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EXCEPTIONAL HYDRO-METEOROLOGICAL PHENOMENA FROM 2013 - ISRAEL. CASE STUDY: YARKON BASIN

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ABSTRACT. Exceptional hydro-meteorological phenomena from 2013 - Israel. Case study: Yarkon Basin. Distinct hydro-meteorological phenomena are well studied all over the world, especially in the last years, as a result of their strong effect over natural and also social environment. Their spread and way of expression present a great diversity determined especially by land's natural environment particularities, and also by their position inside climatical zones. After the study makes a brief presentation of Israel's geographical position, it presents the particularities of Yarkon hydrographical basin compared with other adjacent basins that flow into the Mediterranean Sea. In this context the Yarkon Basin was selected, with many land researches and laboratorial evaluations of extreme rainfalls from January – February 2013. Using these data there were developed some ideas for area rehabilitation and options for future basin sustainability.

Key words: environmet, Israel, Yarkon Basin, rainfalls

Israel natural environment

Israel territory is crossed on all its length from north to south by an orographic network the Mediterranean Plain – west from the Jordan Rift Valley, and the Dead Sea – to the east. Some depressions appear between mountains, with aspect of low plateaus (Yehuda, Galilee); some rivers have their streams here – going west (Quichon, Nahal Taninim, Hadera, Nahal Alexander, Yarkon-Ayalon, Lakhish, Hevron, Besor) or east (Harod, Tirza, Darga, Arugo, Ze'elim, Boqeq) (Fig.1).

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Negev mountain area is crossed by structural – tectonical depressions corresponding to one of the most representative structural world reliefs: three big anticline box canyons with big craters (makhteshim). These depressions, totally closed, have an oval long form with the direction north-east – south-west: Makhtesh Ramon (big axis – 34 km, and small axis – 7 km), Makhtesh Hagadol (big axis – 16 km, small axis – 5 km), and Makhtesh Hakatan (big axis – 8 km, small axis – 4 km). Altitudinal amplitude of Israel's relief exceeds 3000 m, with the lowest point at the bottom of the Dead Sea's Har Ha Melah – in Hebrew) basin: - 800 m (below sea level) and – 427 m (below sea level in 2013) for water table level – the lowest level in the world; and the highest point on the south-western ridge of Mount Hebron (2814 m), near Lebanon – Syria border, with the highest point inside Israel – 2236 m. This ridge with a length of 60 km splits into several ramifications: Har Meron – 1208 m (towards west) near Quishon Valley, Samaria

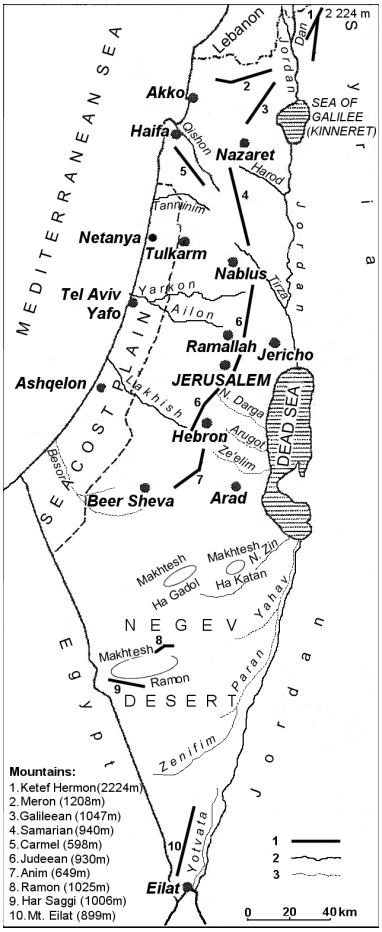


Figure 1. Israel general map. 1 – orographic system; 2 – hydrographic network

Mountains (towards south), which continue on the other side of Jerusalem with the Judaean Mountains and Negev Desert – Har Ramon (1035 m), Har Saggi (1006 m) and Eilat Mountains (899 m). Israel has a Mediterranean climate with transition to dry-tropical climate, but with four uneven seasons: very short spring and autumn (only 1 – 3 months), and long summer (4 – 5 months) and winter (3 – 4 months). Solar radiation is high (between 182 and 207 kcal/cm^2) enough according to country's latitude. Winter months are extremely hot, with an average temperature of July and August that exceeds 30°C. This thermal discomfort is amplified by the moisture brought by southern air currents determined by water evaporation from the Nile River in Upper Egypt. Air moisture is also high on coastal areas, and slowly decreases towards east and south-east.

Rainfalls (Fig. 2A) decrease from north (above 1100 mm/year on the Israel slopes of Hermon Mountain in Upper Galilee) to south (below 25 mm/year in south

Negev Desert towards Eilat). They present an uneven distribution for each season: rainfalls are concentrated especially between October and May (72 % fall in November and December), and in the other months are absent. Because of land's altitude and of moist air coming from the Mediterranean Sea, northern areas receive especially snow that melts rapidly in summer, supplying Jordan River course and springs (***1940).

Evaporation in this area is very high (Fig. 2B). Winter is mild with snow only on high northern mountains and sometimes in massifs near Jerusalem (Har Yehuda), extremely rare in Jordan and Dead Sea Rift (Midbar Yehuda), where some valleys may freeze (Nahum, Levi, 2000).

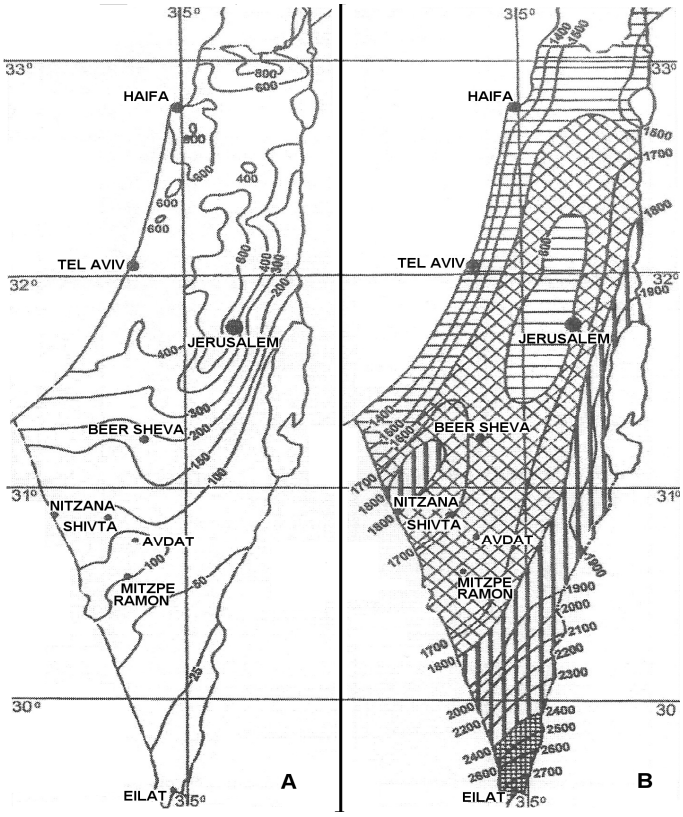


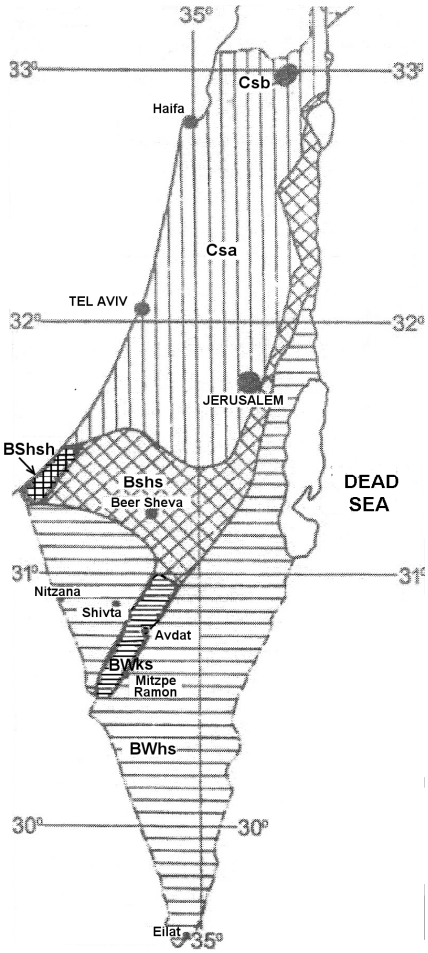
Figure 2. Israel annual atmospheric rainfalls (A) and annual evaporation (B) map.

A dry tropical climate phenomenon that appears in south Israel is "Khamsin", a dry and hot wind. According to Arabic tradition, this wind lasts for 50 days, hence the name "*khamsīn*" that in Arab means "fifty".

Rainfalls quantity decrease from north (Hermon Mountains – over 800 mm/year) to south (Arava Valley – below 25 mm/year), and evapotranspiration is very strong, increasing from 1400 mm/year on coastal areas to over 1700 mm/year towards Eilat Gulf in south (Atlas of Israel).

This is why the Israel's Mediterranean coast is the most exposed to extreme meteorological phenomena that have devastating hydrological effects even in areas with no running water.

According to Koppen Classification, in Israel (Fig. 3) appear the following climatic areas: a Mediterranean climate in north, with high temperatures; a dry steppe tropical climate in the central part and in southern and eastern desert areas.



(according to Koppen Classification): **B,** arid climate; **C**, warm temperate climate (average monthly temperatures
of the hottest month between -3 and +18°C);
BS, steppe climate; **BW,** desert climate
(**a,** average temperatures of the hottest month over +22°C;
b, average temperature of the hottest month over +22°
C, but with 4 months with average temperatures over +10°C;
h, dry and hot climate with annual average temperature over +10°C;
k, dry and cold climate, with annual average temperatures below +18°C,
but with average monthly temperature of the hottest month over +18°C;
s, humidity below 10 mm/year).

Figure 3. Climatic regions map in Israel

Water is the essence of life in Israel too

It is not an accident that from the beginning of mankind people settled near big water courses such as the river valleys of Indus, Jordan, Tigris and Euphrates. This is how human settlements appeared in the middle of arid areas, where people settled near oases, and later using rainfall water gathered in small manmade depressions or dams built on rivers or reservoirs. When water quantity from rainfalls had extremely increased, there appeared flooding even in such dry lands as those from Israel.

Surface hydrographic network from Israel is dominated by Jordan's hydrographic system, which even though it has a small hydrographic basin in the eastern part of Israel, it has a strong supply network coming from Hermon Mountain represented by Dan and Snir tributaries; after it passes over Hula and Kinneret lakes, it reaches the Dead Sea with 50 mc/s discharge, which is not enough to insure an even water balance. Other rivers like Yarkon, Nahal Tanimin, Ain Hanaman, Beit Shan etc., have low discharge.

In the northern part of Israel precipitation falls as snow – in Harmon Mountains and north Golan Heights between 1000 – 2000 m altitude, and sometimes snow falls also at 700 – 800 m altitude (Tzvat, Jerusalem, Judaean and Negev Mountains). In coastal plain areas, snow is a very unusual phenomenon, but exceptional events happened in April 2th, 1990, and in April 12, 1949 on Mount Carmel, central mountains and Jerusalem. Snowfall appeared also in November 28, 1953 in central (Jerusalem) and the northern (Galilee) Israel region. The highest snowfall quantities in Israel's history fell on February 9th and 10th, 1920, when it was so cold that in Jerusalem appeared a snowpack of 98 cm thick and even 116 cm on outskirts. This especially affected town's infrastructure, becoming almost non-existent, and also produced large damages. Over 50 cm thick snow layer fell on mountains and many cities have been affected: Afula, IYokneam, Nazareth, Carmel, Makhtesh Ramon, Mitzpe Ramon, Tel Aviv and other surrounding cities. Snow exceptionally fell near Eilat.

Rainfall quantities that have fallen among–1995-2009 based on data recorded by National Meteorological Institute network, together with records made in 14 automatic stations from Israel, showed in all years a rainy season. Both at north of Ashkelon (where in the period September – April 85% of the annual average quantity fell), and at south of Beer Sheva – Eilat line (where 82% of the annual average quantity fell) the presence of a multiannual rainy season can be distinguished. Differences appear determined not only by altitude, but also by local natural environment conditions. According to these, seasonal rainfall quantities vary as follows: in northern mountains (Galilee Mountains and Golan Heights), based on data from Golan Heights meteorological station, fall in average 751 mm (88% of the multiannual average); in southern Golan Heights, at Gamla Station – 478 mm (83% of the multiannual average); at Mizpe Harshim – 740 mm (77% of

the multiannual average); in Knan Mountains at Tzvat – 644 mm (77% of the multiannual average). This variability is greater on the Mediterranean coast, decreasing from north to south: at Naharia – 473 mm (but 92% of the multiannual average); at Haifa – 655 mm (75% of the multiannual average); Nahal Aviv – 406 mm (70% of the multiannual average); Negba – 333 mm (67% of the multiannual average); Ashkelon – 316 mm (66% of the multiannual average). On stations from northern and eastern valleys: Snir – 645 mm (94% of the multiannual average); CaKfar Blum – 456 mm (91% of the multiannual average); Tveria – 336 mm (88% of the multiannual average); Sade Eliahu – 253 mm (90% of the multiannual average) and Merhavia – 359 mm (77% of the multiannual average). Central mountains (Judaean and Shomron): at Jerusalem – 387 mm (72% of the multiannual average) and Beit El – 286 mm (71% of the multiannual average). In lowland regions: at Kfar Ornis (Modein Region) – 415 mm (93% of the multiannual average) and Beit Dagan – 482 mm (92% of the multiannual average); in northern Negev Desert at Be'er-Sheva – 132 mm (67% of the multiannual average) and Sade Boker – 54 mm (58% of the multiannual average). The rainfall decreases very much towards south: Eilat – 27 mm (121% of the multiannual average) (Steinberger, 2011).

Western hydrographic system (Western Mountain Basin)

This hydrographic system, known with the name of Yarkon – Nahal Taninim Basin, is the western part of the Israeli mountain aquifer that also includes the eastern and north-eastern aquifer. It includes Hadera, Nahal Alexander, Nahal Taninim, Yarkon, Kishon Lakhish and Besor basins, with running waters and infiltrated waters flowing towards west. This hydrographic system spreads from the watershed of Judaean and Samaria Mountains in east till the Mediterranean Sea in west. Its northern border follows the Yizrael Valley (Carmel Mountain), and the southern one – Sinai Peninsula (Weinberger et al., 1994, cited by Gabbay, S., 2001). The major hydro-geological unit that includes this system is the Judaea Aquifer, composed of limestone and dolomite from the Late Crateceous period in east, and chalkstone and marl from the Eocene and Senonian periods. The aquifer is divided into a superior (almost impermeable marl) and inferior layer (clay), thick of 40 – 120 m (Weinberger et al., 1994; cited by Gabbay, S., 2001). Underground waters from more than half of our hydrographic system are brackish waters, but the rest are high quality underground waters. North of Netanya, underground waters interfere with salty waters that come from west from the Mediterranean Sea.

Underground water pumping into the Yarkon – Nahal Taninim basin began in 1950 and later intensified to 110 – 220 mil m^3/year in 1957 (Goldschmidt and Jacobs, 1958; cited by Gabbay, S., 1982). This increase was accompanied by a gradual decrease of underground waters level, and as a consequence – the dry-out after 1960 of some springs from the upper Yarkon River. Similar to this case, in Nahal Taninim

Basin the spring decreasing rate in 2009 has 16 mil m^3, when the annual average in 1993-2009 was 45 mil m^3/year. Although many spatial and temporal hydro-geological models were for western hydrographic basins, considered to be part of a unique aquifer system, still it's recharging is considered to be extremely difficult. The average natural regeneration is exceeded by continuous water pumping from aquifer. Total aquifer recharging decreased from about 369 mil m^3/year in 1973 – 1992, to about 333 mil m^3/year in 1993 - 2009. More, the western aquifer interferes with partly saline underground water that comes from sea waters. So, the decrease is determined by general rainfall decrease in Israel in last 30 years, but also by underground water pumping increase, so aquifer water is severely affected.

Hydrometeorological situation of 2012/2013 winter

In all rainy season from 2012/2013 (09.01.2012 – 05.01.2013) there were registered 35 rainy days, first on 09.11.2012. According to data registered by the Agricultural Engineering Meteorological Station of Tel Aviv, rainfall decrease was of 68 mm, respectively 107% over the multiannual average. Till this season, highest rainfall values in rainy season were registered at the Haifa Meteorological Service in 1960/1961 and 1989/1990. We can observe that not only rainfall values were extremely high, but also their spatial and temporal distribution was unusual. So, multiannual average was much exceeded in December – January, which determined increased water volume with almost 18% in rivers flowing to the Mediterranean Sea and from western Israel orographic system in February – March. Also the Kineret Lake level (the Galilee Sea) increased considerably. So, the Kineret Lake level was – 212.30 m (10.01.2012) at the beginning of 2012/2013 rainy season and it exceeded previous year level by 1.1 m and two years ago level by 1.38 m, reaching at the end of 2012/2013 rainy season – 209.86 m, an increase of 2.44 m from the beginning of hydrological year (1.47 m increase from previous year level and 2.53 m from two years ago level). In January 2013 alone, the Lake's water level increased by 1.24 m over the highest January water level from the last 20 years. Pouring rain storm that happen in 01.05 – 01.11.2013 determined the Kineret Lake water level increase by 73 cm, and strong rainfall from 02.19 – 02.26.2013 determined a level increase to 89 cm. This way lake water reached 503 mil m^3, an increase of 40% from multiannual average in 1993 – 2012.

The Dead Sea chloride concentration at the beginning of rainy season (09.01.2012) was 26 mg/l when water level reached – 412.40 m, and at the end of rainy season (05.01.2013) it decreased to 241 mg/l – water level of – 426.93 m (0.89 m lower than the same period of previous year and 2.49 m from two years ago). The Dead Sea level decrease for this year was reasonable compared to those from past years, determined by unusual high water level from tributaries in January 2013 – over 70 mil m^3.

Other exceptional meteorological situations

At the beginning of 2002/2003 rainy season, after a low pressure area settled over the eastern Mediterranean Sea, air circulation reversed reaching south/east – north/west direction. This allowed moist air masses from the Red Sea to reach the dry land of Sinai and Negev. As a consequence, there were heavy downpours with locally catastrophic consequences. As an example we present the October 15th cloud-burst at Eilat, with rainfall intensity of 80 mm/l/hour that created water sheets that washed fertile soils from around. Also in Negev – October 30 – 31 – were recorded significant rainfall quantities and flooding. These phenomena reappeared in December 19 and 20th, when the eastern Mediterranean Sea was covered by a low pressure area. There were not high rainfall quantities, but cold air stagnated over the area for a long time. Floods appeared in small water basins, with surfaces of 5 – 7 ha, with stony soils for more than 30% of their surface.

Table 1. Rainfall quantities (mm) between October 30-31, 2002

City	October 30	October 31	Total quantity
Lahav	18,3	7,3	25,6
Mashash	1,2	6.0	7,2
Dvir	10.0	2.2	12.2
Omer	27.2	36.7	63.9
Be'er-Sheva	20.0	16.5	36.5
Be'er-Sheva Sud	18.0	15.4	33.4
Oranim	13.5	0.0	13.5
Nahal Hazerim	14.7	0.0	14.7
Sade Boker	8.2	0.0	8.2
Mizpe Ramon	20.8	4.0	24.8
Hatzeva	14.5	0.0	14.5
Neot Smadar	2.0	0.0	2.0

Case study: Yarkon Basin

The Yarkon hydrographic basin is situated in central Israel and is the biggest basin in Mediterranean coastal region. The Basin surface has a triangular shape, with its base towards east on the Shem – Jerusalem watershed and its top towards west, at north of Yafo Peninsula, with a surface of 1085 km^2. Initially, this was a smaller basin and did not include the Ayalon River basin as it does today

(Mazor, 1996). It has modified its course throughout history towards Yafo Gulf from the Mediterranean Sea, shaping a new water channel towards the north, flowing into the Yarkon River at 3.5 km before it reaches the Mediterranean Sea. This is the way contemporary hydrological studies divide Yarkon Basin into two hydrographic sub-basins:

- Yarkon sub-basins, a surface of 990 km^2, where the Yarkon River receives 3 tributaries with secondary basins: Cana (240 km^2), Rabo (40 km^2), Shila (400 km^2), and also main river own basin surface (310 km^2)
- Ayalon sub-basin, a surface of 815 km^2, with two tributaries: Arif and Natuf.

The hydrographic basin is supplied by rainfalls and its tributaries, bringing a total of 1100 mil m^3/year. From these quantities, only 10% flow as surface waters in the Yarkon Basin, and 90% infiltrate into deep ground waters captive in Turonian and Cenomanian rocks.

The *Yarkon River* was during the proclamation of the State of Israel, at the middle of the last century, an all year clear water river, with a length of 63.5 km and a multiannual average discharge of 8 m^3/s, second after the Jordan River (*** 1967). After spring catchment in river's middle section for use in Tel Aviv water pumping plants (1955), the Yarkon River almost disappeared, its actual length shrinking to 27.5 km, beginning at Tel Afek – Nafarim Basin near Rosh HaAin springs – till it reaches the sea. Only few water streams remained inside the river's basin from its original springs. Now, the Yarkon River is supplied only by rainfall and used water that comes from local consumers, industrial water and residual water that flow into the river in its middle section. This is the Yarkon River's most problematic section, especially after discharging 25000 m^3 of use water from around Kfar Sava, Hod Hasharon and Ramat Hasharon villages. The river's lower section presents a low discharge, completed only by cooling waters coming from the Reading Steam Power Plant. In the 60's, more than 90% river water was used for supplying Tel Aviv water needs, but also country's south needs through the National Channel, Yarkon – Negev Section. We must remember that at the beginning of the last century, the coastal plain crossed by the Yarkon River was a big swamp supplied by the Yarkon River. Its tributaries are: Shila, Rabo, Cana and Ayalon. This is the reason why downstream Ramat Hasharon and Bnei Brak sections, which are not inhabited due to their difficult hydrogeological conditions, were transformed into a green space: Yarkon Park.

Its development began in 1969 with diking and agglomeration of some old abandoned loop temporary ponds from right of the Yarkon, that were limited by a forest named Bereshit. This made it possible for a leisure lake to be developed, but also this forest could grow helped by tree planting in Ganei Yehoshua. In the same plain, but in its northern side were planted tropical trees that are organized into a Tropical Garden. This lake advances more towards west close to river's mouth between Ramat Aviv (north) and Yehuda (south) districts.

From 2004, more than 20 mil $ were used for river bed renewal, especially in the Tel Aviv section. A parallel water catchment basin for waters that flow from the Yarkon was made under a permanent hydrological control. Also, some fish and aquatic plants species were brought into the river to help cleaning it and rebuild the biotope.

The *Ayalon River,* the biggest Yarkon tributary, flows in the south Yarkon basin and has a length of almost 50 km. As said before, it had an independent course over history, flowing straight into the sea in the north Yafo Gulf. Its current lower sector is relatively young and it was formed during sand dunes migration that used to retain river course inside the sea's coastal plain near; this way, the Ayalon River created a new course curved towards the north, flowing into the Yarkon River. It springs from Zeev Hill in the Benjamin Mountain (Judaean Mountains), and after it crossed mountain area, it forms a large valley – the Ayalon Valley. There was constructed a water reservoir in 1950, which is nowadays not functional. Its middle course passes east from Kfar Shmuel and Mihmar Ayalon villages, where it receives the Aly and Shar HaGay tributaries. Here it passes near the Neser concrete factory and near the border of Lod Town, after that reaches coastal plain. Here it passes near Ben Gurion Airport and crosses Ariel Sharon Park, entering Dan conurbation. The river's lower sector suffered many major transformations determined by Ben Gurion Airport enlargement or road building inside Tel Aviv. Residual water flows into river inside Lod and other small towns around it. In the last years it could be observed an improvement of river water quality, but after the rainy season, due to high evaporation values, the Ayalon River dries out.

The actual lower Ayalon sector, formed after joining the Yarkon River, has a "bird head" shape (*Rosh Tzipor* in Hebrew) that overlooks the entire coastal region. This space is now used as a park – Ayalon Park, with some old everglades and hydrophilic vegetation, a proof that natural surrounding environment didn't change such a long time ago. This is the way this area is now preserved and opened for visitors. This park from Yafo suburb of Tel Aviv had a lot to suffer after 2013 winter extreme rainfalls. On January 8th, 2013, the Ayalon River had a discharge of 420 m^3/s which caused severe flooding. Because this kind of event has happened in the past, measures were taken to prevent park and east Tel Aviv and Ramat Gan districts flooding by building the Ayalon reservoir, with high and paved banks. Even so, the 2012/213 winter floods exceeded reservoir's storage capacities, which led to further flooding, urging roads and railroads closing near the Ayalon River.

After analyzing the effects of these extreme meteorological phenomena from January 2013, we can say that extreme rainfall from river's middle sector took by surprise house holdings from Tel Aviv and adjacent roads and railroads. Road and railway traffic has been stopped and people have been warned against travel on these routes. Even so, many vehicles ventured inside flooded areas and authorities had to intervene, helped by helicopters that saved many people driven to

the sea by river currents. To evacuate water surplus from Tel Aviv, firemen had to pump high water quantities that blocked roads for more than 10 hours. There were also evacuated houses, in some place energy supplies were stopped because of fear of electric shocks due to extreme humidity. These things determined extreme measures taking for supplying people that were isolated by flooding waters. Some of the local emergency commandment's measures were school closing for 24 hours and building temporary road bridges over Yarkon and Ayalon rivers, from Tel Aviv to Ramat Gan District and Tel Aviv Central Railway Station.

Conclusions

Today 12 coastal rivers and 2 rivers from the Jordan Basin are going through sustainable rehabilitation plans. Other 20 rehabilitation projects were made for: water cleaning, river bed enlargement, soil conservation, landscape support and natural parks and reservations development (Gabbay, 2001). These were all made in the context of river and basin rehabilitation for exceptional rainfall water storage lakes on riverside of the Yarkon, Nahal Alexander, Kishon, Lakhish, Harod, Nahal Taninim, Hadera and Jordan Rivers (Shimson, Gabbay, 2012).

Only the Yarkon River is crossing the highest density regions of Israel, including the capital Tel Aviv. River deterioration began in 1955, when the river level decreased due to the National Channel deviations towards the Negev Desert. Together with discharge decrease, water quality decreased due to household or industrial waters discharge into the river's course, and also to garbage and debris throwing into river bed, all determined wild life extinction. These frequent foods determined by exceptional rainfall determined the establishment of the Yarkon River Authority in 1988, composed of 19 local organisations and authorities. This was, in fact, preceded by the Law of Israel River Authority Establishment in March 5th, 1962 at Knesset, and also by providing a legal framework (made by lawyer Dr. Richard Saster) in 1985. In June 17th, 2008, the Yarkon River became the "Twin River" of the Los Angeles River from Los Angeles, with the occasion of celebrating Tel Aviv Centenary (Shapiro, 2008). We must say that this event was preceded by a bed cleaning and regularisation program that were intended to improve the Yarkon River management, making it usable for leisure and recreation activities such as navigation, fishing and swimming. Hundreds of tons of waste have been dragged out of the river to establish its initial depth and to enable natural water flux. Also, river banks were consolidated and the Yarkon Park was expanded, and some hiking and cycling roads were set up. Kfar cleaning station was inaugurated in 1999, trees were planted and hydrophilic vegetation was restored at Ramat Hasharon in 1999, these all allowing fish reinsertion into the Yarkon River. At the same time, the Yarkon River was chosen as model for a national educational river rehabilitation program; also a research centre was built on its margins.

Program's success can already be seen in flora and fauna regrowth on a land segment of 7.5 km near Rosh Ha'ayin. This way, the Yarkon Park became the "green lung" for 2 million inhabitants from Tel Aviv area. The Yarkon River Master Project wants to develop a continuous parks and green area system for this area, called "Central Park Israel".

Today, after January 2013 rainfall in the Yarkon Basin, hydrological studies must be made in all the Yarkon Basin and also for natural processes research to determine water transport capacity and to prevent river flooding in each river segment and also in whole ecosystem. There was a proposal for river course modification into the Mediterranean Sea using an underground tunnel below river bed, but its high costs made it not an available option; instead it was chosen to invest in improving floodable land from the Ayalon Park Project to catch flood waters.

REFERENCES

1. Gabbay, S. (1982*), Selected papers on the Environment of Israel,* Environmental Protection Service, Ministry of the Interior, State of Israel.
2. Gabbay, S. (2001), *Rehabilitation of Israel's Rivers*, Israel Environment Bulletin
3. Mazor, A. (1996), *The Philistines on the banks of the Yarkon River*, in Dereh Eretz. Stone, Clay and Adam, Tel Aviv.
4. Nahum, L, N. (2000), *Climate characteristics of the Negev,* Center for Educational Technology.
5. Nathan, C.(2010), *Resursele de apă şi starea Mediului în Deşertul Negev. Israel*, p. 23-33; 60-73; 110-129, Editura Universitară, Bucureşti
6. Shapiro, M. (2008), *Unique agreement between Tel Aviv and Los Angeles on NRG*, Ma'ariv, 15,june, 2008.
7. Shimson, B. & Gabbay, S. (2012), *Environmental Chellenges,* Springer-Science & Bussines Media, B,V.
8. Steinberger, H. (2011), *Research Meteorology and atmospheric sciences*, The Hebrew University of Jerusalem.
9. *** (1940), *Meteorological Observation for the year 1939*, from Hebrew University Mount Scopus including solar radiation, 88 pp., Jerusalem.
10. *** (1967), *Rainfall maps and tables of the Dead Sea and Jordan Valley*. Catchment area, 145 pp., Jerusalem.