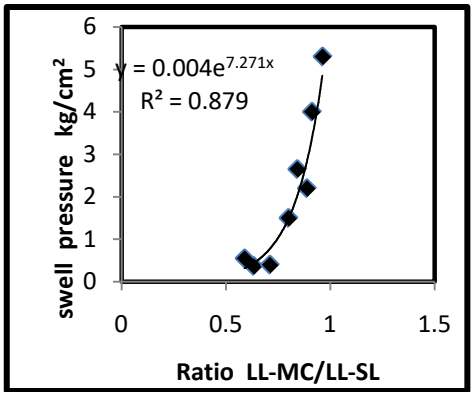

Figure 13: Shrinkage Limit Ratio for sampling area 29

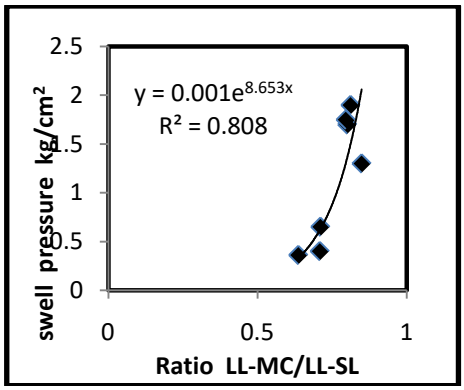

Figure 14: Shrinkage Limit Ratio for sampling area 15

d) Swelling pressure and shrinkage limit ratio (Is)

After obtaining a lot of swelling pressure results from the consolidation test and also having one large number of regression analyses equations, with high regression coefficient for the swell parameters, the first thought was to obtain a plot relating swelling pressure with the brand new shrinkage limit ratio. The idea was strengthened after reading Rao and Rao {24} paper about classification of expansive soils. The plot was obtained from the values of swelling pressure and the values of shrinkage limit ratio (Is). In order to avoid plotting difficulties because soil samples were from different areas (figures 12, 13, 14), the laboratory obtained values were plotted as groups of soil samples having similar liquid limit. For these three groups of soil were calculated, one group having LL=40-50%, another group of values having LL=50-60% and one third group having LL=60-70%. From figure 15 we can see there is one exponential relation of type $x=ab^x$ with moderate coefficient of correlation and each exponential curve represents a group of sampling points, having similar liquid limit percent. Also we can say that when the shrinkage limit ratio (Is) has small value (0.4, 0.5, 0.6), swelling pressure is low. When the value increased, the swell pressure also is moderate or high, and when the shrinkage limit ratio (Is) value is 0.9 or 1.0, then the swelling pressure is very high. The conclusion is, if we have sufficient measurements, from the shrinkage limit ratio (Is) graph we can extract useful values for swell pressure of the tested area.

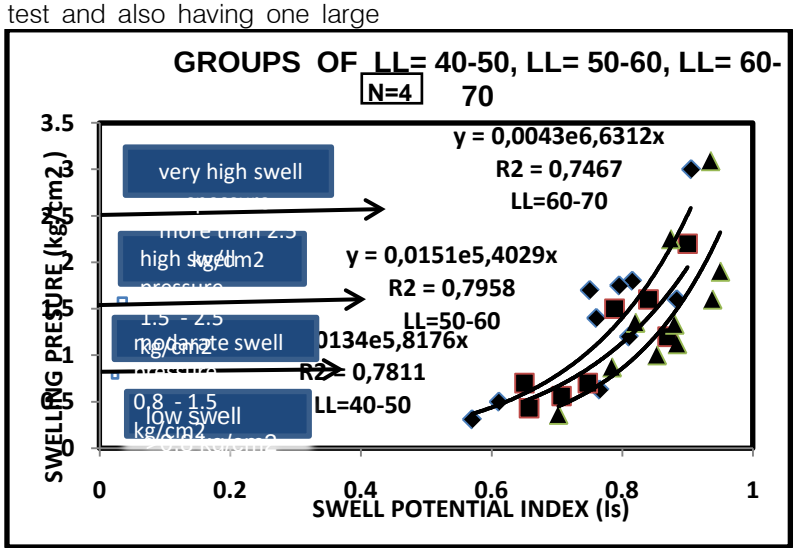

Figure 15: Scatter plot of some tested areas, showing the relationship between swelling pressure and swell potential index. Each exponential curve represents group of sampling points, having similar liquid limit percent.

IX. Multiple Regression Analyses

The general purpose of Multiple Regression is to learn more about the relationship between several independent variables and a dependent variable. From the literature (Holtz and Gibbs 1956 {16}, Van der Merwe 1964, Chen 1976 {10}, it is well known that some physical properties of the soil such as liquid limit, clay content, free swell, can predict the swell potential of a clay soil. Regression analysis is widely used for prediction and is also used to understand which among the independent variables are related to the dependent

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variable, and to explore the forms of these relationships. Since there is not empirical expression from Greek swelling clay soils to predict swelling potential or swelling pressure and we had a large number of samples and laboratory results, an effort was made with regression analyses to correlate swelling pressure (SP), liquid limit (LL), plasticity index (PI), clay content (2μm), free swell in suspension (FS), bar linear shrinkage (LS), water content (MC), (Table 5).The results shows that there is a good linear relation of the type y = ax+b.

Multiple linear regression analyses were carried out for every one sampling area, to relate the measured natural and engineering properties, using the statistical computer software program for Excel. For this purpose, an investigation was made into the possible relationship between swelling pressure and the various swell governing factors. The value of correlation coefficient relating with the investigated properties was used to assess the quality of the particular correlation model, higher values being an indicator of a more appropriate model.

In general then, multiple regression procedures will estimate a linear equation of the form:

$$Y = a + b_1*X_1 + b_2*X_2 + ... + b_p*X_p$$

For each individually investigated Area the multiple regression analysis showed good correlations in all the combinations studied. Table 5shows the resulting equations and all values measured in this study, from undisturbed soil samples, which were collected from eight different Areas for the statistical analysis.

Table 5: Summary of multiple regression analysis for different sampling areas

Sumpling Area	Equations	Parameters	Coefficient R^2
Area 1	SP = -0.6024 w + 1.1341 Ic	SP, M.C., Ic	0.90
	LL = -4.482 + 1.3225 PI – 0.1268 FS + 3.0279 LS – 0.735 2μm	LL, PI, FS, LS, 2μm	0.97
	FS = -35.85 – 1.68 LL+ 2.67 PI + 11.51 LS – 2.167 2μm	FS, LL, PI, LS, 2μm	0.94
	SP = -0.14 – 0.09 LL + O.16 PI + 0.02 FS + 0.14 LS – 0.11 2μm	SP, LL, PI, FS, LS, 2μm	0.92
Area 7	SP = 4.7397 – 0.2186 w + 4.1179 Ic		
	LL = 2.869 + 0.7291 PI+ 0.2847FS + 0.8077LS – 0.268 2μm	SP, M.C., Ic	0.95
	FS = 14.142 + 2.45 LL – 2.34 PI – 0.008 LS + 0.185 2μm	LL, PI, FS, LS, 2μm	0.91
	SP = 0.94 – 0.22 LL – 0.15 PI – 0.04 FS + 0.56 LS + 0.39 2μm	FS, LL, PI, LS, 2μm	0.96
		SP, LL, PI, FS, LS, 2μm	0.92
Area 30	SP = 0.2754 – 0.0577 w + 1.7367 Ic		
	LL = -44.67 – 0.5375 PI + 0.6815 FS + 4.6416 LS + 0.409 2μm	SP, M.C., Ic	0.90
	FS = 58.54 + 1.08 LL + 1.00 PI – 5.38 LS – 0.542 2μm	PI, FS, LS, 2μm	0.92
	SP = 9.10 + 0.17 LL +0.18 PI –0.09 FS –1.17 LS –0.08 2μm	FS, LL, PI, LS, 2μm	0.95
		SP, LL, PI, FS, LS, 2μm	0.87
Area 12	SP = 3.8121 _ 0.1062 w + 0.0066 Ic		
	LL = 117.308 + 2.7893 PI + 0.7222 FS –5.3889 LS –2.594 2μm	SP, M.C., Ic	0.96
	FS = -198.33 + 0.465 LL – 3.081 PI + 11.597 LS + 4.058 2μm	PI, FS, LS, 2μm	O.92
	SP = -31.47 + 0.05 LL – 0.54 PI + 1.20 LS – 0.04 FS + 0.82 2μm	FS, LL, PI, LS, 2μm	0.93
		SP, LL, PI, FS, LS, 2μm	0.91
Area 25	SP = -0.9740 + 0.0059 w + 1.3953 Ic		
	LL = 16.105 + 1.2059 PI – 0.2788 FS + 1.2902 LS – 0.029 2μm	SP, M.C., Ic	0.92
	FS = 14.191 + 0.224 LL – 0.016 PI + 0.799 LS + 0.715 2μm	PI, FS, LS, 2μm	0.96
	SP = -0.33 + 0.07 LL + 0.04 PI – 0.25 FS + 0.79 LS + 0.029 2μm	FS, LL, PI, LS, 2μm	0.96
		SP, LL, PI, FS, LS, 2μm	0.82
Area 28	SP = -0.5667 – 0.0097 w + 1.7352 Ic		
	LL = 40.49 + 0.4795 PI + 0.3665 FS – 0.7701 LS – 0.317 2μm	SP, M.C., Ic	0.94
	FS = -3.47 – 0.146 LL – 0.460 PI + 3.11 LS + 1.35 2μm	PI, FS, LS, 2μm	0.97
	SP = 0.14 – 0.01 LL + 0.03 PI + 0.01 FS – 0.17 LS + 0.04 2μm	FS, LL, PI, LS, 2μm	0.92
		SP, LL, PI, FS, LS, 2μm	0.86
Area 29	SP = 0.1492 – 0.0284 w + 1.3943 Ic		
	LL = -117.497 + 0.1516 + 0.3236 FS + 7.6588 LS + 0.663 2μm	SP, M.C., Ic	0.95
	FS = -16.426 + 2.731 LL – 0.953 PI + 3.598 LS – 1.736 2μm	PI, FS, LS, 2μm	0.98
	SP = -30.88 – 0.15 LL – 0.09 PI – 0.01 FS + 2.23 LS + 0.27 2μm	FS, LL, PI, LS, 2μm	0.94
		SP, LL, PI, FS, LS, 2μm	0.94
Area 15	SP = -1.0166 + 0.0003 w + 2.2391 Ic		
	LL = 3.9328 + 0.9234 PI + 0.2035 FS + 0.1213 LS –0.070 2μm	SP, M.C., Ic	0.94
	FS = 28.06 + 0.341 LL – 0.544 PI + 0.128 LS + 0.769 2μm	PI, FS, LS, 2μm	0.95
	SP = -3.19 – 0.04 LL + 0.01 PI + 0.02 FS + 0.27 LS – 0.04 2μm	FS, LL, PI, LS, 2μm	0.99
		SP, LL, PI, FS, LS, 2μm	0.92

SP = Swelling pressure
LL = Liquid limit
MC = Moisture content
FS = Free swell

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LS = Bar linear shrinkage
2μm = colloid content
N = Number of equation
R^2 = Coefficient of correlation

Multivariate statistical method was used to identify key model index properties by detecting interactions between variables. For this correlation between free swell, swell pressure and potential indices measured were analysed using Pearson's correlation test chart (Table 6).

The Pearson's correlation varies from +1 through zero to –1, where +1 indicates perfect linear relation. The dependant variable was swell pressure and the independent variables were all the measured soil properties. From the results the swell pressure behaviour of the soil depends on a multitude of variables.

Table 6: Pearson's correlation chart, Area 28

	SP	LL	PI	MC	FS	LS	2μm
SP	1						
LL	0,499	1					
PI	0,732529	0,923733	1				
MC	-0,95932	-0,41148	-0,68126	1			
FS	0,968208	0,515936	0,712314	-0,89149	1		
LS	0,925799	0,449577	0,662551	-0,90055	0,875296	1	
2μm	0,929392	0,588749	0,77714	-0,88073	0,857321	0,8	1

Table 7: Pearson's correlation chart. Area 4.

	SP	PI	MC	FS	LS	2μm
SP	1					
PI	0,84211	1				
W	-0,8343	-0,9706	1			
FS	0,70431	0,90879	-0,8579	1		
LS	0,87388	0,96687	-0,8911	0,86424	1	
2μm	0,66603	0,88698	-0,8277	0,81828	0,89256	1

From all tested sampling areas with Multivariate statistical method it was concluded:

- There is a strong correlation between swell pressure and natural moisture content. This relation has the type $Y = ax^b$ with correlation coefficient R^2 =0.80 to R^2 = 0.98, which indicates a perfect linear relation in the 100 percent of tested samples.
- Also there is a strong correlation between free swell and bar linear shrinkage results having the type of $Y = ax^b$ where b>0 and correlation coefficient R^2 =0.80 to R^2= 0.96, which indicates a perfect linear relation for the 60% of soil samples. For the rest 40 percent of the results there is one moderate relation having R^2 =0.791 to R^2= 0.522. ,
- The correlation between liquid limit and free swell index revealed a good linear relation, having the type Y = ax-b and for the 64%of samples one correlation coefficient between R^2 =0.80 and R^2 = 0.96 . For the rest 34% of samples the coefficient varies between R^2 =0.780 and R^2 = 0.635 (moderate).
- The correlation between plasticity index and colloids percent revealed a that there is a strong relation of type Y = ax-b, For the 32% of samples the correlation coefficient varies from R^2 =0.922 to R^2 = 0.888. The rest 68% of tested soil have one correlation coefficient between R^2 = 798 and R^2= 0.687, (moderate).
- The correlation between liquid limit and bar linear shrinkage revealed one linear relation having the type Y = ax-b, but with respect to correlation coefficient is a moderate one, because only 50% of samples has R^2 =0.80 and R^2 = 0.96. The rest 50% has one not acceptable coefficient R.
- The plasticity index vs bar linear shrinkage graph indicates that in all the samples the coefficient of correlation is strong, r=0.815. Also bar linear shrinkage values start from 8% and goes on up to 23.3%.
- In the bar linear shrinkage – clay content graph there is a tendency for linear relation, but since the points were scattered, it is better to consider the envelope of the points.

X. Summary

1. Expansive soils cause billions of dollars of damage to homes and property each year. If the propensity of a soil to shrink and swell is known before construction, shrinkage limit results can give

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information to design engineers, because if it is known the ability of soil to shrink or swell before construction, damage can be avoided.

2. The statistical analysis of the relationships between swelling pressure and index properties of the soils such as moisture content, linear shrinkage, free swell, clay content, liquid limit and plasticity index, showed that is satisfactory, with a high linear correlation coefficient to exist between them. Multiple regression analysis can be used to predict volumetric changes in a swelling soil.

From Pearson's correlation chart we can conclude.

3. There is very strong correlation between swell pressure and natural moisture.
4. There is very strong correlation between free swell index and bar linear shrinkage
5. A moderate correlation exists between liquid limit and free swell index. A moderate correlation also exists between plasticity index and colloids percent.
6. A strong correlation exists between plasticity index vs bar linear shrinkage.
7. The correlation between liquid limit and bar linear shrinkage revealed one moderate linear relation.

XI. Implications

The Author feels that the above described research has clearly indicated that index properties of a clay soil, such as liquid limit, plasticity index, natural moisture content, free swell index, shrinkage limit, related with swell pressure, can satisfactory predict that a soil contains expansive clay, even if we don't know the mineralogy of soil, and we highly recommend multi regression analyses for prediction purposes. Also more studies similar to the one presented in this paper will be necessary to strengthen this assessment.

XII. Conclusions

From the above mentioned research, it is difficult for the swelling clay in Greece to detect which type has the stronger swelling potential, because don't exhibit significant differences.

s.a.29 (terra rossa) swelling 11%, swell pressure 5.7 Kg/cm^2,
s.a.15 (alluvial) swelling 10,5%, swell pressure 2.7 Kg/cm^2,
s.a. 4 (terra rossa) swelling 13%, swell pressure 6.0 Kg/cm^2,
s.a.2.(terra rossa) swelling 13%, swell pressure 3.0 Kg/cm^2,
s.a.11 (terra rossa) a swelling pressure 6kg/cm^2
s.a6 (terra rossa) a swelling pressure 6kg/cm^2
Of course, in some districts with terra rossa, the swell pressure (after 72 h desiccation) was exceptionally high: sampling area 25 (town of Tripolis) a swell pressure 11.0 kg/cm^{2}to 12.5 kg/cm^2

All tested clay types have montmorillonite (smectite group) as major clay mineral, accompanied by illite, chlorite, kaolinite. Also mixed layer clay minerals with quartz, feldspar and calcite, are present. Most substantial parameters for the swelling clay to exhibit high swell pressure are the percentages of active minerals, the value of cation exchange capacity and of course the transaction of moisture content, from the dry to wet condition.

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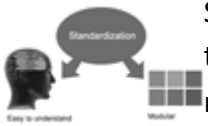

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13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

19. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

20. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

21. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

22. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



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Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



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Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

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Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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