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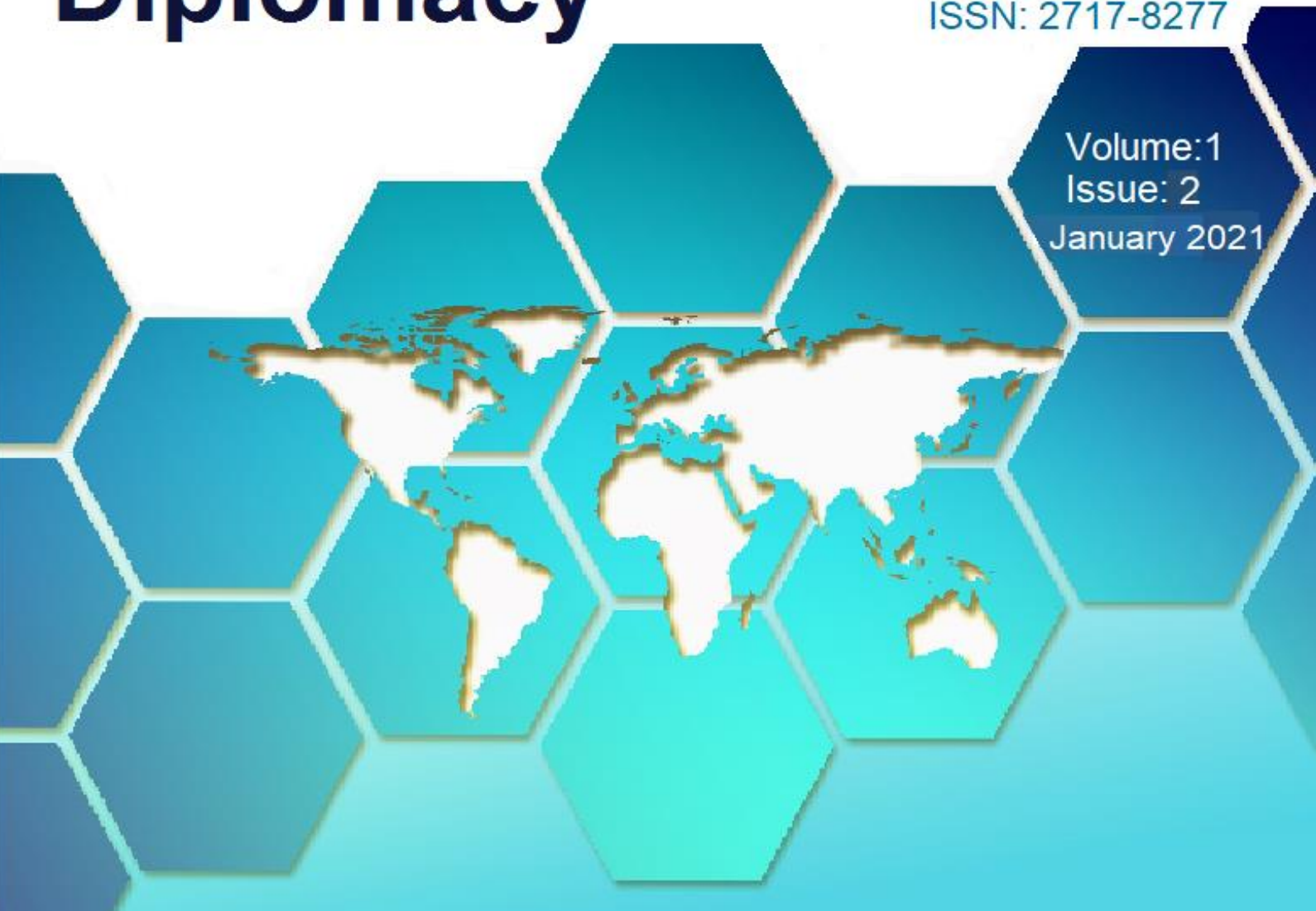

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Contents

THE OCCURRENCE OF FLOODS IN SÃO PAULO, BRAZIL: THE IPIRANGA STREAM BASIN CASE STUDY

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Abstract

The present study refers to the occurrence of cyclical and constant flooding in the Metropolitan Region of São Paulo (RMSP). The RMSP presents every year in the summer, riverside roads and avenues with interrupted or hindered traffic. Properties near the rivers are also affected by the elevation and overflow of the water level on the flood plains. The objective of this work is to apply the multitemporal perspective in Integrated Landscape Analysis method, to fully evaluate the physical and anthropic environment factors, as well as how the changes that occurred over time were responsible for the landscape configuration and reconfigurations. The case study is the Ipiranga Stream Watershed, in the city of São Paulo/SP, which recorded 82 flood events between 1965 and 2017, predominantly in the period between 2010 and 2017 (46 events). The events occur due to the combination of natural characteristics - the elongated shape and low watershed slope, the rise of 24h amount and intensity rainfall, and anthropic characteristics, such as the expansion in soil impermeability rates and structural changes in the main channel and tributaries. The data survey shows the ineffectiveness of structural measures, highlighting that some additional measures need to be implemented to minimize damages.

Keywords: metropolitan floods, urban watersheds, urban flood management,

1. INTRODUCTION

The changes imposed by men in the urban environment trigger or accelerate the geomorphological processes, often de-characterizing the original physical environment. These changes cause environmental damage and consequences, such as the induction of landslides, floods, subsidences, among others. Ultimately, these consequences cause social and economic risks and losses to man himself (Leopold, Wolman ve Miller, 1964, Ward, 1978; Goudie, 1994; Guerra ve Marçal, 2006; Szabó, Dávid ve Lóczy, 2010; Moroz-Caccia Gouveia, 2010).

According to data from the Swiss RE Institute (2018), the total economic losses due to natural disasters in 2017 were in the order of USD 337 billion. Regarding global social data, more than 11,000 people lost their lives or disappeared when these disasters occurred, while millions were left homeless.

Currently, floods are the type of natural disaster that occurs most frequently in the world, with impacts related to human (dead and affected) and financial losses. The occurrence of floods in urban areas has been intensified by the waterproofing of soils, by the occupation of the plains and also by the anthropic changes in watercourses, such as rectifications and plumbing.

In bibliographic reviews there are several concepts for flooding. For this work, it was decided to adopt the overbank flood or simply flood that represents the overflow of the waters of a watercourse, reaching the floodplain or lowland area (Carvalho, Macedo ve Ogura, 2007; Amaral ve Ribeiro, 2009). Flood occurrences, which are defined by the elevation of the water level in the drainage channel, due to the increase in flow, reaching the maximum level of the channel, without overflowing however, are not included in this analysis. Urban flooding, which represents a momentary accumulation of water in certain places due to deficiency in the drainage system and is not related to the dynamics of water courses, will not be considered in the analysis either.

Floods in urban basins have been discussed in several recent studies, which address issues related to land use, occupation and anthropogenic changes, which supplanted the natural morphological characteristics of the original landscape, without observing that the river plains played the role of river floods dampening. Among these studies, Faccini et. al. (2015) and Faccini et. al. (2016) in Italy, Boudou, Danière ve Lang (2016) in France, Cœur ve Lang (2008) who evaluated historical data from Europe, and Rodrigues (1997, 2005), Moroz-Caccia Gouveia (2010) and Luz (2010) with applied studies in the Metropolitan Region of São Paulo / SP.

In São Paulo, the process of occupation of floodplain areas began in the 1930s, with the rectification of its main river, the Tietê River, for the future implementation of marginal avenues and the use of central areas. Those actions were motivated by sanitation and salubrity, which, based on the hygienist principle, aimed to capture and conduct surface runoff quickly through channeling and rectification of natural channels. Soon after, the rectification of another important river, the Pinheiros River, took place to conduct the water to the Henry Borden Power Plant in order to generate electricity. As a consequence, the rectifications freed up the floodplain areas and grounded meanders for real estate projects. Later, with the Avenues Plan, in the 1950s, this model was adopted in other areas. In the 1970s, floodplains and valley bottoms were institutionalized as axes for the expansion of urbanization by the government at the time. Thus, the occupation of the floodplain areas of water courses was not only the result of disorderly occupation, but also of an action of political incentives for real estate projects and for the installation of important road systems (Seabra, 1987; Rolnik, 1999; Custódio, 2002; Travassos, 2004; DAEE, 2012; Kanashiro, 2013; Anelli, 2015).

This article presents the case study of the urbanized basin of Ipiranga Stream in São Paulo / SP, which since the 1930s has had recurrent floods, which affect the local population since the occupation of the floodplain areas in the 1960s. With the application of the Integrated Landscape Analysis under a multitemporal perspective, it was sought to determine the behavior of the factors of natural and anthropic environment that contributed to the imbalance of the dynamic relationship between society and nature and that influenced the increase in the occurrence of floods in the area in the last decades.

The Integrated Landscape Analysis is based on the conceptions of Geosystems, developed by Bertrand (1971), Sotchava (1978) and Monteiro (2000), in the studies of Ecosystem and Ecodynamics, by Tricart (1977), and Environmental Fragility, developed by Ross (1994). To analyze the dynamics of the system, as recommended by Cooke ve Doornkamp (1990), the data were evaluated from a long-term perspective. Therefore, in addition to the integration of information from the physical and anthropic environments, it is important to add the multitemporal analysis, which starts from an initial state, that is, from the earliest information on a given area, and, over the period evaluated, seeks to

identify which alterations occurred in the factors of the physical and anthropic media caused changes in the dynamics of the landscape. In urban areas, physical factors must be correlated with the evolution of land use. Based on studies of past events, one can observe the evolution of the frequency and magnitude of the phenomena to propose effective damage mitigation measures.

For the analysis, the variables that contemplated the natural aspects of the basin were selected, such as morphology and rainfall and anthropic interventions, such as soil waterproofing and changes in drainage channels. The results show that the floods are conditioned by the natural characteristics of the basin, as its shape and low slope favor the accumulation of water and slow runoff, in addition to the increase of annual rainfall totals. As anthropic characteristics, we highlight the expansion of soil impermeability and the interventions carried out on the main channel and tributaries of the stream, which intensified the incidence of flood events in the basin.

2. MATERIALS AND METHODS

The proposed methodology seeks to analyze the landscape components from a multitemporal perspective. Data on natural components (landforms, drainage and precipitation characteristics) and anthropic components (history of floods recorded in the basin, soil impermeability and land use rates, changes in water courses) were used for analysis, from a comparative perspective over a few decades.

The landforms and the characteristics of the drainage network were analyzed based on the elaboration of slope, hypsometric and geomorphological maps, in a scale 1: 50.000, for the assessment of the natural susceptibility of the basin to floods. The cartographic base, hydrographic data, the delimitation of the basin and the level curves with equidistance of 5 meters were obtained from the official base of the Municipality of São Paulo (PMSP-Digital Map of the City of São Paulo, 2017) and from planialtimetric sheets of the Metropolitan Cartographic System, prepared by EMPLASA (1980/1981). To analyze the morphology of the basin, the classification proposed by Strahler (1957) and the parameters defined by Horton (1945) were initially applied for quantitative analysis of watersheds and drainage channels. The morphometric parameters of the drainage basins are strongly correlated to their hydrological characteristics and, therefore, were evaluated to estimate their influence on floods, as proposed by Zăvoianu (1985) and Kochel (1988). In addition to the morphological parameters, the characteristics of the valleys and the transversal profiles were associated as instruments of analysis, based on the elaboration of a geomorphological and hypsometric map (Ross, 1992).

Precipitation information was obtained from IAG-USP Meteorological Station E3-035, located upstream of the basin, for the period between 1933 and 2016, and Climatological Bulletin (IAG-USP, 2016), in order to verify possible changes in the climatic behavior that could cause greater volumes of rain in the basin. Studies previously carried out in the study area and at a regional level were surveyed to parameterize the analysis.

To assess the history of flooding in the basin, information from Santos ve Amaral (2017) was collected, who consulted the following media and official source/period: data from the digital newspaper Ipiranga News were accessed for the period between 2009 and 2016; the digital collection of the Folha de São Paulo newspaper allowed access to editions from the period between 1960 and 2016; the digital collection of the Estado de São Paulo newspaper allowed access to editions from 1875 to 2017; the Emergency Management Center (CGE / PMSP) file covered the period from 2000 to 2017. In addition to the survey carried out by Santos ve Amaral (2017), data from the São Paulo State Flood Alert System file were evaluated, Department of Water and Electricity, Hydraulic Technology Center Foundation

(SAISP/DAEE/FCTH), which comprised the period from 2007 to 2017. There were analyzed as proposed by IG (2009), Gutjahr *et al.* (2010) and Fernandes da Silva *et al.* (2014), with registration in pre-established forms, in order to allow comparative assessment and standardized data. The flood history aims to verify the points in the basin where the floods occurred, and whether, over time, there was an increase in the number of sites affected and the recurrences in each of these sites.

In order to assess the changes generated by the anthropic impact of population growth and the consequent waterproofing of the surface, it was decided to resort to a multitemporal analysis, based on maps, aerial photographs and satellite images, in order to limit the progress of the built areas and the anthropic and structural changes in the main channel and tributaries over the last century, as proposed in Boudou, Danière ve Lang (2016), Faccini *et al.* (2015), Faccini *et al.* (2016) and Cœur ve Lang (2008). Maps from the SARA BRASIL Project (1930) were consulted, the aerophotogrammetric images from the years 1940 and 1954, obtained from PMSP (Digital Map of the City of São Paulo, 2017), and from 1958 and 1994, which, as well as the images of the years 2010 and 2017, were obtained from the collection of the Geological Institute (IG) (digital material).

3.RESULTS AND DISCUSSIONS

The proposed methodology was applied to the Ipiranga Stream Basin, located between the neighborhoods of Água Funda and Ipiranga, south of the city of São Paulo/SP, which annually presents flood events that restrict the circulation in roads and cause damage in homes and businesses. The stream is one of the main tributaries of the Tamanduateí River, part of the Alto Tietê Water Resources Management Unit, which covers the municipalities of São Paulo Metropolitan Region (Figure 1).

According to DAEE (2011), the floodplain area of the Alto Tietê Basin, according to projections, may have been reduced from 140 km² to 70 km², reducing the water retention time from 48 to 12 hours due to its occupation and consequent waterproofing.

The Alto Tietê Macrodrainage Master Plan (FABHAT, 2016) assessed the situation of the existing structures in the RMSP for dampening rainwater. There are currently 36 reservoirs that total a reserve volume of more than 5 million m³. The construction of another 104 new reservoirs in the basins composing the Alto Tietê is also planned. The total volume to be stored in the new 55 holding reservoirs planned for the entire Tamanduateí River basin is around 9 million m³, of which 9 of these are designed for the Lower Tamanduateí River Basin, of which the Ipiranga Stream is an affluent (DAEE, 2012). This data points out that the problem of urban flooding occurs at a regional level and not just at a local one. According to FABHAT (2016), the contribution of the Tamanduateí River represents about 40% of the maximum flow in the main channel (Tietê River). This same study indicates that only structural measures in the basin are not sufficient to contain new floods, highlighting the importance of non-structural measures, such as the preservation of permeable green areas.

Rodrigues (2015) analyzed studies that compared the storage capacity of the temporary retention reservoirs built in the RMSP in relation to the amount of rainwater that would be stored in the river plains of the same region. In case it was not occupied and waterproofed, the original compartment of the floodplain would store 353 million m³ of water, which is equivalent to the construction of 1,772 reservoirs, with an average volume of about 200 m³ each.

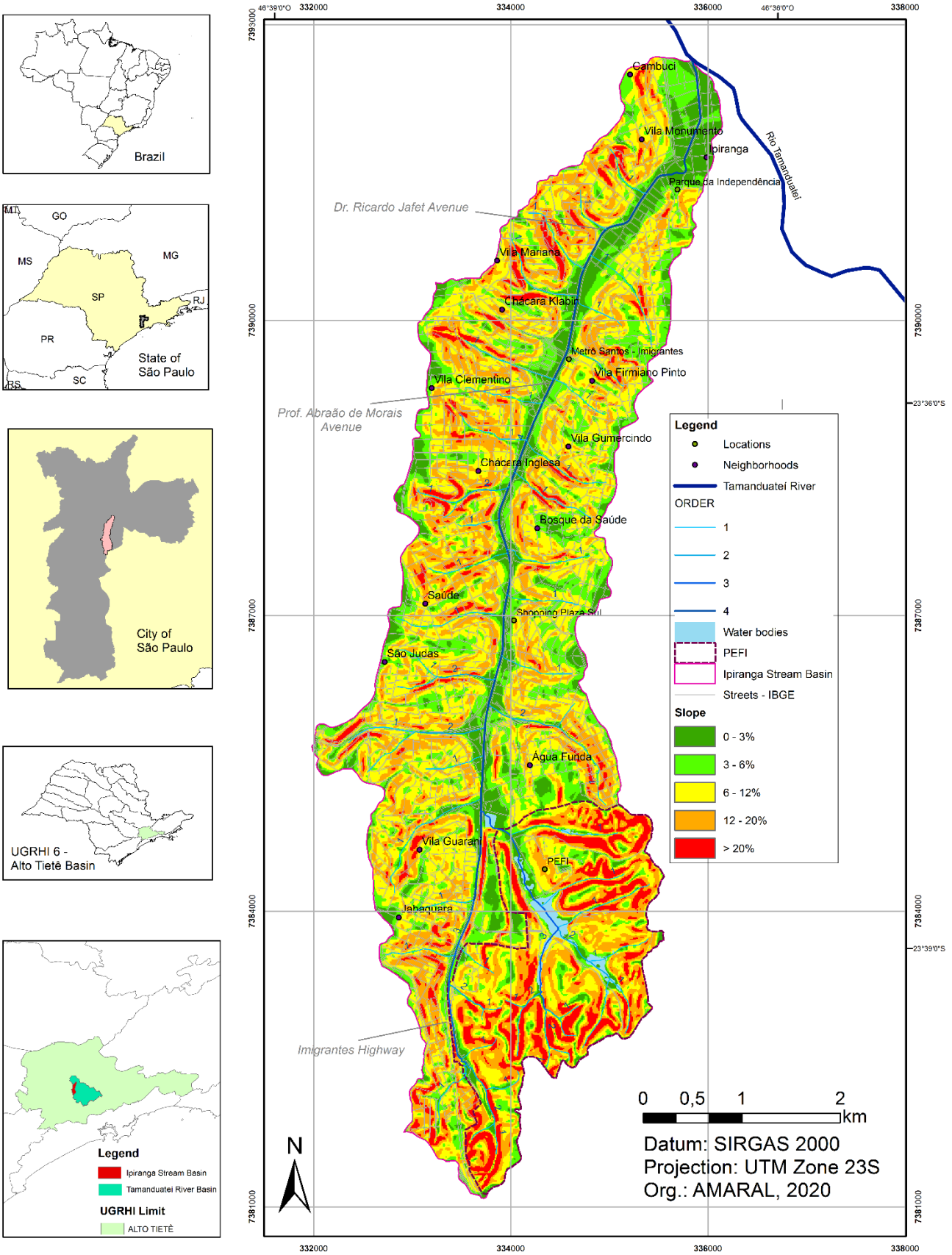


Figure 1: Location of the Ipiranga Stream Basin, São Paulo/SP, with slope classes and hierarchical order of the channels (according to Strahler, 1957).

Along the banks of the Stream are the avenues Dr. Ricardo Jafet and Prof. Abraão de Morais, roads that connect the south zone to the city center, presents a large flow of vehicles, and considerable commercial and residential infrastructure. These avenues are also important accesses from the capital to the coast via Imigrantes Highway (Figures 2 and 3).

The length of the main course is approximately 11 km and its contribution area corresponds to 23 km². Approximately 80% of the basin's area is urbanized and the remaining 20% is represented by the residual forest of the Fontes do Ipiranga State Park (PEFI), where the main sources of the stream are located. PEFI is one of the most significant remnants of the Atlantic rainforest inserted in an urban area in Brazil, with an area of 4.8 km².

As main physical and drainage characteristics, the basin has a dendritic pattern, elongated and rectangular shape, S-N orientation, with a predominance of low to medium declivity, between 0 and 12%. The main course of the drainage network is 4th order, and the tributaries are perpendicular to the main course and most are 1st order channels. The main channel gradient is 0.57%. These values of slope of the basin and channel, as well as the elongated shape of the basin, are generally associated with a low to moderate level of susceptibility to flooding. The hypsometry of the basin has altitudes that vary between 730 and 836 meters. The topographic range between the largest divider and the mouth of the basin is 106 meters. Transverse profiles show that from the medium course downstream the river plain becomes wide and flat, favoring slow flow and accumulation of rainwater.

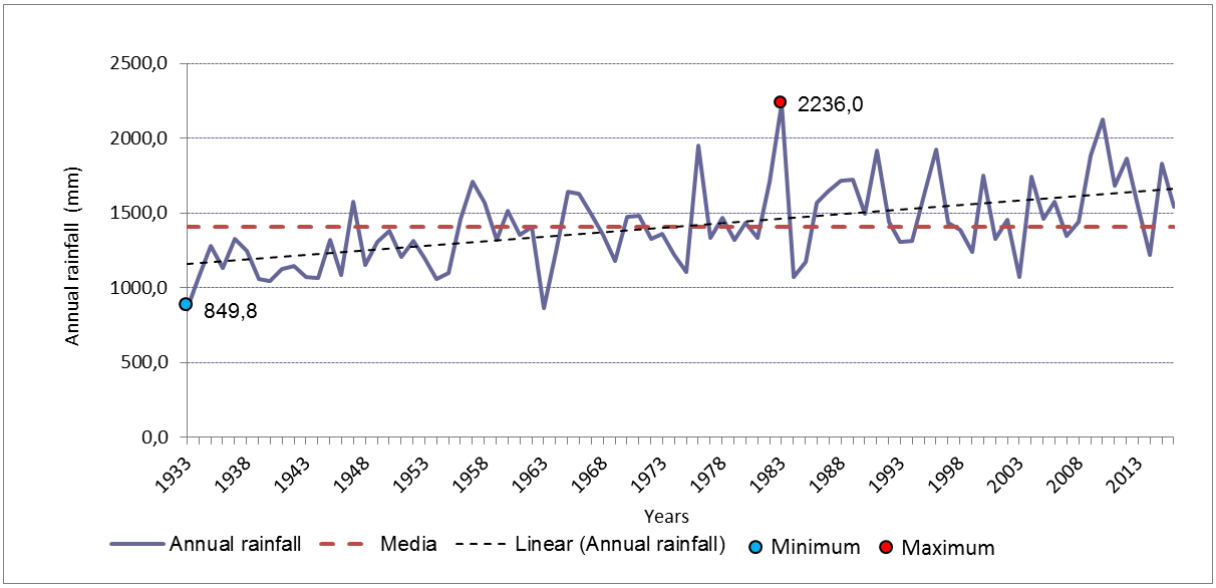
Figure 2 - View of the middle course of the basin towards the upstream. On the banks of the Ipiranga Stream are the lanes of Prof. Abraão de Morais Avenue. Photograph: Amaral, 2018.

Figure 3 - View of the medium course towards the downstream. On the banks of the Ipiranga Stream are the lanes of Dr. Ricardo Jafet Avenue. Photograph: Amaral, 2018.

Regarding rainfall characteristics, the analysis reveals that in the period between 1933 and 2016 there is a tendency of increase by about 30% in the annual rainfall index, which corresponds to an increase of about 500 mm in the annual totals of the last years, and an increase of 2.3 ° C in relation to the average temperature (IAG, 2016). The average annual rainfall in the period was 1,409.5 mm, the maximum annual value occurred in 1983, with 2,236 mm and the minimum value in 1933, with 849.8 mm (Figure 4). The monthly maximum rainfall occurs in the months of January and March, which characterize the intense and concentrated rains in the summer period, when there is a greater

frequency of floods. In the average of the evaluated period, the maximum in the month of January reached 653.2 mm and in the month of March 470.7 mm.

Monteiro (1973) indicated that the high and the low amounts of annual rainfall are justified by the Tropical and Subtropical Climates that can present alternately dry and moist years. São Paulo and the Metropolitan Region of São Paulo are crossed by the Tropic of Capricorn what influences, as a transition band, in the annual distribution of rainfall, sometimes more to the south, other times more to the north. The proximity of the Atlantic Ocean (56 km), the altitude of 856 m and the dynamics of the urban climate can also influence in the disponibility of water vapour and the formation of rainfall.



Data source: Meteorological Station E3-035 from IAG / USP (2016). Org.: Amaral, 2018.

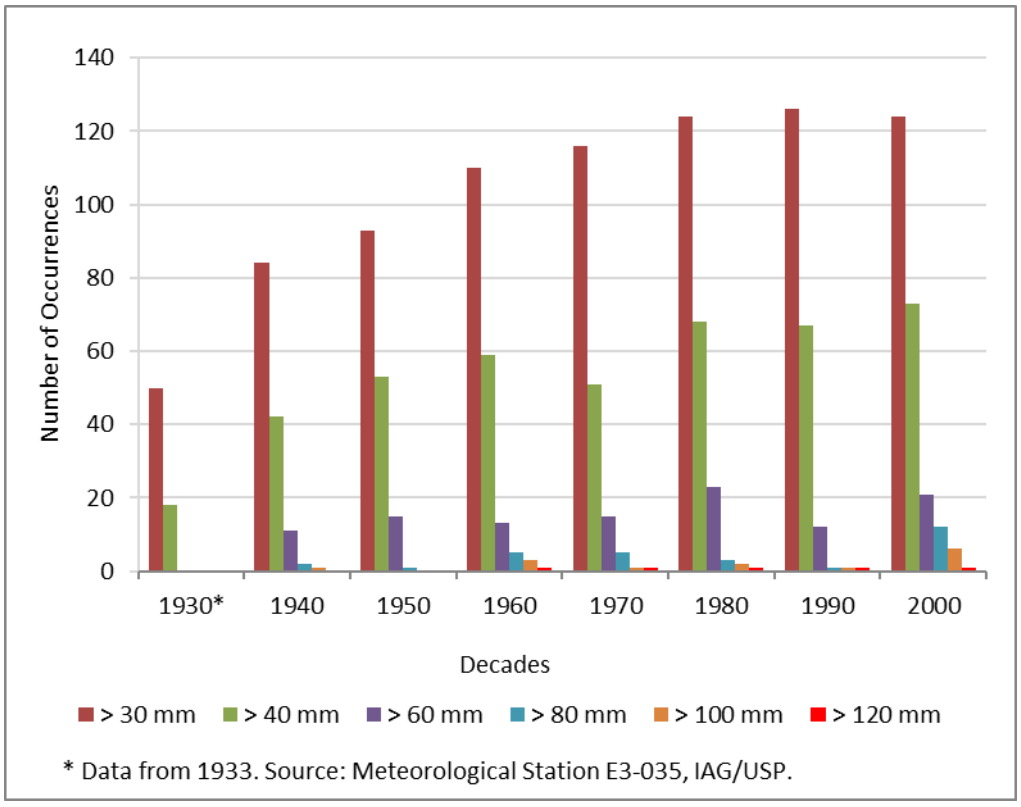
Figure 4: Annual rainfall data in the Ipiranga Stream Basin, São Paulo / SP, with a linear trend (dotted line), between 1933 and 2016.

Ferreira ve Amaral (2017) found that from the 1940s on, rainfall became more intense in the place, with the occurrence of several and frequent events above 60 mm in 24 hours. Since the 1960s, more episodes of extreme rainfall greater than 80 mm/day have occurred, and in that same period, there has been the occurrence of at least one rainfall greater than 120 mm/day in each decade (Figure 5). In March 1966, a 24-hour rainfall was recorded, which stood out as the record for the period, with 145.9 mm (IAG, 2016).

Xavier, Xavier ve Dias (1994), also evaluated the data from Meteorological Station E3-035, but referring to the period between 1933 and 1986. The authors consider that changes in daily precipitation may occur due to the local effect, induced by urbanization, or due to a global scale climatic cause, or the overlapping of both. They point out that the first years of data collection at the station reflected the situation in a peripheral area, which was gradually modified by the anthropic occupation around the park. Therefore, rainfall data are more likely to show, throughout its temporal evolution, changes attributable to the influence of the urban environment. In the event that the highest rainfall increased in the summer, they attribute that they are due to the permanence of the ZCAS (South Atlantic Convergence Zone) in that period of the year. Another explanation of a climatic nature

for the positive rainfall anomaly in São Paulo in the months of May and June would be the presence of El Niño more frequently in recent decades.

Tavares ve Silva (2008) also emphasize that the topographic configurations of the edges of the Atlantic Plateau, combined with the effect of the heat island in the metropolitan areas (Xavier, Xavier ve Dias, 1994), lead to abundant and concentrated rainfall in the summer period.



Source: Ferreira ve Amaral (2017). Org.: Amaral, 2018.

Figure 5: Daily rainfall totals greater than 30mm in the 1930s to 2000s, in intervals of 30, 40, 50, 60, 80, 100 and 120mm.

Zilli *et al.* (2017) evaluated the rainy events in the Southeast Region of Brazil and also found an increase in the number of days with precipitation and in the intensity and frequency of extreme rain events. The records identified that the variation in patterns occurs, particularly, close to the main urban centers.

Salvadore, Bronders ve Batelaan (2015) cite that studies in different countries have found increased rainfall in urban areas, comparing pre- and post-urbanization conditions, and concluded that the increase in rainfall was around 5 to 15%. However, there are still uncertainties as to which factors of local scale would have most directly interfered in this change. Among the main factors are changes in land use, changes in surface roughness patterns due to urbanization and air pollution.

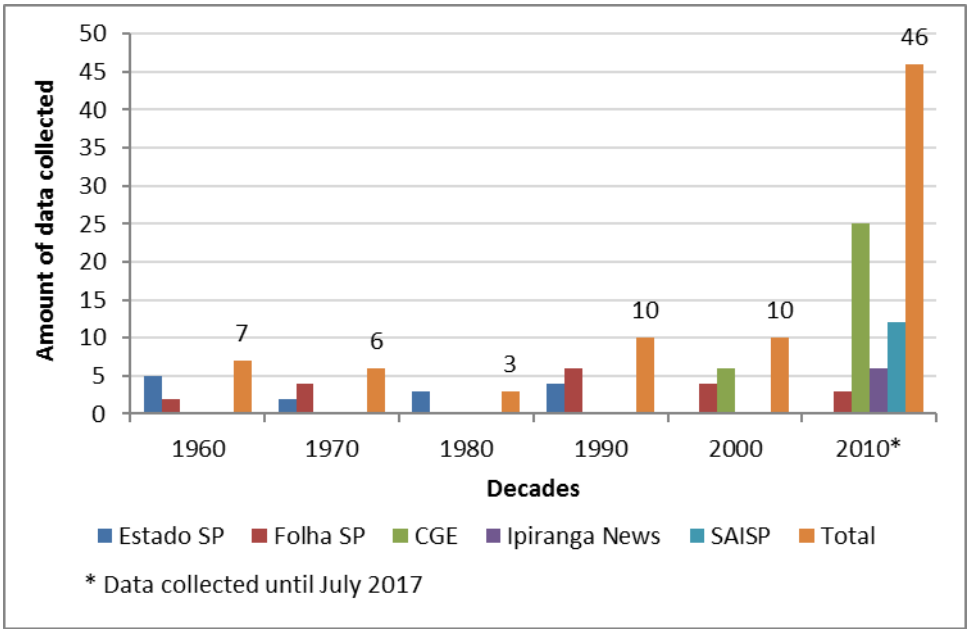
According to the studies presented, urbanization and the formation of heat islands can cause changes in the intensity of rainy events, especially in the summer, contributing to the occurrence of flooding events. However, a specific complementary study to prove this effect in the Ipiranga Stream Basin is necessary.

In relation to anthropic characteristics, we sought to correlate the history of floods recorded in the basin with soil impermeability rates, related to urban density, and the changes made in watercourses, over decades.

Data collected from consultations with digital information media (newspapers) and official sources (CGE/PMSP and SAISP/DAEE/FCTH) show that the amount of news reporting floods in the Ipiranga Stream Basin has increased in recent decades (Santos ve Amaral, 2017). No information was found prior to the 1960s, as before that period a large part of the area of the Stream plain was not occupied by dwellings and, therefore, floods were not recorded because they did not compromise human actions.

In total, 82 flood events were recorded in the basin in the period between 1965 and 2017, concentrated mainly in the last 3 decades, distributed as follows: 7 events in the period between 1965 to 1969, 6 in the period between 1970 to 1979, 3 between 1980 to 1989, 10 between 1990 and 1999, 10 between 2000 and 2009 and 46 events in the period between 2010 and 2017 (Figure 6).

In order to assess the changes generated by the anthropic impact of population density and the consequent waterproofing of the surface, it was decided to resort to a multitemporal analysis, based on maps, aerial photographs and satellite images, in order to delimit the progress of the built areas and the changes on banks and water courses.



Org.: Amaral, 2018.

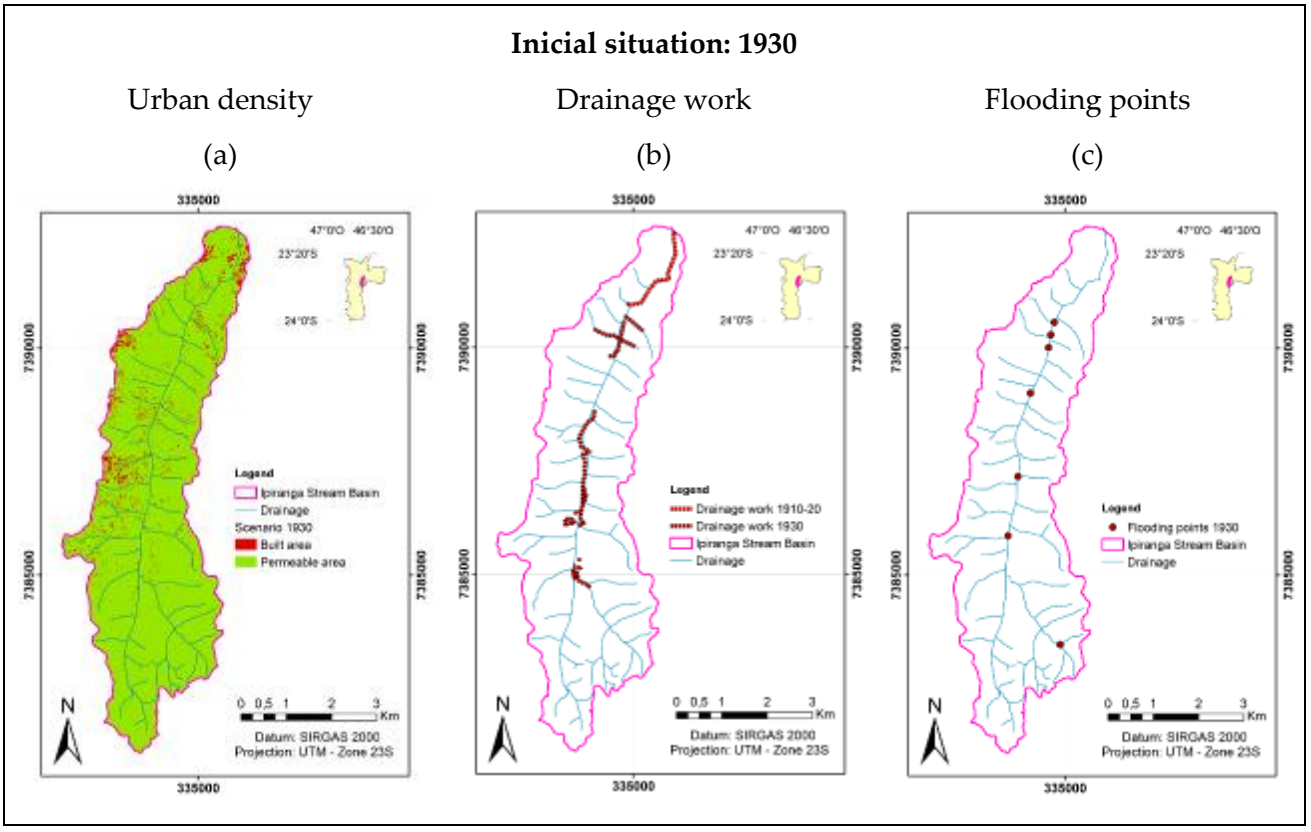
Figure 6: Amount of data collected on flood events in the Ipiranga Stream Basin, São Paulo / SP, for decades and source of information.

Figures 7 to 10 show the multitemporal evolution of urban density, the structural works carried out and the recorded points of flooding. This evolution is portrayed in 4 time frames (1930 - 1962 - 1994 - 2017), with intervals of 32 years between the first scenarios (1930, 1962 and 1994) and 23 years until the last (2017). These intervals were defined according to the dates of the aerophotogrammetric and satellite images obtained, which were used in the interpretation of urban density.

The initial situation of the multitemporal analysis is in 1930. The Mappa Topographico evaluation of the Municipality of São Paulo (SARA BRASIL, 1930) of the Basin area reveals that the urban density started in the north and northwest. Permeable areas were considered to be land without sealed surfaces, regardless of the presence of vegetation, including allotments under implementation phase (exposed soil) (Figure 7a).

Before 1930, in the period between 1910 and 1920, interventions were carried out on the stretch downstream of the main channel of the Ipiranga Stream, to enable access to the Paulista Museum (Museu do Ipiranga), an important municipal tourist spot. There were also several works on the main channel and its tributaries, in order to make it possible to occupy the middle course areas and in the upstream section for the implantation of the Botanical Garden in the Parque do Estado area (currently PEFI), with rectifications, open and closed channels (Figure 7b).

In this initial situation, areas mapped as swamps or natural water accumulations by Sara Brasil were considered as flood points. During this period, there was no occupation in the vicinity of the flooded areas (Figure 7c).



Org.: Amaral, 2019.

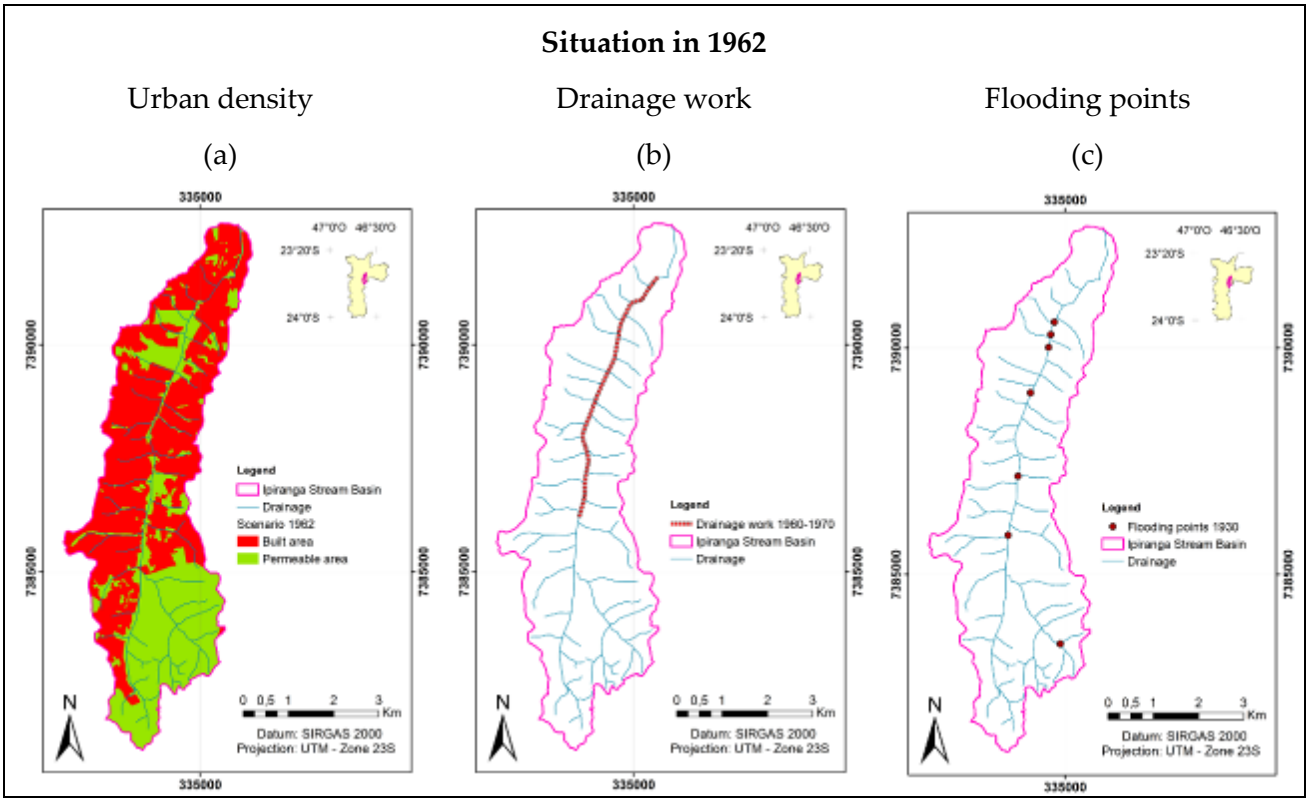
Figure 7 - Situation in 1930: (a) Built Area = 3.38%; Permeable Area = 96.62%; (b) Open and closed rectifications and channels. (c) Flood points, mapped as swamp areas (Sara Brasil).

Over the 32-year interval (1930 to 1962) urbanization advanced towards the south of the Basin (Figure 8a).

In the 1960s, new interventions were carried out in the watercourse, including in sections that had already been modified previously. Rectification and open channeling works were carried out on the

main channel for the construction of Av. Água Funda, now called Av. Dr. Ricardo Jafet, on both banks of the stream (Figure 8b). The opening of the avenue was in 1967 and the works were completed in 1970, with part of the São Paulo Avenues Plan Program.

It is estimated that the flood points mapped on the Sara Brazil Map (1930) remained active, since, until 1962, the areas called swamp did not yet have close occupations (Figure 8c).

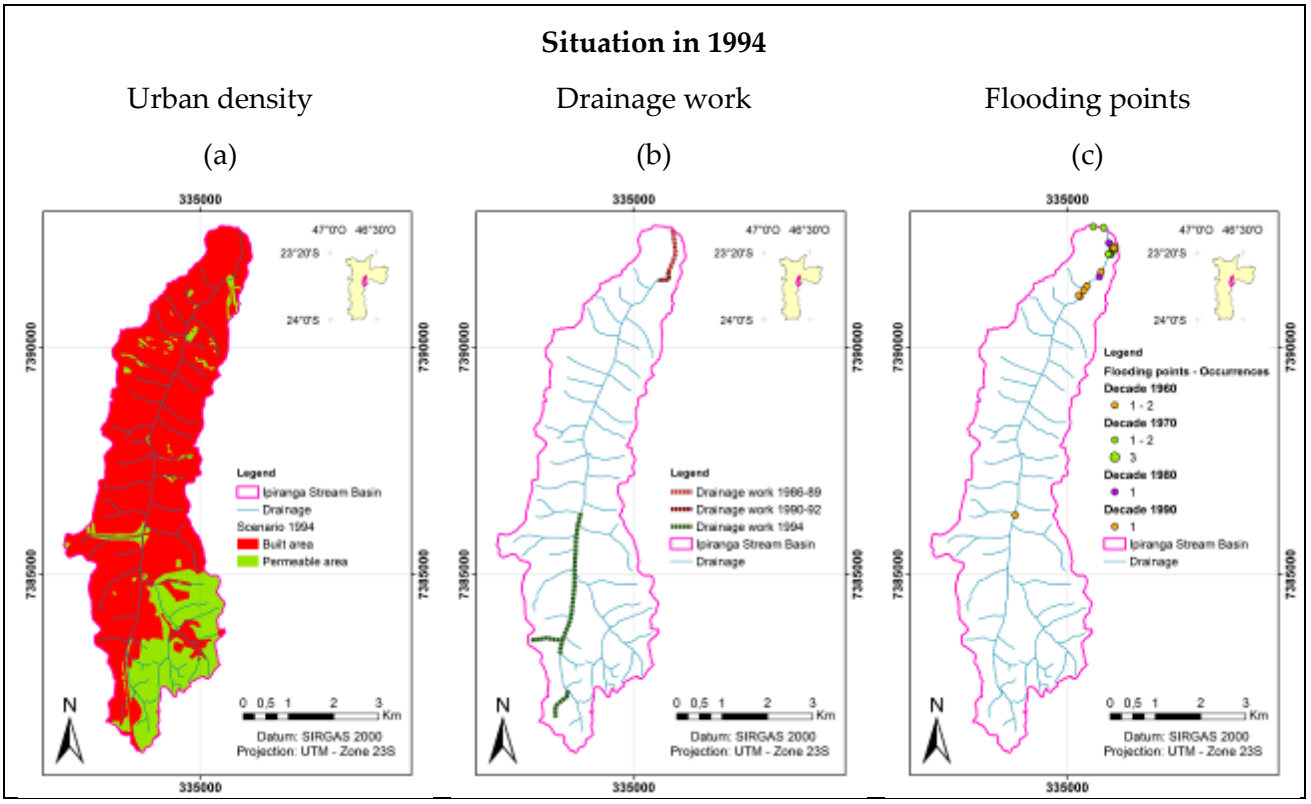


Org.: Amaral, 2019.

Figure 8 - Situation in 1962: (a) Built Area = 60.23%; Permeable Area = 39.77%; (b) Beginning of the rectification and canalization works in the open over a large section of the main course. (c) Flood points remain the same as in the 1930s.

In the period between 1962 and 1994, urbanization occupies practically the entire length of the basin, leaving as permeable areas the few fragments of vegetation in areas protected by parks (such as PEFI and Parque da Independência), in areas of central flowerbeds of great avenues or in small public green areas. Since the 1990s, there has been stability in the horizontal expansion of urbanization (Figure 9a).In this period, several works were also carried out on the main channel, such as the expansion of the channel, maintenance of margins and silting in order to correct problems related to flooding in the downstream stretch, and another stretch of open channeling of the canal was carried out mainly to enable access from the avenue to the Imigrantes Highway (connection with the coast) and the underground channeling of tributaries (Figure 9b).

During period that starting in 1965, the first reports of flooding in the Ipiranga Stream and related damages are recorded. The news describes flood events in the downstream portion, which at the time had a more densely populated occupation. Between January and May 1968, 5 events were recorded, and in 4 of these events the level of water reaching homes and businesses was over 1.4 m. The news from the 1970s also reports occurrences in the downstream portion, near the mouth of the Ipiranga Stream on the Tamanduateí River. Damage was reported to about 150 homeless families and obstructed traffic for almost 12 hours, with a water level greater than 1.2 m. In the 1980s, the news still refers to floods in the downstream portion, with about 60 homeless people. The occurrences of floods were recorded at the beginning of the decade, always in the summer period. In the 1990s, the amount of news related to the floods in the Ipiranga Stream increased considerably and most of the points identified are located in the downstream portion, and one point in the middle course. In 1996 there were 4 recurrences and damage related to traffic interruption, damage to homes and industry is reported, and in one of the events around 16 thousand people were without electricity (Figure 9c).



Org.: Amaral, 2019.

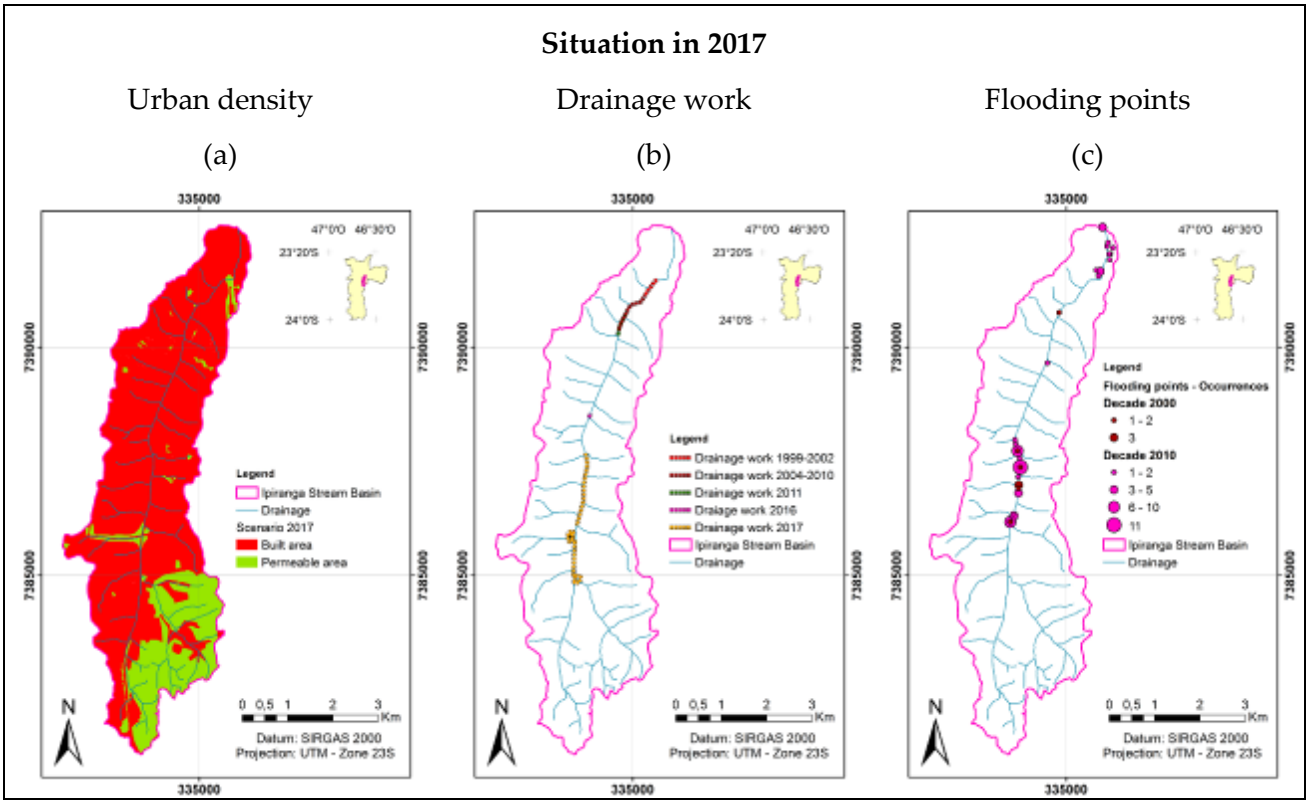
Figure 9 - Situation in 1994: (a) Built Area = 79.44%; Permeable Area = 20.56%; (b) Expansion of the main channel, recovery of margins and reconstruction of bridges, closed tributary channels; (c) Points registered in the news, by decade and number of occurrences in each identified point.

At the end of the 1990s, land with exposed soil became rare and on a small scale. The verticalization process then started with the construction of many residential and commercial buildings, mainly in the middle course portion of the basin (Figure 10a).

During the period of 1994 to 2017, several works were also carried out on the main channel and its tributaries to correct problems related to floods, such as the expansion of the river channel,

maintenance of margins, de-silting and interventions at intersections over the stream. Based on a study carried out by the City of São Paulo in 2014 and financed by the Federal Government, in 2017 the works to prevent floods in the basin began, with a project to build a temporary containment reservoir with two compartments and a storage capacity of 200 thousand m³ and de-silting of a lagoon to be transformed into a flood reservoir with a storage capacity of 100 thousand m³. It was also foreseen the expansion of the channel of the open channeled section along the middle course, which presents several points with record of recurrent floods. The completion of the works was initially scheduled for 2019 (Figure 10b).

In relation to the flood points, in addition to the news from newspapers from that period, the occurrences recorded by the CGE / PMSP, starting in 2000 and from 2007 onwards, SAISP / DAEE / FCTH data are also included. The number of occurrences continued to increase, but there were also more points of flooding in the middle course of the stream, in addition to recurring episodes in these points. The news reported one case of death, several cars dragged by the force of the water and water level reaching 2 meters high. In the decade of 2010 there was an increase in the points of flooding in the middle course, but the occurrences in the downstream points still remained. One of these points located in the middle course presented 11 occurrences in the period between 2010 and 2017. The news reports damage to homes and businesses, cars submerged and dragged by water, neighborhoods without electricity, in addition to traffic interrupted for several hours. In some events, the water level reached 1.6 m in height (Figure 10c).



Org.: Amaral, 2019.

Figure 10 - Situation in 2017: (a) Built Area = 80.39%; Permeable Area = 19.61%; (b) Maintenance of margins, construction of temporary reservoirs, de-silting and expansion of the main channel gutter; (c) Points registered in the official news and information from CGE/ PMSP and SAISP/DAEE/FCTH.

4. CONCLUSIONS

Floods in urbanized areas have social consequences that involve properties, assets and people affected, and foster the need to manage the associated risks. The problem related to urban flooding is common in most large cities. In these cases, the lack of planning for the occupation of the basins becomes evident, with the absence of measures of use restrictions in the areas of the floodplains. The other urban alterations also stand out, such as the accentuated waterproofing of the soils and the interventions in water courses, which hinder the preservation and maintenance of water resources.

The analyzed data show that despite the several drainage related works in the Ipiranga Stream Basin, in São Paulo / SP, carried out in the last century, the areas with records of flood events have remained active, and although over the years they have changed location in different stretches of the basin, the history of events found an increase in the frequency and magnitude of these events.

The increase in records of flood events in the basin in recent decades may be related to several factors, which act together, of which the following stand out:

a) The natural characteristics of the basin's morphology indicate that the elongated shape of the basin, as well as its low slope, favors the accumulation of water due to the slow flow, making the area prone to the occurrence of floods;

b) The analysis of the rainfall data reveals the tendency of increasing annual precipitation in the basin. The finding of the increase in annual totals and the occurrence of greater volumes of daily precipitation in the place, mainly above 60mm / day from the 1940s, characterizes a greater volume of water concentrated in the basin and in the main channel. It is also important to highlight the occurrence of one rainfall event higher than 120 mm/ day in each decade, recorded since the 1960s. In the municipality of São Paulo, intermittent or continuous and / or moderate to strong precipitation above 60mm already causes a state of attention and monitoring by the official departments for the potential for flooding and urban flooding. Previous studies on changes in the annual amount and distribution of precipitation in the Ipiranga Stream basin, as well as other studies that discussed the characteristics of urbanized areas, evaluate that the causes of these changes may be due to urbanization and heat islands effect, or they may have a regional or global climatic cause;

c) The greater transmission of news by the media may be due to the impact of floods on the dynamics of circulation and the local economy. The history of events collected data from consultations with digital information media (newspapers) and official sources (CGE / PMSP and SAISP / DAEE / FCTH) and in total 82 flood events were recorded in the basin between 1965 and 2017, more than half (46 events) were recorded between 2010 and 2017. Official sources (CGE and SAISP) provided specific and detailed data for the basin, although some of these events were also reported in the newspapers. It is noteworthy that this information was incorporated into the history from the beginning of its operation, in 2000 and 2007, respectively;

d) The expansion of soil waterproofing rates influences directly on runoff. In the 1930s, the built areas represented only 3.38% of the total area of the basin; in 1962, the built areas already reached 60% of the total basin. They evolved to 79% in 1994 and to 80% in 2017, when they showed stagnation. These characteristics changed the permeability of soils and, consequently, the dynamics of runoff in the basin over the analyzed period;

e) As verified in history, to make the occupation of the basin viable, changes in the watercourse, in several channels and rectifications in the main channel and in the tributaries were made. These modifications allowed the displacement of the flood points identified over time. As a particular

stretch of land was subject to construction, other portions of the previously unscathed plain began to experience flooding events.

Based on the integrated assessment of natural and man-made factors, there is a growing tendency for flooding phenomena at the site, in case interventions that give greater importance to local characteristics are not made.

In this case, flood-fighting projects should opt for the conservation of lowland areas, such as, for example, the construction of a linear park along the main course. Studies carried out by the Municipality of São Paulo evaluated that due to the fact that the basin already has a consolidated occupation on the banks of the Ipiranga Stream and the Avenues Dr. Ricardo Jafet and Prof. Abraão de Morais, the alternative of building the linear park was not viable due to the high cost of expropriations and reallocations, in addition to problems related to land issues. However, over the past 30 years, approximately $ 400 million has been invested in works and the floods continue to cause damage and risks to the population and traffic on the site.

Structural works to contain floods, which are part of the genesis of river plains, have not shown satisfactory and permanent results. In these works, as has been indicated throughout recent history, it has always been a priority to facilitate the flow of water, through rectifications, enlargements and deepening of the channels, promoting changes in the locations of chronic floods. Temporary rainwater retention solutions, through the construction of large reservoirs, were not sufficient to contain flooding during times of heavy daily or even hourly rainfall. In view of this, small works along the basin should be prioritized with the objective of temporary retention through public and private micro reservoirs with the aim of promoting the retardation of runoff water flows throughout the entire basin.

Thus, it is considered that addittional measures can be used concurrently with structural measures already in progress, such as the implantation of some points of temporary water accumulation, such as retention systems in the slopes - for example, rain gardens or the implantation of permeable pavements - in the middle course to the downstream section. These measures do not need large extensions of continuous areas, require little investment to be implemented and can minimize economic, environmental and social problems.

It also highlights the importance of making awareness effort on how to live with risk so that they can avoid further loss of life and property.

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SOUTHEASTERN ANATOLIA PROJECT (GAP) IN TURKEY AND FOOD SECURITY IN THE MIDDLE EAST

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Abstract

Turkey's Southeastern Anatolia Project, GAP (Güneydoğu Anadolu Projesi), is a water-based regional development project implemented in a geopolitically important region where transboundary waters under the influence of political factors and changing climate in the global warming era. The analysis of the GAP, which has been under construction for a long time, will be beneficial for new integrated projects and regional development policies.

GAP is located in the geographical area called Upper Mesopotamia, where the first complex civilizations known were born and developed. Moreover, the location of the region at the crossroads of trade routes has made the history of this geography very colorful. Prehistoric settlements of human societies since ancient times haunted lead the stones of today's course and the Republic of Turkey in this region.

In addition, the GAP is implemented in lands neighboring geography that has 60-65% of the world's oil reserves and where the struggle for hegemony is intense. This project, which started more than 40 years ago and is nearing completion encountered many socioeconomic and political problems throughout its progress,. In this article, the development process of the original project is outlined by emphasizing the increasing importance of the GAP in providing Sustainable Food Security in the region.

Keywords: GAP, Southeastern Anatolia Project, Food Security, Middle East, Regional Development

1.INTRODUCTION

The GAP was planned to generate 26.9 billion kWh of hydroelectric energy annually by constructing 22 dams and 19 hydroelectric power plants with an installed capacity of 7.302 MW . In addition,

according to the GAP Action Plan, 1.058 million hectares of agricultural land would be irrigated after its completion (GAP 2019).

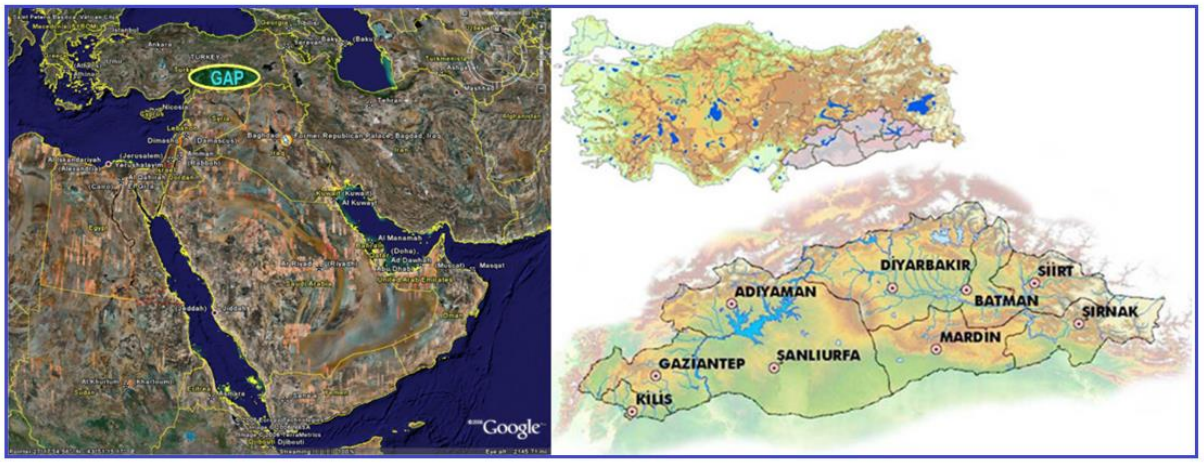

Figure 1 Geopolitical location of the GAP Region and main rivers (GAP 2014).

1.1.Development Process of the GAP

The main purpose of the GAP, which includes 9 provinces shown in Figure 1, is to increase the income level and life quality of the people living in the region by assessing the resources of Southeastern Anatolia Region, in order to eliminate the developmental differences between the region and other regions of the country, whilst ensuring economic and social development by increasing productivity and employment in the rural area. (GAP 2014). It was decided to use the Tigris and Euphrates waters for agricultural irrigation to increase productivity and hydroelectricity generation by constructing dams and irrigation infrastructures.

The first studies on the Euphrates and Tigris rivers, which are the water resources of the GAP, started in 1936 in line with the directive given by Atatürk (Bağış. A.İ, 1998). Flow measurements and topographic studies on the Euphrates were made by the Electrical Works Survey Administration (EİE), which was established in 1935. The research studies were completed in 1958 and it was determined that a total of eight dams, three on the Euphrates River and five on the Tigris River, were possible to be established and approximately 20 thousand hectares of land were estimated to be irrigated. With the establishment of the State Hydraulic Works (DSI) in 1954 and the initiation of their regional studies, the project was further expanded. Seven project packages on the Euphrates and six project packages in the Tigris basin were combined to form a project bundle consisting of 13 projects within the infrastructure of the GAP.

State Hydraulic Works (DSI) undertook the construction of Keban Dam in 1966 and completed it in 1974. In the following years, the Karakaya Dam construction was started, and in 1980 the Euphrates and Tigris projects were combined and gathered under the name GAP. The construction of the Atatürk Dam started in 1981. In 1986, the State Planning Organization (DPT) was given the task of handling the GAP within the framework of integrated regional development and carrying the works out in coordination with other state organizations and stakeholders.

In the GAP Master Plan, which sets the development goals for the region out, is foreseen as a significant change in the Southeastern Anatolia Region, and the things to be done have been tied to a certain schedule. In this process of change, economic and social targets were determined, the main strategy was to ensure the stimulation of agricultural development to make Southeast Anatolia an export region. The development stages of the GAP are given in Figure 2.

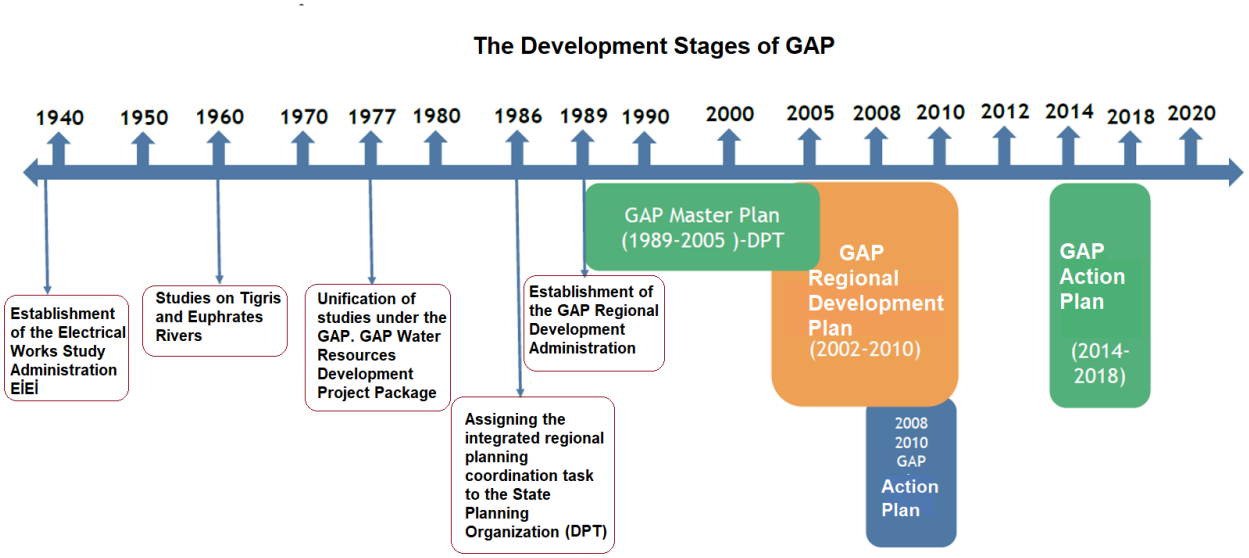

Figure 2.The development stages of the GAP (GAP Broşürü 2020).

GAP Regional Development Administration (RDA) was established in 1989 to take the responsibility of carrying these studies out, and the preparation of GAP Master Plan was coordinated by them. Unfortunately, the Gulf War, Iraq embargo, terrorist activities, economic crisis followed each other at that time interval of scheduled completion of the project. Especially in the second half of the 1990's, the Master Plan had significantly deviated from the targets due to the financial problems, and it was clearly understood that, it would not be possible to complete the GAP in 2005. On the other hand, global awareness of environmental issues has increased, and concepts such as public participation, ecological pressure and footprint, sustainable development and sustainability of investments, as well as gender-balanced development, all have come to the fore. For all these reasons, the need to prepare a new plan that would bring a different approach to regional development has arisen. (GAP BKİ 2020).

1.2.Management of GAP

As mentioned above, the transformation of the GAP into an integrated regional development project (GAP 2019), lead to establishment of the GAP Regional Development Administration in 1989, with its headquarters in Ankara and the Regional Directorate in Şanlıurfa, to carry out the work to be done in this framework. The GAP Regional Development Administration was established for fifteen years, and affiliated to the Prime Ministry and in the beginning, structurally expanded into the Southeastern Anatolia Project Supreme Council and Southeastern Anatolia Project Regional Development Administration in time (GAP 2020).

The GAP Administration has also been assigned to carry the secretariat services of the GAP High Council out. The GAP Supreme Council, which is the highest decision-making body of the

organization, examines and decides on all kinds of plans, projects, and programs prepared by the GAP Administration. The Council was under the chairmanship of the Prime Minister, the State Minister in charge of the GAP, the State Planning Organization (DPT), Undersecretariat's affiliated Minister of Public Works; consisted of the Minister of Housing. The Minister of Agriculture and Rural Affairs has also been a member of the GAP High Council since December 2, 2002. When necessary, other Ministers have also been invited to the GAP Supreme Council regarding their issues (GAP 2020).

The initial 15-year period of the GAP RDA was extended for three years in 2004, five years in 2007, five years in 2012, and until December 31, 2019, in 2016. In addition, the headquarters of the organization moved from Ankara to Şanlıurfa in 2009, and the liaison office, which served for a while in Ankara, was closed at the end of 2015 (Gökçe B.). GAP RDA was affiliated to the Ministry of Industry and Technology with Decree No. 703 dated 2/7/2018.

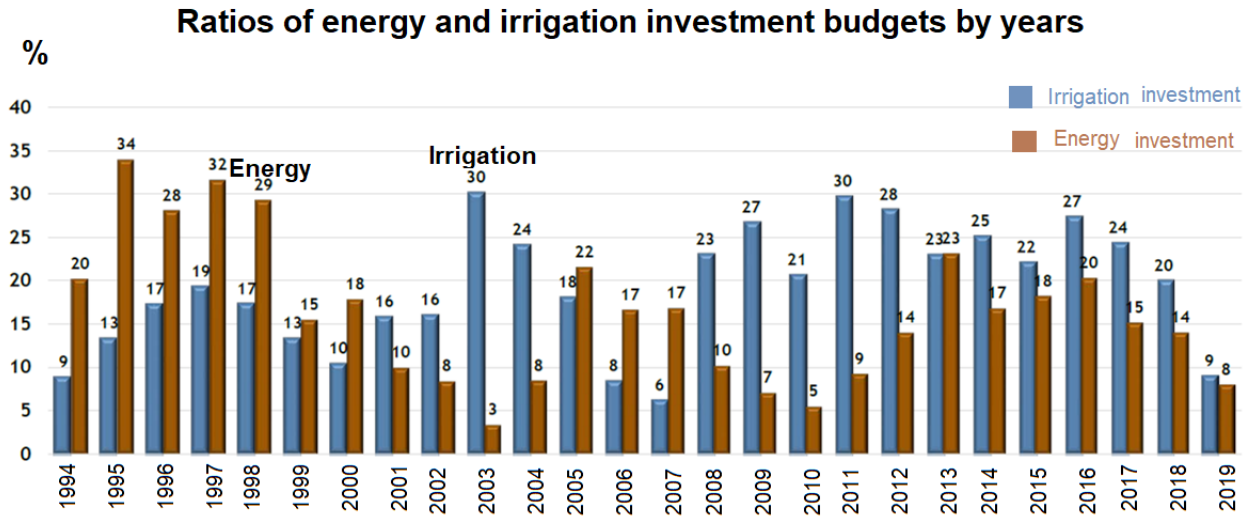

Figure 3. The budget ratio values allocated for irrigation and Hydroelectric Power Plant (HEPP) investments by years in the GAP (GAP Broşürü 2020).

2.GAP REGIONAL DEVELOPMENT PLAN (2002-2010)

In the initial GAP investments more shares were allocated for Hydroelectric Power Plant (HEPP) than shares for irrigation investments, but this policy has been changed in favor of irrigation investments since 2008 (Figure 3). With the decision of the Council of Ministers taken in June 1998, 2010 was determined as the target year for the completion of all investments in the GAP. The necessary coordination task for the completion of the GAP with all its sectoral components on the prescribed date was given to the GAP Regional Development Administration accordingly. Thus, unlike the Master Plan, of which its preparation started in 1989, the GAP Regional Development Plan (BKP), which regards human development as a priority target, emerged in line with the "sustainable development" approach and comprised the active participation of stakeholders from various segments. One important feature of this plan is that its enclosure of an "action plan" consisting of the projects to be implemented.

2.1.Basic Objectives of the Plan

In the preparation process of the Regional Development Plan, three main objectives were determined in line with the demands of the stakeholders;. these are "Developing development infrastructures and protecting the environment", "improving human resources" and "reducing intra-regional development disparities". This plan, which was prepared after the Master Plan, focussed on infrastructure building, human resources development, and environmental protection. Meanwhile, with the understanding of reducing the differences of development levels within the region, more local projects have been started to be implemented in the GAP. This step has also emerged as an opening against the delay in social benefits expected from the project.

The Regional Development Plan envisaged that all of the investments and projects determined in the GAP Master Plan and subsequent studies would be realized by 2010. In this plan, principles such as human orientation, participation, human development, social development and sustainability, have been brought to the fore (GAP BKİ 2020).

The total resource need of the Plan covering the period of 2002-2010 was calculated as 23.4 billion dollars with 1998 prices. 12 billion dollars of these investments would be from the state budget; and the remaining $ 11.4 billion of investment was expected to be covered by the private sector. The development axes given below are taken as a basis in the 2008-2012 GAP Action Plan within the scope of the Regional Development Plan.

2.2.The GAP Action Plan 2008-2012

The plan was prepared basing on the 4 main development axes:
1) Realization of economic development
2) Ensuring social development
3) Infrastructure development
4) Improving institutional capacity.
Within the scope of this action plan, 73 "Main Actions" and more than 300 "Projects and Activities" took place.

2.3.The GAP Action Plan 2012-2018

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In the 2012-2018 Action Plan, "Increasing Liveability in Cities" was added as the fifth axis to the previous version. 115 "Main Actions" and 494 "Projects and Activities" took place within the scope of this action plan. As can be seen, the plan objectives and development axes of the project were revised by taking the developments into account.

2.4.Target Completion Years of the GAP

The target completion years of the project were specified as 2005 in the GAP Master Plan, 2010 in the GAP Regional Development Plan, and 2012 in the GAP Action Plan, but these goals could not be achieved. According to the 2019 Latest Status Report published by GAP-RDA, the realization rate of energy projects was given as 78% and the realization rate of irrigation projects was 53%. (GAP 2019).
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Presence of terrorist activities in the region and insufficient public funds have been effective factors in the continuous postponement of the completion date. The author made the following statement about the completion date of the project in his book published in 2011 (Yıldız & Özbay):

"It seems very difficult to reach the full completion in the GAP before 2023. This difficulty will arise from the fact that the project is an integrated project, includes 40 public institutions and 270 projects, even if the continuity of funding is provided, and it will take a long time for the land and farmers to prepare for agriculture for irrigation investments. It would be more appropriate to accept the year 2040 for the final development situation at the whole Basin scale. "

The current situation of the Project also reveals that the year 2040 is a correct prediction for the final development at the basin scale; however, feedbacks from this project have already been received as hydropower for a long time. It must also be noted that, developments in other areas have taken place as sub-projects at the provincial scale; the increase of the share of GAP region in Turkey's exports can be mentioned as an example in the this context, which reached to 5.34% in 2019, also by providing employment to 235 000 people (GAP Brochure, 2020).

3.INTERNATIONAL DIMENSIONS OF THE GAP

GAP has also affected international relations as an integrated project based on the development of transboundary waters. In this context, Syria, Iraq, and Iran are sharing the transboundary waters with Turkey and interacting with each other. Especially, bilateral and trilateral relations emerged after the GAP has gained international dimensions. Considerable increase in the objections of the riparian countries to the projects on the rivers of Tigris and Euphrates have been observed during the development and internationalization stages of the GAP, especially since the early 2000s, there have been serious internal conflicts and civil war in Iraq and Syria.

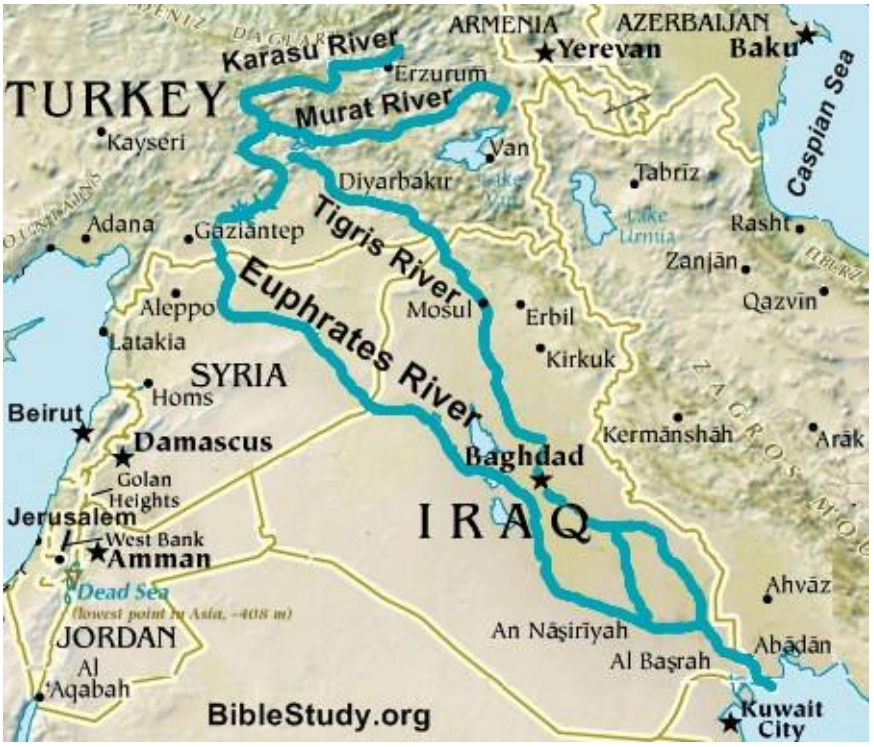

Figure 4.The GAP Region, Tigris and Euphrates River Basins and riparian countries(GAP Raporu 2008).

Nearly for a decade after the devastating conflict began in Syria, millions of people have been displaced and water infrastructures were destroyed. The current situation in the region indicates that it would be more appropriate to evaluate the transboundary waters of the GAP with a different paradigm than that of the past approach. In other words, the new paradigm should evolve towards the sharing of the benefits of water for regional development and food security, instead of the sharing of water by riparian states for their use (Figure 4).

The basis of this new understanding of regional cooperation and development should be to benefit from the potentials of the countries in the region at the highest level with a mutual benefit approach, which requires working on joint projects for regional development. These regional projects may be formed in cooperation under the coordination of a common central unit. This institutional structure can play an active role in project development and implementation to activate the local potentials of countries. In this context, feasible common goals can be set to ensure equitable, rational, and effective use of water for water and food security. Accordingly the GAP is evaluated as an integrated infrastructure in this study, which can be utilized for production of common benefits and protecting interests of all parts. In short, the GAP is a concrete project in which cooperation can be realized through joint investments aiming to increase and protect the stability of the region in the medium term. In summary, the GAP has emerged as an infrastructure that could offer various opportunities to beneficiaries who are aware of the advantages of such region-wide cooperation. It is worth to mention here that, the GAP was planned, as an integrated development project, during the Cold War

global economic and international relations period and has become a project bordering a region being politically unstable and being reshaped, while political developments related to climate change are increasing the regional benefits of the GAP.

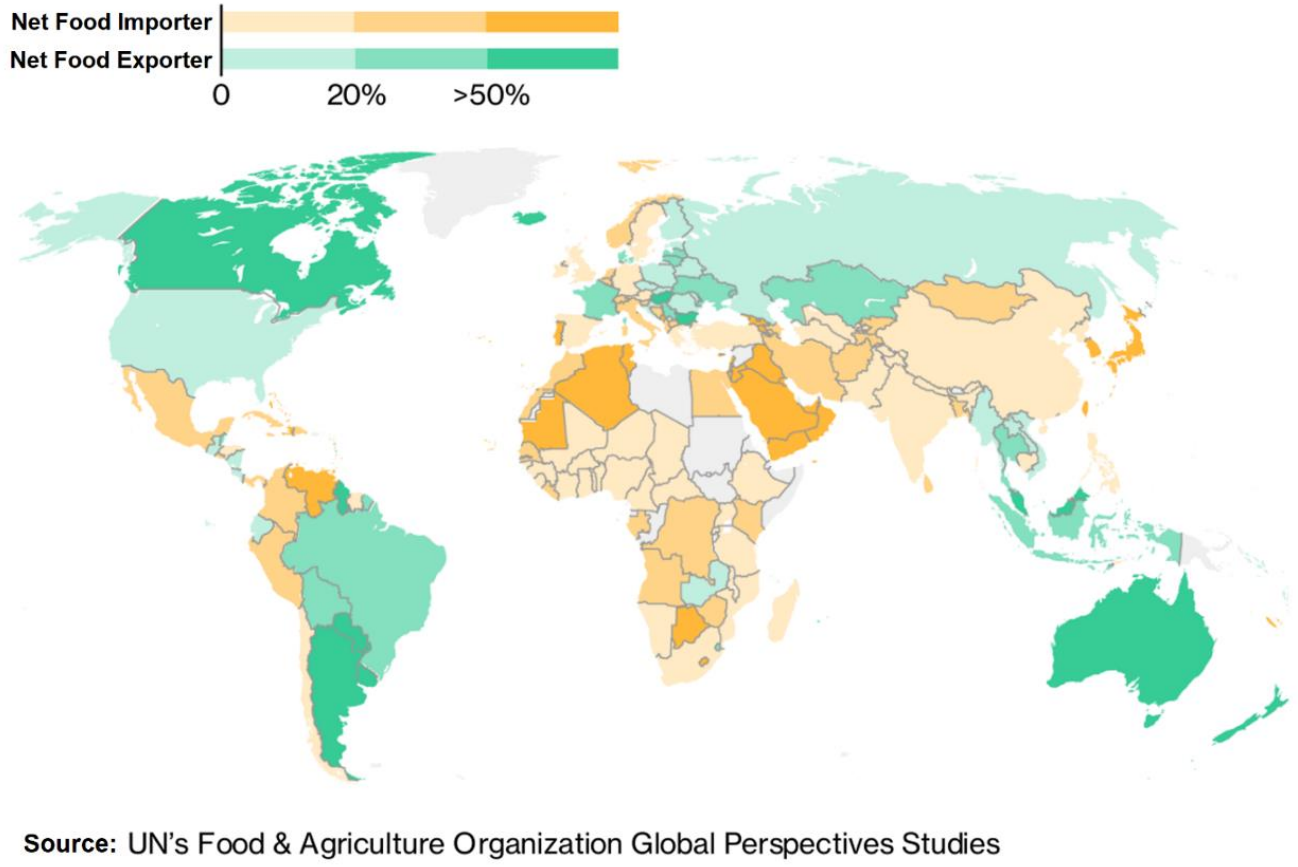

Figure 5. States of countries in the world food trade (Global Trade)

4.FOOD SECURITY OF THE ARABIAN PENINSULA

With the rapid population growth in the Middle East and the Arabian Peninsula, the demand for food is also increasing. As shown in the map issued by UN (Figure 5), the Arabian Peninsula is seen as a net food importer. There is an annual food market of 30 billion dollars in this region. Distant countries such as the European Union, USA, Australia, New Zealand, Brazil, and Canada stand out in this food market(Şahinöz A, 2011).

In an interview, Prof.Dr.Ahmet Şahinöz said, "Middle Eastern countries cannot meet their food demands with their production due to geographical reasons. Therefore, food imports of these countries will increasingly continue for many years. A production planning in the GAP region is required by considering the structure of food market of the Middle East countries." (Şahinöz A.).

With the further development of the GAP, a significant part of the demand in this market can be optimally met from the production in the GAP under much more favorable conditions. When the relations in the region are considered with the understanding of win-win instead of zero-sum, geographic proximity, consumption patterns, and similarity in consumption habits will facilitate

cooperation in this field. However, it is not unlikely that the political developments in the region, together with climate change, will cause the securitization of water and feed instability. The GAP is an infrastructure that will provide many opportunities for stability and cooperation in the Arabian Peninsula if it is planned from today.

5.LESSONS LEARNT FROM THE GAP

The Southeastern Anatolia Project has demonstrated that the goal of completing an integrated regional development project is primarily based on water as a time-bound resource, therefore giving a date for its completion is not appropriate. However, it is worth considering the criticisms, which are known have been risen regarding the floods affecting settlements, historical and cultural assets, forcing internal migration, being the source of increasing inequalities and social degeneration, being detached from the realities and needs of the people of the region, and finally being uncapable of achieving to the promised changes within the prescribed time (Bilgen A, 2018).

While preparing the Master Plan, it was not taken into account that the integrated character of the GAP, which includes agriculture, industry, transportation, education, health, rural infrastructure sanctions, would weaken the probability of the completion of it in scheduled time. This situation caused the weakness of the integration and the connection of the project components. Product planning could not be appropriately implemented in the project and cotton production exceeded the planned level.

In 2008, the GAP Report of the National Industrialists' and Businessmen's Association (Bilgen A.) it was stated that "This delay not only decreased the technical profitability of the project but also caused the postponement of the development expected from the project in socio-economic terms." The same opinion was shared by Mehmet Kaya, President of the Diyarbakır Chamber of Commerce and Industry at that time (Kaya M.).

The GAP Regional Development Administration aimed a total development with the project. However, the insufficiency of the funds allocated to the project, the socio-economic and cultural differences of the region from other regions, and the terror problems affected the holistic progress of the project. Besides, the training of the farmer and the preparation of the soil could not be carried out in coordination with the agricultural infrastructure during the project implementation.

5.1.Some Factors Delaying the Completion of the GAP

The reasons causing a delay in the completion of the GAP in 2005 as planned, or more precisely, further progress in the project, can be listed as follows (Bilgen A.)

- Institutional factors such as central government, cumbersome bureaucracy, lack of institutional capacity, and lack of coordination between state institutions,
- The administrative structure of the GAP-RDA and administrative factors such as uncertain tenure, institutional capacity, and lack of authority arising from this structure,
- Economic factors such as insufficient financial resources, insufficient public, and private sector investments,
- Security factors such as preventing the private sector from investing in the region due to PKK terrorism supported by regional and non-regional countries,

- Political factors such as insufficient political will and lack of political stability

5.2.Benefits from the GAP

- While the rate of participation in the workforce was 34% in 2007, it has reached 42.2% in 2015, in parallel with the increase in the employment rate in the region, and the employment rate, which was 28.3% in 2007, has risen to 35.2% in 2015.
- Exports, which was 3.3 billion dollars in 2007, has reached 8.8 billion dollars in 2015, the share in the country-wide exports has also increased from 3.1% to 6.1%; while total exports of the country have increased by 34%, the region succeeded to increase exports by 168 %.
- New universities have been established in the region and the schooling rate increased.
- The number of hospitals in the region has increased and the capacities of existing hospitals have been increased.
- There has been an increase in transportation services as well; highways have been developed, new airports and terminals have been built (Su Krizi 2020).

6.CONCLUSION AND DISCUSSION

The GAP as an integrated regional development Project, which has been going on for almost half a century; it definitely is worth investigating for similar water-based development projects.

Considering the integrated feature of the GAP and its development phases, it has been revealed that it would not be possible to complete within the specified periods, after the first 20 years. It should be regarded as an ongoing process, although postponing the completion date many times caused unrest and a decrease in social expectations from the project, some deviations from the project goals, the uninterrupted continuity of the project for decades is considered a highly important success.

First of all, the extension of the project completion time made it possible to talk about a GAP with more flexible boundaries and expandable objectives. Since the beginning of the implementation of the GAP, many changes and developments have been experienced in the fields of water management, security, economy, and international relations, as well as scientific and technological advances in the world. The GAP has been a project where two generations of directors have worked and developed in the field of technological and new management models.

Many changes, transformations, and fractures from the Cold War to the present have brought many different concepts such as social development, emancipation, security, sustainability, participation, good governance, and democracy to the agenda of the project executives in the GAP's practices. Accordingly, the flexibility of the GAP made it possible to constantly redefine the project and to be developed and reproduced accordingly.

When the history of the project is examined, it will not be surprising to see that the completion of the GAP with all its functions and new developments will extend towards the mid-2000s. Mass migration from the border to the GAP region, due to both the Gulf war and the Syrian civil war, military and international political developments in the region are reshaping the regional impact of the GAP on a wider scale, as well as extending the completion period of the project. For example, the GAP Region has prevented the social problem from getting worse by accepting most of the mass migrations caused by the civil wars in the region. 1,162,302 is the number of Syrian refugees in the GAP region's total population, 32,42% of the number of Syrians in Turkey: This is the One-third of all registered Syrian

refugees in Turkey live in Sanliurfa and Gaziantep cities. It should be noted that developments in the GAP have had a significant effect on providing this opportunity to refugees(GAP 2019).

As of 2019, 571,591 hectares (54%) of irrigation projects, which are subject to criticism due to their slow walking in the GAP, have been put into operation (GAP 2019). The completion rate of energy projects in the GAP is given as 78%.

Hydro energy generation projects that have been completed earlier than irrigation projects, which have been spread over a long period in the GAP. This time difference causes many speculations about the reasons of this delay.

The reason of early completion of the energy projects in the GAP is these energy projects are their easiness of starting and shorter payback period than irrigation projects, as well as contribution to meeting the increasing energy needs of the country, and their much less need for secondary preparations. Additionally, farmers, soils of the fields to be irrigated, irrigation unions, agricultural product warehouse, logistics services, and marketing facilities should be prepared for irrigation practices. Setting this necessary chain takes time and needs to be well prepared, considering the fact that chains are as strong as their weakest link. Due to the security, socio-economic and socio-cultural characteristics of the region, various problems were experienced in the realization of these preparations as steps that complement each other. For example, failure to comply with the planned crop pattern, improper irrigation in the Harran Plain resulted in salinization. Some irrigation projects had to add drainage systems afterward. While the drainage waters returning from irrigation to a transboundary stream, any disruptions in the purification and reuse of these waters created problems. Since the cotton planting in the region exceeded the plan targets, the weaknesses in the institutional structure of the water users organizations decreased the progress rate. State Hydraulic Works (DSI) General Directorate has decided to convert all irrigation projects, including those that have been implemented, into modern irrigation systems in the region in the early 2000s.

Progress of the GAP has been much slower than that planned in the begining, but it should be noted that it reached to the current level of realization slowly but without any interruption. 22 dams and 19 hydroelectric power plants, 9 drinking water projects, and about 1 million hectares irrigated area will serve not only Turkey, but also the whole region's food security and stability.

The experiences gained from the GAP show that a water-based integrated regional development project requires more attention for farmer education and training in parallel with building engineering infrastructures such as dams ,irrigation channels etc..

Considering about 40 year period of implementation, it would be a more realistic goal to complete such a large and integrated project in interrelated sub-regional parts.

In conclusion we should be aware of that, the GAP has potential to serve not only development of Turkey, but also peace and stability of the whole region.This can be achieved by regional development and mutually beneficial approach among the neighboring countries in time.

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FROM SOCIALIST KIBBUTZ TO FREE MARKET ECONOMY: WHAT COUNTS FOR ISRAEL'S WATER MIRACLE?

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Abstract

This paper aims to adequately summarize the integral components to understand the state of water allocation in Israel. To do so, it first discusses the biblical roots of water and what it meant for the early Zionist settlements in the region. Once establishing the basis for the culture surrounding water for Israelites; it emphasizes on the importance of water in national security and state-building in Israel. It later discusses how these national security and state-building concerns led to the current state of geographical borders. Presenting the current layout of the Occupied Palestinian Territories (OPTs) and their administrative mechanisms; this section concludes by listing the main water issues faced in Israel and disputes with the OPT's and the Kingdom of Jordan over shared water resources. Listing allocation, politicization and privatization of water as the main issues; the following sections elaborate on these topics. In doing so, it first lays out the government initiatives, policies and partnerships constructed to tackle these issues. The paper subsequently examines how all the aforesaid tools led to the advancement of the Israeli WaterTech industry with a specific focus on its prevailing sub-sectors. Namely, desalination, wastewater management, water network management, irrigation and finally water safety and security.

Keywords: water allocation, Israel, private sector development, water governance

"You can tell a lot about a country by the way it manages its water."

—Shimon Tal, former head of the Israel Water Commission

1.INTRODUCTION

Due to irregular, unequal and severe yearly downpour regimes of rain, the Middle East region has always been exposed to shortages in the water. With this in mind alongside the growing processes of salinization, pollution and growing population the scarcity of water is expected to grow. According to the policy report highlighted by the OECD (2011), water allocation arrangements are not equipped to serve the 21st century hence emphasizes the reformation of water allocation that can benefit both individuals and society in general Moreover, the policy builds on the following two key messages calling for the necessity of a reform. Firstly, the policy report highlights the competition over access to water resources is intensifying due to population growth, particularly in vulnerable (semi) arid regions such as the Middle East, leading to degraded water quality and climate change. Consequently, water allocation is generally tackled as a high priority in political agendas. Secondly, the policy report highlights that decisions by the authority or those in the power of water allocation are bound to historical preferences and usage patterns, often tracing their roots to previous decades or even centuries (OECD, 2019). In other words, competition, hence, power is dominated by particular entities or individuals and manifested in political agendas in water location. Water is therefore disproportionately allocated to certain users and is highly context-dependent. Thereupon, the location of water resources and choices made over its policies can be deemed as important indicators on determining laws and borders whilst demonstrating political power or being used to benefit national interests by authorities (Rosenthal & Sabel, 2009). As the findings show despite half of the country is a desert, Israel currently has a water surplus, thus, becoming a net exporter through their technological prowess in water distribution and deemed as the only water independent country in the Middle East region.

2.CULTURE OF WATER: THE ISRAELI KIBBUTZ AS A CASE STUDY

Allocation of water resources, in particular, played an important role in the creation of the Israeli state. Established through the early Zionist settlements; the Zionist movement put great importance on agricultural activity and water. According to Dare and Evans (2017), a kibbutz was regarded as a way of community life and traditionally based on agriculture developed by Jewish newcomers to Palestine long before the State of Israel was established. Moreover, Munnin summarizes that the kibbutzim established during this period under the British mandate, enjoyed by many members. Adding that most of these newcomers being enthusiastic, many were ideologically motivated youngsters. Inevitably, kibbutzim movements later developed different ideological and political orientations leading to a military role in actively partaking in the protection of the Yihuv.

According to their national narrative "Jews had been landless urban-dwellers alienated from their promised land" (Selby, 2003, p.66). Hence, Zionism not only advocated for return to Palestine but "redemption of the Jewish people through agrarian physical labor and the transformation and rebirth of the wasteland of Palestine into a land of milk and honey" (Selby, 2003, p.66). Prioritizing their claim over water resources, Zionists ought to establish control over them. Following a labor Zionist ideology, settlers thus identified water as a weapon in territorial struggle (Selby, 2003).

After the official establishment of the Israeli state in 1948, water policy naturally became a vital tool for securing the physical presence of the country in the region. Moreover, because of the colonial roots of the Israeli state, water policies were largely discriminatory favoring the state's needs against the

Palestinian minority (Selby, 2003). Additionally, a combination of a labor Zionist elite and a state-led public discourse further served the objectives of Israel in extending their control over regional water resources. To exemplify, Israel's water policies mainly aimed at securing and extending the availability of water for Israeli settlements located in OPT's restricting Palestinian's access to the water supply which later led to be one of the reasons for the intifada.

Nevertheless, the Israeli national security discourse continues to view water as a part of national security and an integral component to state-building that can be traced back to the kibbutz movement as a milestone in nation-building through agriculture.

To conclude, from the earliest days, Israel pursued water strategies and policies to advance state-building playing an important role in the Israeli national security agenda (Ecopeace, 2018). Consequently, Israeli water issues still remain highly controversial and continue to aggravate existing tensions among trans-boundary water resources shared by it's neighbours, with OPT's in particular.

2.1.Current boundaries of Israel: Water & State Building

As established above, water issues are central to Israel's geopolitical considerations. Moreover, as Morag (2001) discusses, the objective of maximizing control over water resources ultimately resulted in what would, in 1948, become Israel's northern and northeastern borders. Followed by revised borders in the northeastern part of Israel in 1967, the current geopolitical calculus of Israel is illustrated in Figure 1 along with the three distinct Israeli-occupied West Bank areas with different administrative measures. According to the current negotiations, Area A is exclusively administrated by the Palestinian Authority; Area B is administrated by both Palestinian Authority and Israel; and Area C including Israeli settlements and administered by Israel. Israel, however, still faces chronic water problems that are both man-made and natural.

Figure 1. Curren Geopolitics of Israel(ABC 2017).

2.2.Government Initiatives, Policies and Partnerships on Tackling Water Crisis

After 1967, the Israeli governments' tasks largely revolved around maintaining the West Bank's water network, controlling the volume and flow of water supplied to the Palestinian communities and billing (Siegel, 2015). The water department then traditionally functioned as an intermediary agent between military authorities and the Palestinian population. Post-1967 actions of the Israeli water authority claimed widespread control overseeing the allocation in the West Bank, hence restricting the amount of power given to Palestinian users themselves. In other words, Israel emphasized a widespread power "to control and restrict the activities of individual water users" (Siegel, 2015).

A report published by the United Nations in 1992 starting with the quotation: Like desert camels of thirst dying, While on their backs water-bearing. (Arab verse after Emile Habiby) summarizes the main limitations about the power play and lack of Palestinian control over water resources which explains the focus on the effects of water on individual users. Firstly, it focuses on diversion, depletion and control of Palestinian water resources adding that the effects of annexation in the Palestinian land and illegal settlement policies along with legal and institutional constraints on the Palestinian water economy systematically creates dependency over Israel. The report proceeds by stating that restrictions on development activities requiring water and water-related measures are repressive and discriminatory for the Palestinians. It concludes by adding that the overall impact of Israeli policies on Palestinian water consumption creates insufficient availability and quality of water. As a result, leading to a lack of protection of Palestinian water resources, water security and technical cooperation plans both on a national and international scale.

2.3.Allocation of Water Resources

As mentioned above, post-1967 activities of the Israeli government to tackle the (semi) arid nature of climate was accompanied by restrictive measurements taken on allocation of water resources without recognizing Palestinian rights (Dweik & Shuval, 2007). According to Sustainable Management of the West Bank and Gaza Aquifers or SUSMAQ, this unfair allocation of resources led to drying up Palestinian springs and wells by drilling nearby deep wells for their own use, intercepting groundwater from reaching Gaza coastal aquifer, polluting the groundwater aquifers by the wastes of Israeli settlements and mining the West Bank aquifers by dense networks of wells. By constructing separating walls, Israeli government further solidified control over the water distribution.

Due to Israeli restrictions on drilling, deepening and rehabilitation, Palestinian water projects require an approval where Israel holds a de facto veto power (Corradin, 2016). Consequently, only a limited number of Palestinian projects on water and sanitation are granted permits to be executed (Corradin, 2016) with against a near 100 percent approval rate for the Israeli ones. Additionally, the repercussions of control over water distribution affect areas A, B and C distinctively. To illustrate, as stated by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) refusal rate of water and sanitation projects between 2010 and 2014 is standing at 98.5 percent with over 50 projects being demolished (Corandin, 2016) in Area C. Whereas for Area A and B lack of sufficient water resources still remains a major problem with 18.5 percent of the water being bought from the national water company of Israel. This practice is largely criticized by leading international agencies

since it is claimed that Israel essentially sells the water back to Palestinian's. One of the leading advocates on this phenomenon is the United Nations in which accuses Israel for the violations and the human right to clean water and sanitation (Klawitter, 2007).

2.4.Politicization of Water: Arab-Israeli conflict

As described above, the Israeli government adopted discriminatory water policies and mechanisms when allocating water, especially to OPTs. The failure to maintain cooperation in preserving the shared groundwater resources with the Palestinians hence made water a top contributor to the conflict. According to Lipchin (2007), the problem between Palestinians and Israelis on water is not about water availability, use, and supply or any remaining technical problems. Instead, it is a political competition over the Palestinian land. More specifically, who controls and owns what is in historical Palestinian land. In the longer term, the occupation of water also forces Palestinian to leave their land deprived from their right and ability to cultivate it.

2.5.Shift to Free Market Economy

Above-mentioned, control over water was lavishly and traditionally controlled by the Israeli government's water department in OPT. In other words, according to Siegel (2015), the ideological basis of Israel's control was heavily led by restrictive laws and policies followed by the government. After the peak and widespread globalization in which businesses can operate and trade on an international scale, water inevitably became treated as an economic commodity. With the introduction and adaptation of the free-market economy by the Israeli government, the state currently adopts a capitalist economy paving the way for privatization and treating water as an economic source whilst maintaining a state-controlled and centrally planned approach to its water (Siegel, 2015).

Advocating for private ownership, pro-business and pro-innovation was first suggested and properly executed by Ariel Sharon when he came to power in 2003 as the prime minister. His vision, however, was properly implemented by his successor Benjamin Netanyahu starting from 2009 serving as the new prime minister. The gradual transformation of the pro-business approach of the government currently endorses and progressively extends the funding of it's businesses working in the high-tech industry and making technology work for their favor dominating the water technology business (Siegel, 2015).

The Israeli government planned such a shift to the market economy by first hiring an outside consultant to identify the state of the water market. Once analyzing the potential size of the growing efforts in technology and funded industry, the Israeli government concluded that water held a major export potential bringing millions in revenue (Siegel, 2015). Being convinced that the water industry was fragmented; entry wouldn't be blocked by industry giants. In other words, government-funded Israeli companies held the potential to become the most significant export businesses. This led to the formation of a special kind of holding company, the incubator which serves to find innovations across the country that is worth getting funded by the government. Accordingly, allowing the government-owned institutions to provide funding for start-ups.

3.INVESTING IN WATER: WATER INCUBATORS

Holding the title of one of the leading investors worldwide, The Clean Fund of Israel, constructs a strategic partnership with Israel's national water company (or Mekorot). In doing so, they fund Israel's top academies, water institutions and private entrepreneurs aiming to create a platform for developing and commercializing water innovations.

3.1.Outward Looking Entrepreneurs & Technological Prowess

Growing focus and investment in research, higher education and infrastructure reserved for the water industry combined with the large body of technically skilled natives and immigrants quickly paved the way for a technology revolution in the country. Today, Israel is often deemed as the start-up nation becoming an industry leader in entrepreneurial culture (Siegel, 2015). Ditching the old paradigm in water -or the traditional centralized model executed by Israel before the technology revolution/boom, the new one thereupon focuses on increasing water's efficiency whilst making every drop count.

Ranking third after Iceland and Hong Kong, Israel is also ahead of global powers like the US in entrepreneurship. (Getz and Segal, 2008). Consequently, the country is characterized by a high level of entrepreneurship and innovation. In 2007, in the Global Entrepreneurship Monitor (GEM) Israel was ranked the first ("Entrepreneurial Behaviour and Attitudes", n.d.). According to Gidron et.al. (2015), Israel's success in the areas of both high-tech and entrepreneurship can be interpreted in several ways. Besides governmental support, Weisfeld (2015) adds that mandatory military service forces the Israeli to make life-altering decisions and expands their social network. On the other hand, there is also a great sense of solidarity among Israelis that makes them to favor staying in the country and become angel investors themselves for upcoming startups

3.2.Israeli WaterTech Industry

According to Schafer (2013), new water systems can be designed to reduce the use and treatment costs of water by introducing systems such as desalination, wastewater management, water network management and irrigation whilst ensuring water safety and security. Hence, while the new paradigm prioritizes the efficient way of allocating water it also aims to ensure its sustainability. According to Ben-Zoor and Priampolsky (2016) Israel currently ranks as a superpower in water technology while also considered a world leader in the areas of water desalination, water recycling, water security and more. In addition, due to the success of Israel overcoming it's water shortage; in June 2015 the World Bank signed a cooperation agreement allowing for the penetration of Israeli water technology into developing countries. Enabling its patented technology to be introduced in developing countries. Israeli companies today count as the ones with the highest exports (Ben-Zoor & Priampolsky, 2016).

According to Start-up Nation Central, Israeli WaterTech companies function in the field of (1) desalination, (2) wastewater management, (3) water systems and network management, (4) drip

irrigation and (5) water quality accounting for more than 180 water companies in total. Figure 2 taken from the highlights of the Start-Up Nation Central's 2017 water technology highlights the spread of the industry as follows:

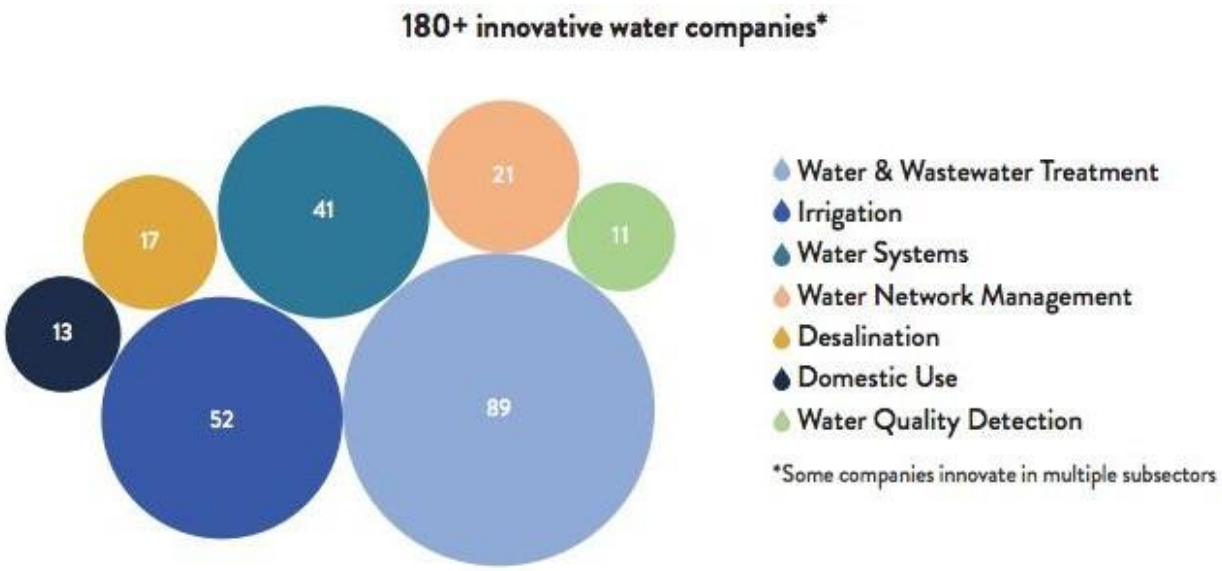

Figure 2. Innovative water companies (Watertech Highlights)

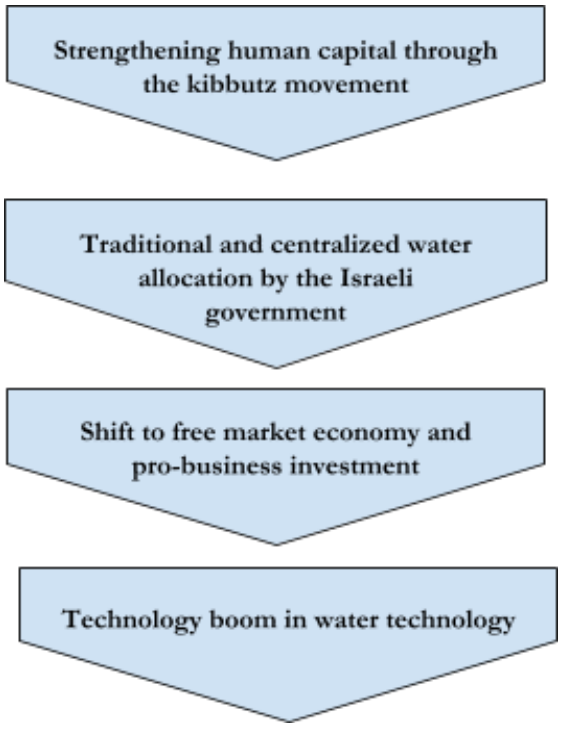

Figure 3. The technology boom in water technology

4.CONCLUSION

To conclude, the key innovations in the Israeli water sector can be regarded as an accumulation of pro-business decisions made by Israel's vision to dominate the water export industry through; a unified water infrastructure, large-scale treatment of wastewater for agriculture, large-scale desalination facilities for assuring water-independency, employing efficient irrigation technologies and finally providing a secure and supporting ecosystem/environment for water industry to thrive and innovate. In other words, the development of the grounds in which water become a treatable commodity as summarized below:

According to Start-up Nation Central, Israeli WaterTech companies function in the field of (1) desalination, (2) wastewater management, (3) water systems and network management, (4) drip irrigation and (5) water quality accounting for more than 180 water companies in total. Figure 2 taken from the highlights of the Start-Up Nation Central's 2017 water technology highlights the spread of the industry as it is given in Figure 3.

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ENHANCING EFFICIENT USE OF BIODIVERSITY-PROVIDED ECOSYSTEM SERVICES DISTRIBUTED OVER RURAL AREAS TO SERVE METROPOLITAN MUNICIPALITIES

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Abstract

Ecosystem Services (ESS) are used inefficiently in cities due to present land-use patterns that have been shaped through centuries. Though ESS are provided by biodiversity in grasslands, forests, wetlands, etc. in rural areas, they are produced in rural lands and are mostly used in urban areas.

Beneficiaries of achieving land consolidation to increase ESS production efficiency are urban dwellers and local economies. This will improve their living conditions in addition to presenting the facility of effective resource management tools to municipalities. In particular, low revenue earning urban dwellers, and the unemployed segment will be the most benefiting parts under recent circumstances.

Launching such an efficiency promoting a programme, each functional ecosystem unit should be mapped to denote provisional, regulatory ESS, including their frequency, overlapping regulatory areas and provisional ESS type per unit area, distances to the city, availability and unavailability due to laws regarding ownership, physical barriers, functional discontinuities. Mapping with data received from Geographical Information System (GIS) would be inadequate, thus we propose to use of LUCAS statistical framework mapping which is carried out in the field, by observing, and measuring the sources quantitatively by relevant expertise reflecting the local economic conditions of farmers.

Keywords: land consolidation, provisional ecosystem services, regulatory ecosystem services, biodiversity, rural areas, municipalities, land use, LUCAS mapping.

1..INTRODUCTION

Both natural and semi-natural agro-ecosystems provide various services for people, including food, fibre, potable freshwater, water mass to regulate climate, wood for heating energy and housing materials. Different land-use patterns and cover changing factors like population and economic expansion, built-up area expansion etc. have forced human beings to convert agricultural land to non-agricultural purposes. Accordingly, in the last years, many natural ecosystems have been converted into farming areas, monoculture plantations, tourism etc., which have caused externalities.

The capacity of delivering ESS essential to social well- being is impeded by climate and land-use change, causing a significant alteration in the quality of functions and services of many ecosystems.

Land consolidation to rearrange the spacing of lands in rural areas to make ESS into the best possible functioning state is required under drought, poor soil conditions, climate change impacts, overuse, and the presently emerging severe social-economic conditions faced by farmers, villagers, and the working class almost in every rural region of the world.

The present landscape pattern in rural lands somehow supports the production efficiency of ESS insufficiently

2.CURRENT SITUATION IN EUROPE AND TURKEY

Until now, spatial planning has been primarily interrelated with cities. It is increasingly becoming clear that the rural regions surrounding built-up areas have an important influence on urban spaces, in terms of climate, energy supply, water management and transport planning etc.

European Union (EU) so far has neglected exploration of ways to reveal how ESS providing areas should be spaced in rural areas to optimize the benefits of urban users and wildlife. Ignored wildlife management practices have resulted in transmission of diseases from wild to human populations, which in turn caused the increase of medical expenses. During the science-policy interface making for the EU Commission (Brussels) period, EU environmental data evaluation and reporting organisations in cooperation with European scientific research institutions have ignored the discrepancies between national economies of EU governments. Such inequalities are usually hidden, but they considerably force the constraints arising from different social-economic classes. Such imbalances in distributing social-economic welfare opportunities can be corrected by a change programme, which gathers ESS producing rural land units to hamper inequity amongst different revenue level owning social classes. That is why large city municipalities of the EU may launch such innovative programmes in the surrounding rural lands which would serve the cities.
According to Helmholtz Centre for Environmental Research (UFZ) press report*(URP 2020)*, featuring speeches by Federal Minister of Education and Research *Anja Karliczek*, Minister-President of Saxony *Michael Kretschmer* and Lord Mayor of Leipzig *Burkhard Jung*, the two-day conference will also present the new edition of the Leipzig Charter on Sustainable European Cities. *(URP 2020).*
The first version of the charter was adopted in 2007 by the ministers from all EU Member States responsible for urban development. It called for strategies to strengthen integrated approaches to urban development with regard to the development of urban neighborhoods (Monprapussorn

2018). Likewise, similar speeches have been made by some leading municipalities after June 2020 elections in Turkey. For instance, Ankara mayor Mr. Mansur YAVAŞ, and İzmir mayor Mr. Tunç SOYER has consciously started their new agricultural policies to support rural people by pricing fairly their ESS dependent commodities, while marketing them directly by means of municipal facilities. In other words, they appreciate the real value of rural regions, and the farmers in terms of marketing, noticing that farming products always depend on regulatory, and provisional ESS.

ESS providing rural ecosystems spaced in line with ownership properties, including a reduction in field size originated from inheritance and the present legislation shaped through centuries in Turkey, which have caused inefficient maintenance and use of ESS, particularly in crowded tourist areas around Antalya, Mersin, and Muğla, river catchment basins located in İstanbul, and human settlements areas over lowlands, which are extremely valuable for farming in Karşıyaka, Bostanlı, Bayraklı, and Bornova districts. Nonetheless, local and central governments in Turkey have yet not launched ESS saving projects directly. Similarly, Turkish applied science research institutions called "Teknokent" in Turkish (Technocity – Technopark), have never been interested in developing innovative instruments to receive the utmost level capacity of ESS from rural lands.

The demand for rural land use by the increasing land development enrichment trend recently observed in İstanbul and its surroundings threatens the existence of ESS in river basins. The most striking example is the suppressed potable water provision needs due to ongoing unsustainable land use of river basins, e.g. Ömerli dam, and its surroundings in the water catchment area. Another example is from the water demand of İzmir from Manisa rural regions, i.e. river basin.
Sustainable and resilient - these are the urgent demands that are increasingly being placed upon the well-functioning interaction between town and countryside. Sustainability is important, for example, to prevent global warming and climate change, erosion and desertification environmental pollution by means of an intelligent transport policy, to use existing buildings and spaces efficiently and to minimise the consumption of energy and resources (Monprapussorn 2018).

3.WATER, BOTH A PROVISIONAL AND REGULATORY ESS

Understanding the relationship between water quality and ecosystem services valuation requires a broad range of approaches and methods from the domains of environmental science, ecology, physics, physical chemistry, chemistry and mathematics. The fundamental challenge is to decode the association between 'ecosystem services geography' with water availability, its quality distribution in time and space. This demands the acquisition and integration of vast amounts of data from various domains in many formats and types.

4.CHALLENGES

Land use pattern determines volume, intensity, coverage of ESS in many ways, such as, ESS is generated more efficiently in biodiversity conservation prioritized areas, such as protected areas, The intensity of unsustainable land use taking place particularly in overlapped urban and rural regions intersections with the highest levels of ESS loss,

Farming in the neighboring areas to resilient ecosystems increase the efficiency of ESS production,

The state of soil is also important for natural habitats continuity, maintenance, and sustaining wildlife,

In general, nature conservationists ignore the state of soil in agricultural areas, arable lands, vineyards, semi-natural grasslands, meadows, and natural habitats where wildlife is the dominant inhabitant. However, the grazing management, tillage, soil compaction and other farming activities are vitally important in generating ESS in natural ecosystems, and protected areas they concentrate solely on them. This attitude towards ESS generation and rural development by the conservationists is one of the challenges of Turkey. In Europe, the situation is quite different as farmers are trained by their cooperatives and European Forum on Nature Conservation and Pastoralism (EFNCP). They reflect ecology in policy development with special emphasis on farmers' conditions which is resulted in ESS protection consciously.

5.METHODS

Urban and rural areas can jointly establish sustainable partnerships for mutual benefit, and this cooperation must be developed by considering current research topics, such as regional circular economies, land use management, digitalisation and dealing with extreme events in the context of urban-regional development. To achieve this task, part of the budgets allocated to urban infrastructure investments should be used for ESS improvement investments by governments and municipalities. This can be achieved by choosing the best fit and the **easiest application method** which adjusts ESS efficiency level in a given rural region by planning land consolidation to the extent that maximise the EES efficiency for the given region.

Although national and local scales have been managed separately by different authorities, as the surrounding rural area of cities are becoming increasingly important for solving problems, so a new pattern of regional development and cooperation is required. The aspiration to give more thought to what lies beyond city boundaries is new," says Sigrun Kabisch, who is also the chair of the scientific advisory board of the EU Joint Programming Initiative (JPI) on Urban Europe (JPI).

In addition, towards attaining a more productive and resilient ecosystem network to provide optimal health conditions for urban dwellers, a new kind of protected areas network in Europe and Turkey should be established in a way to produce the most possible degree of ESS generation. This kind of protected area network should be aligned in accordance with physically connecting the beneficiary effects of the ESS type, which is needed much in that region. For example, if region X is in need of provisional water ESS, whereas region Y fibre and wood, the authority and the common stakeholders will preferentially design the land consolidation pattern towards obtaining Y type ESS to produce fibre and wood most efficiently.

Those rural regions in which agricultural fields, meadows, grasslands, human settlements, tourist places dominate, instead of grasslands, vineyards, meadows, and wetlands, the people of the regions will serve less ESS to the city interrelated with the rural lands. This weakness will lead to receiving less ESS in terms of quantity and intensity in the urban centre and will cause poverty.

Basically, biodiversity and ecosystem resilience level can be enhanced by restoring degraded natural ecosystems, and ecosystems which have already gradually being converted into artificial ecosystems due to invading urban activities in rural lands. This is not so easy, because saving natural resources are still not measured and reported per rural region which feeds the central urban areas. To remedy this problem, Turkey should use LUCAS mapping method to determine the consumption level of resources in advance of reaching the city centre (LUCAS 2020).

Which landscape pattern produces more of the desired ESS types for the given city can also be determined by establishing a one-to-one correspondence between each kind of landscape grids per desired ESS type for that region. This planned, well-targeted spacing of ESS via appropriate land consolidation methods will increase the efficiency of the overall cumulative effect of ESS produced in the vicinity of urban centres. They will be used by the urban population living in the central core and peripheral parts of big cities. Moreover, such economically and ecologically calculated measurement techniques will resolve social problems occurring in society, especially in crowded cities, where the population of poor people is big enough.

6.RESULTS AND CONCLUSIONS

The productivity and sustainability of a wisely selected land-use system is determined between variou6.s land resources, climate and the human activities shaped by the social-economic system implemented for each country. As the undesired climate change impacts, exponential world population increase, unemployment, and the globally collapsing economic system urge us, countries and unions like European Union, and international organisations should be transforming themselves from the descriptive age to measurement era.

The Common International Classification of Ecosystem Services (CICES) developed from the work on environmental accounting undertaken by the European Environment Agency (EEA). It supports their contribution to the revision of the System of Environmental-Economic Accounting (SEEA) which is currently being led by the United Nations Statistical Division (UNSD).

At present, CICES has been aware of by many international organisations and leading western and eastern countries. However, they somehow have stayed still in an inactive, and reluctant state, do not try to build up an ESS based management models for governments, and municipalities. They have repeated the same descriptive classification systems each day in a more detailed manner but try not to introduce this knowledge into ecological informatics, government and municipality management. As a result, a big gap between recent findings of science and the governance methodology of governments and management of natural resources and urban dweller population by municipalities, and other public institutions arise (Yan at al. 2016). In the last years, the number of science-policy interface bureaucrats, and academicians who have content themselves only with data evaluation, assessment, and reporting, have been increased enormously in western countries, particularly in European Union which has been followed by Turkey through EU membership negotiations. This increment has paralysed the use of concrete measurement, calculation techniques to cope with local resource management challenges. Turkey and the EU should fill the gap between science, science-policy interface, and governmental and municipal management as urgently as possible.

As valuation, pricing of real estate, luxury human settlements construction, banking, and finance sector favoured by the rich social classes, incorporation of natural resources, and assets into national accounting system could still have not achieved after valuing, pricing of natural resources. In other words, priority given to financial resources has shadowed the primary importance of sustainable management of ESS for years. The consumption patterns of certain social classes in such developing countries and Europe have deprived of the public from a carefully managed resources economy. Meanwhile, as scientific measurement and calculation techniques are overlooked, financial sectors, namely banking, stock exchange, the emergence of land development rich class and so on have suppressed more efficient use of ESS, and more easily overshadowed government and municipality infrastructure at the expense of ignorance of big populations living in crowded cities. For this reason, land consolidation to save the highest possible level of natural capital in terms of ESS efficiency maximizing has the utmost importance to sustain both natural resources conservation and keeping society calm in welfare by means of providing equity. In fact, presently each country has expressed its economic situation by listing its natural resources quantitatively with the financial sources.

Land consolidation in accordance with properly spaced ESS in line with city services, such as transportation, water sharing, heating, including spiritual, cultural ESS orderly spaced integrity will improve also tourism, farming, nature conservation, revenue fair distribution of the city at hand. This overall gain will restore imbalanced revenue distribution amongst economic welfare classes in cities for the sake of protecting low revenue gainers, and the middle class who have presently been suppressed by the rich. After properly spacing ESS via land consolidation, payments for ecosystem services (PES) in such countries can hamper social class discrepancies while serving an increased level of ESS to municipalities for the sake of urban dwellers.

Further studies for the benefit of Ankara, İzmir, and İstanbul municipalities to exploring efficient ways of rural resources should be carried on by scientific organisations and science policy-making bureaucracy centres without any delay. Such studies are extremely important in advance of sustainable use management of urban resources located in rural areas by means of sophisticated computations. The government will benefit from the municipalities' and European Union's experiences to extend this policy implementation tool to satisfy national-level economic use of sources in this severe climate change induced source shortage era.

So resilient rural area ecosystems properly managed by urban municipalities will provide sustainable cities for the sake of big human populations. That's why big city municipalities should manage also rural areas besides downtown, in accordance with ecosystem management methods usually implemented by protected area agencies.

Present ESS spacing in rural regions has caused loss of various kinds of ESS in huge quantities which in turn has resulted in relatively expensive water prices for domestic and industrial use. Pricing of water used in cities does not take into water retention capacity, and resilience keeping maintenance costs in the rural. Likewise, fruits and vegetable prices in cities do not reflect regulatory water ESS costs. Combined with extreme living expenses for biodiversity-related agricultural works carried out by the farmers, conserving and maintenance of soil are extremely difficult. This challenge caused a nearly collapsed soil water system managed by farmlands which in turn caused decreased amount and quality of water ESS, and water needing provisional food ESS for the benefit of both wildlife and

urban dwellers. To overcome this externalisation, the actual cost of ESS should be reflected to the market prices of fruits, vegetables etc. in order to support the livelihoods of farmers. This can be achieved by Ankara, İstanbul, and İzmir Municipalities, and the Finance Ministry for the benefit of the Turkish economy.

Regarding water ESS pricing, Ankara and İzmir Municipalities have kept household water consumption prices cheaper enough, whereas the private sector value higher prices for bottled drinking water. That means that the private sector never considers the expenses of farmers, and villagers in providing water retention in rural areas to keeping the water budget constant in water catchment areas, thus never consider emergence, production, maintenance of water ESS. In case of villagers, farmers, and farming workers abandon rural lands due to suppressed agriculture under global financial market conditions. With the result that we propose water and other ESS valuation, and Payment for Ecosystem Services should be determined by big city municipalities, instead of the private sector.

The correlation between the costs of ESS generated in ecosystems in rural regions and the national taxing system, through eliminating negative economic externalisations should be evaluated and incorporated into the national accounting system to decide new taxing system. Governmental organisations and private information technology, databases management, and operational research companies working for them can achieve this task.

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JPI Urban Europe Project – the knowledge hub for urban transitions https://jpi-urbaneurope.eu/#:~:text=JPI%20Urban%20Europe%20welcomes%20the,from%20various%20disciplines%20and%20sectors

SOME METHODS OF WATER CONSERVATİON IN AGRICULTURE WHICH MAY ALSO BE INTEGRATED TO ACHIEVE HİGHER PRODUCTIVITY AND QUALITY ECOLOGICALLY

II. Some Methods and Their Physiological Bases of Benefits

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Abstract

Plant growth and productivity and water use efficiency (WUE) in terms of physiology and crop productivity are *the result of many interrelated* and complex factors, some of which are being changed by global warming. Vast majority of plant propagators have limited power of interference and control of these factors at natural conditions, especially under pressure of cost-profit ratio and environmental concerns. It will be attempted to review some promising methods, their outstanding performances and potentials in terms of productivity and water use efficiency (WUE) within the framework of sustainable agriculture at constantly changing climatic conditions and to attract attention to the potential of integrating some of them for higher water economy and productivity **to attract attention to the possible benefits of using a***rtificial intelligence in* **meta-analytical approaches to the challenging meta-problems, by integrating the prospective advancements obtained by researchers all over the world. In the coming third part of the article, s**ome prospective ecological approaches to agricultural ecosystems for integral and economic solutions to the growing problems in the era of global warming and population growth. The purpose of the study will be to draw attention to possibility of alleviation of the growing worldwide problems in agricultural production to some extend by integration of some methods, techniques deserving higher interest and wider practical applications considering billions of people living in rural areas and depending on their agricultural production, and also the locus of food production.

Keywords: Plant physiology, global warming, ecological agriculture, water economy

1.INTRODUCTION

As it is well known fact nowadays that, so called "green revolution"or "intensive agriculture"lost its prosperity and replaced by approaches like "The new Green Revolution: Sustainable intensification of agriculture by intercropping" (Martin-Guay , Paquette , Dupras *et al.* (2017). Intercropping and use of synthetic chemicals for instance, have been two of the methods getting popularity, but some other successful techniques do not seem to receive that level of attention. The aim of this study is to attract attention to some successful methods, techniques which can be assessed for higher productivity and water use efficiency (WUE) in the era of global warming, consequent climate changes and related environmental problems.

2.CLIMATE SMART AGRICULTURE

The media on the "Internet of things" (IoT) names the offered technology as "IoT for All Technology" and describes the concept named as smart, or precision agriculture, or smart farming in the article titled "Smart Farming: The Future of Agriculture" (IoT for All. Smart Farming, 2020). The description there is a management concept to provide the infrastructure to leverage advanced technology including big data, cloud and the IoT for tracking, monitoring, automating and analyzing operations by software-management, using sensors for monitoring. It was added that the importance of smart farming was growing, due to increasing global population and demand for higher crop yield, by using natural resources efficiently and sustainably. Presence of sophisticated information and communication technology offers the possibility of this development at the era of increasing need for climate-smart agriculture.

Kim, Lee, & Kim (2020) in their article titled "A Review of the Applications of the Internet of Things (IoT) for Agricultural Automation"described the benefits of the of modern Information and Communication Technologies (ICT) into agriculture. According to the author, the applications of capital-intensive and hi-tech system to smart, precision farming was increasing operational efficiency accompanied by lower costs, reduced waste, and higher yield quality. Obviously, the capability of monitoring light, humidity, temperature, soil moisture, etc. and automating the irrigation system offers very efficient water economy. It was added that this modern approach was not only applicable to conventional, large farming operations, but to other growing or common trends like organic farming, family farming performed at complex or small spaces, particular cattle and/or cultures, preservation of particular or high-quality varieties, etc. Another advantage of the method would be enhancing transparency of farming business.

Food and Agriculture Organization of United Nations (FAO) cooperated with International Atomic Energy Association (IAEA) for development of methods and techniques using stable isotopes such as $N^{15,}$ C^{13} and necessary equipment, consumables for smart farming, smart agriculture applying intelligent operations (IAEA, 2020). The list given there covered IoT sensors and actuators for soil scanning and water, light, humidity and temperature management; telecommunications technologies such as advanced networking and geo-positioning systems (GPS), hardware and software for specialized applications and for enabling IoT-based solutions, robotics and automation, data analytics tools devices such as precision equipment, unmanned aerial vehicles (UAVs) and robots for decision making and prediction of the quantitative data collected on the weather data and changes of climate, crop yields, properties of soils, fertilizer applications, machinery and animal health etc. As seen clearly, the need for capital investment, financing operation and hiring operation, maintenance specialists are high. Additionally, it is obvious that the necessary infrastructure is not available everywhere.

IAEA mentions that satellites and drones could also be used for gathering data for entire field and forwarded to IT systems for tracking and analysis also in order to reduce overall costs, improve the quality and quantity of products, the sustainability of profitable agriculture and waste reduction, careful management of the demand forecast and delivery of goods to market in time to reduce value loss and waste. It was added that precision agriculture was concentrating on the right growing parameters to provide the right crop that was in demand. In the section of the article on the future of

smart, IoT-driven farming, which is also named as "third green revolution,"referring to the combined application of information and communications technologies. It can be noted here that, there is one overlooked, neglected problem called global warming related climate changes and the related risk management solutions. The only topic related with global warming and related climate changes by IAEA was decreasing impact of agricultural activities on greenhouse gas emissions by smart agricultural practices.

Although excessive growing of global ecological footprint is closely related with technological advancements accompanied with exploiting natural resources and polluting environment, it seems that the solutions to the environmental problems will also be offered by development of sustainable, green technologies (**Shaikh**, 2017). As he said, "Green technologies have a promising future in meeting the needs of economic sustainability. But, environmental and social sustainability factors need to be reinforced in a mutual manner.". One way to achive this goal may be using the integration of the results of studies obtained in different disciplines, and the success obtained by utilizing the possibilities offered by the AI for early diagnosis of cancer is a good example (Huang, Yang, Fong *et al.* 2020). The researchers said that developments in statistics and computer engineering had encouraged scientists to apply computational multivariate statistical analysis to analyze the prognosis of the disease in order to increase the accuracy of diagnosis depending on empirical predictions significantly. They added that with the applications of AI, especially machine learning and deep learning in clinical cancer research, cancer prediction performance had reached new heights. Their review article aimed to present advantages of the application of AI to cancer diagnosis and prognosis, and summarizing its advantages, specifically with regard to its unprecedented accuracy, which was even higher than that of general statistical applications in oncology.

Frankfield, J. (2020) described AI as "The simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. The term may also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving.", and added that its ideal characteristic was its ability to rationalize and take actions to have the best chance of achieving a specific goal, by learning, reasoning, and perception. The author too, stressed the achievements in the healthcare industry for dosing drugs and different treatment in patients, and for surgical procedures in the operating room, and added that AI was continuously evolving to benefit many different industries. The examples given were self-driving cars, detect and flag activity in banking and finance, making trading easier by making supply, demand, and pricing of securities easier to estimate, agricultural production was not mentioned at all.

Talaviya, Shah, Patel *et al.* (2020) attracted attention to the growing supply and demand problem in agriculture sectors, and described the new automated methods as the solution of satisfaction the food requirements and provision of employment opportunities to billions of people in their review article. They added that AI technology could protect the crop yield from various factors like the climate changes, population growth, employment issues and the food security problems, referring to the projection published by UN, which was claiming that 2/3rd of world's population would be living in urban areas by 2050. The authors stated that AI would be needed to lessen the burden on the farmers by automating several processes, reducing risks and providing farmers comparatively easier and more efficient farming. They presented the main concern of their study as to audit the various

applications of AI in agriculture, such as for irrigation, weeding, spraying with the help of sensors and other means embedded in robots and drones, to save the excess use of water, pesticides, herbicides, maintaining soil fertility, increasing the efficiency of man power, elevating productivity and improving the quality of the products. They also covered the weeding systems through the robots and drones, various soil water sensing methods along with automated weeding techniques, using drones for spraying and crop-monitoring, and added that the least digitalized agriculture sector would gain momentum for the development and commercialization of agricultural technologies. They referred to a study showing that AI was based on the vast domains like Biology, Linguistics, Computer Science, Mathematics, Psychology and Engineering, and attracted attention to the potential contribution to rural development, also referred to another report on a proposed system for flower and leaf identification and watering by using IOT. The AI-based technologies were helping to improve efficiency in all the fields, and managing the challenges faced by various fields in the agricultural sector like the crop yield, irrigation, soil content sensing, crop-monitoring, weeding, crop establishment. Talaviya *et al.* (2020) added that technological solutions already enabled the farmers to have more and improved the quality of output with less input, also ensured faster delivery; they also presented a projection predicting that farmers would be using 75 million connected devices, and an average farm would generate an average of 4.1 million data points every day by 2050.

Nelson, Valin, Sands *et al.*(2014), on the other hand, approached to the current problems by looking from different perspectives in their comprehensive review article titled "Climate Change Effects on Agriculture: Economic Responses to Biophysical Shocks"and explained the significance of the topic by indicating the presence of plausible estimates of climate change impacts on agriculture, which required integrated use of climate, crop, and economic models. They investigated the contribution of economic models to uncertainty in the impact chain by using nine economic models, which included the direction of management intensity, area, consumption, and international trade responses to harmonize crop yield shocks from climate change. They added that, as the magnitudes were differing significantly, the magnitude of differences depended on model structure, particularly to the specification of endogenous yield effects, land use change, and propensity to trade.

Nelson *et al.* (2014) criticised the results obtained by the previous studies for the substantial variations in models, scenarios, and data used; described their approach as a part of a collective effort to systematically integrate three types of models. Considering the definition of meta-analysis, it can be stated that their approach was meta-analytical; meta-analysis is defined as a quantitative statistical analysis of several separate but similar experiments or studies in order to test the pooled data for statistical significance since 1976 (Merriam-Webster, 2020). They focussed on the economic component of the assessment, investigating endogenous responses of nine global economic models of agriculture representing seven standardized climate change scenarios produced by two climate and five crop models which included adjustments in yields, area, consumption, and international trade. Parameters such as biophysical shocks derived from the IPCC's representative CO_2 concentration pathway, mean biophysical yield effect with no incremental fertilization would be a 17% reduction globally by 2050, relative to a scenario with unchanging climate were used. Endogenous economic responses were found to reduce yield up to 11%, increase area of major crops by 11%, and reduce consumption by 3%. Agricultural production, cropland area, trade, and prices

would show the greatest degree of variability in response to climate change, and consumption show the lowest. The sources of the differences included model structure and specification, disagreements were on the relative responses to climate shocks, so Nelson *et al.*(2014) drew attention to the need of research activities to improve the representation of agricultural adaptation responses to climate changes. As it can be clearly seen from their conclusion, there is a need for understanding the details of the adaptation and resistance mechanisms of living organisms to changing abiotic and biotic environmental conditions within a wide range of population complexity.

Although, one of the solutions offered by biotechnological inventions is using seeds of genetically modified organisms (GMOs), this approach created some moral and legal problems, as Bouchie (2002), for instance, wrote on the topic approximately two decades ago. Lo (2013) published an article titled "Monsanto Bullies Small Farmers Over Planting Harvested GMO Seeds", and Peschard, (2019) reported recently that **Monsanto won $7.7 billion lawsuit in Brazil, but farmers' were determined to continue fighting to stop its 'amoral' royalty system.** More recent and attractive biotechnological innovative development, is genetical modification by using CRISPR-Cas method, Barrangou (2015), for instance, wrote on the roles of CRISPR-Cas systems in adaptive immunity and beyond to stress the prospective potential of the technique, and Cai, Chen, Liu *et al.* (2017) reported another success of CRISPR/Cas9-mediated targeted mutagenesis in delaying flowering time in soya bean. There are much more examples of course, but Cohen (2020) on the other hand, drew attention to the legal problems arised recently in the articled titled "The Latest Round in the CRISPR Patent Battle has an Apparent Victor, But the Fight Continues".

As very well known, independent from complexity, autotrophs are the starting point of ecosystems, and their sustainability depends on the adaptation and resistance mechanisms of their primary producer members. This is the reason of the increasing interest of researchers on plant ecophysiology, and focusing on physiological mechanisms of survival under global warming and related changes in climate. Acclimation as well as adaptation, tolerance and resistance can be defined as the ability of organisms to cope with stress, either natural such as temperature changes, salinity variations, oxygen level fluctuations, and plant toxins, or chemicals depending on anthropogenic inputs of many different classes of contaminants into the environment. Biagianti-Risbourg, Paris-Palacios & Mouneyrac (2013) defined **acclimation** or physiological **adaptation** as the second phase of stress, and referred to numerous papers defining **adaptation a**s synonymous of **resistance,** the word that was frequently used in the scientific literature as a synonym for **tolerance**. They mentioned that several authors had tried to clarify these terms, but none of the proposed terms had been adopted generally. Here, the terms defined by Biagianti-Risbourg *et al.* (2013) will be used: "Acclimation as well as adaptation, resistance, or tolerance can be defined as the ability of organisms to cope with stress, either natural such as temperature changes, salinity variations, oxygen level fluctuations, and plant toxins or chemicals depending on anthropogenic inputs of many different classes of contaminants into the environment." complementary to the expression "Considering the fact that autotrophs or primary producers are the sources of energy to lotic food webs by acquiring their energy from sunlight and materials from nonliving sources, such as some bacteria and protists, algae and higher plants, their coping mechanisms to stresses should be considered as the vital ones."(Allan & Castillo, 2007).

The title of the chapter written by Surowka, Rapacs & Janowiak (2020) is "Climate Change Influences the Interactive Effects of the Simultaneous Impact of Abiotic and Biotic Stresses on Plants"is

reflecting the framework of their study on the influence mechanisms covering alteration of habitats, changing the natural conditions affecting organisms and functioning of ecosystems. The influences of changes in climatic conditions on the members of fauna can be appended to their list; as a matter of fact, they covered the topics "meta-organism" and "holobiont"in their text, and stressed the importance of integral approach to all communities. They focussed on microbiota and plants, and attracted attention to the differences in combined effects of randomly interacting several natural abiotic and biotic stress factors in the fields and the controlled laboratory conditions. Such differences might lead to changes of strategies adopted by plants to susceptibility or tolerance through modifying the primary and secondary metabolisms; changes in nutrient availability, nutrition and their metabolism would cause deviations in C and N metabolisms and C/N ratio.

Dubey, Kumar, Mohammad *et al.* (2020) reminded that *Fabaceae* family members were important for sustainable agriculture and human health due to their high protein content and maintaining the nitrogen economy of the soil, especially in semi-arid and arid regions at global warming era. Therefore, they attracted attention to the need of an integral approach and identification of physiological and biochemical traits that could contribute to enhancement of legumes growth and productivity under stress conditions, which was a major challenge for the plant breeders and geneticists. Although the application of biostimulants/biofertilizers have emerged as eco-friendly solutions for tackling these problems, they said, diverse substances and microorganisms were defined as biostimulants, such as Plant- Growth-Promoting Rhizobacteria (PGPR), bacterial and fungal endophytes or endosymbionts, which were enhancing plant growth and productivity, nutrition use efficiency (NUE) and plant performance under stress conditions. Thus, they added, such microbial bioinoculants were playing a dual role as biostimulant and biocontrol agent, so theh said, global market for them had reached up to $2,200 million by 2018, with particular reference to *Fabaceae* family, but still lacking peer-reviewed scientific evaluation. So, they aimed to provide latest advances in the application of plant biostimulants and scientific information related to the nature, mechanism of action and effects of biostimulants on *Fabaceae* spp. under abiotic stress conditions.

As a matter of fact, Stepanova, Yun, Likhacheva *et al.*, (2007) for instance, attracted attention to the central role of hormones in the coordination of internal developmental processes with environmental signals. They added that a combination of physiological, genetic, cellular, and whole-genome expression profiling approaches had been employed in their study to investigate the mechanisms of interaction between two key plant hormones: ethylene and auxin. They presented results obtained by quantification of morphological effects of ethylene and auxin hormones in a variety of mutants, which indicated that auxin biosynthesis, transport, signaling, and response were required for the ethylene-induced growth inhibition in roots, but not in hypocotyls of dark-grown seedlings. Analysis of the activation of early auxin and ethylene responses at the cellular level, and global changes in gene expression in the wild type versus auxin and ethylene mutants which lead to a simple mechanistic model for the interaction between those hormones in roots. They concluded that ethylene and auxin could reciprocally regulate each other's biosyntheses. They were affecting each other's response pathways, and/or act independently on the same target genes.

Salazar, Hernández & Pino (2015) referred to the article by Netting (2000), who reviewed the literature to compare stressed and non-stressed plant metabolisms to reveal the interrelationship between pH, abscisic acid (ABA) and integration of metabolism in stress and normal conditions. Netting had evaluated cellular responses to stress and their implication for plant water relations and concluded

that actively controlled physiological changes under stress conditions were leading to increase WUE and water storage in order to increase tolerance and preparation for water transport and use at cellular level by physiological and biochemical changes. Salazar *et al.* (2015) reminded in their excellent article that agriculture was severely impacted by water stress due either to excess (hypoxia/anoxia) or deficit of water availability. Hypoxia/anoxia was associated with oxygen (O_2) deficiency or depletion, inducing several anatomical, morphological, physiological, and molecular changes related with adaptation, such as changes in shoot length, aerenchyma and adventitious roots formations. They focussed on the role of association between ABA and ethylene in the major physiological responses to decreasing O_2 level and root respiration, stomatal conductance, photosynthesis, fermentation pathways in roots, changes in gene expression. The expression of ethylene receptor genes were affected, and ethylene seemed to have a crucial role in anatomical and physiological effects during hypoxia/anoxia. Ethylene accumulation was inhibiting ABA biosynthesis enzymes and also activating ABA breakdown to phaseic acid. Drought was primarily sensed by the roots, which were inducing a signal translocated to shoots triggering physiological and morphological changes. They added that several genes were regulated by osmotic stress through ABA-dependent or ABA-independent pathways; some previous studies had suggested a sharp cease in leaf growth by ethylene, and also antagonization of the control of gas exchange and leaf growth upon drought by its own and ABA accumulation.

Another important physiological mechanism that take part in water stress adaptation and response are the relations between some hormones and enzymes. Ullah, Manghwar, Shaban *et al.* (2018) reviewed the literature on the topic, and after mentioning the importance of understanding the mechanism of drought tolerance in enhancing acclimation, they also attracted attention to the role of phytohormones. After mentioning ABA as the main hormone intensifying drought tolerance through various morpho-physiological and molecular processes including stomata regulation, root development, and initiation of ABA-dependent pathways, they added jasmonic acid (JA), salicylic acid (SA), ethylene (ET), auxins (IAA), gibberellins (GAs), cytokinins (CKs), and brassinosteroids (BRs) as the other very important phytohormones in congregating the challenges of drought stress in their comprehensive article. Their conclusion can also be taken as another invitation to integral approaches to find efficient solutions to complicated problems.

Duque, Almeida, Silva, *et al.* (2013) referred to some articles which described the phases of physiological responses to abiotic stresses. They described the sequence as a functional decline in the alarm: stress reaction, resistance, exhaustion and regeneration phases, which could occur only if the damage was not too severe. Sensing was the first and a very complex issue, covering multiple and variable mechanisms. common to all stresses. They exemplified by some stresses directly affecting the underground parts of plant bodies, such as drought, flooding, and others like photoinbition affecting directly the aboveground structures to the necessity of having different sensing mechanisms. The researchers mentioned the most common model of sensing external stimuli, binding a ligand to a specific receptor, and added that it was suitable only for chemical stresses, such as nutrient depletion stress, not for physical stresses related with temperature and others. They also referred to experimental evidences reported pointing to the possibility of sensing cell water homeostasis, depending on isolation of a transmembrane hybride-type histidine kinase from *Arabidopsis thaliana* acting as osmosensors. Level of sugars generated by photosynthesis was given as another example, playing an important role in sensing and signaling, modulating stress responses and also growth and development through changing the source and sink tissues. Sensing was

followed by one or more signaling and activation of signaling transduction cascades, preparing restitution counter reactions which would lead to resistance development, accompanied by functional declines of photosynthetic performance, transport or accumulation of metabolites and/or uptake and translocation of ions, which could lead to acute damage and death.

Duque *et al.* (2013) also covered the literature on restitution of counter reactions in their article, and attracted attention to the results showing the importance of the rate of stress imposition, more pronounced decline of physiological functions at higher dehydration rates. High rates, they said, could at least partly be related to the increased production of active oxygen species (AOS), and referred to the finding in the C_4 grass *Setaria sphacelata,* showing a decrease in the key enzyme of C_4 photosynthesis, phosphoenolpyruvate carboxylase (PEP carboxylase) after several days of water stres; but, observation of several-fold increase of its activity after a short period of acute stress.

Raza, Ashraf, Zou *et al.* (2020) also reviewed the literature on mechanisms and perspectives of plant adaptation and tolerance to environmental stresses. They covered a wide range of stresses from waterlogging, drought and salinity to chilling, freezing and high temperature, and also elevated CO_2 as the factors affecting plant and crop physiology. They also stressed the importance of differentiation of responses to single and multiple stresses, and drew attention to the variable responses at cellular, physiological and transcriptional level. Histological and anatomical responses can be added to their list, and a very similar complexity can be mentioned here: aging, senescence and programmed cell death processes also cover focussed processes transcriptional, translational, physiological changes in the cells, tissues and organs, as Woo, Masclaux-Daubresse & Lim (2018) discussed. Different physiological and biochemical processes are very well known to be altered by drought, such as water relations, gas exchange, photosynthesis and the metabolism of carbohydrates, proteins, amino acids and other organic compounds. The effects of drought on plant growth, gas exchange, water relation and osmoregulation have been widely studied for a long time as reviewed by Anjum, Xie, Wang, *et al.*(2011).

Feller & Vaseva (2014) also reviewed the literature on physiological impacts of drought and high temperature, but they covered agronomically important plants. They stressed the importance of stomatal control, which could lead to permanent closure of some of them by waxy deposits, and irreversible drop in photosynthesis rate at stressed leaves. Heat sensitivity of Rubisco activase enzyme of genera, spp. and cv.s might also become a limiting factor for photosynthesis. In addition to these effects, accumulation of reactive oxygen species (ROS) and partial conversion of free amino acids into compatible solutes such as proline, and accompanying lower rates of both nitrate reduction and de novo amino acid biosynthesis were typical developments. Induction of proteins such as dehydrins, chaperones, antioxidant enzymes and the key enzyme for proline biosynthesis were playing an important role as protective mechanisms in leaves. The effects of long-distance translocation of the solutes related with development of leaf senescence were also important. The researchers concluded that such factors were relevant for the overall performance under drought and heat, and should be considered for genotype selection and breeding programs.

Jalil & Ansari (2020) reviewed the literature on plant stresses and their implications on crop productivity, they were right to include the stresses of pesticides and toxic metals in the list of abiotic stresses. Obviously some other chemical and physical stresses can be added to the list here, such as dust pollution (Sett, 2017), combined air pollutants (Papazian & Blande, 2018), and toxic organic soil

pollutants (Copaciu, Opris, Ninemets *et al.* 2016). Jalil *et al.* (2020) claimed that plant yield was affected primarily by insufficient water availability or diminished nutrient uptake. As a matter of fact, it is known since eightees that low soil potentials were depressing nutrient uptake by roots, and also subsequent translocation upwards until their adaptation (Shone & Flott, 1983), if they do not reach to *permanent wilting* point (PWP) under the stress of course. They found that rapid growth of nodal roots assisted by osmotic adjustment might be related to adaptive development to ensure resumption of nutrient and water uptake following the stres period. Ahanger, Morad-Talab, Abd-Allah *et al.* (2016), stressed the importance of proper supplementation of mineral elements to crop plants, which could contribute to avoid drought stress through their active participation in several defence mechanisms like osmoregulation and antioxidant systems. They added that the level of knowledge on this important subject was far away from understanding the impact of drought stress on plant mineral nutrition, although developing useful strategies that could be adopted to mitigation of the damage caused by the drought and consequent nutrient deficiency. The researchers reminded that although the deficiency of macronutrients could be readily observed and targeted, micronutrients might directly or indirectly affect the susceptibility of plants to stress factors via changing enzyme activity, modulating the signal transduction pathways and/or producing some metabolites that could not be observed easily. It may be meaningful to mention here that some micronutrients are involved in the metabolism of plant growth hormones, as the prosthetic groups of key enzymes. They are cofactors that bind tightly to proteins by a covalent bond, capable of binding the same substrate to different enzymes. As also known very well, micronutrients can also bind to some enzymes loosely, as a coenzyme, (Silva, Nogueira, Silva (2010).

Van Overbeek (1956) reviewed the physiological, practical and economical aspects of PGRs in his comprehensive article entitled "Agricultural Application of Plant Growth Regulators and Their Physiological Basis". The popularity and wide use of synthetic hormones in agricultural production was examplified and explained in terms of competitive pricing of their formulations, as it would be expected, as a matter of fact, the first subtitle of the article was Economical Aspects. His assessment was quite normal in fiftees, when the Father of Green Revolution era, Norman E Borlaug received the Nobel Peace Prize in 1970 for his work increasing crop yield and preventing hunger, or as called, Malthusian tragedy in developing countries (Muhanta, R. K. 2009). As known very well, publication of the book Silent Spring by R. Carson in 1962 triggered an environmental movement, as Taylor, P. (2016) used as the title of the article on this milestone of environmental history timeline. As he put it, "Silent Spring triggered an environmental movement" and described the triggering as "such we have known the toxic effects of chemical agriculture, basically from the very beginning. We have suffered both massive environmental damage, disease and pest resistance, and human health issues."

An earlier, less known movement actually targeting sustainability with a broader perspective was International Commission on Irrigation and Canals (ICID), which was established on 24 June 1950 by 11 founder developing countries; the aim was expressed as "Being a leading scientific, technical, and professional not-for-profit international organization working in the field of irrigation, drainage and flood management to promote and achieve sustainable agriculture water management."(International Commission on Irrigation & Drainage - ICID). This, not very well known international commission of countries from Africa and Asia, located at the center in Delhi, published an article titled Second Green Revolution (ICID, 2020). After referring to the beginning of the Green Revolution attributed to N. Borlaug, in the 1940s in Mexico depending on newly developed disease resistant high-yield wheat varieties combined with new mechanized agricultural

technologies, which enabling Mexico to export wheat instead of importing half of the wheat consumed in 1960s, it was noted in the article that the Green Revolution in Mexico spread worldwide, due to this success.

Basic ingredients of this revolution was attributed to High Yielding Variety (HYV) seeds with superior genetics, use of chemicals-pesticides and fertilizers and multiple cropping system supported by the use of modern farm machinery and proper irrigation system in addition to expansion of farming areas accompanied with changes in the thinking of farmers, rural development, trade and the surplus which supported development of industries.
It was added by ICID that, when world started to realize the environmental challenges, a framework for the Second Green Revolution (SGR) aligning itself with the sustainable development principles had been articulated and comprehended to cover the regions such the African Continent and and Southern part of Asia, putting emphasis on small and marginal farmers. Increasing their production sustainably by applying integrated programmes taking care of all aspects of agriculture from soil characteristics, matching seeds, grains, conversion to food and its marketing after value addition were the goals. As a network of Agriculture Water Management professionals, it was declared that they would make a substantial contribution towards sustainable rural development in underdeveloped and developing regions by articulating how irrigation and drainage could make second green revolution a realty.

Research Center on Local and Traditional Knowledge– IPOGEA.(2017) and Traditional Knowledge Focus Group (AFCD, 2014) are also examples of scientific institutions focusing on the traditional sustainable ecosystem management and production methods, techniques. As a matter of fact, the related Article 19 of Chapter 12 of UNCCD Agenda 21 accepted in 1992 (UNCCD- UN, 2017) noted that governments, with the support of the relevant international and regional organizations, should develop land-use models based on local practices for the improvement of such practices, with a focus on preventing land degradation. Models should incorporate the interaction of both new and traditional practices to prevent land degradation and reflect the resilience of the whole ecological and social system. A very recent example has been reported by **Kloppers** (2020) under the title of "A small indigenous group offers an example of how to save the world", telling how Gumbi clan living in northern KwaZulu-Natal conserved the world's third most biodiverse hotspot, which had lost more than 18% of natural habitat and nearly 50% of terrestrial ecosystems were threatened, by the method named as "sharing life with nature". They had to restore 20,000 ha. of land degraded by overgrazing and abondoned and marginally suited for agriculture in the 1960's. Meli, Rey-Benayas & Brancalion (2019) wrote an article on scientific approaches to land sharing/sparing in order to discuss the way of thinking to reach decisions promising success. They discussed four questions consisting of the main focuses of restorative interventions, which restorative interventions should be implemented where; and the major factors influencing restoration outcomes. They recommended careful planning to minimize trade-offs to maximize synergies, consideration of the spatial distribution and configuration of the final land uses with its social context to find the right balance between land sharing/sparing approaches.

Leff, **Bardgett** & **Wilkinson** (2018) reminded the presence of some knowledge on the numerous ways on the influence of plants on the composition of soil communities, ans draw attention to the lack of clear information on plant community attributes could be used to predict the structure of soil communities. They performed tests in both monocultures and field-grown mixed temperate

grassland communities to see whether plant attributes predict soil communities including taxonomic groups from across the tree of life covering fungi, bacteria, protists, and metazoa. The composition of all soil community groups was affected by plant species identity, both in monocultures and in mixed communities. Moreover, they said, plant community composition predicted additional variation in soil community composition beyond what could be predicted from soil abiotic characteristics. Analysis of the field for aboveground plant community and the plant roots compositions suggested that plant community attributes were better predictors of soil communities than root distributions. However, neither plant phylogeny nor plant traits were strong predictors of soil communities in either experiment. They concluded that grassland plant species were forming specific associations with soil community members and that information on plant species distributions could be used to improve predictions of soil community composition; such specific associations between plant species and complex soil communities were key determinants of biodiversity patterns in grassland soils.

Such findings have certainly lead to changes in the paradigms and inevitably affected the approaches to agricultural practices and the use of PGRs and other agricultural inputs. Hasnain, Bakhsh, Hussain et al. (2020) for instance, aimed to highlight the impact of the most popular synthetic auxin, naphthalene acetic acid (NAA) applications with some irrigation regimes on the productivity of coarse rice under agro-ecological conditions. Their field experiment was comprised of two factors with four levels (0, 60, 90, 120 mL ha-1) of NAA and irrigation at the depths (60, 75, 90 and 105 cm) of soil profile. The data was interpreted to observe the changes in plant height (cm), productive tillers (m^{-2}), sterility percentage (%), biological yield (t ha^{-1}), and grain yield (t ha^{-1}). The benefit cost ratio (BCR) was also calculated, and their results indicated the effectivity of NAA in improving paddy yield and better BCR value. The maximum yield was attained at NAA 90 mL ha^{-1} at 75 cm irrigation depth, the increase in grain yield ensured better economic returns. Several other positive effects at various applications of this synthetic auxin and its derivatives have been known since fiftees and no adverse effects of NAA and several derivatives were found by U.S. EPA in 20th century (U.S. EPA, 2004).

Hac-Wydro and Flasinski (2015) on the other hand, studied on membrane-damage effect of indole-3-acetic acid- IAA and 1-naphthaleneacetic acid-NAA PGRs on *Arabidopsis thaliana* and animal (rat liver) model membranes, considering their widely use in agriculture to control the quality of the crop. However, they said their accumulation in the environment made them hazardous for the living organisms and investigated to compare the effect of natural (IAA) vs. synthetic (NAA) auxin on the organization of plant and animal model membranes, and searched for a possible correlation between membrane-disturbing effect of these compounds and their toxicity. They evidenced that auxins caused destabilization of membranes, decreased their condensation and weakened interactions of molecules. The alterations in the morphology of model systems were seen and as expected the effects were concentration-dependent. NAA was found to act on animal vs. plant membranes more selectively than IAA, both induced the strongest disordering in model lipid system at the concentration, which was frequently reported as toxic to animal and plants. They proposed that membrane-damage effect might be important in the mechanism of toxicity and should not be ignored in further investigations, as per the rules of the "Green Revolution 2" in agricultural production.

Shifeng, Yanming , Xiao, *et al.* (2014) also attracted attention to the the hazards that had brought along with the PGRs to food safety and human health, increasingly becoming the focus of world attention. They studied on controlled release formulations (CRFs) in overcoming the drawbacks of conventional

PGRs formulations by allowing usage of minimum amount of PGRs for the same activity. They prepared a controlled-release formulation of NAA and indole-3-butyric acid (IBA) by using a characterized synthetic nanohybrid material and studied their release kinetics . They found that nanohybrids of NAA and IBA simultaneously intercalated in LDHs possessed good controlled release properties, and added that the environmentalist concerns related with accumulation of residues of persistent organic chemicals or their derivatives forming in the environment had been leading the researchers to search for *more eco-friendly alternatives.* Pal, C., Dey,C., Kumar, S. *et al.* (2007), on the other hand, aimed to synthetise and introduce an eco-friendly PGR group and succeeded to obtain 3,3-Diindolylmethane and its derivatives, which were also tested for their PGR activities by them. But, this bioactive compound group derived from cruciferous vegetables such as broccoli, cauliflower, kale, cabbage, brussels sprouts, turnips, kohlrabi, bok choy, and radishes (Maruthanila, Poornima & Mirunalini, 2014) have been and are widely used for their anticancer potential (Isabella, 2016), not for agricultural practice.

Westfall, Muehler & Jez, (2013) are also in the group of research teams who have reviewed the enzyme actions in the regulation of plant hormone responses; they exemplified the contribution of amino acid metabolism to the synthesis of ethylene, auxin, and salicylic acid (SA), stimulation of ethylene production, by cyclization of *S*-adenosyl-L-methionine (AdoMet) into 1-aminocyclopropane-1-carboxylic acid (ACC) by ACC synthase and subsequent oxidation into ethylene by ACC oxidase, and regulation of ACC synthase, which was controlling ethylene production. Aromatic amino acids were precursors of auxins and salicylic acid (SA) synthesis, biosynthesis of indole-3-acetic acid (IAA) auxin from tryptophan was catalyzed by tryptophan aminotransferase and YUCCA flavin monooxygenase. YUCCA (YUC) flavin-containing monooxygenases (FMOs), which were catalyzing a rate-limiting step in auxin biosynthesis and that YUCs were essential for many developmental processes. Maintenance of bioactive IAA levels were required a balance of synthesis, storage, degradation, transport, and modification. SA was playing a critical role in plant responses to biotrophic pathogens, and SA synthesis required chorismate amino acid as the processor. Hanafy, Khalil., Ei-Rahman *et al.*(2012) showed the relations between the IAA synthesis processor tryptophane, Zn trace element and IAA levels once more at field studies on orange trees. As pointed out by them, plants were undergoing several physiological and biochemical changes in response to stress, such as changes in relative water content, photosynthesis, metabolism of carbohydrates, proteins, amino acids and enzyme activity.

Hassan, Aamer, Chattha *el al.* (2020) reviewed the effects of drought stress on plant physiological and biochemical processes, also affecting stomatal conductance, which was increasing leaf temperature, decreasing plant growth, development and crop productivity. They mentioned the changes in membrane permeability, nutrient uptake and chlorophyll and assimilation. They added that there were some management approaches that could provide quick solutions to this problem, such as understanding the role of nutrition on drought tolerance, and exemplify the role of zinc, although they said its role in plant growth and development under normal conditions was well understood, conversely its role in drought tolerance was poorly understood. Zn was an important component of carbonic anhydrase and a stimulator of aldolase, which were involved in carbon metabolism, an integral component of several biomolecules such as lipids, proteins and co-factor of auxins; therefore, it was playing an important role in plant nucleic acid metabolism. However, there was lack of information regarding Zn-induced mechanisms conferring drought tolerance in plants. Therefore,

they said the review would address different effects of drought stress on plants and show the pending research gaps in plant physiological, biochemical and molecular aspects and Zn cross talk with other molecules in Zn-induced drought stress tolerance. They also supported the literature claiming that the hormones were playing a role of paramount relevance in regulating several plant processes and ABA was the most prominent plant hormone in response to water deficit conditions. They added that it was primarily synthesized in the vascular system, and transported to the target tissues by xylem and phloem, permitting bi-directional transport between roots and shoots.

However, Hassan, *et al.* (2020) said, under drought stress, pH was significantly increasing in the apoplast, and ceasing ABA translocation. ABA was known to serve as a root-to-shoot signal reducing transpiration by inducing embryogenesis abundant (LEA) proteins accumulation and consequent plant adaptation to drought. So, this decrease in ABA translocation was accompanied by a rapid reduction of cytokinin and gibberellin levels; as cytokinins were delaying leaf senescence, and improving plant resilience under drought stress, this development was meaning a loss in resilience against drought stress. They added that plants were accumulating various substances including proteins and amino acids in response to drought stress, and altering, generally decreasing the amount of proteins; increasing the accumulation of osmolytes as proline by increasing its synthesis or by reducing the activities of degrading enzymes. Its and other osmolytes accumulation were reducing cell water potential, and increasing WUE, and protection of delicate cell components from oxidative stres. Proline biosynthesis was playing a vital role in the energy balance between chloroplasts and mitochondria; in conclusion, they said drought was disrupting various physiological, biochemical and molecular processes determining reductions in growth, yield and quality. Zinc availability, uptake and transport mechanisms were one group of the key parameters involved in the related developments in adaptation and acclimation success of plants, which were reviewed thoroughly in the comprehensive review article by Hassan, *el al.* (2020).
Plants possessing the ability to acquire and retain more water have high WUE, and can withstand drought conditions better than the others; however, response of plants to drought stress largely depended on the severity of drought, as well as the growth stage of plant, according to Medrano, Tomas, Flexas *et al.* (2015). They drew attention to the measurement of WUE at leaves by portable instruments measuring leaf gas exchange rates and displaying the values related with photosynthesis and transpiration, which might or not reflect the daily integrals or whole plant status. They considered the results of the tests on grapevines were showing the worse part of the discrepancy, and the lowest correlations found in midday measurements, when the water stress was reaching a peak. So, they sought to evaluate the importance of spatial and temporal variation in carbon and water balances at the leaf and plant levels. The results showed them that the position of the leaves, that were governing average light interception in the canopy, showed a marked effect on instantaneous and daily integrals of leaf WUE. They also evaluated night transpiration and respiration rates and contribution of respiration values to total carbon balance. This approach enabled them to identify two main components, which were removing the discrepancy between leaf and whole plant WUE affecting daily carbon gain and water loss, and leading to the large flux of carbon losses by dark respiration. Their practically very important conclusion was the need to revise the WUE evaluations among genotypes or treatments.

As Silva, Nogueira & Silva (2010) also mentioned, under drought conditions nutrient uptake was impaired as a result of reduced soil moisture, which was leading to decrease in the soil nutrient

availability and translocation from roots to the shoots and leaves; decrease in transpiration rate created an imbalance in active transport and membrane permeability. They added that the inevitable changes in different physiological processes needed to be understood as much as possible, in order to develop better management strategies to cope with drought stress and consequent nutrient deficiency.

As all of the stresses, plant response to water stress is known to depend mainly on the severity and duration of the stress and the growth stage of the plant, but its management is closely related with the physical and chemical properties of the soil (Geng, Yan, Zhang, *et al*., 2015). Their approach to address the question was different, they designed experiments with maize to identify changing tendencies of microbial biomass carbon content and the proportion of microbial biomass carbon in soil organic carbon under different drought conditions by measuring the content of microbial biomass carbon. They collected soil samples about 10 cm far away from the rhizosphere of the maize, and measured microbial carbon quantities to identify effects of extreme drought on agriculture soil ecosystem. They showed that the optimum mass water content of soil for microbial biomass carbon was 19.5 %, and the demarcation point of microbial biomass carbon to drought was 14.3 %, which could be used to demonstrate alters and degradation of soil ecosystem and the irrigation requirement of crops. The researchers also evaluated sustainability of different drought soil ecosystems after rainstorm with rehabilitation, and found that soil ecosystem could recover after interfered by moderate drought; its tolerance to drought, in terms of its function and activity were also improved. They added that soil systems could not adapt to severe drought stress, could barely recover and restore from extreme drought within a few days with their damaged function and structure. Their conclusion was related with the mass water content of soil, it should be kept above 10 % to maintain soil system function and structure, and these soil ecosystem should be watered when mass water content was lower than 14.3 %, which provided reference for improving the soil to increase the grain output. Actually similar decrease in soil fertility is known to occur following erosion, eroded and transferred soils lose their fertility to some extent (Zhao, Shao, Omran *et al*., 2011).

It must be mentioned here that, optimization of such plant-soil-water-nutrition relations at field conditions is not as easy as it seems; as a matter of fact, Fahad, Bajwa , Nazir *et al.* (2017) provided a detailed account of plant responses to heat and drought stresses with special focus on highlighting the number of commonalities and differences in their review article. They also attracted attention to the level of the complexity involved, and stated that only a holistic approach taking the different management options into account could deal with heat and drought stress simultaneously could offer a win-win approach in future. Their aim was described as covering conventional and modern management strategies, and presenting a critical discussion on salient responses to them. They referred to a study presenting the analysis of the global data covering studies published from 1980 to 2015, which showed up to 21% wheat and 40% yield loss in maize due to drought, and another report showing that global wheat production was simulated to decline by 6% for each ^{o}C rise in average temperature. They added that, in spite of the expectation of increase in crop production in some cooler regions overall impact of increasing temperatures on global food security would still be negative, and the severity of the damage was generally unpredictable, because of the complexity. But, earlier studies they referred showed them that impaired radiation use efficiency and decreased harvest index were the major yield reducing factors under limited supply of soil moisture. They also mentioned some earlier reports showing oxidative damages in addition to damages to protein metabolism and enzyme activities and cell membranes.

Fahad *et al.* (2017) added that the yield to be obtained was basically depending on the complex integration of different physiological processes, which were mostly affected negatively by drought stress. As known, and mentioned by them, the negative impacts of drought on the yield mainly depended upon the severity of the stress and the plant growth stage; drought at the pre-anthesis stage would shorten the time to anthesis, but after anthesis it would reduce the period of grain filling in cereals. So, they included evaluation of some studies on the enzymatic control of grain filling in cereals, which showed the role of four major enzymes; decreases in their activities under the drought conditions were leading to losses in the yield of major cereals. Another reference cited in their article was reporting that exposure to drought stress at the flowering stage was leading to complete sterility due to disturbed assimilate supply to the developing ear. The seed filling could be accelerated and would lead to poor quality and reduced yield. In short, the outcome was poor germination and stand establishment, scorching of the twigs and leaves with sunburn and senescence, floret sterility inhibited fruit growth. Depending on the development stage of cereals, adverse effects would vary with the timing, duration, and sternness of the heat stress. Inside a floret, anthers, and pollens were more susceptible to high temperature than ovules, and at ≥30°C could lead to reduction in the growth and net assimilation rate, consequent low biomass accumulation along with early leaf senescence.

Fahad *et al.* (2017) also presented some data on the drought induced reduction in the yields of some major field crops, and added that drought and heat stress were definitely causing significant reductions in growth. The extent of the damages were depending on growth stage and severity of the stress; generally higher sensitivity of reproductive phase was causing a substantial reduction in the yield. Drought stress was disturbing certain parameters including the leaf water potential (LWP), leaf and canopy temperature, transpiration rate, and especially stomatal conductance; low stomatal conductance was leading to increased the leaf and canopy temperature and WUE. Actually, as Reddy (2019) pointed out leaf water potential (LWP) was known as the indication of the whole plant water status, and maintenance of LWP at high values was found to be associated with dehydration avoidance mechanisms; so, Reddy suggested that its levels might be used as an easy and fast way to screen sorghum genotypes for drought avoidance.

Fahad *et al.*2017 also exemplified the importance of this parameter by referring to a report which indicated that higher WUE of drought resistance of wheat cv.s was mainly due to the decreased accumulation of the dry matter by the lower rate of transpiration through stomata. They added that this also greatly impacted the nutrient relations of the plants; since nutrients including N, Si, Mg, and Ca uptake was performed by diffusion and mass flow. They referred to another study showing that plants were trying to adapt by increasing the length and surface area of roots, changing their architecture into capturing such less mobile nutrients. Another study they referred was on the reduction of less mobile nutrients such as P at soil moisture deficit times by reducing growth of the roots. Although they did not mention in their excellent review, any retardation of root growth would lead to decrease in the synthesis and upward translocation of cytokinin hormones, which took part in regulating a variety of biological processes implicated in plant development and stress responses (Liu, Zhao & Zhang, 2019). As they put it, cytokinins (CKs) were mobile adenine derivatives, acting as chemical signals regulating a variety of biological processes implicated in plant development and stress responses by a complicated intracellular traffic, intercellular movement, and in short- and long-distance translocation. They were also serving as hormonal signals functioning in processes such as cell division and differentiation, seed germination, apical dominance, leaf senescence, root growth, branching and nodulation, nutrient homeostasis, and stress responses. The researchers referred to a

study which showed that CKs were synthesized in different cell types in both roots and shoots, and cross-talk with other phytohormones, particularly auxins, to regulate plant growth and development. This hormone group were also acting as chemical signals mediating both local and long-distance communications, and were transported between neighbour cells or translocated as acropetal and basipetal messengers in long distance between roots and shoots.

Ahmad, Jaleel, Salem, *et al.*(2010) reviewed another aspect of physiological developments related with abiotic stresses, changes in enzymatic and nonenzymatic antioxidants and their roles in adaptation and resistance. Reactive oxygen species (ROS) were produced in plants as byproducts even by photosynthesis and respiration processes, and their accumulation could lead to oxidative stress by creating an imbalance between the production of ROS and antioxidant defense. As ROS caused rapid cell damage by triggering a chain reaction, they add, cells were evolving enzymatic and nonenzymatic antioxidants to scavenge the indigenously generated ROS. Ahmad *et al.*(2010) reviewed the studies that reported the results obtained by manipulating various enzymes in order to study the role of the antioxidant systems. They covered enhancement of changes in environmental stress tolerance by over expressed or downregulated enzymatic and nonenzymatic antioxidants and also topics such as signaling performances of ROS, redox, Ca, growth and transpiration inhibitor ABA.

The primary effects of abiotic stress was defined by them as ion imbalance and hyperosmotic stresses leading to a cascade of the molecular network activating stress responsive mechanisms to re-establish homeostasis and to protect and repair damaged proteins and membranes, by turning a number of genes. It can be added here that, hormones trigger a series of biochemical and physiological changes in different organs and tissues,by changing composition of active genes, enzyme concentrations and activities or their activators and inhibitors.

Ahmad *et al.* also referred to the studies evidenting the transfer of electrons at a high-energy to molecular oxygen (O_2) to form ROS, such as singlet oxygen ($^1O_2$), superoxide ions (O_2-) and peroxides (O_2^{2-}). They mentioned that ROS targets were high-molecular mass molecules, such as membrane lipids or mitochondrial DNA, or nucleotide peroxides, especially at the level of thymine. So, they referred to a study showing that ROS could induce damage to
almost all macromolecules, and mitochondrial DNA was more sensitive than nuclear one. They added that, in stress conditions ROS concentration was elevating to damaging levels in chloroplasts, mitochondria, and peroxisomes, limitation of CO_2 fixation in turn decrease oxidized NADP+, which serves as an electron acceptor in photosynthesis. This limitation wass leading to overreduction of ferrodoxin during photosynthetic electron transfer, and capture of the electrons by O_2 to form superoxide radicals (O_2-), which were triggering chain reactions generating more aggressive oxygen radicals, their accumulation to lipid peroxidation, ultimately membrane deterioration and cell death. They referred to studies that showed H_2O_2 production in peroxisomes during photorespiration and the polyunsaturated fatty acids (PUFAs) were the major ones in the plant cell membranes that were particularly susceptible to attack giving rise to complex mixtures of lipid hydroperoxides. Extensive PUFA peroxidation was decreasing the fluidity of the membrane, increasing leakiness, and caused a secondary damage to membrane proteins; there were studies indicating that DNA could also be modified by ROS in many different ways, HO- was the most reactive, damages of $_{mt}$DNA and $_{n}$DNA were not completely random, as mutation clusters at hot spots, and indirect modifications of DNA had been observed. Oxidative DNA modifications, which had also evidented, could lead to changes

in methylation of cytosines, which were important for regulating gene expression. Protein oxidation induction by ROS or byproducts was a widespread phenomenon and often used as a diagnostic marker for oxidative stress, since ROS were predominantly implicated in causing cell damage and playing a major physiological role in intracellular signaling and regulation, and interfering with the expression of a number of genes and signal transduction pathways as reported in earlier studies referred by Ahmad *et al*. All of the toxic effects of ROS were counteracted by enzymatic and nonenzymatic antioxidative system such as: superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), glutathione reductase (GR), ascorbic acid (AsA), tocopherol, glutathione and phenolic compounds etc. which were contained in groups in each of cellular compartments.

Boivin, Fonouni-Farde & Frugier (2010) drew attention to another related and important topic in their review article titled "How Auxin and Cytokinin Phytohormones Modulate Root Microbe Interactions". As, they said, large range of microorganisms could associate with plants, and make neutral, friendly or hostile interactions; the ability of plants to recognize compatible and incompatible microorganisms, to limit or promote their colonization was crucial for their survival, and elaborated communication networks were determinants in this association. Phytohormones were modulating the associations and coordinating cellular and metabolic responses associated to the progression of microorganisms across different plant tissues. They reviewed hormonal regulations by focusing on auxins and cytokinins, considering their involvement in the symbiotic or pathogenic interactions between roots and soil bacteria and fungi associations, to highlight similarities and differences in cytokinin/auxin functions amongst various compatible versus incompatible ones. It may be meaningful to add only some points to their valuable contributions here; as mentioned above by referring to several studies, roles of some other hormones and inhibitors also deserve to be studied in future.

3.CONCLUSION

As mentioned in the first part of the review, and supporting references presented also in this article, several researchers have found it relevant to stress the need to integral approaches to the problem imposed by climate change and its effects on agricultural production. Although some technological advancements offer some effective solutions to the existing problems, they need considerable capital investments, increased in operational costs that cannot be defrayed by the farmers of many countries. Insufficiency of necessary infrastructure and/or qualified human power may be the reason of impracticability and frustration of purpose. As put forward and discussed by FAO in the publication titled "Putting Farmers at the Center to achieve the Sustainable Development Goals – SDGs" rural poverty was a major problem (FAO). Almost 80 percent of the world's poor and food insecure were living in rural areas, mostly depending on agricultural production for their subsistence, most of the rural poor were small-scale family food producers, who were depending on agriculture and aquaculture for their food and income but were facing many difficulties accessing productive resources, opportunities and markets. There were more than 600 million farms and more than 90 percent of farms were running by an individual or a family who were relying primarily on family labor, occupying around 70–80 percent of farmland and producing more than 80 percent of the world's food in value terms.

Considering these bitter facts, some methods, techniques must be developed and presented to agricultural production sector, which are affordable and profitable for more of the people producing food for themselves and consumers. As known, there are industries using various plant products as raw materials. In the third coming part of the article, an attempt will be made to review some prospective approaches which are fitting in this framework.

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OPTIMUM WATER RESOURCES ALLOCATION BY ARTIFICIAL IMMUNE SYSTEMS

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ABSTRACT

This study proposes an optimization model using Artificial Immune Systems (AIS) for allocation of water resources among different sectors, such as agriculture, industry, livestock production, drinking and domestic, environmental water demands; also for energy, tourism, mining, aquaculture and commercial water demands. The modified Clonal Selection Algorithm (modified Clonalg), which is a class of AIS, was used in the study. An objective function of the model was based on both maximum benefit (income) and optimum water satisfaction of the sectors. The model was implemented in a scenario covering the mentioned sectors for testing its performance efficacy. The results demonstrated that the model is applicable for the optimal water resources allocation.

Keywords: Water resources, water allocation, optimization, modelling, modified Clonalg.

1.INTRODUCTION

As is known, approximately %97 of the Earth's water consists of the oceans and seas. Rest of water resources are glaciers, groundwater and surface water, etc (Shiklomanov, 1993). Therefore, fresh water resources for drinking, domestic and utility water are so limited; consequently, allocation of limited water resources becomes a crucial optimization problem for the sectors.

In this regard, there are many studies concerning an optimum allocation of water resources; Shangguan et al. (2002), for instance, proposed the model of recurrence control for a regional optimum allocation of irrigation water resources, determining an overall maximum efficiency, Wang et al. (2003) proposed the cooperative game theoretic approach for solving the water allocation problems, Perera et al. (2005) presented REALM (resource allocation model) for management and planning of water supply, Sethi et al. (2006) improved the models of chance-constrained linear programming and deterministic linear programming for allocating available water resources and lands optimally on seasonal basis, Messner et al. (2006) applied an integrated methodological approach for a water allocation conflict in the German Spree River watershed, Letcher et al. (2007) provided the generalised conceptual framework for an integrated assessment modelling of water resources allocation, Li et al. (2009) improved the model of multistage fuzzy-stochastic programming for supporting sustainable water resources management and allocation, Nikoo et al. (2014) proposed the nonlinear interval optimization model based on simulating annealing and particle swarm optimization for optimal allocation of waste load and water in the downstream river, Das et al. (2015) improved the model of linear programming for optimal water resources and land allocation in different sectors of the Hirakud Canal Command, Roozbahani et al. (2015) introduced the model of multi–objective for optimal water allocation considering social, environmental, and economic benefits, Nguyen et al. (2016) proposed the improved ant colony optimization algorithm for optimum crop and irrigation water allocation, Li et al. (2017) developed the model of inexact fuzzy stochastic simulation-optimization programming for the optimum irrigation water allocation of the water sources, Zhang et al. (2017) improved the model of fuzzy credibility–constrained interval two-stage stochastic programming for optimizing a water distribution of the different industries based on a water demand estimation under multiple uncertainty conditions, Li et al. (2018) developed the model of interval linear multi–objective programming using a fuzzy programming method for the irrigation water allocation.

As an alternative to the related literature, a heuristic optimization model using the modified Clonalg was developed to allocate water resources for different sectors considering maximum satisfaction of water demand and maximum economic benefit in this study. The results showed that the model is useful and feasible in allocation and planning of water resources.

2.MATERIAL AND METHOD

2.1.Model Formulation

The modified Clonalg by Eryiğit (2015) was utilized to allocate water resources. The modified Clonalg was illustrated for optimization problems in Figure 1, where Ab is a population of antibody randomly

created, f is the antibody's antigenic affinity (objective function), C is a population of cloned antibodies, C* is a population of the mutated antibodies. New genes are created for each antibody clone by considering the certain probability subject to an optimization problem, named as "probability rate" (PR) in the modified Clonalg. A clone number of the antibodies can be computed as the following (De Castro and Von Zuben, 2002):

$$N_C = \sum_{i=1}^{N_{Ab}} round(\beta \cdot N_{Ab}) \qquad i = 1, \cdots, N_{Ab} \tag{1}$$

where N_c is a total clone number, β is a coefficient of multiplying, "round" is a rounding operator for the integer.

A mutation rate can be calculated as below (De Castro and Von Zuben, 2002):

$$\alpha_i = \exp(-\rho \cdot f_i) \tag{2}$$

where α_i is a mutation rate, ρ is a coefficient of decay, and f_i is a value of antigenic affinity (a value of objective function) normalized between 0 and 1.

Description of Ab:

$$\begin{bmatrix} Ab_1 \\ \vdots \\ Ab_i \\ \vdots \\ Ab_{N_{Ab}} \end{bmatrix} = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1nd} \\ \vdots & & & & \vdots \\ x_{i1} & & \ddots & & x_{ind} \\ \vdots & & & & \vdots \\ x_{N_{Ab}1} & \cdots & x_{N_{Ab}j} & \cdots & x_{N_{Ab}nd} \end{bmatrix} \rightarrow \begin{bmatrix} f_1 \\ \vdots \\ f_i \\ \vdots \\ f_{N_{Ab}} \end{bmatrix} \quad i=1,\cdots,N_{Ab} \quad j=1,\cdots nd \tag{3}$$

where N_{Ab} is the total antibody number (population Ab), x_{ij} is a gene of Ab_i (decision variable of f_i), nd is a gene number of Ab_i. In this study, x_{ij} corresponds to an amount of water allocated to each sector. f was maximized depending on amounts of water (genes) constituted and mutated throughout processes of the modified Clonalg.

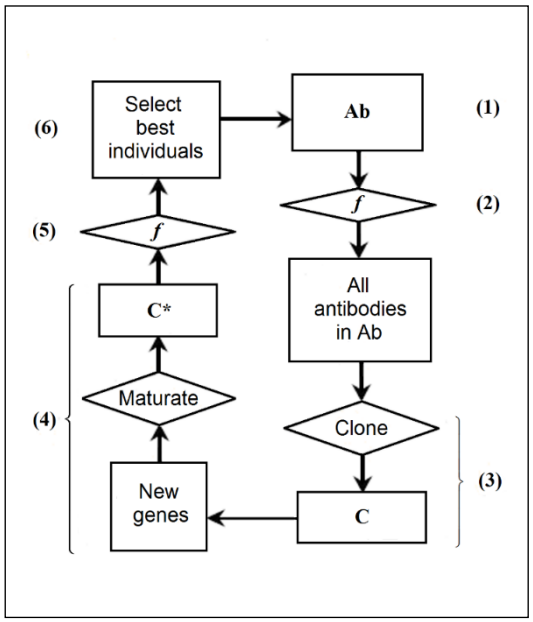

Figure 1. A diagram of the modified Clonalg (Eryiğit, 2015).

In order to optimize water resources allocation for the sectors two objective functions were considered, and both objective function were simultaneously maximized depending on each other. Maximum satisfaction of water demands of the sectors was aimed by first objective function (OF_1) while maximum economic benefit (income) was aimed by second objective function. (OF_2). OF_1 and OF_2 are expressed as follows (Babel et al., 2005):

$$OF_1 = \frac{1}{n}\sum_{i=1}^{n}\frac{S_{ai}}{D_{ni}} \tag{4}$$

where S_{ai} is a water allocated to sector i, D_{ni} is a normal water demand of sector i, and n is a total number of water demand sectors.

$$OF_2 = \left[\frac{\sum_{i=1}^{n} S_{ai} \cdot NER_i}{AW \cdot NER_{max}}\right] \tag{5}$$

where NER_i is a net economic return (income) per unit volume of water from sector i (USD/m^3), AW is an available water (total water amount, m^3), and NER_{max} is a maximum net economic return among the sectors (USD/m^3). The values of OF_1 and OF_2 are between 0 and 1.

The sum of OF_1 and OF_2 multiplied by the respective weights was maximized in this study. The sum of them (OF_{12}) is as the following (Babel et al., 2005):

$$OF_{12} = w_1 \cdot OF_1 + w_2 \cdot OF_2 \quad (6)$$

where w_1 and w_2 are the respective weights depending on a user. In this study, w_1 and w_2 were assigned as 1.

2.2.Application of the Optimization Model

The model was applied to a scenario regarding an allocation of water resources among 10 different sectors in order to test its performance. According to the scenario, there are ranges of minimum and maximum (or normal) water demands of the sectors, and unit economic benefit (income) of each sector. Total amount of water for the allocation was assumed as 300,000,000 m^3. Ranges of the water demands and unit benefits were as given in Table 1.

The optimization model was coded in Matlab R2014a programming software, and the PC having Intel I5 Core 2.5 Ghz Processor was used for the analyses. The model was run 100 times to obtain the maximum value of OF_{12} until a maximum number of iteration (IN) is reached in each run. A random number generation was performed during generating an initial set of water amounts allocated in each run.

Table 1. Ranges of the water demands and unit economic benefits of the sectors in the scenario.

Sector	**Min. water demand (m^3)**	**Max. water demand (m^3)**	**Unit economic benefit (USD/m^3)**
Drinking water	100,000,000	200,000,000	9
Environmental water	75,000,000	150,000,000	7
Agriculture	20,000,000	200,000,000	10
Industry	0	55,000,000	7.5
Energy	0	25,000,000	8.5
Mining	0	30,000,000	10.5
Livestock production	0	40,000,000	10
Aquaculture-Fisheries	0	50,000,000	1.5

Tourism	0	18,000,000	9
Commercial water	0	14,000,000	12

3.RESULTS

Range searching for the model was performed in the ranges of minimum and maximum water demands of the sectors (see Table 1) depending on OF_1 and OF_2 for optimum water allocation. Results of the water allocation for the sectors were given in Table 2.

Table 2. Results of optimal water allocation.

Sector	**Allocated water (m^3)**	**Total allocated water (m^3)**
Drinking water	100,000,000	299,999,999.9
Environmental water	75,000,000	
Agriculture	20,000,000	
Industry	0	
Energy	25,000,000	
Mining	30,000,000	
Livestock production	18,000,000	
Aquaculture-Fisheries	0	
Tourism	18,000,000	
Commercial water	14,000,000	

After running the model 100 times the best, fittest value for OF_{12} (f) value was found as 1.2945 by allocating minimum water demand values to the sectors of drinking water, environmental water, agriculture, industry and aquaculture-fisheries, while allocating maximum (normal) water demand values to the other sectors (energy, mining, tourism, commercial water) except livestock production (see Table 2 and 3). The range of water demands of drinking water, environmental water and agricultural irrigation sectors are very high. Therefore, the model selected the minimum water demand values of these sectors in order to allocate sufficient water to the other sectors for maximization of OF_1. On the other hand, the water was not allocated to the sectors of industry and aquaculture-fisheries, due to their lower unit economic benefits (7.5 and 1.5 USD/m^3) than energy, mining, livestock production, tourism and commercial water sectors. The model also allocated maximum water demands of the sectors of energy, mining, tourism and commercial water in order to maximize both OF_1 and OF_2. Furthermore, as all of the total water (300,000,000 m^3) could be allocated to the sectors, these results are reasonable.

Table 3. The modified Clonalg's parameters and performances in the application.

N_{Ab}	β	ρ	PR	IN	Max. OF_{12}	Max. OF_1	Max. OF_2	Run time (sec)
100	1	10	0.25	500	1.2945	0.555	0.7395	111.5

N_{Ab}: Population number. β: Coefficient of multiplying. ρ: Coefficient of decay. PR: Probability rate. IN: Iteration number.

4.CONCLUSION

The weight coefficients (w_1 and w_2) to be used in OF_{12} calculation selectable by the water resources planner. If the satisfaction of the water demands is aimed rather than the economic benefit, w_1 can be increased. In contrast, if the economic benefit is intended, then w_2 can be increased. In this study, both weight coefficients were selected equally. In case of changing the values of w_1 and w_2, the results of the water allocation might be different.

The results demonstrated that the model is useful and feasible in the water resources allocation and planning, and it can be used as an alternative to the other models in the literature. In future studies, the model may be tested under different water allocation conditions.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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