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Political Use of Land and Water Distribution: An Analysis through Statistical Data, Demography, and Remote Sensing

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ABSTRACT

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Sound natural resource management is the corner stone of sustainable development. This issue assumes a more important role in Palestine where the physical scarcity of natural resources is compounded by the political conflict that further reduces the accessibility of these resources to the Palestinians. About 60 percent of the total land area in the West Bank and 24 percent of the Gaza strip are still under Israeli control. Palestinians have access to less than 20 % of their water resources. Problems such as land degradation, depletion of water resources and the degradation of water quality, much of which has accelerated dramatically in the last 30 years, has negatively impacted the social fabric and has had far-reaching social and political implications. At present, the land of Palestine is being subjected to two contradicting developmental plans in which the Israelis have the upper hand and are thus hampering Palestinian efforts to promote sustainable development of their natural resources. This means that conservation, management and protection of natural resources must be done in the context of restricted ability and a constantly changing and tentative political situation. This paper outlines how GIS is used to monitor land use changes under adverse political conditions.

RESUME

Utilisation politique de la distribution des terres et de l'eau : une analyse par les données statistiques, la démographie et la télédétection

La gestion raisonnée des ressources naturelles est la pierre angulaire d'un développement durable. Cette affirmation est encore plus importante en Palestine, où la pénurie physique de ressources naturelles s'ajoute au conflit politique qui réduit encore l'accès à ces ressources pour les Palestiniens. Environ 60 pour cent de la totalité des terres de Cisjordanie et 24 pour cent de la bande de Gaza sont toujours sous contrôle israélien. Les Palestiniens ont accès à moins de 20 % de leurs ressources en eau. Les problèmes tels que la dégradation de la terre, la diminution des ressources en eau et la dégradation de la qualité de l'eau qui, pour la plupart, se sont aggravés dramatiquement au cours des 30 dernières années, ont eu un impact négatif sur le tissu social et ont des implications sociales et politiques très profondes. Actuellement, la terre de Palestine est l'objet de deux plans de développement contradictoires sur lesquels les Israéliens ont la mainmise, ce qui leur permet d'entraver les efforts palestiniens de promotion d'un développement durable de leurs ressources naturelles. Cela signifie que la conservation, la gestion et la protection des ressources naturelles doivent être réalisées dans un contexte de capacités restreintes et de situation politique en perpétuel changement et



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timorée. Cette allocution souligne comment le GIS est utilisé pour faire le suivi de l'utilisation des terres dans des conditions défavorables.

Introduction

Palestine, as defined here, comprises two physically separated landmasses namely Gaza Strip and the West Bank including East Jerusalem. Its total area¹ reaches approximately 6,210 km² (ARIJ, 1998). Gaza Strip, the smaller of the two covering an area of 365 km², is a coastal zone at the southeastern extreme of the Mediterranean and on the edge of the Sinai Desert. The West Bank², covering an area of 5,659 km², can be divided into four topographic regions: the Jordan Valley, the Eastern Slopes, the Central Highlands, and the Semi-Coastal Zone. Israel occupied these areas since June 1967.

During this period the Israeli occupation attempted to control all aspects of life of the Palestinian people. This was done through selective laws taken from previous Turkish, British, and Jordanian rulers in addition to 1,500 military orders used to tighten its control. Since that time, Israel has either confiscated or declared as closed areas over 55% of the West Bank and 22% of the Gaza Strip, thereby placing it out of Palestinian reach. Israel has continued to expand Jewish colonies and their infrastructure on illegally confiscated Palestinian, which is mainly agricultural land. Palestinians had neither access to official statistical data nor were they permitted to conduct their own statistical surveys and research through any official source.

In 1991, the Middle East peace process was launched in Madrid to put an end to the historic Arab Israeli conflict guided by the principles of 'Land for Peace' and the United Nations Resolutions 242 and 338. Israel and the Palestine Liberation Organization signed the declaration of principles (DOP) which was followed by Oslo I and Oslo II agreements as an interim step towards a final peace treaty with Israel. The Interim agreement divided the lands of Palestine into three classifications: areas A, B, and C). The Israeli military withdrew from lands classified as area A, and the Palestinian Authority assumed complete autonomy over administrative and security issues. This marked the first time that a Palestinian government retained sovereignty over any of their land. However, this area comprises now a mere 12.1 % of the West Bank and 74 % of the Gaza Strip. In area B, the Palestinians have full control over civil society except that Israel continues to have overriding responsibility for security. These areas constitute now 26.9 % of the West Bank and comprise most of the Palestinian towns and villages. In area C, Israel retains full control over land, security, people and natural resources.

Long before the Palestinian self-autonomy, ARIJ was able to conduct its own surveys by overriding the restrictions imposed on the Palestinians. Although ARIJ

¹ Including the Dead Sea which covers almost 186 km²

² Not including the Dead Sea



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conducted field surveys through a special team, still such surveys were never enough to satisfy and answer the many arising questions of landmasses and water allocations. Instead, ARIJ used another form of statistical information production and estimation. Unlike the traditional methods of data collection and surveying, ARIJ used a relatively newly and evolving technique to assess and estimate some statistical figures. With the introduction of Geographical Information System GIS and Remote Sensing RS at ARIJ, some parameters were estimated and evaluated for the first time in the Palestinian history. These include the size of cultivated areas; percentage of irrigated to dry farming agriculture, storage capacity of an aquifer, the topography of landmass and other environmental and agricultural information.

But how does GIS help in supporting and protecting human rights? The GIS mentioned above is defined as a tool to collect, store, access, manipulate and retrieve information of spatial geographical data sets for a specific purpose at will (Burrough 1998). With the use of GIS, ARIJ was not only able to retrieve and produce estimates of statistical variables and environmental and agricultural figures, but also was able to get information on land masses of both politically or military restricted areas where Palestinians had no access at all, and on remote areas where it is hard and sometimes impossible for a surveyor to access or reach due to the nature of the environment there. Thus, despite of the physical or natural barriers and political or military actions, GIS knows no barriers and offers an open window and wide-opened opportunities to the world with few limits.

Predictions and forecasting were also possible through monitoring the land mass changes with a time series of satellite images acquired from different sources at different time frames. And for the first time in the Palestinian history, and as the fruit of several years of surveying and research, the first and full-detailed atlas of Palestine (West Bank and Gaza Strip) came into light.

Reference base maps (Israeli/Paestinian disagreements)

There is a gap between Israelis and Palestinians regarding the base maps. Palestinians calculate the areas of the West Bank and Gaza strip that were occupied in 1967 i.e. a total area of 6210 sq. km. On the other hand, Israel deducts the following from this area:

Area of East Jerusalem =	71 km ²
No Man's Land =	52 km ²
Dead Sea +	195 km ²



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It is important to mention here that in Oslo I and II, there was no mention of percentages, but areas. Percentages were introduced in Wye memorandum. Due to the imposed Israeli restrictions on Palestinians, many NGOs, local organizations, and also the PNA “before conducting the first census survey” failed to formalize even the simplest model for population studies. Population density and demography were a complete mystery. It was not until 1997 that the first census and population results were revealed long after the peace talks. Before the census, it was estimated that the Palestinian population was 0.9 million in the West Bank and East Jerusalem, and 0.6 million in Gaza. Only rough estimates were made to determine the Palestinian population density, based on the given figures at that time but they all failed to simulate the actual figures that clearly were different. The census results came as a shocking bomb, eradicating the previous convictions about population. The survey unveiled that the population of Palestine is 2.89 rather than 1.5 million of which 1.87 million live in the West Bank and East Jerusalem while 1.02 million live in Gaza! (PCBS, 1998). Of this population, approximately 12% live in refugee camps under harsh conditions. The result is even extraordinary when compared to the Israeli population. Again, the issue can not be discussed without unveiling the political restrictions imposed on the Palestinians. Though it was mentioned that the West Bank covers 5,659 km² of the previously defined Palestine, Palestinians have not got complete access over the area mentioned. This is due to the existence of settlements, military bases, and bypass roads with large buffer zones that are spread over the whole area and in which Palestinians have no access on at all. After the peace process has started, the Israelis invented the idea of bypass roads claiming that a bypass road is a safe passage between the many spread Israeli colonies in the West Bank. But the idea behind bypass roads was far beyond safety or security. The main reason was to separate the Palestinian built up areas into disconnected areas spread here and there with no interconnections. This has made transport and navigation a nightmare to Palestinians working in other cities or districts, not to mention that transport expenses has risen dramatically, which definitely affects the local Palestinian economy.

For some specific purposes, population density of a country could be defined as the number of human beings living in that specific country divided by the total area that this country spans. This assumes that inhabitants have full access over their country regardless of the condition and nature of land cover type, climate, and topology, whether a desert or an agricultural land, a seashore or mountain hills, this all counts in a country’s area. In the case of Palestine, a modification of this definition is obviously needed! Though the boundaries of the West Bank are clearly defined and mapped, and its area is easily determined, still this area can not be used as the total area in which Palestinians live in.



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Table 1: Bypass roads' length and buffer area in the West Bank.

	Existing bypass roads	Planned bypass roads	Total
150m buffer zone	47.5 km ²	39.6 km ²	87.1 km ²
Total length	315.4 km	261.9 km	557.3 km
Area percentage	0.84 %	0.70 %	1.54 %

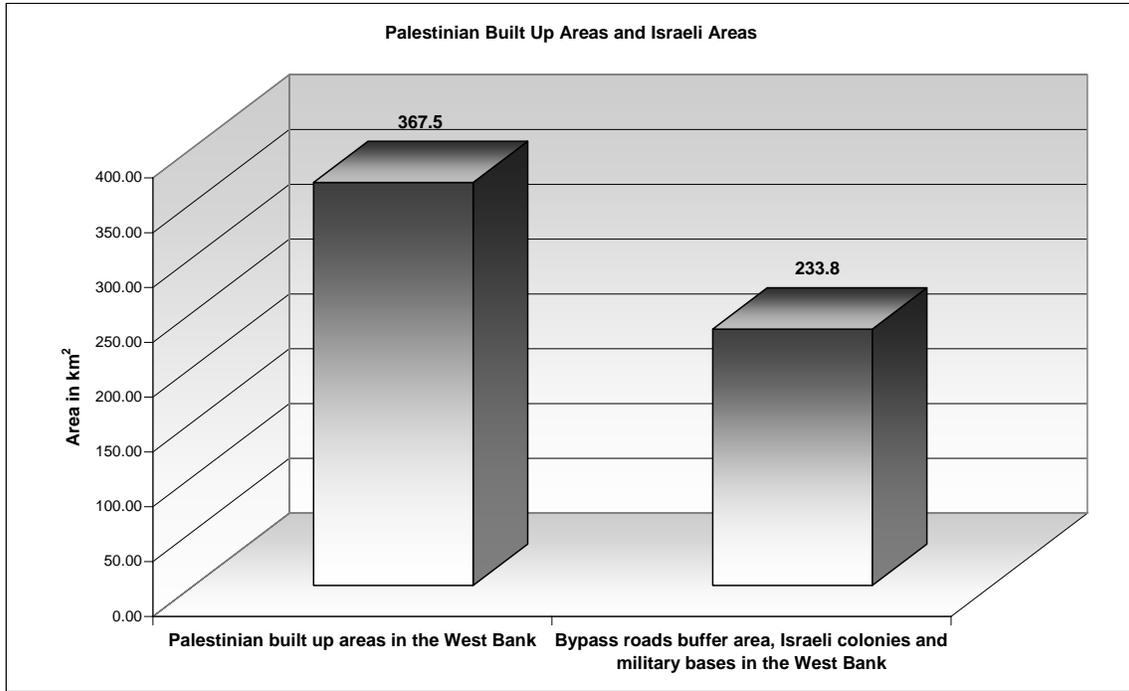
Area of W.B = 5659 km²

Table 2: Districts, population, and Palestinian built up areas.

District name	Built Up areas km ²	District Area km ²	Population
Jenin	38.20	572.55	203026
Tulkarm	27.40	245.30	134110
Tubas	5.98	365.92	36609
Nablus	42.54	613.47	261340
Qalqiliya	13.08	174.41	72007
Ariha (Jericho)	10.23	608.68	32713
Salfit	10.39	202.03	48538
Ramallah	52.09	848.67	213582
Alquds (Jerusalem)	36.52	353.64	328601
Bethlehem	36.09	607.35	137286
Al Khalil (Hebron)	95.02	1067.34	405664



Slide 1

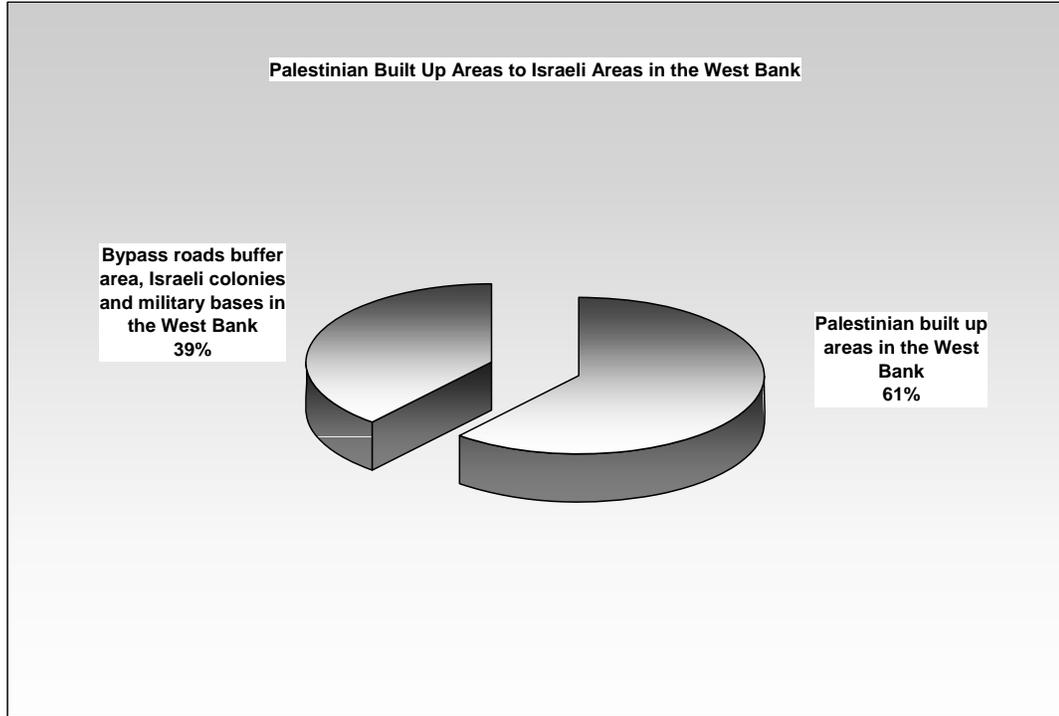


Slide 1 shows a comparison between the two tables. It shows all the Israeli colonies, bypass roads, military bases and closed areas to the size of the Palestinian built up area. Shockingly the size of the buffer zone around the bypass roads is almost one fourth of the whole Palestinian built up area in the West Bank, which reaches 6.49 % of the area of the West Bank!



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Slide 2

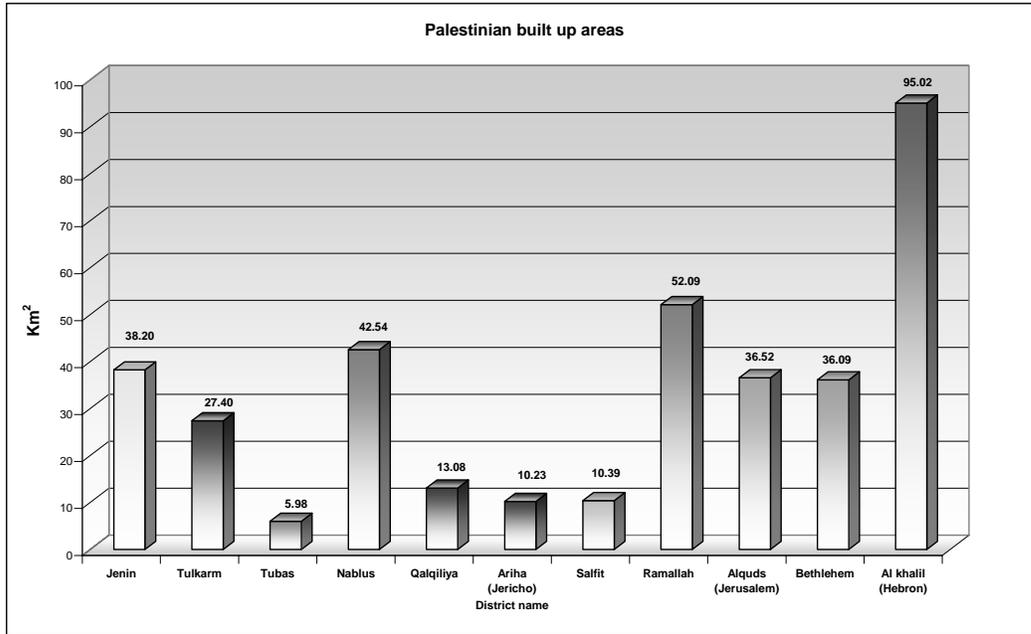


Slide 2 is an alternative pie chart display view. It shows a comparison between areas that are currently accessible to Palestinians versus the areas that are under the Israeli control, including colonies, military bases and road buffer zones.

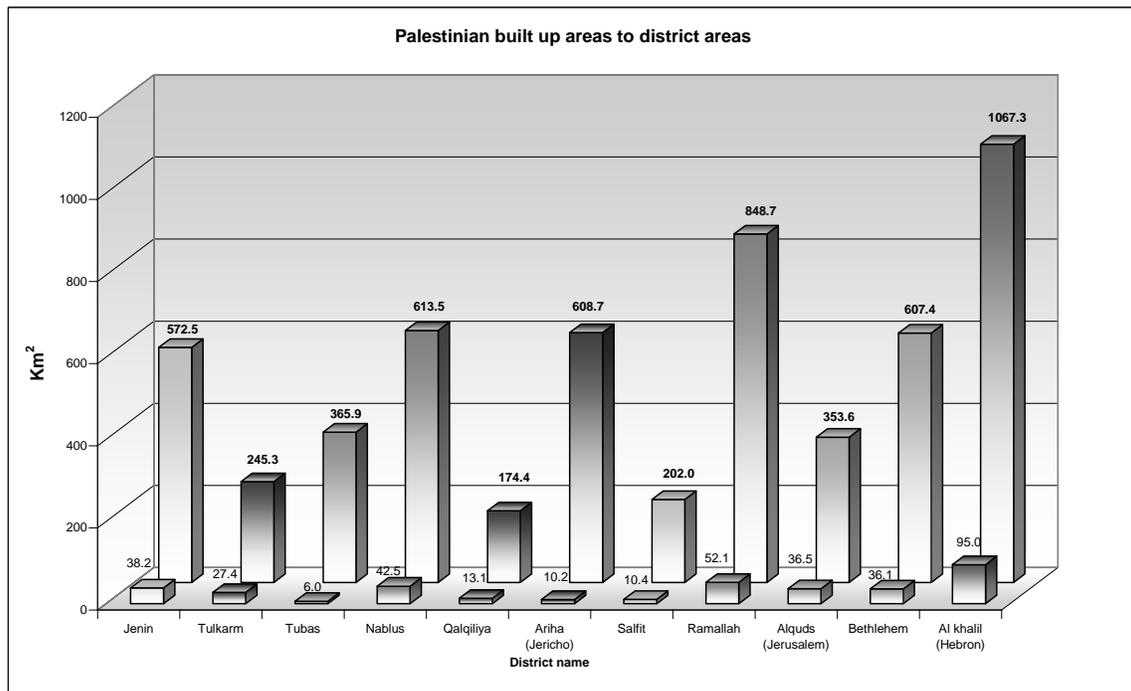
The size of the total Palestinian built up area in the West Bank reaches no more than 367.5 km², which is equivalent to 6.49 % of the total area of the West Bank.



Slide 3



Slide 4





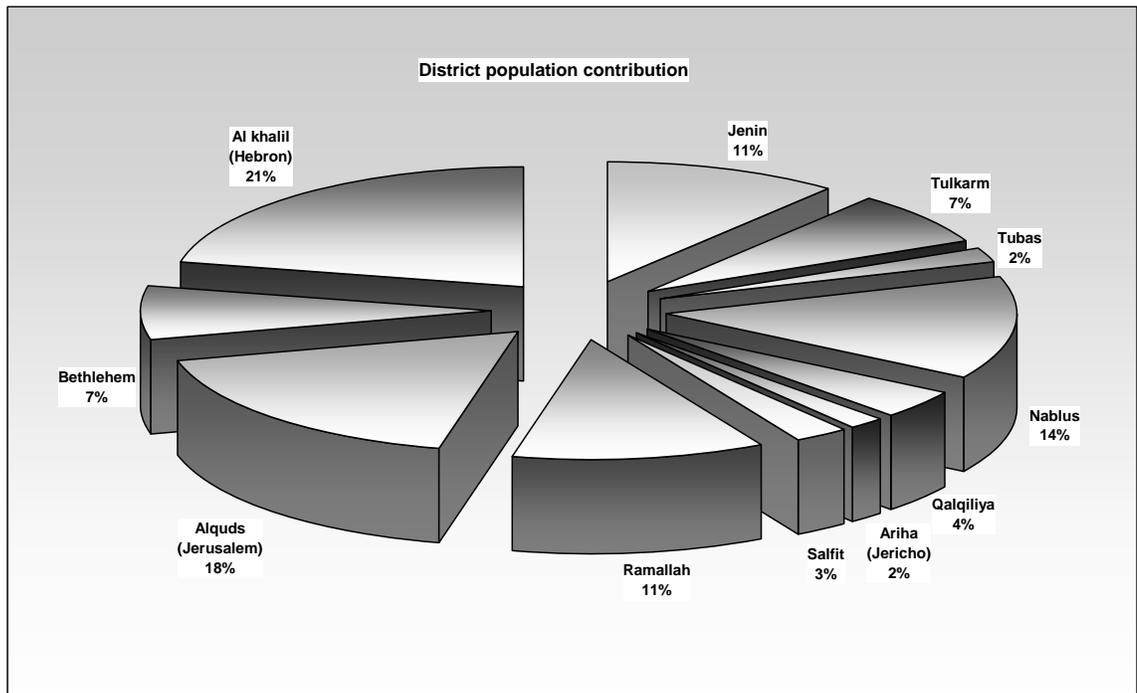
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Slide 3 shows the size of the Palestinian built up areas in each district, and a comparison of the built up area to the district area is illustrated in Slide 4, notice the difference.



Population density in Palestine is considered very high when political attention and restriction on land use are considered. The average population density calculated on areas currently inhabited by Palestinians³ in the West Bank reaches 5097 individual per km². This figure is different in area A, where Palestinian major cities are, than it is in area B. In contrast, the population density in Israel does not exceed 261 people/km² (Statistical Abstract of Israel, 1997).

Slide 5



Slide 5 shows the contribution to population of each district (Notice the contribution of Jerusalem).

Land use and Population

Palestinian Built-up Areas

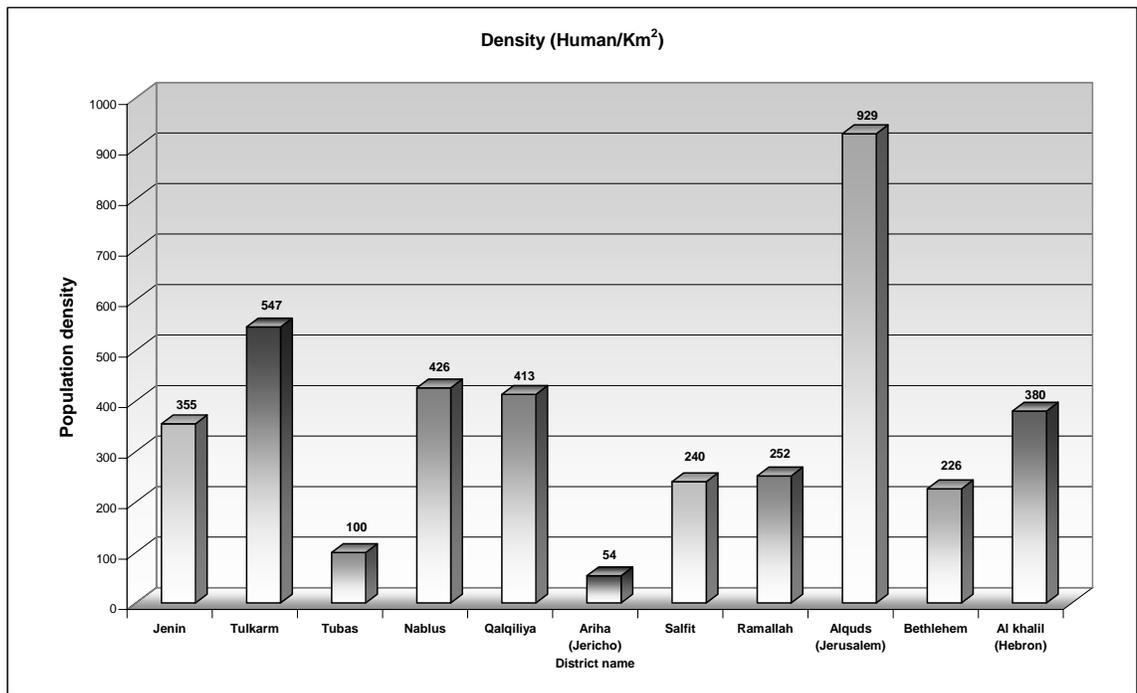
There are approximately 684 Palestinian built-up areas in Palestine, of which 642 are located in the West Bank covering an area of 35,893 hectares. In addition, there are 18 refugee camps scattered throughout the West Bank, hosting approximately 103,022 refugees. Almost 90% of the Palestinian built up areas in the West Bank are located

³ Palestinian built up areas covering area A, B, or C



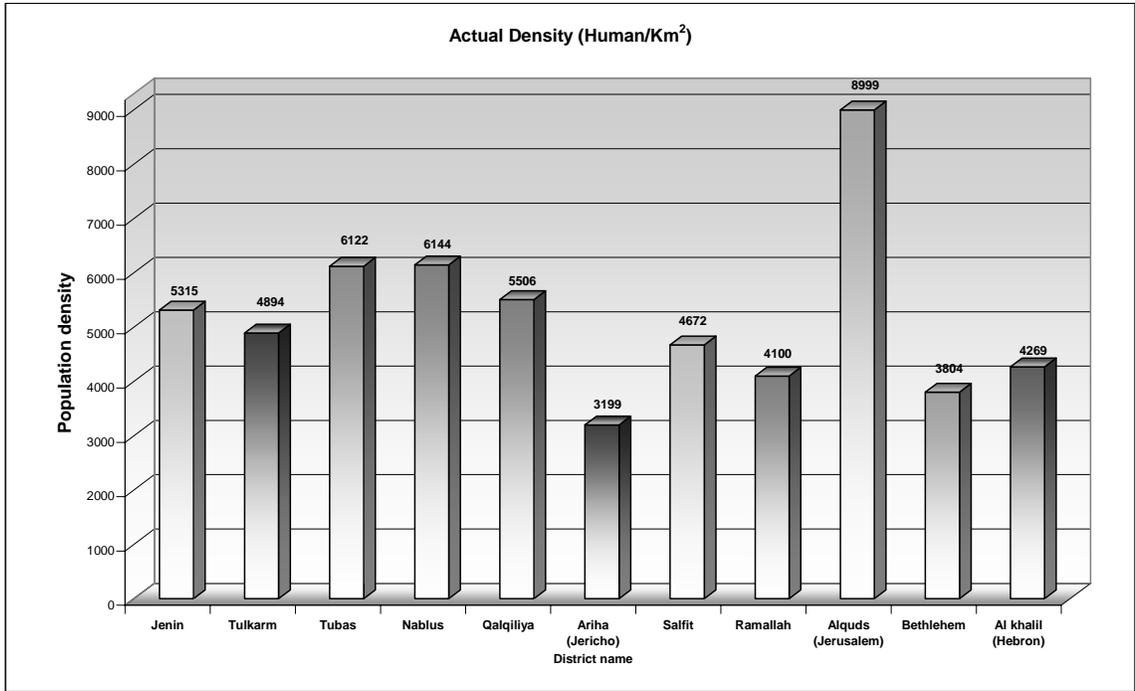
within the mountain range of the Central Highlands and the Western Slopes, whereas a limited number are located in the Jordan Valley. This is largely due to restrictions imposed by Israel on granting building permits. There are 42 Palestinian built-up areas in the Gaza Strip, which cover an area of 4,694 hectares, along with 8 refugee camps hosting 250,604 refugees. Table 2 above gives an accurate record for population in each district. Unlike Palestine, under stable and normal political conditions, population density (for a specific use) could be defined as the total number of inhabitants by the total area. For the case of Palestine this is quite impossible, since district political boundaries are no more than lines on a map, and the actual area accessible to Palestinians is far much less than the district area. The situation will be even worse in the future as the Israeli government continues confiscating Palestinian lands, demolish houses, and uproot trees. Since the early 1970's, Israel has pursued a policy of settling Jewish immigrants in Palestine in an attempt to change its demographic character. Presently, there are 18 Israeli colonies in the Gaza Strip with an estimated 6,000 Israeli colonists, and over 200 in the West Bank with a population of more than 350,000 colonists; 170,000 of whom reside in East Jerusalem.

Slide 6

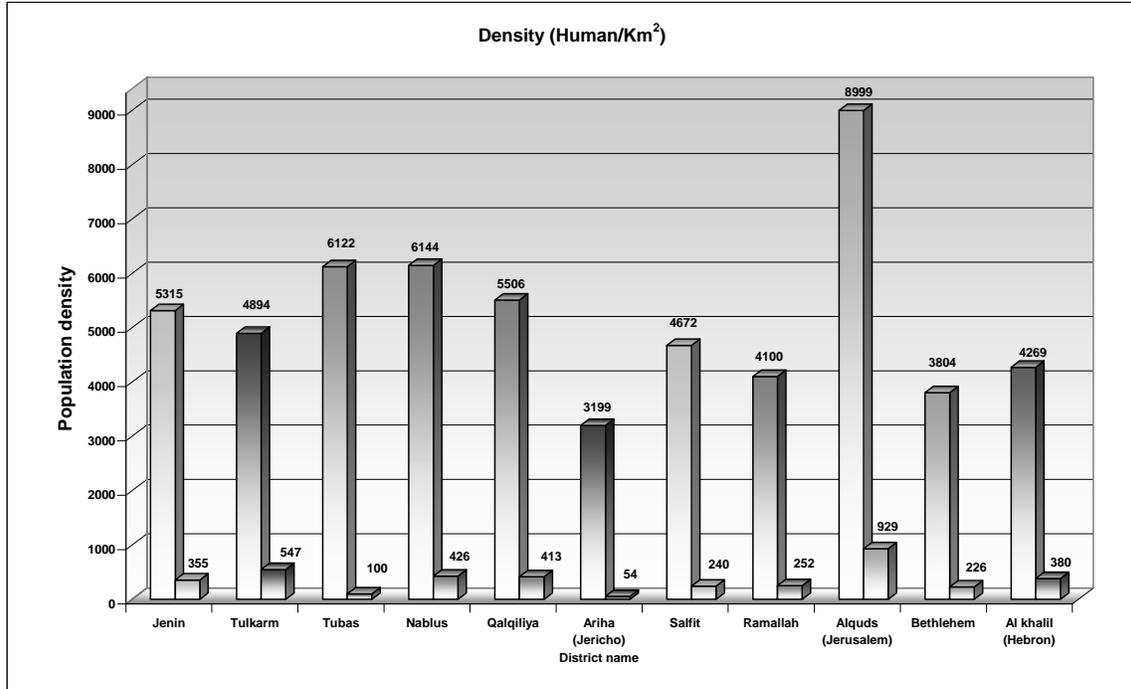




Slide 7



Slide 6 shows the Palestinian population density under stable and normal political conditions. Notice the two extremes of the graph, namely Jericho and how low its population, and Jerusalem and its population. Slide 7, on the other hand, shows the actual population density of each district. Notice how the figures changed dramatically especially in Jericho from as low as 54 to 3199 individuals per km². The worst situation occurs in Jerusalem where population reaches almost 9000 inhabitants per each square km, even in the lowest case Jerusalem is still highly populated. In contrast, the population density in Israel does not exceed 261 individual/km², which is still less 3.5 times the lowest population case of Jerusalem (Statistical Abstract of Israel, 1997), see Slide 8.



Slide 8

Jewish Settlements

Following the 1967 war, Israel embarked on a policy of settling Jews in the Palestinian Territories in an attempt to alter its demographic character and appropriate its natural resources. At present, there are more than 250 Israeli settlements and sites in the West Bank occupying an area of 10,846 hectares (2.0% of West Bank land). These settlements are distributed all over the West Bank, primarily condensed around East Jerusalem and in the Jordan Valley. Building in the Eastern Slopes and the Jordan Valley areas has been restricted to Palestinians since 1967. Except in the Jordan Valley, most of the Israeli settlements have been constructed on hilltops and/or in the vicinity of Palestinian communities in a manner that prevents the latter development. East Jerusalem and Bethlehem are clear examples of cities surrounded by clusters of settlements that limit their growth. In the months following the signing of the Wye Agreement, 11 new Israeli settlements have been established, 3 in Ramallah, 4 in Nablus, and 4 in Hebron districts (Arab Studies Society, 1998). Due to the constraints on building areas, much of the housing construction in the West Bank is being done on agricultural land. There are 18 settlements in the Gaza Strip occupying approximately



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905 hectares (2.5% of the Gaza Strip land). Most of these settlements are found in the southwestern and northern part of the Gaza Strip adjacent to the Mediterranean coast.

Roads

There are 1,255 km of main roads and 2,556 km of secondary roads in the West Bank while in Gaza, there are 565 km of roads. The building of settlements is compounded by the construction of a series of by-pass roads. These are built for the use of Israeli settlers, to link Israeli settlements to each other and with Israel, and to avoid contact with Palestinians. The construction of by-pass roads commonly occurs along the perimeter of Palestinian built-up areas. A 75-m “safety zone” on either side of these roads restricts Palestinians from any type of construction activity. The by-pass roads so far built in the West Bank exceed 228 kilometers in length, whereas the planned roads are estimated at 565 kilometers. With the safety buffer zone they enjoy, the construction of these by-pass roads requires the confiscation and destruction of approximately 96 km² of Palestinian land, most of that is agricultural. In the Gaza Strip there are three by-pass roads with a total length of 22.7 km.

Yellow Areas

Yellow areas are found in the Gaza Strip. In these areas, Israel retains full control over land, security, people, and natural resources. The majority of Israeli settlements in the Gaza Strip lie in these areas. They are composed from three main pieces of land with an area reaching 1,655 hectares. The largest is located in the southern part of the Gaza Strip on the Mediterranean shore. In total, these areas occupy approximately 20 km, or 48%, of the Gaza shoreline.

Closed Military Areas and Bases

Closed military areas are used as military training zones for the Israeli army. These areas occupy approximately 117,754 hectares of the West Bank (20.2% of the total area of the West Bank). Moreover, there are 71 military bases in the West Bank, covering a total area of about 3,870 hectares. The Gaza Strip contains approximately 29 closed military areas occupying an area of 170 hectares of land. The closed military areas are mainly found in the Jordan Valley. Although most of these areas have low agricultural value, they constitute the major grazing areas in the West Bank. Since Palestinian pastoralists are denied access to these areas, the remaining grazing areas currently suffer from severe overgrazing and are under threat of permanent desertification. Furthermore, the wildlife and the rich biodiversity, which characterize the closed military areas, are threatened by the action of the heavy military tanks and vehicles. These areas are



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currently empty of any substantial Palestinian population centers.

Cultivated areas

The Palestinian agricultural sector shares the combined characteristics of both intensive irrigated farming primarily in Gaza strip, the Jordan Valley and the Northern districts of the West Bank (Agro-ecological zones 5, 1 and 4, respectively) as well as the extensive rainfed farming which is dominant in the West Bank highlands (Agro-ecological zone 3). Despite the small size of the West Bank and Gaza, these areas enjoy a diversity of climatic regions, which makes it possible to grow almost anything all year around. The cultivated areas in the West Bank and Gaza strip are 164,300 ha and 17,196 ha respectively. Rainfed farming is the predominant agricultural pattern in the West Bank covering 94 % of the total cultivated area. In 1996, the total area of plant production in rainfed areas in the West Bank was 152,000 ha, divided mainly between vegetables (5.1%), field crops and forages (28.5%), olives (52.9%) and other fruit trees (13.5%). Productivity of these crops varies annually since it is totally dependent on rainfall and on the suitability of the weather conditions.

The total area of the irrigated lands in the West Bank was 9,473 ha, while in Gaza, it reached 10,600 ha. Almost 92.7% of the total irrigated areas in the West Bank are concentrated in two agro-ecological areas; the semi-coastal region (Jenin, Qalqilya, and Tulkarm areas), and the Jordan Valley. Vegetables constitute 67% of the total irrigated areas in the West Bank. About 65.3% of the vegetables are grown under open field, 15.8% under low plastic tunnels, 7.5% under high plastic tunnels and 11.4% under plastic houses. Fruit trees form about 26.5% of the total irrigated lands in the West Bank, while field crops constitute 6.5%. In Gaza Strip, vegetables constitute the largest area followed by citrus.

Range land

Total range land area in the West Bank and Gaza strip amount to 202,000 ha, most of which (150,000 ha) lie in Agro-ecoregion 2.

Forests and Nature reserves

There are 23,200 hectares of forests in the West Bank and Gaza. While Israel has declared 48 nature reserves in the West Bank, with a total area of almost 33,070 ha (5.7% of the West Bank's area). These nature reserves are distributed mostly over the Eastern Slopes and the Jordan Valley of the West Bank. Only 13 reserves are located in area B, a mere 11.3% of the total area designated as nature reserves. These reserves are under the authority of the Palestinians.



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Water Resources

Water is a very scarce and valuable resource in semi-arid and arid regions such as Palestine. The total current water use in Palestine is estimated to be about 286 MCM/y. Agriculture continues to be the largest consumer of water accounting for about 60% of total use (174 MCM, including 86 MCM in the West Bank and 88 MCM in the Gaza Strip) (PWA, 1999).

Day by day, the water crisis in the world increases due to the increasing demand on this valuable resource coming from the agricultural and industrial sector feeding and serving the society. Unfortunately the demand on this resource exceeds the amount available, which in return reflects on the economy of a certain country, since agriculture and industry are highly dependent on the availability of water. Only few people realized the fact that the scarcity of water resources in the Middle East played a major role in reshaping the political boundaries of the Middle East countries, since in most of the wars, water was one of the top priorities and targets to be controlled over. The scarcity of water in Palestine has created many problems that reflected in a retrograding sense on the Palestinians' economy and social life. Not only it is having a water shortage problem, but the Palestinian Water Authority PWA is suffering from financial deficit as well. Israel has ignored the network supplying Palestinians with water and put it off the shelves of its priorities, leaving it in a mess with lots of leakage in the network.

Palestinian entitlements for water include the underground water of the West Bank and Gaza aquifers, in addition to their rightful shares in the waters of the Jordan River as



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riparians. The groundwater regime in the West Bank is a multi-aquifer and sub-aquifer system (Aquifer System) which is mostly recharged from rainfall on the West Bank Mountains. The annual renewable freshwater water of this aquifer ranges from 600 MCM to 650 MCM according to different Israeli and Palestinian sources. The structure of the hydrological system is complex. The axes of the main structural anticlines divide the groundwater to the west, to the east and to the north. Accordingly, the hydrological system related to the West Bank can be divided into three major aquifer Systems, the Western, the Northeastern and the Eastern Aquifer System (or basins).

The Western Aquifer System, which is the largest, has a safe yield of 360 MCM per year (of which 40 MCM brackish). Eighty percent of the recharge area of this basin is located within the West Bank boundaries, whereas 80% of the storage area is located within Israeli borders. Groundwater flow is towards the coastal plain in the west, making this a shared basin between Israelis and Palestinians. The groundwater being mainly of good quality, this source is largely used for municipal supply. Israelis exploit the aquifers of this basin through 300 deep groundwater wells to the west of the Green Line, as well as through Mekorot (the Israeli Water Company) deep wells within the West Bank boundary. Palestinians, on the other hand, consume only about 7.5% of its safe yield. They extract their water from 138 groundwater wells tapping the Western Aquifer System (120 for irrigation and 18 for domestic use) in Qalqilya, Tulkarm, and West Nablus. There are 35 springs with an average flow discharge exceeding 0.1 L/s located in this aquifer system.



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The Northeastern Aquifer System has an annual safe yield of 140 MCM (of which 70 MCM brackish). Palestinians consume only about 18% of the safe yield of their aquifers in the Jenin district and East Nablus (Wadi Al Far'a, Wadi El Bathan, as well as Aqrabaniya and Nassariya) for both irrigation and domestic purposes. There are 86 Palestinian wells in this aquifer system (78 irrigation wells and 8 domestic wells). The general groundwater flow is towards the Bisan natural springs in the north and northeast.

The Eastern Aquifer System has a safe yield of 100-150 MCM per year (of which 70 MCM brackish). It lies entirely within the West Bank territory and was used exclusively by Palestinian villagers and farmers until 1967. After 1967, Israel expanded its control over this aquifer and began to tap it, mainly to supply Israeli settlements implanted in the area. The most important springs in the West Bank are in this basin. Seventy-nine springs with an average discharge greater than 0.1 L/s provide 90% of the total annual spring discharge in the West Bank. There are 122 Palestinian groundwater wells in this aquifer system (109 for irrigation and 13 for domestic use).

Gaza Coastal Aquifer is a continuation of the shallow sandy/sandstone coastal aquifer of Israel (shared aquifer). About 2200 wells tap this aquifer with depths mostly ranging between 25 and 30 meters. Its annual safe yield is 55 MCM, but the aquifer had been over-pumped at the rate of 110 MCM resulting in a lowering of the groundwater



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table below sea level and saline water intrusion in many areas. The main sources of salinity are deep saline water intrusion from deeper saline strata, seawater intrusion, and return flows from very intensive irrigation activities.

The Jordan River System is the only permanent river, which can be used as a source of surface water in Palestine. It is 360 km long with a surface catchment area of about 18,300 km² of which 2,833 km² lie upstream of the lake Tiberias outlet. The average annual flow of this river is about 1311 MCM. The Jordan river initiated from three main springs: the Hasbani in Lebanon, the Dan in Israel and the Syrian Golan Heights, and the Baniyas in the Syrian Golan Heights, to form the Upper Jordan river basin. The water of this basin flows southward through Lake Hula towards Lake Tiberias. In the absence of irrigation extraction, the Jordan River system would be capable of delivering an average annual flow of 1,850 MCM to the Dead Sea. The riparians of the Jordan River are Lebanon, Syria, Palestine and Jordan.

Annual precipitation for the Upper Jordan and Lake Tiberias averages 1,600 mm and 800 mm respectively. Downstream of Tiberias is the Lower Jordan river basin which joins the Yarmouk and Zerka rivers originating from Syria and Jordan in the east. The outlet of this basin is toward the Dead Sea in the South. As a result of water diversion from the Upper Jordan by Israel, there is no fresh water to flow downstream of Tiberias. In normal years, Israel allows a flow downstream from Lake Tiberias of just 60 MCM of



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water basically consisting of saline springs, which were previously used to feed the lake, and sewage water. These are then joined by what is left of the Yarmouk, by some irrigation return flows, and by winter runoff, adding up to a total of 200-300 MCM. Both in quantity and quality this water is unsuitable for irrigation and does not sufficiently supply natural systems either (www.fsk.ethz.ch/encop/13/en13-cho.htm).

The Palestinian use of the Jordan River before 1967 was through 140 pumping units. Immediately after the occupation these pumping units were either destroyed or confiscated by Israeli authorities. In addition, large irrigated areas of the Jordan Valley used by Palestinian were closed as a military zone and later given to Jewish Settlers.

Different plans have been proposed and concepts developed for the Jordan River and to identify shares of various riparian entities along the basin. One of the most relevant schemes is the Johnston Plan (1954) which proposed the construction of the West Ghor canal. Under the Johnston Plan, the proposed West Ghor Canal would have supplied 150-250 MCM/y from the River to the West Bank, but plans were never carried out.

Artesian wells constitute the only source of irrigation water in the Gaza Strip. However, due to over-extraction and seawater intrusion, more than 50% of the irrigation water is currently brackish. In the West Bank, wells and springs contribute almost equal amounts of irrigation water, though the vast majority of springs are concentrated in the Jordan Valley (Jericho district).



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Currently, total irrigated areas in Palestine cover some 240,000 dunums (126,000 dunums in the West Bank and 114,000 dunums in the Gaza Strip) which represents about 11% of total agricultural land. Almost 93% of the irrigated areas in the West Bank are concentrated in two agro-ecological areas: the semi-coastal region (Jenin, Qalqilya and Tulkarem areas) and the Jordan Valley. Vegetables constitute 67% of the total irrigated areas in the West Bank, fruit trees (including citrus) account for about 27%, while field crops constitute 6.5%. In the Gaza Strip, citrus trees (44,000 dunums), other fruit trees (13,000 dunums) and vegetables (43,000 dunums) account for about 87% of the total irrigated areas, with the remaining 13% grown to field crops.

Water use efficiency of irrigation, measured in terms of water use per unit area (CM/dunum), is around 600 CM/du on average. However, this average masks wide regional variations ranging from 400-500 CM/du in the coastal and semi-coastal zones to about 900 CM/du in the Jordan Valley. Higher efficiency in the coastal and semi-coastal zones is attributed to the extensive use of plastic houses and the fact that water in these zones comes from reliable irrigation wells equipped with piped networks for water distribution. The lower efficiency in the Jordan Valley is due to dependence on springs as major sources of water in these zones. Spring discharge has high variability and large amounts of spring water are lost every year due to lack of storage facilities, especially in winter months when the demand is less. Water is distributed by open earth and concrete



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canals, thus large amounts are lost through seepage and evaporation. Moreover, the extensive use of traditional irrigation methods on large areas of open field vegetables contributes significantly to lower efficiency.

The regional differences in water use efficiency can also be attributed to the relatively more abundant supplies of irrigation water (primarily from springs) in the Jordan Valley compared to the other zones. This is reflected in large regional differences in irrigation water prices which vary from about 0.03 \$US/CM in the Jordan Valley, 0.12-0.14 \$/CM in the Gaza Strip, and 0.21-0.34 \$/CM in the Jenin and Tulkarem areas. The price of water has a direct bearing on providing farmers with incentives to adopt modern irrigation technology and the lower prices in the Jordan Valley could explain to a large extent the current low levels of water use efficiency in this zone.

Rapidly deteriorating water quality is of paramount concern in the Gaza Strip. Water quality has deteriorated due to over-extraction and the corresponding seawater intrusion, increased salinization, excessive use of fertilizers, pesticides and uncontrolled discharge of sewage water in the soil and the natural drainage system. These factors have affected the productivity of the agriculture sector and could soon cause irreversible damage to land and water. In the West Bank, water quality is generally considered acceptable, with no serious indications of pollution in the deep aquifer. However, water contamination in the shallow aquifer is increasing, particularly in the more urbanized semi-coastal zone. Salinization of irrigation wells is increasing in the Jordan Valley,



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where farmers are resorting to mixing brackish water with fresh spring water to allow for irrigation.

Conclusion

GIS is a very valuable tool that can be used for monitoring and assessing geographical and landuse data especially under adverse political conditions. Clearly, the Israeli occupation of Palestine has brought about severe environmental degradation. The restrictions on land use, the construction of Israeli settlements and by-pass roads, the relocation of Israeli industries, and the many restrictions imposed upon the Palestinian people have had devastating effects on the environment, and stopped those who care most about the health of the land from being able to maintain it. The results of these practices will affect the lives of all who will inhabit these lands for generations to come. It is hoped that GIS will be effectively used in mitigating the environmental degradation in Palestine leading to the promotion of sustainable development in the area.



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References

- World Bank, Water Management Strategy in the Middle East and North Africa, World Bank, Washington, 1995, pp. 11
- PWA Beit Jala, Bethlehem, Beit Sahour, Final statistical index, 1997
- Environmental Profile for the West Bank, Volume (1), district of Bethlehem, ARIJ, 1995
- Water supply and demand in Palestine, Harvard University, January 1994
- Leonardo Hosh, Preliminary Evaluation of the Potential of Aquaculture in Palestine, ARIJ, August 1995
- Isaac, J., Sabbah, W., 1998. Water Resources and Irrigated Agriculture in the West Bank. Applied Research Institute-Jerusalem, Bethlehem, West Bank.
- Palestinian Central Bureau of Statistics PCBS, 1997, “Available for free from the internet”