CHAPTER 3 THE STUDY AREA

3.1 General Conditions of the Study Area

3.1.1 Topography and Landscapes

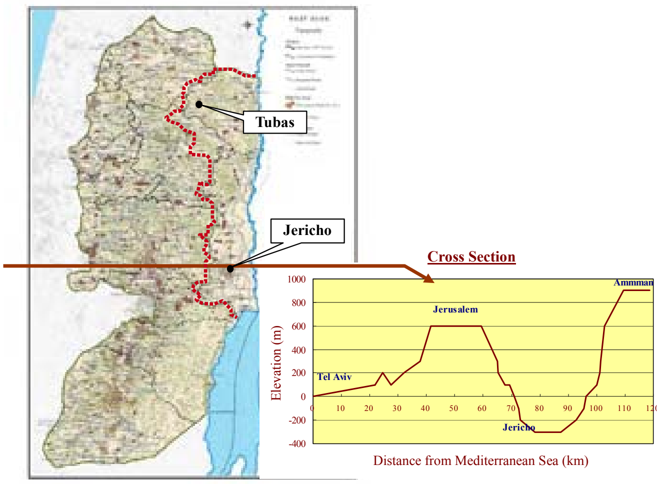
The landscape and topographic condition in the Study Area are varied and can be categorized into three types, namely mountainous areas, foothills, and flat areas, described as follows:

(i) Mountainous areas are located in the upstream area of Wadi Far'a. The elevation reaches up to 600 m above sea level;

(ii) Most of the Study Area is covered by foothills with steep slopes. The elevation of the foothills range from 0 to 200 m above sea level; and

(iii) Flat areas, which are lower than the sea level and have relatively high agricultural production, lie along the Jordan River. The length and width of the areas are about 10 km and 1 to 2 km, respectively.

Figure 3.1.1 shows the topographic map and the cross section from Tel Aviv to Amman. The distance of the section between the highest elevation at Jerusalem and the lowest at Jericho, is only about 15 km. The topographic relief of the section changes from around 600 m above sea level to less than 300 m below sea level. This indicates that the average gradient of the section is about 17%.



Source: MoP, Jericho Regional Development Study Project in Palestine, JICA Study Team.

Figure 3.1.1 Topographic Map of the Study Area

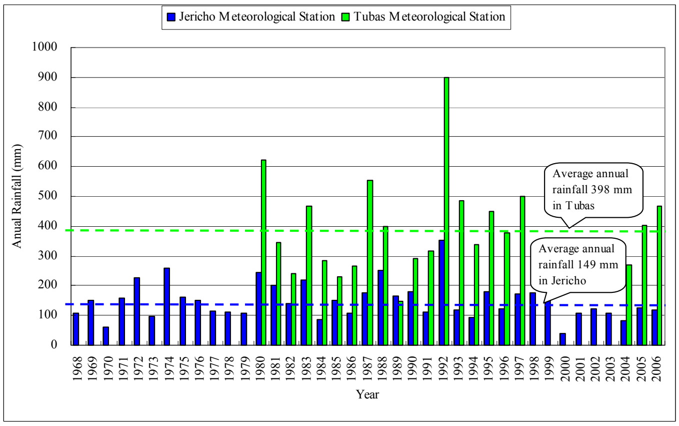
3.1.2 Climate

The Study Area is characterized by long, hot, dry summers and short and moderate winters. The climate conditions are as described in the following sections.

(1) Rainfall

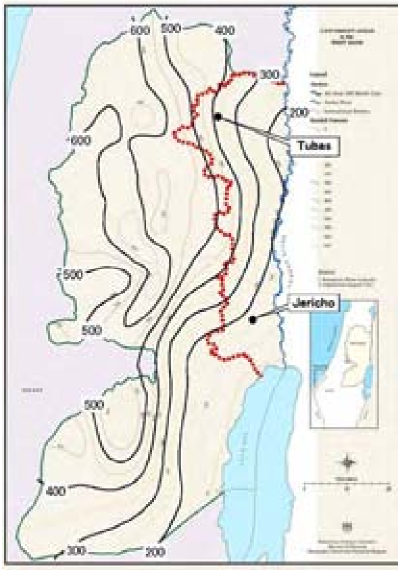
Rainfall is considered as the main source of water in the Study Area. Large part of the rainfall is observed in the winter season, especially between mid-November and March, with marked annual variation. Potential evaporation rate exceeds the rainfall. Therefore, the soil water content is rarely saturated in rain-fed agricultural land.

Figure 3.1.2 shows the annual average rainfall at the Jericho and Tubas meteorological stations. As shown in the Figure, the long-term average annual rainfall is 149 mm and 398 mm, respectively. The total annual rainfall also varies from location to location. Rainfall ranges from 80 - 200 mm/year along the flat areas to 200 - 350 mm/year in the mountainous areas as shown in Figure 3.1.3. The total number of rainy days ranges from 50 in the western part to 25 in the eastern part. Figure 3.1.4 shows the monthly rainfall from the Jericho and Nablus meteorological stations in 2004. As in the normal summer months, i.e., from May to September, there was no rainfall at all in 2004.



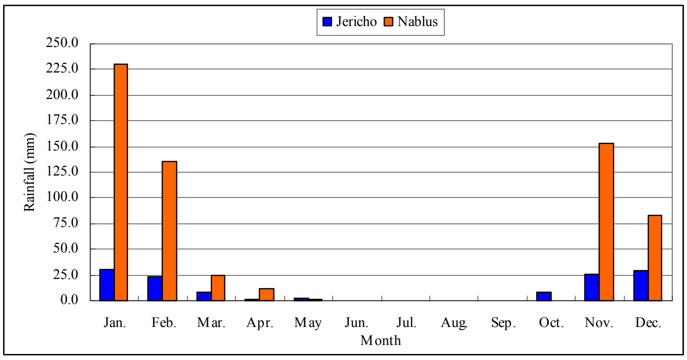
Source: Database, PWA.

Figure 3.1.2 Annual Average Rainfall from Jericho and Tubas Meteorological Stations



Source: MoP

Figure 3.1.3 Long-term Annual Average Rainfall of the Jordan Valley

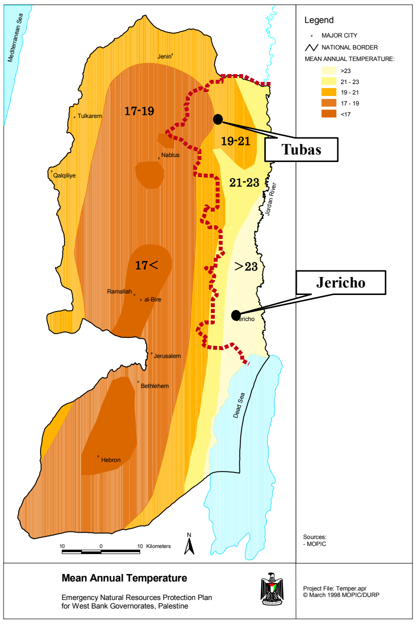


Source: PCBS, 2004.

Figure 3.1.4 Monthly Rainfall from Jericho and Nablus Meteorological Stations in 2004

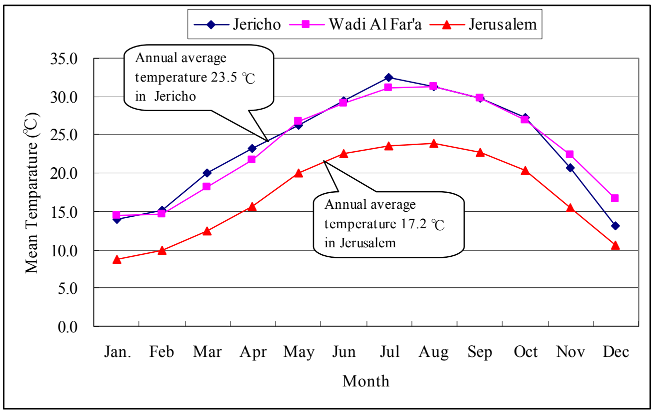
(2) Temperature

Temperature is strongly affected by geographical condition, altitude, marine exposure, and etc. Figure 3.1.5 shows the mean temperature in the West Bank (WB). The mean monthly temperature in Jericho, Wadi Far'a (Tubas Governorate) and Jerusalem are shown in Figure 3.1.6. The mean monthly temperature in Jericho and Wadi Far'a ranges between a minimum of 13.1 ^{o}C in December to a maximum of 32.4 ^{o}C in August.



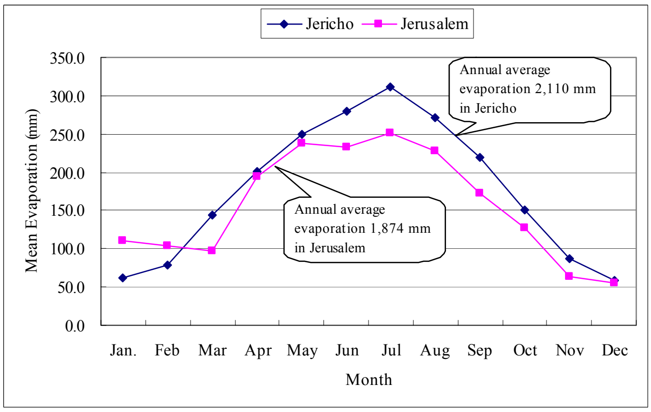
Source: MoP

Figure 3.1.5 Mean Temperature in WB



Source: Meteorological Conditions in the Palestine Territory Annual Report, PCBC

Figure 3.1.6 Mean Monthly Temperature



Source: Meteorological Conditions in the Palestine Territory Annual Report, PCBC

Figure 3.1.7 Mean Monthly Evaporation

(3) Evaporation

Evaporation rate in the Study Area is high due to high temperature, intensive sunshine and low humidity, particularly during the period of May through September. Annual average evaporation in Jericho reaches around 2,100 mm as shown in Figure 3.1.7. No data is available at the other meteorological stations in the Study Area.

The climate of the Study Area is extremely dry because of the aforementioned conditions. Rainfall is limited during winter to spring, and is scarce in summer. Therefore, most of the localities in the Study Area suffer from extreme shortage of safe and reliable water supply for domestic and agricultural uses during summer.

Although, only the limited parts of the Study Area have been cultivated presently due to the insufficient water, the genial climate enables cultivation of the vegetable crops throughout the year. Shipping the crops during the off-crop season will bring considerable benefit to the agricultural sector in the Study Area. In this context, it is expected to secure the sufficient water for the advantages of agriculture in the Study Area.

3.1.3 Geology and Hydrogeology

Generally, Jordan Valley Area is part of the Eastern Basin in WB. The existing main aquifer systems within the Study Area consist of the following:

(i) The Holocene Aquifer;
(ii) The Pleistocene Gravel Aquifer (Samra formation);
(iii) The Neogene (Miocene – Pliocene) Aquifer (Beida formation);
(iv) The Eocene Aquifer (Jenin sub series);
(v) The Upper Cretaceous Aquifer (Jerusalem, Bethlehem, and Hebron formations); and
(vi) The Lower Cretaceous Aquifer (Yatta, Upper Beit Kahil, and Lower Beit Kahil formations).

These aquifer systems are described in detail below.

(1) First Aquifer: the Shallow Aquifer

The Holocene Quaternary aquifer, Pleistocene Samra aquifer and Neogene conglomeratic Beida aquifer represent the shallow aquifer. The geological characteristics of these aquifers are explicated as follows.

1) Holocene Aquifer

This aquifer occurs mainly in the Jordan Valley. It is built up of sub-recent terrigenous deposits formed along the outlets of major wadis. These quaternary fans are still accumulating after large floods and consist of debris from neighboring lithologies, which are deposited according to their transport energy; the biggest clasts are found close to the apex and the smallest close to the fan margin. Transport normally takes place along alternating channels or after heavy rain as sheet flow. Thus, permeable horizons alternate with impermeable lithologies within the deposit. The total thickness is unknown. However, it becomes thicker to the rift margins, and thinner to the center of the rift basin. Boreholes and wells are shallow. The Holocene aquifer often directly overlies the Pleistocene gravel with which it is in hydraulic contact.

2) Pleistocene Gravel Aquifer (Samra formation)

The three members (Samra coarse clastic, Samra silt and Lisan) are lateral facies succession from terrestrial/ fluvial, to deltaic/ limnic and limnic/ brackish lake environments. Lisan, the marl, gypsum and silt unit, is an aquiclude. It is distributed mainly towards the middle of the graben and is about 35 m thick. Samra formation consists of two members: a silt member, up to 20 m thick underlying or interfingering with Lisan and a coarse clastic member further to the west that predominantly consists of gravel, inter-bedded with clay, sand and marl horizons. Exploitable water resources occur in the coarse clastic member. Rainfall recharge is negligible, but the aquifer receives cross flows from the Mountain Aquifer system and some recharge from ephemeral wadis. The aquifer supplies water for agriculture in the Jordan Valley between Jericho and Fari'a Graben. It extends from Jericho in the south to Marj Na'jeh and Wadi Far'a in the north. It may be up to 120 m thick. Borehole yields vary from 20 to 100 m^3/hr. Water quality is variable, with chloride concentrations from 50 mg/l up to 2,200 mg/l in areas influenced by salt domes, hypersaline brines and/or Dead Sea water inflows south of Jericho. The sulphate concentration rises from 100 mg/l in the west to 900 mg/l near Jericho.

3) Neogene (Miocene - Pliocene) Aquifer (Beida Formation)

This is the low part of the Dead Sea group. Beida consists of three lithologies, well-cemented conglomerates, highly permeable, some indurated marl and sandstone and few freshwater limestone of minor aquifer potential. Beida is of local importance at the north-eastern boundary of West Bank in the Jordan Valley and in Wadi Fari'a, especially near the Bardala and Ein Beida areas. Water quality in the aquiferous conglomeratic portion is good (about 70 mg/l chloride). The thickness of the three combined lithologies can be up to 350 m in some places. However, the aquifer is of limited extent and in most places, only about 100 m thick.

4) Eocene Aquifer (Jenin Sub-series)

The Eocene aquifer is extensively used for irrigation whose water table normally occurs within 100 m of the ground surface. The aquifer is situated in the Jenin and Fari'a areas. It consists of thin nummulitic limestone containing chalk, chert bands, and marl, which reduce the groundwater supply potential of the aquifer. There is only limited storage potential and moderate transmissivity. Borehole yields may be dependent on the elapsed time since the last significant rainfall event. The yield of individual wells range from 20-100 m^3/h.

Water quality tends to deteriorate towards the Jenin area due to over-pumping and heavy irrigation activities.

The Eocene is separated from the underlying Upper aquifer by a 100 – 500m thick sequence of chalks and marls belonging to the Nablus Group (Senonian series), which act as the confining unit to the Upper aquifer. In parts of the North-Eastern aquifer Basin, the Nablus Group is a local aquifer.

(2) Second Aquifer: the Upper Cretaceous Aquifer

The upper cretaceous aquifer consists of the Jerusalem (Turonian), Bethlehem and Hebron formations (Upper Cretaceous).

1) Turonian Aquifer (Jerusalem Formation)

The formation of the Turonian aquifer consists of massive limestone (sometimes thinly bedded limestone), and dolomitic limestone with well-developed karst features. Though formulating a part of the Upper aquifer, the Turonian aquifer is isolated from the main part of the Upper aquifer located in both the southern and some part of the eastern West Bank, where the Bethlehem formation whose permeability is very weak is prevailing. The Jerusalem formation is of large lateral distribution and thickness in the Tulkarem and Qalqilya areas (approximately 130 m thick). This forms a good aquifer especially where the saturation thickness is in tens of meters. Water quality is generally good. However, in some areas, there is an evidence of deterioration because of pollution by sewage and agro-chemicals.

2) Upper Cretaceous Aquifer (Bethlehem and Hebron Formation)

The Upper Cretaceous aquifer consists of the Bethlehem and Hebron formations which are mainly interbedded dolomite and chalky limestone. The aquifer is an important regional source of domestic water supply. It is heavily exploited in the areas near Tulkarem and Qalqilya, particularly on the Israeli side of the border, where the recharge is active and the aquifer is shallow. The aquifer is at intermediate depth in the Bethlehem and Hebron areas. Individual borehole yields ranges from 40-400 m^3/h. Depths of the boreholes are generally less than 400 m. The distance to water is rarely more than 220 m below ground surface. The aquifer receives good seasonal recharge. Water quality is generally good (30 – 15 mg/l chloride).

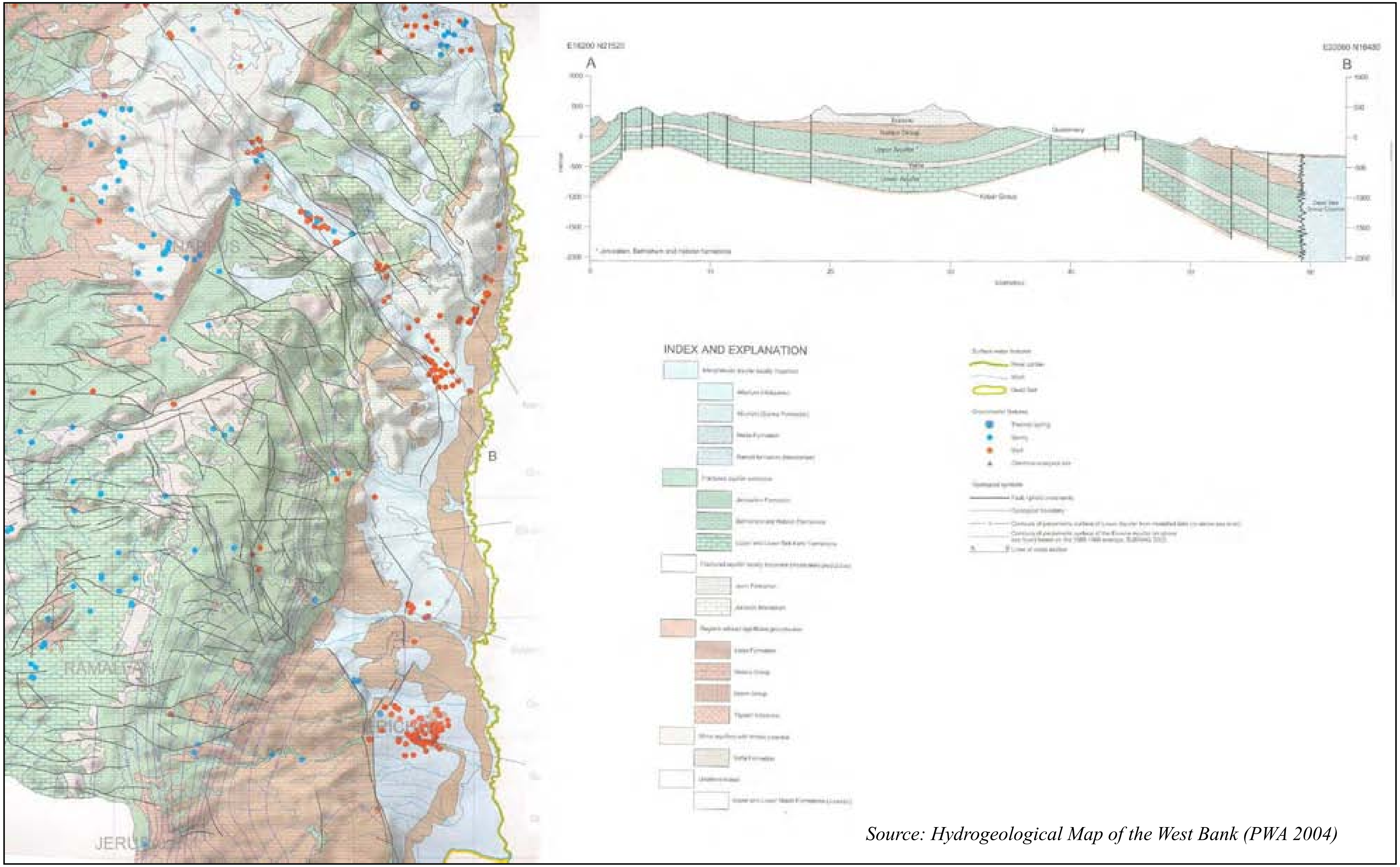
(3) Third Aquifer: the Lower Cretaceous Aquifer (Upper and Lower Beit Kahil Formations)

Part of the Lower Cretaceous Yatta formation hydraulically separates the Upper and Lower aquifers across much of West Bank. The Yatta formation gives rise to minor springs and seepages in the Western aquifer Basin. These draw from small perched aquifers. The piezometric level in the Upper Aquifer is generally higher in elevation than in the Lower Aquifer.

The Lower Beit Kahil formation and Upper Beit Kahil formation and sometimes the lower Part of the Yatta formation comprise the Lower aquifer. This is deeply confined across most of West Bank. It is an excellent regional source of drinking water, the high water bearing capacity and productivity reflects the thickness of dolomitic limestone and limestone (300 to 400 m). Individual borehole yields range from 150 to 450 m^3/h. Boreholes are expensive to drill and vary from 500 to 850 m in depth. Water quality is generally good with chloride values between 20 to 50 mg/min, though slightly higher salinity has been encountered towards the Jordan Valley.

(4) Fourth Aquifer: the Deep Aquifer (Ramali and Maleh Formations)

The Ramali of the Neocomian, and the Upper and Lower Maleh formations of the Jurassic form the Deep aquifer. This aquifer has not been thoroughly investigated and there is a considerable variation in the characteristics of the respective formations from the middle to the north of West Bank. In general, the aquifer offers little groundwater development potential. The Kobar Group forms an aquitard separating the Lower aquifer from the Deep aquifer. However, it is not homogeneous and there is some minor local aquifer potential in the Ein Qinya and Ein AI-Assad formations.



Source: Hydrogeological Map of the West Bank (PWA 2004)

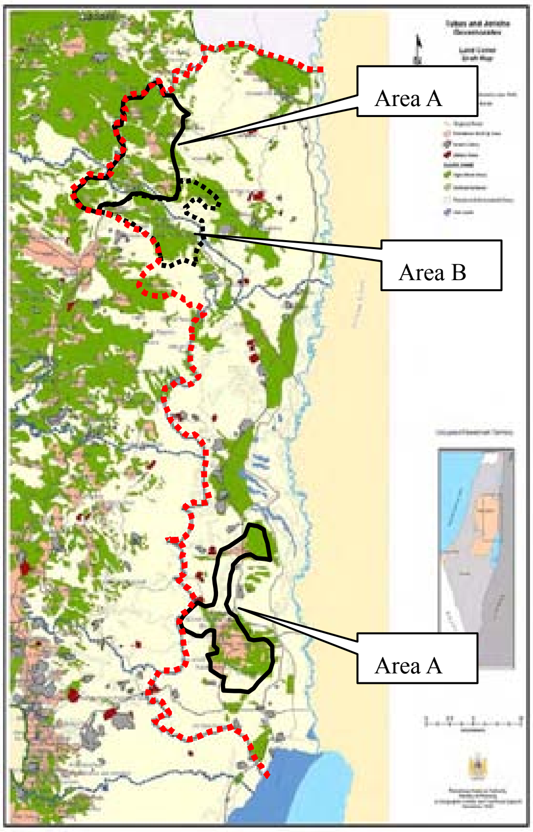
Figure 3.1.8 Hydrogeological Map

3.2 Present Land Use in the Study Area

The latest land use information in Palestine was developed by using satellite images acquired in 1997, although the land use has been changed. The information in the Study Area is shown in Figure 3.2.1. The Study Area can be classified into five types of land cover: namely i) agricultural land; ii) Palestinian communities; iii) Israeli settlement; iv) military base; and v) others.

Agricultural lands are located in the Tubas highland area where relatively abundant rainfall is expected and scattered in the lower Jordan River Rift Valley. Stable irrigation water is conveyed from wells and springs.

On the other hand, over 50% of the Study Area is categorized as others which include rangeland for Bedouin and natural grassland or unused area.



Source: MoP

Figure 3.2.1 Present Land Use in the Study Area

The land use distribution is summarized as follows.

Table 3.2.1 Land Use Distribution of the Study Area

(Unit: km^2)

Land Cover	Area A	Area B	Area C	Total
Agricultural Areas	86	36	219	342
Palestinian Communities	16	2	47	65
Israeli Settlement	0	0	17	17
Military Base	13	3	67	84
Others	32	16	537	586
Total	148 (13.5%)	58 (5.3%)	887 (81.2%)	1,093 (100.0%)

Source: MoP

MoP planned to update the land use map based on high resolution satellite images acquired in 2003. Therefore, the updating work including digitizing based on the satellite images, ground truth and finalization work was completed by MoP in cooperation with MoA under support of the Study on September 2008. This final land use map was integrated into the GIS database developed and officially delivered to organizations concerned under the Study.

3.3 Socio-Economic Conditions

3.3.1 Demography

Total population of Palestine is 3,762,005 in 2005 (see table below). Of which, 2,372,216 people reside in WB, and 97,373 people live in the Study Area, Jericho and Tubas. Population growth rate of Palestine was 3.3% between 1997 and 2005, while those of Jericho and Tubas were comparatively higher at 3.8% and 3.6%, respectively.

Table 3.3.1 Population change between 1997 and 2005

Locality	1997	2001	2002	2003	2004	2005	CAGR*
West Bank and Gaza	2,895,683	3,275,389	3,394,046	3,514,868	3,637,529	3,762,005	3.3%
West Bank	1,873,476	2,087,259	2,157,674	2,228,759	2,300,293	2,372,216	3.0%
Jericho Governorate	31,412	37,066	38,968	40,894	40,909	42,268	3.8%
Tubas District	35,176	41,067	43,110	45,187	45,168	46,644	3.6%
Study Area**	66,588	78,133	82,078	86,081	86,077	88,912	3.7%
Study Area** (Excl. camp)	56,344	66,107	69,443	72,828	72,823	75,211	3.7%

** Compound Annual Growth Rate, ** Excl. Wadi Far'a area*
Source: Palestinian Central Bureau of Statistics (PCBS)

Table 3.3.2 shows the population and population density in the governorate/district in 2005. The total area of WB is 5,655km^2, while that of Jericho and Tubas is 995 km^2. Jericho has the lowest population density at 71 people/km^2, and the density of Tubas is the second lowest with 116 people/km^2.

Table 3.3.2 Area of Governorate, Population and Population Density of the Palestinian Territory by Governorate/ District, 2005

Governorate/ District	Population*	Governorate Area (km^2)	Population Density (Capita/km^2)
Palestinian Territory	**3,762,005**	**6,020**	**625**
West Bank	**2,372,216**	**5,655**	**420**
Jenin	254,218	583	436
Tubas	46,644	402	116
Tulkarm	167,873	246	682
Nablus	326,873	605	540
Qalqiliya	94,210	166	568
Salfit	62,125	204	305
Ramallah & Al- Bireh	280,508	855	328
Jericho	42,268	593	71
Jerusalem	398,333	345	1,155
Bethlehem	174,654	659	265
Hebron	524,510	997	526
Gaza	**1,389,789**	**365**	**3,808**

** Data at the Mid Year.*
Source: Palestinian Central Bureau of Statistics, 2005. Population Projection in the Palestinian Territory. Revised Series. Ramallah-Palestine.

The population in the Study Area was projected as shown in Table 3.3.3. The projection was calculated with an annual growth rate of 2.7%. Based on this, total population in the Study Area is estimated to be about 112,000 in 2010 and 127,000 in 2015.

Table 3.3.3 Population Projection of the Study Area

Locality	2005	2010	2015
Marj Na'ja	743	858	972
Az Zubeidat	1,299	1,498	1,698
Marj al Ghazal	373	431	488
Al Jiftlik	4,264	4,921	5,575
Fasayil	872	1,006	1,140
Al 'Auja	3,886	4,484	5,080
An Nuwei'ma	1,128	1,303	1,476
'Ein ad Duyuk al Foqa	789	910	1,031
'Ein as Sultan Camp	1,972	2,277	2,579
'Ein ad Duyuk at Tahta	937	1,081	1,225
Jericho (Ariha)	19,783	22,830	25,863
Aqbat Jaber Camp	6,147	7,093	8,035
Other Localities	75	85	96
TOTAL JERICHO GOVERNORATE	**42,268**	**48,777**	**55,258**
Bardala	1,528	1,764	1,998
'Ein el Beida	1,048	1,209	1,370
Kardala	160	185	209
'Aqqaba	5,885	6,791	7,693
Tayasir	2,323	2,681	3,037
Al Farisiya	207	238	270
Ath Thaghra	250	289	327
Al Malih	200	230	261
Tubas	15,591	17,992	20,382
Ras al Far'a	679	784	888
El Far'a Camp	5,572	6,431	7,285
Wadi Far'a	2,269	2,618	2,966
Tammun	10,119	11,677	13,229
Al Hadidiya	177	205	232
Other Localities	636	734	831
TOTAL TUBAS GOVERNORATE	**46,644**	**53,826**	**60,978**
Al Badhan	2,353	2,702	3,060
An Nassariya	1,316	1,510	1,711
Al 'Aqrabaniya	870	998	1,131
Ein Shibli	192	221	250
Furush Beit Dajan	1,126	1,293	1,465
Talluza	2,604	2,989	3,386
Nablus Total	326,873	375,201	425,056
TOTAL WADI FAR'A AREA	**8,461**	**9,713**	**11,004**
TOTAL STUDY AREA	**97,373**	**112,316**	**127,240**
TOTAL STUDY AREA (Excl. Camps)	**83,682**	**96,516**	**109,340**

Source: PCBS; JICA Study Team (Jericho Regional Development Study) Estimation
2005-2006: Revised Mid-year Population Projection, Small Area Statistics 2005 (Website)
2007: Revised Mid-year Population Projection (Website)
2008-2015: JICA Study Team (Jericho Regional Development Study) Estimation According to the PCBS Projected Growth Rate of WB

3.3.2 Administration

The Study Area is administratively located in three governorates: Jericho governorate, Tubas governorate, and a part of Nablus governorate. The Study Area covers 29 Local Government Units (LGUs), consisting of 2 municipalities and 27 village councils. At the municipality level, they have a well-organized administrative structure and adequate number of staff, while most village councils lack administrative and financial capacity.

3.3.3 Employment

Total labor force aged 15 years and above of Palestinian is 890,400 persons as of the first quarter of 2007 (see Table 3.3.4). Of this total, unemployed persons reached 192,100, accounting for 21.6%. The labor force in the Jordan River Rift Valley area, consisting of

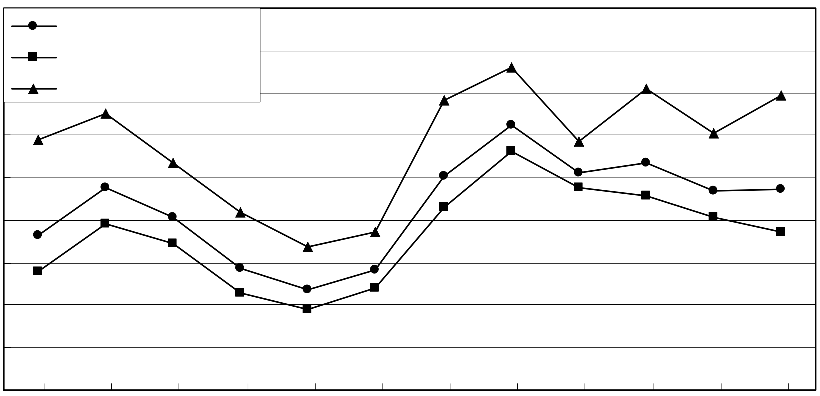
Jericho and Tubas, is 24,100 persons. Unemployment rate of Jericho and Tubas is 14.0% and 23.2%, respectively. Although the rate of Jericho is lower, that of Tubas is higher than in the Palestinian average.

Table 3.3.4 Labor Force Indicators in the Palestinian Territory by Governorate/District, January- March, 2007

Governorate/District	Total Labor Force	Number of Unemployed Persons	Number of Employed Persons	Unemployment Rate (%)
Palestinian Territory	**890,400**	**192,100**	**698,300**	**21.6**
West Bank	**599,500**	**103,800**	**495,700**	**17.3**
Jenin	67,800	15,900	51,900	23.5
Tubas	12,000	2,800	9,200	23.2
Tulkarem	42,500	9,600	32,900	22.7
Nablus	83,800	14,800	69,000	17.6
Qalqilia	21,600	3,300	18,300	15.6
Salfeet	15,800	3,400	12,400	21.5
Ramallah & Al-Bireh	69,700	11,300	58,400	16.2
Jericho	12,100	1,700	10,400	14.0
Jerusalem	100,700	12,100	88,600	12.0
Bethlahem	44,000	7,200	36,800	16.3
Hebron	129,500	21,700	107,800	16.8
Gaza	**290,900**	**88,300**	**202,600**	**30.4**

Source: Labor Force Survey (January- March, 2007)

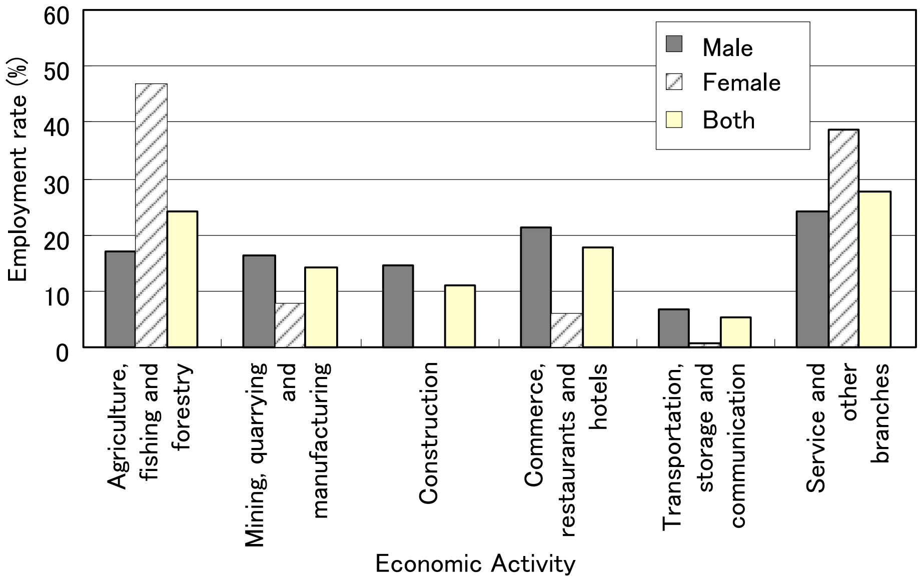
The change in the unemployment rate of the Palestine from 1995-2006 is shown in Figure 3.3.1. During this period, the lowest unemployment rate in both West Bank and Gaza was recorded in 1999 with 9.5% and 16.9%, respectively. Subsequently, however, the rate dramatically increased from 9.5% to 28.2% in West Bank and from 16.9% to 38.1% in Gaza during the period of 1999 and 2002. This was because of imposed restriction of mobility caused by the second Intifada. The rate in WB had improved steadily afterward, while it tended to decrease in Gaza, although fluctuating at a high level. The rate in Palestine in 2006 was recovered at the level in 1996.



Source: (PCBS; Labor Force Survey Round Q1/2007)

Figure 3.3.1 Changes of Unemployment Rate in Palestine during 1995 - 2006

Figure 3.3.2 shows the percentage distribution of employed persons in WB by economic activity and sex in the fourth quarter of 2006. Of the total female labor, 46.7% and 38.7% are involved in primary industry sector and service sector, respectively (See figure below). The ratio of female labor exceeded that of male labor in both economic activities. Female labor has important role in the primary industry sector, while few female laborers can be seen in secondary industry sector.

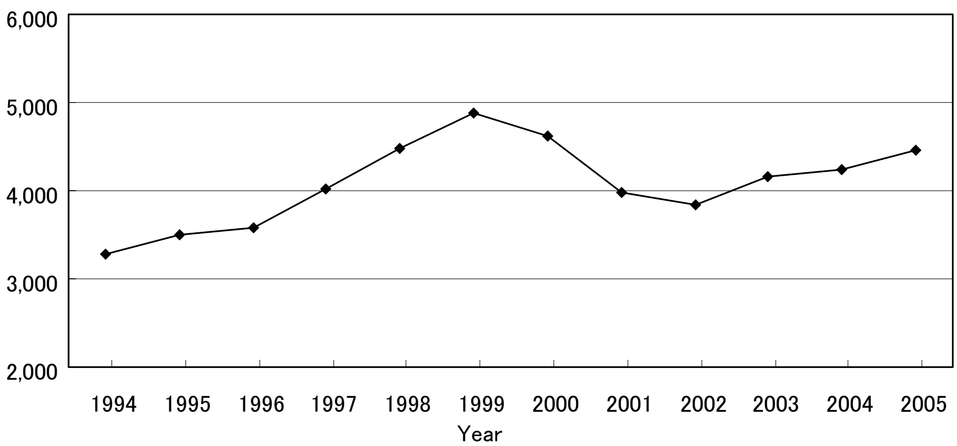


Source: PCBS, Labor Force Survey (Oct-Dec, 2006)

Figure 3.3.2 Percentage Distribution of Employed Persons Aged +15 in WB by Economic Activity and Sex

3.3.4 Economic Trends

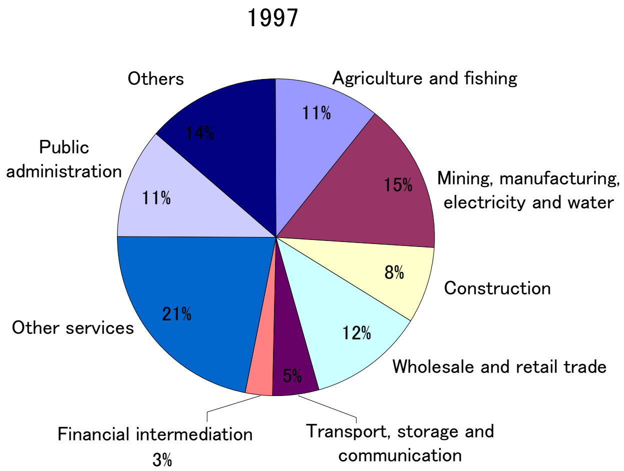
The Gross Domestic Product (GDP) in Palestine had steadily increased during 1994 -1999 period (see Figure 3.3.3). For 3 years between 2000 and 2002, however, GDP dropped about 21% from the level in 1999. The GDP started gradual recovery afterward.

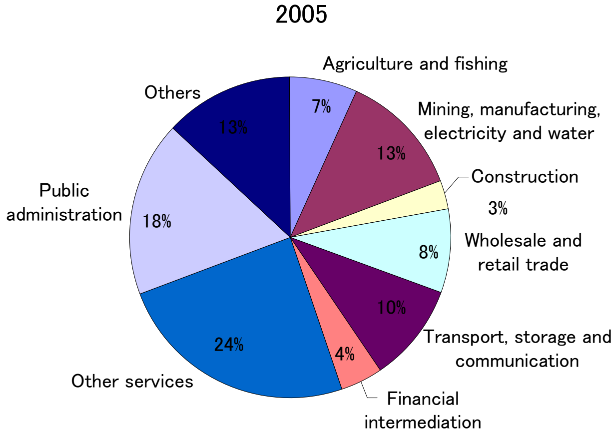


Source: PCBS

Figure 3.3.3 Gross Domestic Product in Palestine, 1994-2005
(at Constant Price, Base Year 1997)

The following figure shows the contribution of economic activities to GDP in 1997 and 2005. The tertiary industry has expanded from 66% to 78% in this period, while the primary and secondary industries had been shrinking from 34% to 22%.





Source: PCBS

Figure 3.3.4 Contribution of Economic Activity to GDP in Palestine in 1997 and 2005

The shrinking of the Palestinian economy after the second Intifada in September 2000 was due mainly to: i) closure; ii) suspension of tax revenue transfer; iii) reduction of labor force to Israel; and iv) over reliance on Israel in trade.

The most significant effect of closure on the economy is the increase in transportation cost (see Table 3.3.5). This rise of transportation cost has limited the liquidity of the labor force and capital, which are basic factors of a market economy. As a result, the Palestinian economy has lost its competitiveness in commodity prices.

According to the revenue clearance system, which was agreed in the Oslo Accords, the Israeli government has to transfer tax on all products imported to Palestinian Territory. This tax transfer has been repeatedly suspended. Since this revenue source contributes to almost half of the revenue of the Palestinian Authority, high budget deficit in the authority has remained[1].

Ratio of labor force employed in Israel and settlements to the total labor force has continued to drop from 23% in 1999 to 9.6% in 2006 (see Figure 3.3.5). Wage in Israel and settlement is quite high compared to the Palestinian Territory (see Table 3.3.6), and the income falling-off from these wage reduction worsens the Palestinian economy.

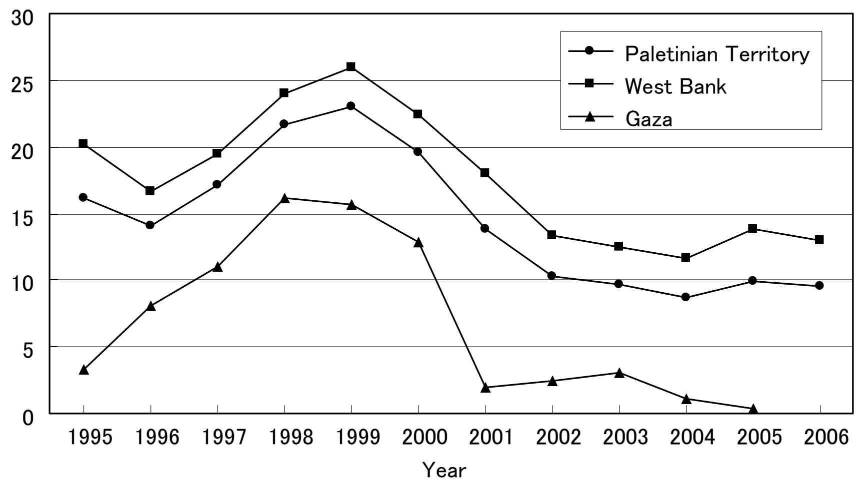
The Palestinian import and export industry has traditionally relied on Israel (see Table 3.3.7). Since Palestine enjoyed a trade surplus with Israel, few trade partners other than Israel had been developed. This led the Palestinian economy to further decline.

[1] Tax revenue transfer was resumed in July 2007.

Table 3.3.5 Consumer Price Index and Rate of Change by Major Expenditure Groups, 2003-2005

Major group of expenditure	Ave. 2003	Ave. 2004	Ave. 2005	Infraction rate 2002-03	Infraction rate 2003-04	Infraction rate 2004-05
Food	129.51	132.3	137.29	4.63	2.16	3.77
Beverages and tobacco	152.04	154.08	162.72	5.09	1.34	5.6
Textiles, clothing and footwear	128.57	127.39	129.46	0.19	-0.92	1.63
Housing	147.27	151.99	158.42	2.3	3.2	4.23
Furniture, household goods & services	122.51	125.42	129	1.4	2.38	2.85
Transport and communications	173.55	184.84	190.66	7.88	6.5	3.15
Education	129.44	134.04	135.47	5.14	3.55	1.07
Medical care	138.59	144.9	148.67	5.73	4.55	2.6
Recreational, cultural goods & services	95.61	95.24	93.9	2.53	-0.39	-1.4
Miscellaneous goods & services	140.6	148.66	156.54	2.26	5.73	5.3
All-Items consumer price index	**137.73**	**141.86**	**146.79**	**4.4**	**3**	**3.47**

Source: Palestine in Figure 2005, PCBS



Source: (PCBS; Labor Force Survey Round Q1/2007)

Figure 3.3.5 Changes of Employment Ratio in Israel and Settlement to Total Employment during 1995 - 2007

Table 3.3.6 Average Daily Wage for Wage Employees by Economic Activity and Place

Economic activity/ Place	West Bank (NIS)	Gaza (NIS)	Israel and Settlements (NIS)
Agriculture, fishing and forestry	48.5	28.2	81.4
Mining, quarrying and manufacturing	66	38.9	117
Construction	78.8	45.6	143.1
Commerce, restaurants and hotels	64.4	34.1	139.1
Transportation, storage and communication	87.5	35.8	161
Service and other branches	87.8	75.3	135.1

Source: PCBS, Labor Force Survey (Oct-Dec, 2006)

Table 3.3.7 Palestinian Imports Indicators, 2000-2004

(Value in Million US$)

Indicator	2000	2001	2002	2003	2004*
Total Palestinian Import	**2,383**	**2,034**	**1,516**	**1,800**	**2,218**
From Israel	1,739	1,352	1,117	1,310	1,593
From EUCC	264	359	161	155	205
From Arab countries	40	37	31	46	65
From other countries	273	234	199	246	299
Net Trade Balance	**-1,982**	**-1,744**	**-1,275**	**-1,520**	**-1,853**

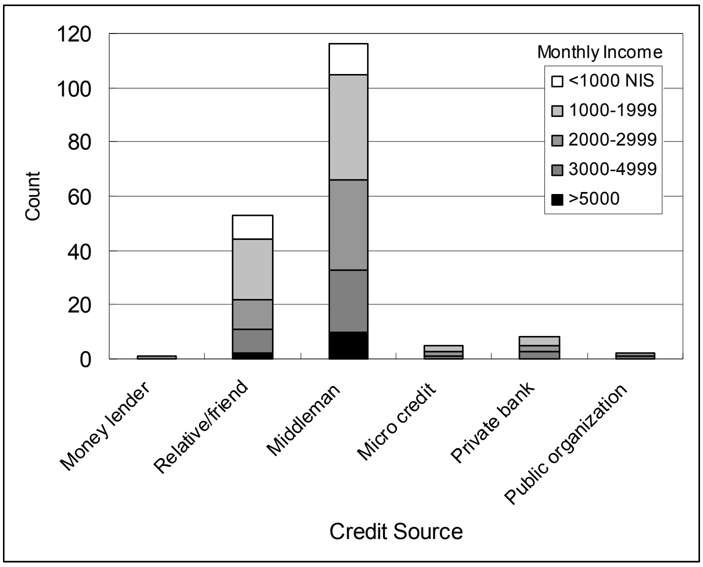
** Data for 2004 are primary data.*
Source: Palestine in Figure 2005, PCBS

3.3.5 Local Financial System

Access to credit for farmers, especially for small scale farmers, is quite limited in the Study Area. Due to the unstable agriculture market and lack of collaterals, commercial banks hesitate to give credit to farmers. This situation has worsened after the 2nd Intifada.

On the other hand, several NGOs currently implement rural credit programs, although with limited amount and outreach. MoA considers establishment of a rural finance institution to support the people in credit access and saving mobilization, but this institution has not yet been identified and seems to take a long time to materialize.

Under the above circumstances, agricultural and rural credits are currently provided through informal channels, such as family, relative, middleman, etc. The following Figure 3.3.6 shows the credit source by average monthly income group. A middleman is the predominant credit source in all income groups, while a relative/ friend is the next second credit source following the middleman. Quite a few formal credit sources, such as private banks and public credit systems, are available for farmers, however, these sources are limited for access only by middle or upper expenditure level of farmers.



Source: Baseline survey by JICA Study Team

Figure 3.3.6 Credit Source by Monthly Expenditure

3.3.6 Education

The West Bank and Gaza Strip (WBGS) adopted a compulsory education system, and net enrolment rate (NER) was 93.7% in 01/2002, although the NER was reported to have dropped to 91.9% in 2003[2]. The Ministry of Education and Higher Education (MoEHE) administers 74.9% of the general education, while the United Nations Relief and Works Agency (UNRWA) and the private sector administer 12.9% and 12.2%, respectively[3].

MoEHE has been performing well over the short period since its establishment. The students in the current education system enjoy a general education with less drop-out rate compared to their parents' generation. According to the socioeconomic survey, 43.5% of the heads of surveyed households have either no education or were drop-outs from primary education.

3.3.7 Health

Health issues in Palestine are characteristic of other lower middle-income countries. The level of "healthiness" of a country can be identified through a number of factors such as infant mortality and access to health care. Infant mortality rate (IMR) of WBGS decreased from below 30 per 1,000 live births in 1997 to 22 per 1,000 live births in 2004[4]. In the short term, even though the number of primary health care centers increased after the 2nd Intifada, the IMR of WB tended to increase from 2000-2004, because of low quality of service resulting from shortage of resources by closure[5]. Jericho's IMR was lower than the WB's average in the same period. Life expectancy in 1970-75 was 56.6 years; this improved to 72.4 years in 2000-05. In the health sector, MoH, UNRWA and NGOs are the main service providers.

3.3.8 Poverty

As Table 3.3.8 below indicates, in the West Bank-Middle, to where the Study Area belongs, is relatively low in poverty among WBGS as well as among WB. However, West Bank-Middle covers urban governorates such as Jerusalem, Bethlehem and Ramallah, which comprised of a wide rural area, thus the poverty level may be higher than the average. Furthermore, poverty rates by main income source shows that people who receive income from agriculture, are quite deep in poverty compared to the other income sources.

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[2] Jericho Regional Development Study Report, 2006, JICA

[3] Education for All, Part One: Diagnosis and challenges, Summary Report 2004, p. 9

[4] Human Development Report 2006, UNDP

[5] Jericho Regional Development Study, JICA, 2006

Table 3.3.8 Poverty Rates According to Actual Monthly Consumption Patterns of Households 1998- 2005

Year	1998		2001		2004		2005	
Poverty line[6]	Deep Poverty	Poverty	Deep Poverty	Poverty	Deep Poverty	Poverty	Deep Poverty	Poverty
Palestinian Territory	12.5	20.3	16.4	25.6	19.5	27.9	18.1	29.5
West Bank	8.4	14.5	11.6	19.8	12	18.9	13.1	22.3
West Bank-North	9.9	18.3	11.7	22.2	15.8	24.9	12.4	22.5
West Bank-Middle	4.6	6.9	3.7	6.7	3.9	6.7	6.7	11
West Bank-South	12.2	20.4	20.6	31.2	16	25	21.4	34.9
Gaza Strip	21.6	33	26	37.2	35.4	46.7	27.9	43.7
Poverty by main source of Income								
Agriculture	24.7	32.3	25	37.5	32.3	13.5	29.7	50.4
Other household business	16.6	24.6	14.5	21.9	24.6	11.5	16.1	27.1
Wages and salaries-Public sector	18	26.1	9.4	16.5	26.1	9.2	10.8	22.9
Wages and salaries-Private sector	21.9	28.8	19.4	28.9	28.8	13.4	19.4	32.6
Wages and salaries-Israeli sector	15.9	22.6	11.4	21.8	22.6	9.3	13.2	20.1

Source: Poverty in the Palestinian Territory, 2006, PCBS

3.3.9 Gender Issue

In the education sector, there is no significant inequality in gender in the basic education level in WBGS. According to the Ministry of Women Affairs, however, drop-out rates in the secondary education level for female and male students in 2003 were 4.8% and 2.9%, respectively[7]. The main reason is the early marrying age of female than that of male. Average marriage age of women is 19.4 years old, while for men it is 24.6 years old.

With regard to economic activity, based on the result of the socio-economic survey conducted by the Study Team, women have limited job opportunities in the Study Area, which is mainly in the agriculture sector, while men have access to other kinds of job.

Table 3.3.9 Full or Partial Participation in Activities by Sex

	House Work (Cooking, Cleaning, etc.)	Management of Family Expenditure	Agriculture Activities	Small Scale Business (Self-employee)	Work at Office (Employee)	Work at Office (Private Sector/NGO)	Handicraft Making for Selling
Male	17.4%	95.2%	96.2%	6.3%	7.8%	62.8%	3.4%
Female	90.9%	81.2%	77.3%	1.0%	1.9%	0.0%	8.6%

Source: Socio-economic survey by JICA Study Team, 2007

6 The relative poverty line and the deep poverty line for a six-member household in the Palestinian Territory in 2006 stood at NIS (New Israeli Shekels) 2,300 (USD518) and NIS1,837 (USD414), respectively.

7 Jericho Regional Development Study Report, 2006, JICA

3.4 Agriculture

3.4.1 Farm Households and Land Tenure Systems

(1) Type of Farm Households

According to information from MoA Jericho and Tubas branch offices, the number of farm households, inclusive of agriculture and livestock, is about 2,200. Although the detailed information about the number of full-time farmers and part-time farmers is limited, it is estimated that about 32,000 persons are engaged in agriculture in the Study Area.

Table 3.4.1 Population and Farm Household Type

Locality Name	Holding Type			Total
	Plant Production	Animal Production	Mixed	
Bardala	39	44	32	115
'Ein el Beida	35	12	34	81
Kardala	14	1	9	24
Wadi Far'a	N.A.	N.A.	N.A.	N.A.
Ras al Far'a	N.A.	N.A.	N.A.	N.A.
Al Badhan	159	13	25	197
An Nassariya	31	28	43	102
Al 'Aqrabaniya	23	25	27	75
Furush Beit Dajan	52	29	32	113
Marj Na'ja	40	13	7	60
Az Zubeidat	51	20	25	96
Marj al Ghazal	30	3	3	36
Al Jiftlik	184	81	19	284
Fasayil	1	69	2	72
Al 'Auja	56	145	55	256
An Nuwei'ma	21	9	0	30
'Ein ad Duyuk al Fauqa	26	9	2	37
'Ein ad Duyuk at Tahta	18	21	15	54
Jeicho City	380	112	90	582
Total	1,160	634	420	2,214

Source: Database, MoA

(2) Land Tenure Systems

Three main forms of land tenure are observed in the irrigated areas of the Study Area, and to a lesser extent, a fourth mixed form is adopted in some areas.

1) Ownership system

According to the result of the questionnaire survey, 44% of farmers are landless and farmers who own 10 dunum and below reaches 65% (see Chapter 6). Most of the farmers belong to either sharecropping or rental system between the farmer and the owner.

2) Sharecropping System

The sharecropping system is an old system which appeared at the beginning of irrigation. In this system, the crop yield (or profit from the crop) is a shared rental between the landowner and a farmer who cultivates the land.

The system includes land sharing as well as irrigation water sharing. In this system, the farmer provides his labor force and experience in farm management and performs all agricultural activities. On the other hand, the landowner provides his land. If the land is not provided, water rights either from a spring or a well provide the necessary irrigation water to the farm and the owner of the water right receives a share of the agricultural output as the return. Other expenses for agricultural inputs such as seeds, transplants, pesticides and fertilizers are deducted from the output of the farm.

The net benefit is then shared by the three stakeholders who are the farmer, the landowner and the water rights owner. Some minor modifications may be performed to this system. The shares might differ from one area to another. In this system, the contract is either in writing or verbal and usually agreed upon in the beginning of the season. The contract describes the duration, the profit sharing and the distribution of expenses and responsibilities among the stakeholders. In many cases, the agreement is only verbal and the distribution of responsibilities are not clearly defined, which results in disagreements and conflicts.

3) Rental System

The rental system is based on the simple renting of the land. A farmer usually pays USD60 to 90 per dunum for the landowner. The rent includes using the water rights if the land is registered as an irrigated land and if there is available water supply from springs. If the land does not have water rights from springs, or the spring discharge is not sufficient, then obtaining/ buying water could be made by the farmer but the rent is usually less due to shortage of water. The rental system makes financing agricultural production the responsibility of the farmer. It does not require any auditing between the farmer and the owner, as well.

However, agricultural development is difficult in this system as the farmer rents the land for a specific period of time and the owner might not renew the renting lease.

4) Combined Rental and Sharecropping System

The combined rental and sharecropping system is based on renting the land from its owner and then sharing it with a farmer. Usually the farmer share cropping the land with some investor who rents the land and finance the proposed agricultural activity. The rent and share cropping system usually includes the water rights if the rent is paid for lands that are registered as irrigated lands and spring water supply is available. However, if the land does not have water rights, farmers buy irrigation water from the well owners. The responsibility of buying water is on the investors and farmers who jointly share in farming the lands. This system of farming is found in the upper parts of the Wadi Far'a

3.4.2 Agricultural Land Use

The agricultural land in the Study Area is categorized into two land units: "Rainfed Land" and "Irrigated Land". The agricultural land use is summarized in the Table 3.4.2 below. As shown in the table, irrigated land covers about 61,000 dunum, which is over 90% of the total agricultural land use in the Study Area.

Table 3.4.2 Agricultural Land Use in the Study Area

Locality	Rainfed Land			Irrigated Land				Total
	Field Crop	Open Field Vegetable	Fruit	Field Crop	Open Field Vegetable	Fruit	Protected Plants	
Jericho	0	0	15	970	13,220	3,525	561	18,291
Nwai'mah, Duyuk	0	0	0	6	1,264	1,261	71	2,602
Al 'Auja	0	0	0	464	2,644	1,477	57	4,642
Fasayil	0	0	0	400	0	159	0	559
Al Jiftlik	0	0	0	3,800	8,863	293	463	13,419
Marj Na'ja, Az Zubeidat, Marj al Ghazal	0	0	0	630	4,421	125	62	5,238
Al Badhan, An Nassariya, Furush Beit Dajan	4,635	137	22	1,550	2,331	2,810	778	12,263
Bardala, Kardala, 'Ein el Beida	850	0	65	280	5,770	152	2,570	9,687
Total	5,485	137	102	8,100	38,513	9,801	4,562	66,700
	5,724			60,976				66,700

Area: Dunum
Source: Database, MoA

The regional characteristics of farming such as vegetable, mixing vegetable and fruit, livestock are observed in the locality.

Table 3.4.3 Characteristics of Farming by Locality

Locality	Characteristics
Jericho City	Vegetable and fruit cultivation
Nuwei'ma, Duyuk	Fruit cultivation, especially banana in the hilly area, Livestock
Al 'Auja	Livestock, Vegetable cultivation
Fasayil	Livestock
Al Jiftlik	Vegetable cultivation There are a lot of seasonal farmer.
Marj Na'ja, Az Zubeidat, Marj al Ghazal	Vegetable cultivation
Al Badhan, An Nassariya, Furush Beit Dajan	Vegetable and fruit cultivation
Bardala, Kardala, 'Ein el Beida	Vegetable cultivation

Source: MoA Database, JICA Study Team

3.4.3 Agricultural Production

Agricultural productions are classified into i) field crops and forages, ii) vegetables, and iii) fruits.

(1) Field Crops and Forages

The main field crops and forages currently cultivated in the Study Area are wheat, barley, dry onion, potato, etc. The following table shows the cropped area, yield and production of field crops and forages in 2004/05.

Table3.4.4 Field Cropped Area, Yield and Production of Field Crops and Forages in Jericho and Tubas (2004/05)

Jericho Governorate						
Crop	Production	Total Area	Irrigated		Rainfed	
			Yield	Area	Yield	Area
Wheat	920	3,680	0.25	3,680	-	-
Barley	295	1,180	0.25	1,180	-	-
Others Clover, Sern	1,230	820	1.50	820	-	-
Dry Onion	1,420	355	4.00	355	-	-
Potato	452	113	4.00	113	-	-
Clover	71	89	0.80	89	-	-
Thyme	19	31	0.60	31	-	-
Meramieh	1	2	0.50	2	-	-
Total	4,408	6,270		6,270		-

Tubas District						
Crop	Production	Total Area	Irrigated		Rainfed	
			Yield	Area	Yield	Area
Wheat	5,355	31,500	-	-	0.17	31,500
Clover	1,960	4,900	-	-	0.40	4,900
Sern	865	3,460	-	-	0.25	3,460
Potato	7,560	2,520	3.00	2,520	-	-
Dry Onion	4,300	1,400	3.50	800	2.50	600
Barley	162	720	-	-	0.23	720
Chick-peas	69	550	-	-	0.13	550
Lentil	40	500	-	-	0.08	500
Local Tobacco	48	400	-	-	0.12	400
Anise	21	330	-	-	0.07	330
Other Seeds	30	300	-	-	0.10	300
Sesame	13	280	-	-	0.05	280
Onion- Tuber	638	220	3.00	210	0.80	10
Other Dry Legumes	32	210	-	-	0.15	210
Cumin	8	130	-	-	0.07	130
Mixed Crops	10	100	-	-	0.10	100
Broom Corn	15	100	-	-	0.15	100
Seed Onion	5	60	0.10	10	0.07	50
Total	21,131	47,680		3,540		44,140

Area: dunum, Yield: ton/dunum, Production: ton
Source: Agricultural Statistics 2004/2005, PCBS

The total production of field crops and forages in the Study Area is 25,539 tons, which is 12.5% of the total production in WB. In the Jericho governorate, 100% of field crops and forages are cultivated with irrigation, but only 7% is cultivated with the irrigation in Tubas district. The average annual rainfall is 149 mm in Jericho. It is very difficult to cultivate the crops under rainfed condition. The total crop production in Tubas is bigger than in Jericho, but yield of the crop in the Jericho is higher than in Tubas.

(2) Vegetables

1) Area, Yield and Production

Vegetables are widely cultivated in WB, especially in the Jordan Valley. Various types of vegetables are cultivated. The cropped area, yield and production of vegetables in 2004/05 are shown in the following table.

Table 3.4.5 Field Cropped Area, Yield and Production of Vegetables in Jericho and Tubas (2004/05)

Jericho Governorate

Crop	Production	Total Area	Low Tunnel		High Tunnel		Plastic House		Irrigated		Rainfed	
			Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area
Squash	13,834	6,917	-	-	-	-	-	-	2.00	6,917	-	-
Eggplant	24,810	4,962	-	-	-	-	-	-	5.00	4,962	-	-
Tomato	18,422	4,008	-	-	-	-	18.00	303	3.50	3,705	-	-
Maize	3,779	3,779	-	-	-	-	-	-	1.00	3,779	-	-
Cucumber	7,011	2,364	-	-	-	-	9.00	462	1.50	1,902	-	-
kidney bean (green)	1,755	2,146	-	-	-	-	1.50	316	0.70	1,830	-	-
Broad bean (green)	742	1,484	-	-	-	-	-	-	0.50	1,484	-	-
Cauliflower	2,334	1,167	-	-	-	-	-	-	2.00	1,167	-	-
Jew's mallow	3,381	1,127	-	-	-	-	-	-	3.00	1,127	-	-
white Cabbage	1,558	779	-	-	-	-	-	-	2.00	779	-	-
Snake cucumber	873	582	-	-	-	-	-	-	1.50	582	-	-
Paprika	940	538	-	-	-	-	2.50	133	1.50	405	-	-
Hot Pepper	764	509	-	-	-	-	-	-	1.50	509	-	-
Okra	250	500	-	-	-	-	-	-	0.50	500	-	-
Onion (green)	279	398	-	-	-	-	-	-	0.70	398	-	-
Pumpkin	183	366	-	-	-	-	-	-	0.50	366	-	-
Total	80,915	31,626		-		-		1,214		30,412		-

Tubas District

Crop	Production	Total Area	Low Tunnel		High Tunnel		Plastic House		Irrigated		Rainfed	
			Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area
Squash	6,169	3,890	1.70	1,620	-	-	-	-	1.50	1,880	1.53	390
Chick-peas (green)	2,590	3,700	-	-	-	-	-	-	-	-	0.70	3,700
Cucumber	10,768	2,971	3.00	450	-	-	6.59	601	2.84	1,920	-	-
Tomato	16,715	2,253	6.00	130	-	-	18.00	290	6.00	1,770	1.50	63
Maize	2,070	1,920	1.50	300	-	-	-	-	1.00	1,620	-	-
Eggplant	7,120	1,240	5.00	320	-	-	-	-	6.00	920	-	-
Broad bean (green)	1,165	1,110	-	-	-	-	-	-	1.50	710	0.25	400
Peas	770	1,100	-	-	-	-	-	-	-	-	0.70	1,100
Muskmelon	1,200	350	5.00	100	-	-	-	-	4.00	150	1.00	100
Okra	66	300	-	-	-	-	-	-	-	-	0.22	300
Hot pepper	435	265	1.50	50	2,000	60	-	5	1.60	150	-	-
Caulifower	100	250	-	-	-	-	-	-	0.40	250	-	-
Snake cucumber	230	230	-	-	-	-	-	-	1.00	130	1.00	100
kidney bean (green)	255	222	1.00	50	-	-	2.50	22	1.00	150	-	-
white cabbage	1,230	205	-	-	-	-	-	-	6.00	205	-	-
water melon	720	120	6.00	120	-	-	-	-	-	-	-	-
paprika	240	150	-	-	-	-	-	-	1.60	150	-	-
kidney bean (yellow)	20	25	-	-	-	-	-	-	0.80	25	-	-
warak lesan	3	15	-	-	-	-	-	-	0.20	15	-	-
Total	51,866	20,316	-	3,140	-	60	-	918	-	10,045	-	6,153

Area: Dunum, Yield: ton/dunum, Production: ton
Source: Agricultural Statistics 2004/2005, PCBS

As shown in the above table, more than twenty kinds of vegetables are cultivated in the Study Area. The major vegetables and their production are: eggplants (31,930 tons or 74% of production in WB), tomatoes (35,137 tons or 35%), cucumbers (17,779 tons or 19%), squash (20,003 tons or 63%), and Maize (5,849 tons or 95%). The total production of vegetables in the Study Area is 132,781 tons, which is 39% of the total production in WB. The Study Area seems to be one of the centers of vegetable production in WB. Under the plastic house condition, the yield is much higher than the other conditions. The yield of tomato is especially high at 18 ton/dunum and cucumber is from 6.5 to 9.0 ton/dunum.

2) Farming system

The vegetable farming system in the Study Area is classified into five types: i) rainfed, ii) irrigated open field, iii) low plastic tunnels, iv) high plastic tunnels, and v) plastic houses. The total irrigated open field is 40,457 dunum, which is 57% of the total irrigated open field in the whole West Bank. In Tubas district, the total protected field is 4,118 dunum. In comparison with Tubas, the total protected field is small in Jericho. Considering the total cultivated field in Jericho and the efficiency of water use at the field level, the potential to develop the protected field is still high. On the other hand, rainfed farming is not feasible because of insufficient rainfall water and high potential evaporation in Jericho.

(3) Fruit Trees

Fruit trees in the Study Area are planted over 22,000 dunum which are equivalent to 20% of the area of fruit tree planted in WB. Bananas (9,800 tons or 3,305 dunum) and Dates (1,274 tons or 1,988 dunum) are planted only in Jericho because of the suitable climate conditions. Such climate conditions and great demand make the dates palm an important tree in the Jordan Valley. Since the local demand of the dates is higher than the production, the prices are kept relatively high. The following table shows the cropped area, yield and production of fruit trees in 2004/05.

Table 3.4.6 Field Cropped Area, Yield and Production of Fruits in Jericho and Tubas (2004/05)

Jericho Governorate								
Crop	Production	Total Area	Non-bearing		Bearing			
			Irrigated area	Rainfed area	Irrigated		Rainfed	
					yield	area	yield	area
Banana	9,800	3,305	855	-	4.00	2,450	-	-
Date	1,274	1,988	1,139	-	1.50	849	-	-
Lemon	942	473	159	-	3.00	314	-	-
Grape	1,251	428	11	-	3.00	417	-	-
Shammoty Orange	645	255	40	-	3.00	215	-	-
Blady Orange	100	102	62	-	2.50	40	-	-
Olive	24	80	-	-	0.30	80	-	-
Clement	48	66	34	-	1.50	32	-	-
Mandarin	33	42	20	-	1.50	22	-	-
Fig	53	35	-	-	1.50	35	-	-
Bomaly	30	25	15	-	3.00	10	-	-
Poppy	15	25	15	-	1.50	10	-	-
Navel Orange	45	15	-	-	3.00	15	-	-
Grapefruit	24	8	-	-	3.00	8	-	-
Francawy Orange	2	7	-	-	0.25	7	-	-
Valencia Orange	6	2	-	-	3.00	2	-	-
Total	14,292	6,856	2,350	-		4,506	-	-

Tubas District								
Crop	Production	Total Area	Non-bearing		Bearing			
			Irrigated area	Rainfed area	Irrigated		Rainfed	
					yield	area	yield	area
Olive	542	13,652	-	1,222	0.14	200	0.04	12,230
Almond (soft)	37	423	-	114	-	-	0.12	309
Almond (hard)	35	231	-	-	-	-	0.15	231

Tubas District								
Crop	Production	Total Area	Non-bearing		Bearing			
			Irrigated area	Rainfed area	Irrigated		Rainfed	
					yield	area	yield	area
Lemon	272	195	59	-	2.00	136	-	-
Navel Orange	358	169	26	-	2.50	143	-	-
Shammoty Orange	395	159	1	-	2.50	158	-	-
Clement	210	105	-	-	2.00	105	-	-
Poppy	150	75	25	-	3.00	50	-	-
Fig	63	72	-	10	1.50	2	1.00	60
Mandarin	80	47	-	-	1.70	47	-	-
Valencia Orange	78	39	-	-	2.00	39	-	-
Grape	73	34	1	2	2.50	28	1.00	3
Date	-	20	20	-	-	-	-	-
Other citrus	15	15	-	-	1.00	15	-	-
Total	2,308	15,236	132	1,348	-	923	-	12,833

Area: Dunum, Yield: ton/dunum, Production: ton
Source: Agricultural Statistics 2004/2005, PCBS

3.4.4 Livestock

Livestock productions comprised of milk production (goats, sheep and cattle), meat production (broiler, goats, sheep and cows), eggs and honey. Most of the Bedouins living in the Study Area are engaged in the livestock sector. The following table shows the livestock production in Jericho and Tubas (2004/05). Milk and meat production covers about 10% and 6.6%, respectively, of the total milk and meat production in WB. The livestock production rate in the Study Area is relatively low in comparison with other areas.

Table 3.4.7 Livestock Production in Jericho and Tubas (2004/05)

Governorate/ District	Milk			Meat				Eggs (million)	Honey
	Goats	Sheep	Cattle	Broiler	Goats	Sheep	Cows		
Jericho	2,875	2,561	2,265	367	709	1,042	129	1	43
Tubas	396	3,822	3,626	646	98	1,555	412	5	25
West Bank	30,344	51,975	78,022	41,863	7,485	21,154	4,211	434	441

Production: ton
Source: Agricultural Statistics 2004/2005, PCBS

3.4.5 Marketing

Agricultural products from the Jordan River Rift Valley are mainly cash crop. The main destination of the produce is Israel and other areas in WB. Due to the warm weather in the winter season, agriculture produce harvested in this area has advantages in the market. With regards to the wholesale market in Jericho, 40% of the produce is distributed out of WB, while the other 60% is distributed in WB including Jericho city[8]. However, Palestinian exports of agriculture products dropped by 54% during 1999-2003, before and after 2nd Intifada, while the total export dropped by 35%[9] in the same period. Farmers have suffered from the drop down of export volumes.

Problems and constraints for agricultural marketing are summarized below:

(i) High cost of agriculture inputs from Israel;

8 Jericho Regional Development Study Report, 2006, JICA

9 Study on the trade among Jordan, Palestine and Israel, 2006, JICA Jordan office

(ii) Difficulty of border crossing, costly and time-consuming security, transport and trade restrictions;
(iii) Long domestic marketing channels (marketing margins are high);
(iv) Insufficient access to latest production technology and management concepts;
(v) Limited availability of marketing infrastructure;
(vi) Lack of Palestinian-controlled export shipping services;
(vii) Limited Palestinian knowledge of global market and marketing requirements;
(viii) Poor understanding of export quality demands, quality and food safety assurance and required post-harvest practices;
(ix) Lack of market information system in domestic and Israeli market;
(x) Absence of Palestinian standards for produce-related measures, by-laws and laboratory equipment;
(xi) Lack of credit system for marketing infrastructures and exporters; and
(xii) Lack of export support program.

3.4.6 Agriculture Extension Service

Agriculture extension service is provided by the Department of Extension and Rural Development in MoA. In the department, there are experts, called subject matter specialists (SMS), in the specific fields of crop production, horticulture, quarantine, livestock, and agriculture machinery. Currently, about 40 SMSs have been appointed in the directorate and carrying out following tasks:

(i) To develop agriculture policy, strategy and implementation plan;
(ii) To formulate the extension plan and its implementation;
(iii) To prepare training plan based on evaluation of training needs of extension staff and its implementation;
(iv) To give technical support to extension staff;
(v) To make materials and tools for smooth implementation of extension activity;
(vi) To designate the purpose and goal for the annual extension plan based on specific policy and strategy;
(vii) To participate in field activities in every step of the implementation plan; and
(viii) To participate in international and domestic workshops and conferences.

In the field level, extension services are provided by the branch office and field office deployed in each region of MoA.

Extension staff appointed in the Jericho branch have jurisdiction over the Jericho governorate. Beside the branch office, there are field offices in Al ‘Auja and Jiftlic. Each field office has two extension staff. One of them is in charge of crop production and another works for livestock. The tasks of extension staff in branch office and field offices are as follows:

For branch office

(i) To plan and implement regional extension plan;
(ii) To collect information on results of extension activities in the region;
(iii) To disseminate and transfer information to research institutions;
(iv) To disseminate information to the farmers;
(v) To conduct field visits;
(vi) To select appropriate farming techniques; and
(vii) To organize regular meetings with farmers and farmer’s groups.

For field office

(i) To conduct field visits and organize meetings with farmers;
(ii) To follow up production activities;
(iii) To collect production information; and
(iv) To advise farmers.

3.4.7 Constraints on Agricultural Development

Major constraints in agricultural development that need to be addressed are as follows:

Agricultural Production:

(i) Yields are low due to inappropriate crop varieties, poor cultural practices and insufficient input;
(ii) Lack of supporting information on decision-making in selecting more profitable products and technologies;
(iii) Insufficient farmers' access to credit for production and marketing;
(iv) High cost of inputs;
(v) Limited access to alternative markets and high export transaction costs;
(vi) Limited availability of food processing market outlets;
(vii) Lack of effective farmers' associations to improve management of water resources, reduce input costs and improve marketing;
(viii) Weak agricultural extension services;
(ix) Inadequate applied research that are closely linked to extension programs; and
(x) Small farm sizes resulting in high production costs, marketing problems, and a complicated process of knowledge dissemination and technology transfer.

Agricultural Infrastructure:

(i) Weak infrastructure for agricultural research: experimental stations are not adequately equipped; sharp shortage of laboratories, equipment, and required systems; lack of trained researchers to cover the major fields in agriculture research;
(ii) Weakness of extension system, plant protection, and veterinary services;
(iii) Poor infrastructure for agricultural marketing sector;
(iv) Weak agricultural and food manufacturing activities;
(v) Lack of data and sometimes confusing information on agriculture; and
(vi) Lack of agriculture technical capabilities.

Agricultural Organization:

(i) Lack of methods for promotion of autonomous corporations and cooperation between businesses to take advantage of the economy of scale and competitiveness in business activities;
(ii) Lack of policy framework and necessary measures required for the formation and strengthening of farmers' organizations;
(iii) Insufficient experience in establishing farmers' organizations, including water users' associations and agricultural cooperatives;
(iv) Absence of guidelines for establishment of adequate organizational management of cooperatives as well as their business activities, such as joint marketing and purchasing; and
(v) Absence of guidelines for appropriate financial management of cooperatives, including introduction of an external auditing system.

Social and Economic Aspects:

(i) Small size and fragmentation of agricultural holdings, and joint (common) ownership, which reduce production efficiency;
(ii) Low returns and high risk in agriculture, which led many to abandon work in this sector, and sharply reduced agriculture-related investments;
(iii) Inadequate agricultural and rural finance system; and
(iv) Weak collective and cooperative work.

Agriculture Extension[10]*:*

(i) Restriction of movement (construction of separation wall, closure and checkpoints);
(ii) Weakness of administration and shortage of budget (new generation staff and modest expertise and skills);
(iii) Low technical capability of extension staff (limited number of expertise and specialization, poor practical and on-the-job training, inappropriate training subjects, inadequate extension materials and equipment, poor communication skills, poor coordination between subject matter specialist and extension staff); and
(iv) Low level coordination between the extension and research institutions (overlap of responsibilities in research institutions, lack of clear administration system and roles).

[10] PCM workshop results of Strengthening Support System focusing on Sustainable Agriculture in the Jordan River Rift Valley (ASAP), 2007, JICA

3.5 Water Resources Management

3.5.1 Watersheds

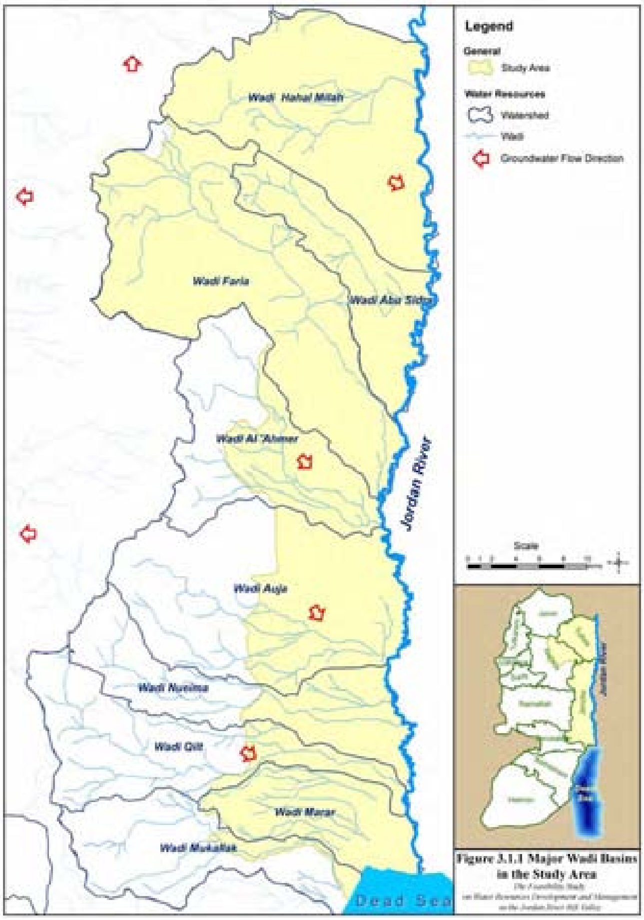
In the Study Area, there are numbers of wadis, which are broadly demarcated into nine major wadi basins as shown in the table below and Figure 3.5.1.

Table 3.5.1 Major Wadi Basins in the Study Area

No.	Name of Wadi	Catchment Area (km^2)
1.	Wadi Hahal Milah	276.1
2.	Wadi Abu Sidra	120.8
3.	Wadi Far'a	336.9
4.	Wadi 'Ahmer	180.1
5.	Wadi Auja	291.4
6.	Wadi Nueima	152.5
7.	Wadi Qilt	172.4
8.	Wadi Marar	102.4
9.	Wadi Mukallak	140.5

Source: PWA GIS Database

As seen in the table, the Wadi Far'a occupies the largest catchment area of almost 340 km^2. The northern part of the Study Area including Wadi Far'a basin is blessed with comparatively abundant vegetation as well as sufficient water resources. In the southern wadi basins, on the other hand, the ratios of low-lying flat and desert areas with annual rainfall of less than 300 mm are relatively larger. Out of catchment areas shown in the table above, rainfall in the desert areas hardly contribute to the yield of water resources, since the monthly evaporation rate therein exceeds the monthly rainfall throughout the year. With regard to the development of storm water harvesting, the previous study[11] identified that,



Source: PWA, MoP

Figure 3.5.1 Major Wadi Basins in the Study Area

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11 :The Potential for Storm water Harvesting in the Eastern Surface Catchment of the West Bank, FORWARD, September 1998

out of the nine major wadi basins, two wadi basins, the Wadi Qilt and Wadi Far'a, are the most promising.

The major water resources that are exploitable in the Study Area are spring water and groundwater. Spring water volume constitutes one of the important water resources in the Study Area. It becomes very less in the summer season, while it remarkably increases in the winter season. Thus, spring water volume largely varies depending on the rainfall amount. On the other hand, groundwater availability responds to the rainfall amount with some time lag, i.e., approximately one to two years, depending on the geological conditions at each location.

Figure 3.5.1 also shows the overall directions of groundwater movement in the Study Area. In general, the watersheds of surface water do not coincide with the boundaries of groundwater and spring water. In the Study Area, the groundwater boundaries lie in the central mountainous area where there is higher annual rainfall of 500 to 900 mm. In the boundary zones, the groundwater generally moves in two different directions, westward and eastward. On the other hand, in the northern parts of the Study Area including the Wadi Far'a, some of groundwater moves into the northern direction.

3.5.2 Agricultural Wells

The role of agriculture is particularly important for the economy of the Study Area because majority of the Palestinians are engaged in the agricultural sector. There are about 60 km^2 (60,000 dunum) of irrigated lands from springs and wells water in the Study Area. These lands are the most fertile and suitable for agriculture in WB.

(1) Available Groundwater Resources

Groundwater is used as the main source of water supply for the Palestinian in the Study Area either by wells or springs.

Water of wells is taken from the quaternary aquifers in the Jordan River Rift Valley. The aquifers are recharged from seasonal rainfall through the outcropping mountainous areas in WB. The eastern basin is considered the main source of water for shallow wells through direct infiltrations from the surface runoff or by lateral flow from the mountain aquifers.

Table 3.5.2 Summary of Agricultural Wells

No.	Locality	Number of wells (Working, Non-pumping)
1	Al 'Auja	10 (7, 3)
2	Al Jiftlik	27 (21, 6)
3	An Nabi Musa	1 (0, 1)
4	Az Zubeidat	4 (2, 2)
5	Bardala	8 (1, 7)
6	Deir Hajleh	2 (0, 2)
7	Fasayil	1 (0, 1)
8	Furush Beit Dajan	8 (5, 3)
9	Jericho (Ariha)	92 (29, 63)
10	Marj Na'ja	13 (7, 6)
11	Wadi Far'a	18 (16, 2)
	Total	184 (88, 96)

Source: PWA Database

The working agricultural wells in the Jordan River Rift Valley are 88 out of 184 wells. The remaining wells are non-pumping and abandoned wells.

(2) Groundwater Use for Agriculture and Livestock

Water allocation from wells and springs in the Study Area is 95% for agriculture and the remaining 5% for human consumption. Water for agriculture is mainly utilized for livestock and irrigation.

The water resources are currently being utilized inefficiently because of improper time-basis water distribution, water conveyance losses from less maintained irrigation facilities, and damaged agricultural wells. Since water demand is expected to increase in the future, efficient utilization of the existing water resources, as well as development of new water resources, is essential for the Study Area.

(3) Condition of Agriculture Wells

Most of the agricultural wells were drilled between 1950 and 1966 with a total depth range from 50 to 200 m. Pumping equipment consists of vertical pumps coupled with diesel-powered engines. The water conveyance system consists of cast-iron and plastic pipes and fittings.

Since 1967, very few wells have been drilled or rehabilitated. It is reported that most wells have clogged screens with high silt accumulation at the bottom. The pumping rates vary between 40 to 80 m^3 per hour and the pumps operate for about 10-12 hours per day. In the summer, when there is higher demand for water, the pumping time may exceed 20 hours.

The functions of the wells have remarkably decreased mainly due to mechanical or hydro-geological reasons. In addition, some of the wells have not been operating due to economic reason.

1) Electromechanical aspect

Some of the pumps and motors are broken due to lack of maintenance activities and there seemed less necessity of repairing the well equipment.

2) Hydro-geological aspect

Water quality and quantity in the Study Area have deteriorated and reduced. The main reason is that the amount of abstraction from the aquifers has exceeded the rechargeable rate of the aquifers. This trend is remarkable in the greater Jericho area.

3) Economic aspect

Some wells have been abandoned due to the increase of their operation cost while others were due to deterioration of the water quality and the availability of better water resources such as spring water or water from Mekorot (Israel Water Company).

Damaged Agricultural Wells

(4) Ownership of Land and Water Source

There are several patterns of the farming system in terms of ownership of land and water source. Basically, land owners and water source owners are the same family. After the owner of the land and water source is dead, his/her ownership is transferred to his/her family. Therefore, the number of shareholders increases, thus the right of well and land management is distributed gradually.

The following are some typical farming systems in the Study Area:

(i) Land owners own both a water source and its whole command area. Only the owner farmers use their land and water;
(ii) Land owners own both a water source and its whole command area. However, owner farmers only partially use their land and water; tenant farmers rent the remaining land with water;
(iii) Owners are not farmers, and they rent out both land and water source to one farmer (leader farmer). The farmer partially uses the land, and again rent out the land with water to other farmers;
(iv) Owners are not farmers, and they rent out both land and water source to several farmers;
(v) Owners hire supervisors and farm labors for agricultural production. Supervisors are usually an agriculture specialist and a mechanical engineer; and
(vi) In combination with above patterns, other farmers, who own or rent adjacent farm lands, use water source.

(5) Operation and Maintenance

Operation and maintenance practices have also several patterns depending on the farming system and scale of cultivation:

(i) Owners have full responsibility for operation and maintenance;
(ii) Owner employs some engineers to carry out operation and maintenance work;

(iii) Leader farmer is fully responsible for operation and maintenance; and
(iv) Farmers hire engineers to conduct operation and maintenance work.

In the Study Area, there is no Water Users' Association (WUA), which is officially registered, except the WUA in Ein Sultan.

(6) Water Charge

Water charges are varied depending on conditions of pumping equipment and scale of cultivated area. In case a motor is used for the pumping power supply, the water charge is cheaper than using diesel engine. Even though diesel engine is used for pumping, an old engine needs more maintenance cost and running cost, and it causes higher water charge. Furthermore, if farmers purchase water from the Israeli water company (Mekorot) by tanker, water charge is different. The following water charge schemes are observed in the Study Area.

(i) Water charge is included in the land rent;
(ii) Water charge is paid by using time, usually the unit is an hour; and
(iii) Water charge is paid by volume, usually the unit is m^3.

(7) Water Rights

Water is public property in Palestine, but the right to extract water belongs to a landowner. Most of agriculture wells in the Study Area are private wells. Each well has a license, which regulates the annual extraction quota, which is decided based on the technical characteristics of the well. If the landowners are not farmers, the water right is practically rented to a farmer who rents the land from the landowners.

3.5.3 Spring Water

(1) Overview of Spring Water Resources

In WB, there are 114 springs with discharges. The report entitled "Water Resources Evaluation in West Bank and Gaza Strip in Year 2003" prepared by the PWA in 2005 summarized the total discharge of all the springs in West Bank in 2003 as shown in the following table.

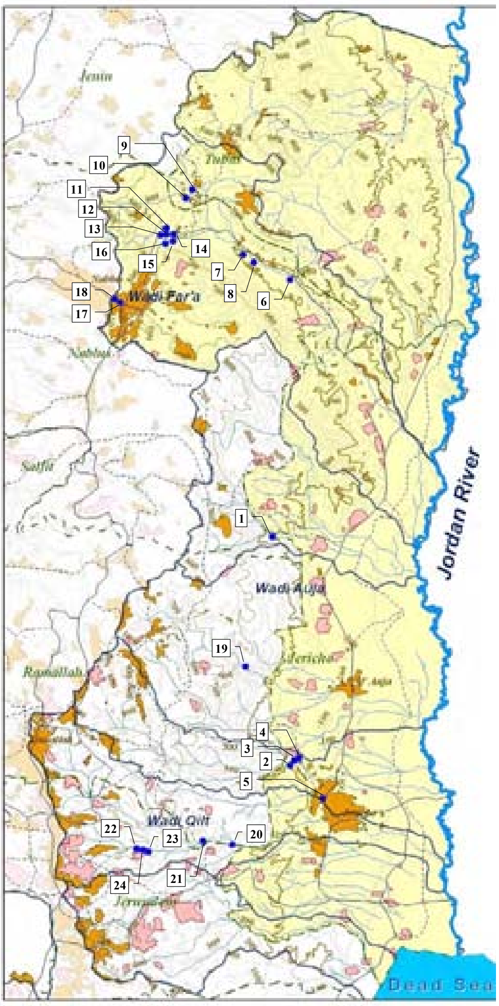
Table 3.5.3 Spring Discharge in West Bank in 2003

Ground Aquifer Basin	Discharge in 2003 (MCM/year)
Eastern	39.82
North Eastern	17.51
Western	3.21
Total	**60.54**

Source: Water Resources Evaluation in West Bank and Gaza Strip in Year 2003

Among the 114 springs, twenty four springs are located in the Study Area. These are listed below with their average discharges:

Table 3.5.4 Spring Discharge in West Bank in 2003



No.	Name	Code	Average Discharge (MCM/yr)
1	Fasayil	AC/054	0.66
2	Al Dyuk	AC/060	4.86
3	Al Nwai'mah	AC/060A	2.60
4	Al Shusah	AC/060B	0.61
5	Al Sultan	AC/061	5.54
6	Shibli	AQ/022	0.85
7	Abu Saleh	AQ/024	0.19
8	Meskah	AQ/025	1.29
9	Al Far'a	AQ/030	5.31
10	Al Dlaib	AQ/032	1.20
11	Sedrah	AQ/036	1.46
12	Hamad & Baidah	AQ/037A	0.88
13	Qdairah	AQ/037B	1.19
14	Jeser	AQ/038	0.14
15	Tabban	AQ/039	1.29
16	Al Subyan	AQ/040	0.19
17	Balata	AQ/043	0.18
18	Dafna	AQ/044	0.13
19	Al 'Auja	AR/020	9.55
20	Al Qilt & Al Fawwar	AS/020	6.55
21	Al Fawwar	AS/021	4.48
22	Far'a	AS/022	0.70
23	Al Jummaizah	AS/022A	0.30
24	Al Ru'yan	AS/022B	0.36

Source: *PWA Database*
Note: *The average discharge volumes of each spring are calculated from the raw data with the unit of L/s measured in 1960-2006.*

The total discharge volume in the Study Area is 46 MCM/year based on the average of the available data of the PWA. This excludes the discharge of Abu Saleh, which has dried up and Al Fawwar, of which its discharge volume is assumed to be included in the data for Al Qilt & Al Fawwar.

The springs are categorized into eight groups according to their locations and origins as shown in the following figure.

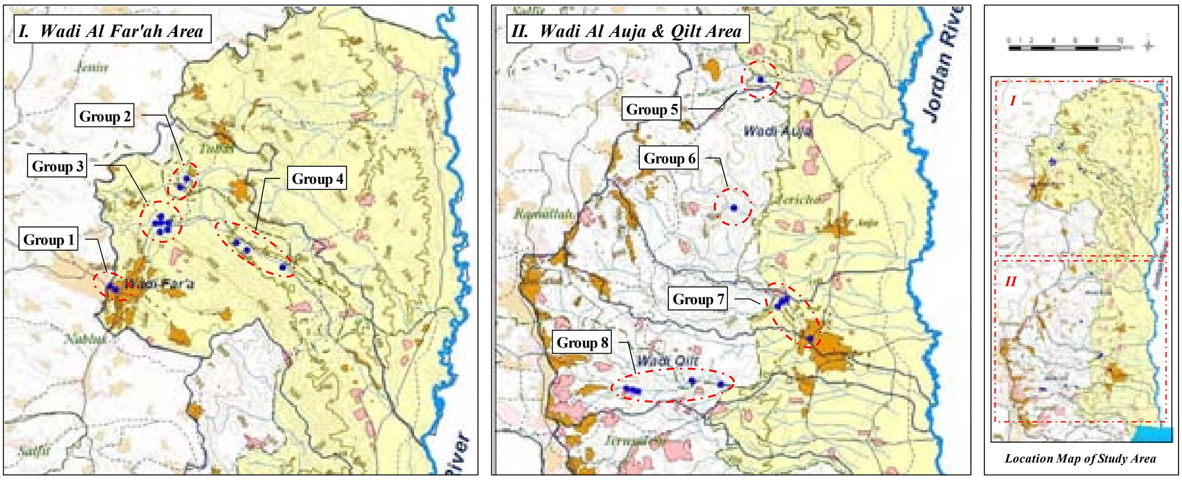


Figure 3.5.2 Location of Spring Group in the Study Area

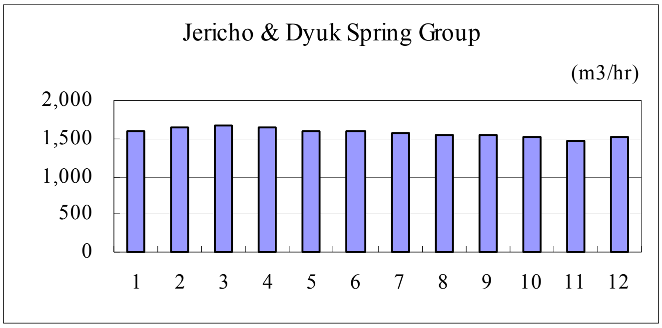
The following table summarizes the characteristics of each spring group.

Table 3.5.5 List of Spring Group in the Study Area

No.	Spring Group	Basin	Catchment	Spring Name	Total Discharge (MCM/yr)
1	Nablus Spring Group	North Eastern	Al Far'a	Balata, Dafna	0.31
2	Al Far'ah Spring Group	North Eastern	Al Far'a	Al Far'ah, Al Dlaib	6.51
3	Badhan Spring Group	North Eastern	Al Far'a	Sedrah, Hamad & Baidah, Qdairah, Jeser, Tabban, Al Subyan	5.15
4	Shibli Spring Group	Eastern	Al Far'a	Shibli, Abu Saleh, Meskah	2.14
5	Fasayil Spring Group	Eastern	Al 'Ahmer	Fasayil	0.66
6	Al 'Auja Spring Group	Eastern	Al 'Auja	Al 'Auja	9.55
7	Jericho & Dyuk Spring Group	Eastern	Al Nwai'mah	Al Dyuk, Al Nwai'mah, Al Shusah, Al Sultan	13.61
8	Al Qilt Spring Group	Eastern	Al Qilt	Al Qilt & Al Fawwar, Far'a, Al Jummaizah, Al Ru'yan	7.91
	Total				**45.84**

Source: *PWA Database, JICA Study Team*
Note: *The average discharge volumes of each spring are calculated from the raw data with the unit of L/s measured in 1960-2006.*

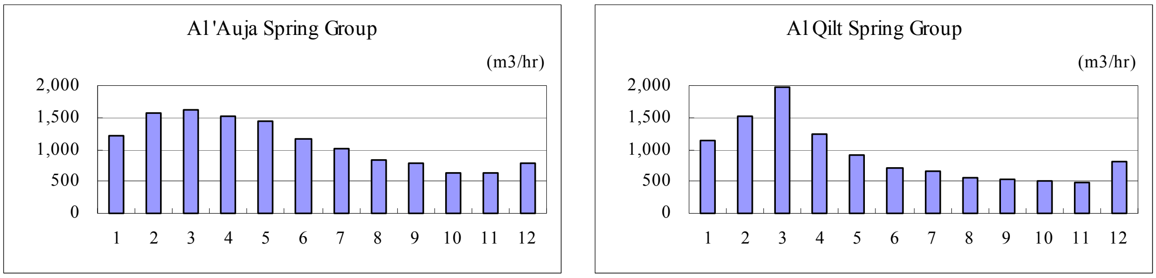
The Jericho & Dyuk Spring Group, which has 4 springs, has the most abundant discharge, which accounts for 30% of all the spring discharge in the Study Area. As shown in the following figure, the discharge volume in m^3/hr is very stable in any season. All the springs in this group have the same characteristics.



Source: PWA Database, JICA Study Team

Figure 3.5.3 Monthly Average Discharge of Jericho & Dyuk Spring Group

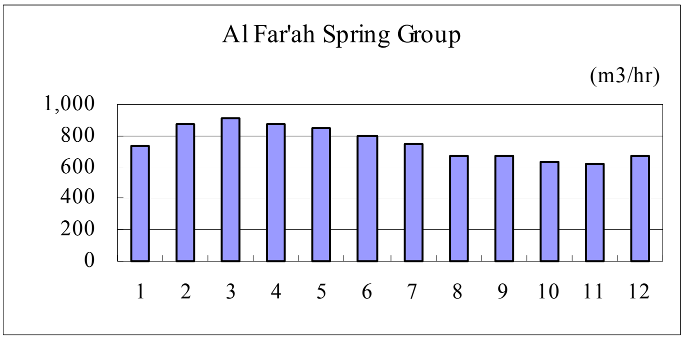
The Jericho & Dyuk Spring Group is followed by Al 'Auja Spring Group, then by Al Qilt Spring Group. There is only one spring in Al 'Auja Spring Group and its discharge volume reaches 9.55 MCM/year. However, the seasonal fluctuation is very sharp. Al Qilt Spring Group also has a considerably sharp fluctuation. Al Fawwar spring is the main spring in this group that causes this feature, which is so-called siphon spring.



Source: PWA Database, JICA Study Team

Figure 3.5.4 Monthly Average Discharge of Al 'Auja and Al Qilt Spring Group

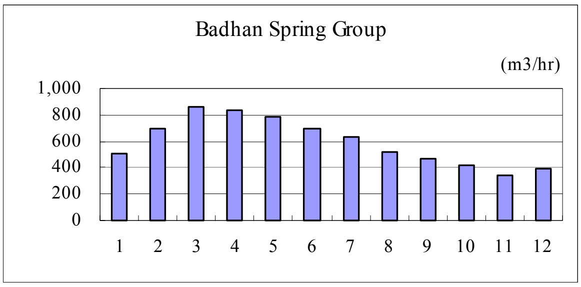
Al Far'a Spring Group, on the other hand, takes the fourth position in the list. Discharge from Al Far'a Spring is especially abundant with an average of 5.31 MCM/year, which is the fourth in the Study Area as a sole spring. This spring group is not so stable but better than Al 'Auja and Al Qilt Spring Group in terms of lesser fluctuations.

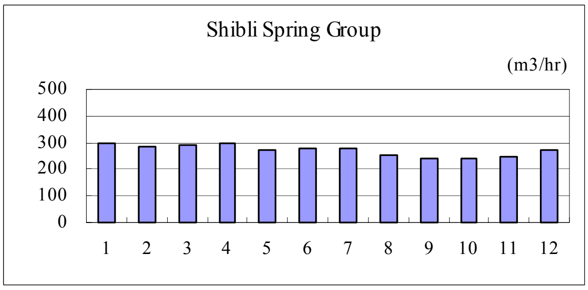


Source: PWA Database, JICA Study Team

Figure 3.5.5 Monthly Average Discharge of Al Far'a Spring Group

The discharge from Badhan Spring Group, which is formed by 6 springs, is more than 5 MCM/year. However, there are only 3 springs, i.e. Sedrah, Qdairah and Tabban, with discharges of more than 1 MCM/year. In addition, most of the springs in the group are unstable.

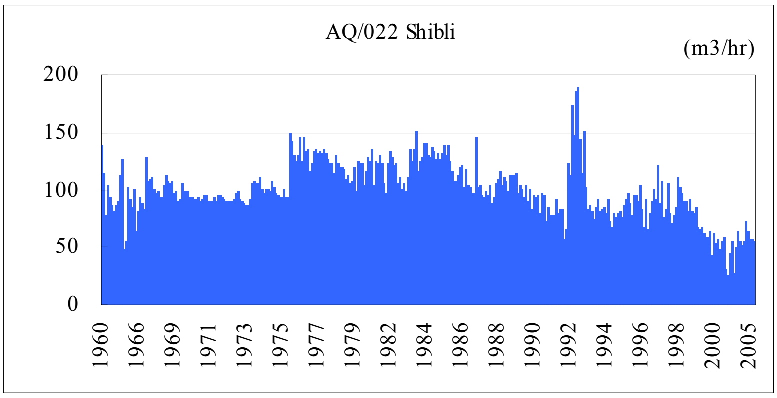




Source: PWA Database, JICA Study Team

Figure 3.5.6 Monthly Average Discharge of Badhan and Shibli Spring Group

The Shibli Spring Group, located beside the Wadi Far'a, has a lower discharge than Al Far'a and Badhan Spring Groups, but has steady discharge throughout the year as shown in the figure above. The most notable characteristic of this group is the tendency to decline in its yield. As shown in the following figure, the discharge volume of Ain Shibli Spring, which is the most reliable spring in this group, has been dropping down on the long term basis. Furthermore, the Abu Saleh Spring has almost dried up.



Source: PWA Database, JICA Study Team

Figure 3.5.7 Historical Discharge of Ain Shibli Spring

Spring water in the Study Area is mainly used for agriculture. From the result of the inventory survey conducted, it is estimated that 90% of the spring water is used for agricultural purposes. The current allocation of each spring to agricultural and domestic purposes was estimated in the inventory survey as shown in the following table.

Table 3.5.6 Estimated Spring Water Allocation to Agricultural and Domestic Uses

No.	Area Group	Total Discharge	Agri. Use		Dom. Use		No Use	
		(Mcm/yr)	(Mcm/yr)	(%)	(Mcm/yr)	(%)	(Mcm/yr)	(%)
1	Nablus Spring Group	0.31	0.00	0%	0.31	100%	0.00	0%
2	Al Far'ah Spring Group	6.51	6.30	97%	0.21	3%	0.00	0%
3	Badhan Spring Group	5.15	5.09	99%	0.06	1%	0.00	0%
4	Shibli Spring Group	2.14	2.11	99%	0.03	1%	0.00	0%
5	Fasayil Spring Group	0.66	0.65	99%	0.01	1%	0.00	0%
6	Al 'Auja Spring Group	9.55	9.55	100%	0.00	0%	0.00	0%
7	Jericho & Dyuk Spring Group	13.61	11.06	81%	2.55	19%	0.00	0%
8	Al Qilt Spring Group	7.91	6.55	83%	0.00	0%	1.36	17%
	Total	**45.84**	**41.31**	**90%**	**3.17**	**7%**	**1.36**	**3%**

Note: "Domestic Use" includes the volume used for industrial and tourism purposes.

All the water from the Nablus Spring Group is used for domestic purposes because the springs are located in areas with moderately high population density and low agricultural potential.

Nineteen percent (19%) or 2.55 MCM/year of the water from Jericho & Dyuk Spring Group is allocated for domestic use, which is very high compared with the other groups. It can be perceived that spring water is sustaining the life and economy in Jericho.

Al Far'a, Al Jummaizah and Al Ru'yan springs in Al Qilt Spring Group are not used because their locations are adjacent to an Israeli settlement. The total volume of these springs reaches 1.36 MCM/year.

(2) Spring Water Use for Agriculture

As mentioned in the previous section, 90% of spring water in the Study Area is allocated to agricultural purposes. If the springs located out of the Jordan River Rift Valley (Ain Dafnah and Balata Springs) and non-used springs located in the upper Wadi Qilt are included, the allocation rate to agriculture reaches 94%. From the result of inventory survey, a more detailed summary of the current situation of water use for agriculture is presented in the following table.

Table 3.5.7 Current Situation of Spring Water Use for Agriculture

Water Source		Served Area	Irrigated Area (Dunum)		Water Volume (Mcm/yr)	Water Use Efficiency (m3/dunum)	Bed-ouin Use	Main Crops				
								Vege-table	Banana	Citrus	Grapes	Dates Palm
Al Far'ah Spring Group	Al Far'ah	Wadi Al Far'ah		1,200	6.30	5,250	N	80%		20%		
	Al Dlaib											
Badhan Spring Group & Shibli Spring Group		Al Badhan	70	13,570	7.20	531	Y	80%		20%		
		An Nassariya	800									
		Al 'Aqrabaniya	1,700									
		Frush Beit Dajan	11,000					70%		20%	5%	5%
		Al Jiftlik										
Fasayil Spring Group		Fasayil (Private)		630	0.65	1,032	Y	70%	5%	10%	10%	5%
Al 'Auja Spring Group		Al 'Auja		5,000	9.55	1,910	Y	70%	20%	10%		
Jericho & Dyuk Spring Group	Al Sultan	Jericho		4,000	3.21	803	N	60%	30%	10%		
	Dyuk	Dyuk		3,300	4.71	1,427	Y	60%	40%			
	Nwai'mah	Nwaim'ah		1,400	2.52	1,800	Y	60%	40%			
	Al Shusah	Nwai'mah (Private)		380	0.61	1,605	Y	40%	60%			
Al Qilt Spring Group		Jericho (Private)		2,000	6.55	3,275	Y	70%	30%			

Source: PWA Database, JICA Study Team

There is actually much more water lost during conveyance for irrigation. Therefore, the water use efficiency indicated in the table above could be higher. Most of the conveyance facilities consist of open concrete canals and natural wadis. According to the inventory survey, water loss reaches at least 20-30 % of the discharge volume. In the case of Al ‘Auja Spring, more than 40% loss in the main open canal have been estimated. It is considered that the main reasons of this much loss are: i) seepage in the natural flow; ii) leakage from the main canals because of cracks; and iii) overflow from the main canal because of insufficient capacity.

The water use efficiency of Al Far’a and Al Qilt Group is very low. It is considered that there are affected by much fluctuation; that is, seasonal surplus water might overflow to the wadis without any use. Likewise, the water use efficiency of Badhan and Shibli Spring Groups are also very low. Most of water from these spring groups is used in Frush Beit Dajan and Al Jiftlik Villages as shown in the irrigated area using spring water from Al Far’a Irrigation Project. This system takes water, not only from Badhan and Shibli Spring Groups, but also from surplus water of Al Far’a Spring Group and untreated wastewater flowing from the Nablus City. In addition, some farmers are using water for irrigation from private wells and it is assumed that their irrigated area is included in the area indicated in the table above. Therefore, the actual water use efficiency may be lower, and it is very difficult to estimate the water use efficiency of this area as well as the area using Al Wadi Far’a Spring Group.

The water use efficiencies of Al ‘Auja, Dyuk and Nwai’mah Springs are relatively high. One of the main crops in these areas is banana, of which the water requirement is very high. Bananas occupy 30-50% of the total irrigated area each. The current water use for bananas in the area is estimated to be around 3,000m^3/dunum. This fact causes the low water efficiency in these areas. However, according to the report, “Water Resources and Irrigated Agriculture in WB” issued by the Applied Research Institute-Jerusalem in 1998, the optimum water volume for bananas in the Jericho area is only around 1,600m^3/dunum. There is therefore a high possibility for the water volume for irrigation to be reduced.

The Jericho area using Al Sultan Spring has quite high water use efficiency. The irrigation methods in this area have been originally advanced from the viewpoint of water- saving agriculture. The new irrigation pipeline system was already installed, and it is expected that water use efficiency will become higher. However, there is friction concerning water allocation between the farmers and the municipality which has responsibility for O&M of the facilities. The agreed allocation volume was that 42% of water is for domestic purposes and 58% is for agricultural purposes. According to the farmers, however, the current allocation has a gap from the agreed rate, that is, only around 40% is allocated for agriculture. The water tariff for agricultural purposes is also one of causes of friction. Based on interviews with farmers, the imposed water tariff includes not only the operational cost but also profit for the municipality.

The qualities of the water sources are high, but some of them are contaminated by untreated wastewater or algae. This fact is caused by: i) insufficient capacity of conveyance systems; ii) lack of operation and maintenance activities; and iii) no wastewater treatment at the upper urbanized areas. The contaminated water is feared to damage emitters of drip irrigation pipes and shortens the life of the filtration equipment.

The farmers in the Study Area normally use drip irrigation pipes or sprinklers for irrigation. The farmers in each area have water rights on an hourly basis. According to the traditional schedule, the farmers open and close their own gates at the branch canals by themselves. The farmers have their own ponds and water of which right they have is filled in the ponds. The water volume in the water right of each varies based on the seasons. This means that the water right is not defined based on volume. In addition, the water used by each farmer in each irrigated area is unknown due to the absence of any measuring system.

(3) Organization for Spring Water Management

1) Overview of Related Organization

According to the result of inventory survey, the organizations for operation and maintenance (O&M) for both domestic and agricultural water facilities and agricultural water users groups are summarized below.

Table 3.5.8 O&M and Water Users Organization

Water Source		Served Area	O&M for Facilities		Water Users Group
			Agri. Facilities	Dom. Facilities	
Nablus Spring Group	Dafnah	Nablus and its surrounding area	-	Nablus Municipality	-
	Balata	Balata Camp	-	UNRWA (Camp Committee)	-
Al Far'a Spring Group	Al Far'a	Wadi Far'a, El Far'a Camp	Village Council	UNRWA (Camp Committee)	*None*
	Al Dlaib	Wadi Far'a	Village Council	-	-
Badhan Spring Group & Shibli Spring Group		Al Badhan	Village Council	-	*None*
		Ain Shibli	-	Village Council	*None*
		An Nassariya	*None*	-	*None*
		Al 'Aqrabaniya	*None*	-	*None*
		Frush Beit Dajan	Al Far'a Irrigation Committee	-	Al Far'a Irrigation Committee
		Al Jiftlik	Al Far'a Irrigation Committee	-	Al Far'a Irrigation Committee
Fasayil Spring Group		Fasayil	Spring Owner	-	*None*
Al 'Auja Spring Group		Al 'Auja	Village Council	-	*None*
Jericho & Dyuk Spring Group	Al Sultan	Jericho, Al Sultan Camp, Aqbat Jabar Camp	Municipality	Jericho Municipality	Ain Sultan Irrigation Cooperative
	Al Dyuk	Al Dyuk	Village Council	Village Council	*None*
	Al Nwai'mah	Al Nwaim'ah	Village Council	-	*None*
	Al Shusah	Al Nwai'mah	Spring Owner	-	*None*
Al Qilt Spring Group		Jericho, Aqbat Jabar Camp	Spring Owner	UNRWA (Camp Committee)	*None*

Source: JICA Study Team

Mainly, O&M for both agricultural and domestic water supply facilities are carried out by the village councils or municipalities, except for Al Far'a Irrigation Project of which O&M is carried out by Al Far'a Irrigation Committee. The activities of village councils for O&M for agricultural facilities are not appropriate. Al Badhan Village Council has no system and no staff for O&M. Al 'Auja and Dyuk Village Council have a responsible person for O&M in the committees and employ workers for cleaning of open canals as required, but methods and frequencies are insufficient due to their limited budget. In most villages, the water distribution lines are maintained by each farmer.

There are only two water users groups in the Study Area, i.e. Al Far'a Irrigation Committee and Ein Sultan Irrigation Cooperative. Normally, the farmers have their own water rights, and according to their water right, they open/close their own gates to take water based on their own cropping area or fill some storage ponds on hourly basis, but not based on volume. This legacy system has been kept throughout the years without any agreements or documents.

2) Water Tariff

The water tariffs of each area for agricultural and domestic purposes are shown in the following table. The farmers have the responsibility for O&M even when water tariff is free and this provided much burden on their part.

Table 3.5.9 Water Tariff

Water Source		Served Area	Water Tariff (NIS/m^3)	
			Agri.	Dom.
Nablus Spring Group	Dafnah	Nablus and its surrounding area	-	3.6-9
	Balata	Balata Camp		
Al Far'a Spring Group	Al Far'a	Wadi Far'a, El Far'a Camp	Free	-
	Al Dlaib	Wadi Far'a	Free	-
Badhan Spring Group & Shibli Spring Group		Al Badhan	Free	-
		Ain Shibli	Free	1.2
		An Nassariya	Free	-
		Al 'Aqrabaniya	Free	-
		Frush Beit Dajan	Free	-
		Al Jiftlik	Free	-
Fasayil Spring Group		Fasayil	Free	-
Al 'Auja Spring Group		Al 'Auja	Free	-
Jericho & Dyuk Spring Group	Al Sultan	Jericho, Al Sultan Camp, Aqbat Jabar Camp	0.36	1-3
	Al Dyuk	Al Dyuk	Free	2
	Al Nwai'mah	Al Nwaim'ah	Free	-
	Al Shusah	Al Nwai'mah	Free	-
Al Qilt Spring Group		Jericho, Aqbat Jabar Camp	Free	1.2

Source: JICA Study Team

Water for irrigation is free of charge normally. This indicates the farmers' point of view that spring water belongs to those living in the spring's area of origin. Only the farmers using Al Sultan Spring are charged for water. According to the interview with the Jericho Municipality, the tariff was set to cover only the O&M cost without any margin for the water itself. However, according to the farmers, the tariff includes the municipality's profit.

On the other hand, the tariff for domestic water from the springs is generally set to be between 1 and 3 NIS/m^3 by the village councils and municipalities, except for Nablus Municipality. The case of Nablus is not special in WB, but it can be mentioned that the difference from the others involves the difference in the operation costs between pumping from a well and the conveyance of spring water by gravity. In the case for Mekorot, the water tariff is set to be around 2.6 NIS/m^3 supplied through WB Water Department (WBWD). Normally, the Mekorot water is supplied for domestic purposes, but the water is supplied even for agriculture in the Bardara and Kardala Villages with the tariff to be 0.4 NIS/m^3 as a special case because of the shortage of water sources in the area.

3) Users Organization for Agriculture

The Far'a Irrigation Committee is formed by 8 major landlords living in Frush Beit Dajan and Al Jiftlik. They have water rights to use water from the Ain Shibli Spring. The committee is not officially registered by any governmental organizations. The function of the committee has been getting weak because of shortage of funds.

A sole official organization formed by the users' side is the Ain Sultan Irrigation Cooperative. The cooperative is registered under the Ministry of Labor as an agricultural cooperative. The cooperative consist of the 9 board members and more than 400 farmers. The total number of users is around 1,000 people. The registration fee which the farmers are charged is JD10. The advanced irrigation system with closed pipelines was constructed by the IFAD fund. Through the project, a joint committee was established comprised of the cooperative and Jericho Municipality with the Agreement. In the Agreement, the water allocation was set to be 58% to the cooperative and 42% to the municipality for domestic water services. In addition, it was agreed that the Municipality had responsibility for O&M for all the facilities including irrigation facilities for 2 years. The term of validity of the Agreement is until the end of 2008. The cooperative desires to handle their own system. However, their capacity for O&M is still very low. Through the project, the cooperative was registered as an official water users association by the National Water Council.

Currently, the Agreement has not been followed with regards to water allocation. The cooperative is complaining to the Municipality about the gap between the agreed allocation and actual allocation, that is, only 52% instead of 58% for irrigation use.

3.5.4 On-Farm Facilities and Management

Many methods of water application are used in irrigation systems. There are three basic methods that have been prevailing in the Palestinian territories; surface irrigation, sprinkler irrigation, and drip irrigation. A number of irrigation methods are hard to categorize since they cross over the traditional boundaries of these three general types[12].

[12] I. Nofal, Water management in small groundwater irrigation schemes in Palestine, 1998.

The three basic methods of water application are described as follows[13]:

Surface Irrigation

Surface irrigation methods are the earliest methods employed for large-scale agricultural production. They have been practiced longer than recorded history. In WB, surface irrigation method can generally be divided into two types; basin and furrow irrigation. Most surface irrigation systems are somewhat labor-intensive, using basically unskilled labor. Furrow irrigation is the most labor-intensive, since water must be guided into individual furrows. Intermediate borders are constructed by either borrowing soil on either side or by dragging soil from the middle of each strip and depositing it at the edge. Terrain places the most severe condition on the adoption of surface irrigation systems.

Sprinkler Irrigation

With sprinkler irrigation, the water is led to the field through a pipe system in which the water is under pressure. Spraying is accomplished by using several rotating sprinkler heads or spray nozzles or single gun-type sprinklers.

Evaporation losses from the spray are small under low wind speed, while at higher wind speed, losses may be considerable and uniformity of distribution will decrease.

Drip Irrigation

Drip irrigation can maintain soil moisture at an appropriate level for the growth of crops in which frequent watering is conducted with the best suited dripping and the water is dripped to the root zone of crops according to the rate of water consumption of the crops.

Compared with sprinkler irrigation, drip irrigation reduces the water loss. The factors are i) infiltration into a deep zone, ii) irrigation of the soil surface between crops, iii) evaporation from the ground surface, and iv) the interception of irrigated water by crops covering up other crops and dispersion into the air. For example, if the sprinkler irrigation field is not arranged in order, the field will be influenced by the wind and the result will be a great loss of water spread outside the field. Drip irrigation has no such effect and it can maintain a very high efficiency of irrigation.

Drip irrigation belongs to micro-irrigation systems, which includes trickle irrigation, subsurface irrigation, with also most of the references include micro-sprayers as part of micro-irrigation. There are several basic types of micro-irrigation. Usually, micro-irrigation systems in use in WB can be divided into either fixed systems which are applied to vegetables, or moving systems, which are typically applied to citrus.

Individual emission devices are used to deliver water to individual trees at low rates of flow. These emitters can be constructed in-line in the tubing or can be inserted into the soft plastic tubing with a barb connection. Line source micro-irrigation is another common system, where flexible plastic tubing is constructed with small perforations (e.g. 1 mm holes) at a fixed interval (e.g. 0.3 m). Another system of micro-irrigation is the micro-sprayer, which is similar to sprinklers. The distinction between micro-irrigation

[13] Some Aspects of Irrigation Systems Performance in Palestine, Issam Nofal, MoA, 2004.

sprayers and sprinklers is the rate of flow (typically less than 10 liter/hour) and the area covered is a single tree or a part of the tree canopy. (Clemmens and Dedrick, 1994) This method is very common in Palestine and the Study Area and it is usually used for especially citrus.

Micro-irrigation is common in greenhouses and for ornamental crops. Micro-irrigation is suitable for soils and topographies that are difficult to adapt to other methods and it can be adapted in extremely sandy soils or to rocky hillsides. Micro-irrigation is frequently used in settings where other methods might interfere with the landscaping. Micro-irrigation is also applied where water is scarce or expensive and it is expected to be the most efficient method. While it utilizes less labor than many other systems, it requires a more skilled labor force. Chemicals can be injected directly through the irrigation water, thus spoon-feeding nutrients into the crop. Micro-irrigation often minimizes weed growth and for some sub-irrigation systems, there are no weeds at all.

Consideration for Micro-irrigation

Emitter clogging is one of the main limitations of a micro-irrigation system. Line source systems are typically cleaned annually or biannually but there is no limited time for replacing new lines; lateral lines should be flushed at least annually to remove any sediments or debris in the line. Filters also need periodic cleaning (weekly) and chloride acid is used in washing the drip network from the accumulation of calcium carbonate precipitated in the lateral lines and caused emitter clogging.

Typical operating pressures for most micro-irrigation systems are 100 to 250 kPa (10 to 25 meter heads), with the higher pressures associated with micro sprayer. Usually these operating pressures; 100 kPa (10 meter pressure head) are needed to operate drip irrigation system with 4 l/h discharge emitters and the 250 kPa (25 meter pressure head) are needed to operate micro-sprayers (Mizyed and Haddad, 1990). In micro-irrigation systems, lateral lines usually do not exceed 100 m in length. The main drawbacks of micro irrigation are the high initial cost and also high O&M cost. Farmers have to monitor the irrigation system in the farm to look for leaks and clogged emitters.

The application of methods of irrigation differs from place to place depending on the climatic conditions, crop type, soil slope, soil texture and quantity and quality of the irrigation water. The comparison of irrigation systems in relation to site and situational factors are shown in following table:

Table 3.5.10 Comparison of Irrigation System in Relation to Site and Situational Factors

Site and situational factors	Furrow Irrigation	Sprinkler Irrigation	Drip Irrigation
Infiltration rate	All Except sandy soil	All	All
Topography	Uniform slops not exceeding 2 percent for cultivated crops	Level to rolling	All
Crops	Vegetables, row crops orchards, vineyards	All	All
Water supply	Large streams	Small streams	Small streams Nearly continuous
Water Quality	All	Salty water possibly harmful to plants	All, potential use of high salt waters
Labor requirement	High, training required	Low to seasonal high, training required	Low to high, training required
Energy requirement	Low	Moderate	Low to moderate
Management skill	Moderate	Moderate	High
Duration use	Short to long	Long term	Long term
Weather	All	Windy conditions reducing performance, good for cooling	All
Chemical application	Good	Good	Very good

Source: Water Resources and Irrigation Agriculture in WB 1998

3.6 Constraints on Water Resources Development and Management

3.6.1 Socio-Economic Conditions

In general, the main constraint in the socio-economic development of the Study Area is caused by the political issues such as Israeli control between Palestine and the surrounding countries. Restriction of movement of human and goods within and outside of Palestine heavily depresses public service and economic activities. Furthermore, capacity development of human resources and institutional development in all sectors of Palestine still remains at an insufficient level and needs further development.

3.6.2 Existing Water Resources

The constraints on agricultural wells and spring water uses are pointed out below:

Agricultural Wells

(i) Most of wells were drilled from 1950 to 1966, thus their capacities have decreased;
(ii) Limitation of wells extractions;
(iii) Drop in groundwater level;
(iv) Lack of electrical power in many areas;
(v) High cost of equipment, spare parts and maintenance work;
(vi) Lack of local cooperative organization for wells maintenance;
(vii) Limitations of qualified local drilling companies and
(viii) Political Issues such as Israeli control to be settled between Palestine and Israel on the water resources development and management including agricultural development

Spring Water

(i) Water is not effectively used because of losses in the main conveyance canals or natural conveyance systems due to seepage, leakage and insufficient capacities of conveyance facilities;

(ii) Water is allocated to the farmers based on an hourly water right system, thus it is expected that farmers waste surplus water than the volume required for their crop;

(iii) There is no water users association to organize the farmers' activities or to control and manage the system, except one. This means that the central governmental institutions cannot control and manage the water resources and water supply services comprehensively;

(iv) The capacity for operation and maintenance for water conveyance facilities are very low in the village councils and farmers;

(v) Some spring sources are contaminated by untreated wastewater in the wadis, i.e. Badhan and Shibli Spring Groups and Qilt Spring Groups;

(vi) Seasonal fluctuation of water discharges causes shortage of water in dry seasons (summer) and useless overflow in rainy seasons (winter); and

(vii) Political Issues such as Israeli control to be settled between Palestine and Israel on the water resources development and management including agricultural development

CHAPTER 4 HYDROLOGY AND HYDROGEOLOGY

4.1 General

This chapter describes the hydrological and hydrogeological conditions of the Study Area, which are clarified through field investigations. This also presents analysis of the data collected in the first and second field work stages.

The availability of the meteo-hydrological data related to the Study Area is described hereunder.

(1) Availability of Meteo-hydrological Data

Meteo-hydrological data was collected from the following organizations during the first field work stage:

(i) Palestinian Water Authority (PWA): Daily rainfall from the database, which covers rainfall stations existing in the whole Palestine area;
(ii) Meteorological Office under the Ministry of Transport: Meteorological records; and
(iii) Najah University: Hourly rainfall and discharge in the Wadi Far’a basin.

Additional meteo-hydrological data was collected during the second field work stage to supplement those obtained during the first stage.

At present, the rainfall observation in Palestine continues to be carried out by the following organizations:

- Palestinian Meteorological Department (PMD)
- Palestinian Water Authority (PWA)
- Palestinian Hydrology Group (PHG)

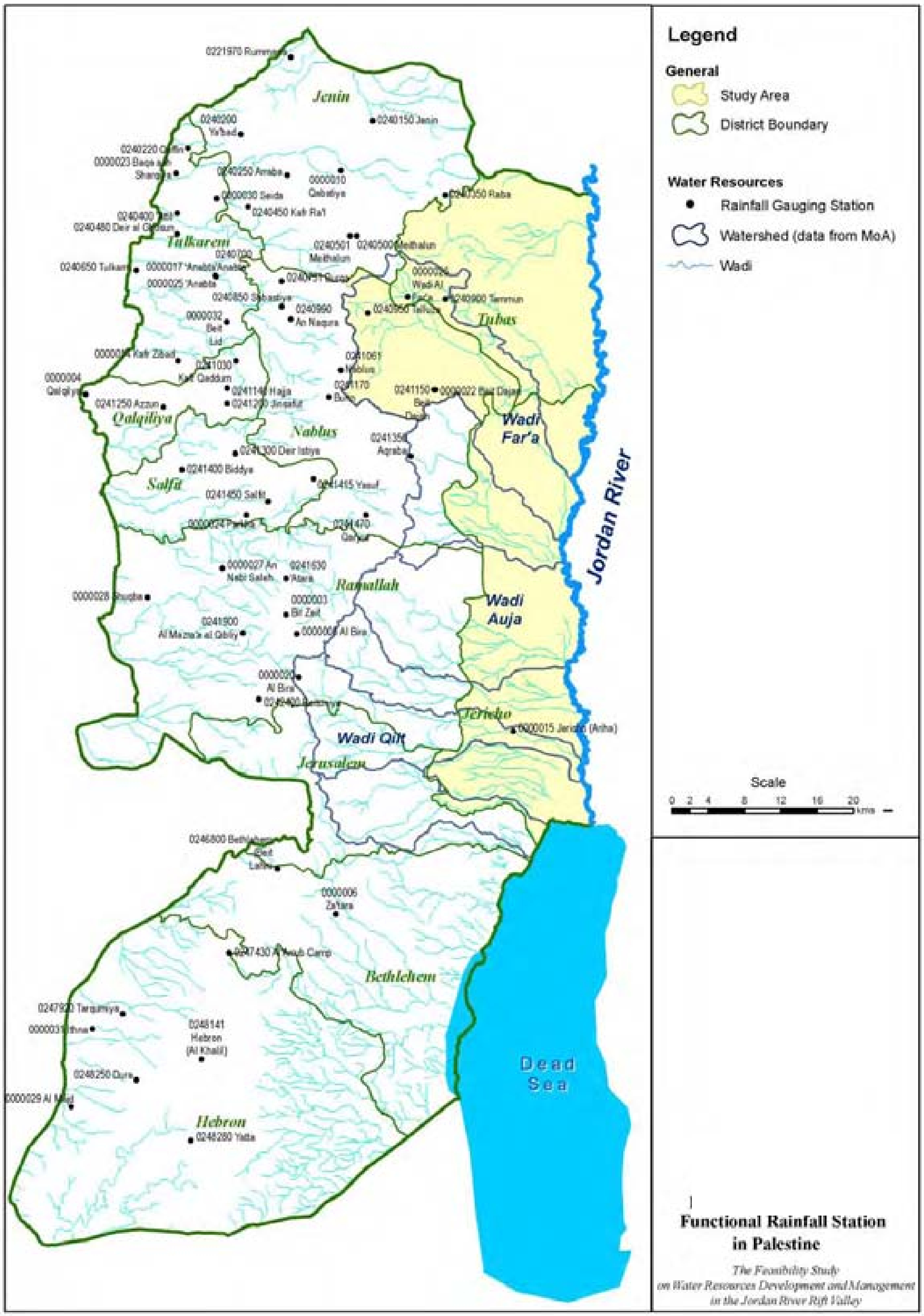
Table 4.1.1 lists the operational rainfall stations in Palestine that are presently registered with the PMD. Locations of these rainfall stations are shown in Figure 4.1.1. As observed in the table and figure, the present meteo-hydrological system involves issues and problems, as follows:

(i) Locations of existing rainfall stations are unevenly distributed in higher densities at highly elevated areas and lower densities at low-lying areas;
(ii) Synoptic stations in and around the Study Area is very less with four numbers, considering that meteorological data, especially evaporation data, are essential in estimating the water resources in the Study Area; and
(iii) There are many gaps and inconsistencies in the meteorological records since the start of the observation, although PMD entrusted to schools the observation activity at many rainfall stations.

Table 4.1.1 List of Rainfall Stations in the West Bank (Functional Stations Only)

No.	Station Code	Coordinates/Ground Level (m)			Locality	Start Date	Max. Of RMR_Year	Status	Type	Ownership
		X	Y	Z						
1	0000003	169.00	153.00	780	Bir Zeit	1954	2002	Working	Manual	PMD
2	0000004	146.90	177.30	58	Qalqilya	1954	2003	Working	Manual	PMD
3	0000006	174.45	120.00	600	Za'tara	1954	2003	Working	Manual	PMD
4	0000008	170.17	150.90	870	Al Bira	1954	2003	Working	Manual	PWA
5	0000010	175.00	202.00	300	Qabatiya	1954	2003	Working	Manual	PMD
6	0000014	157.10	181.00	195	Kafr Zibad	1954	2003	Working	Manual	PMD
7	0000015	194.00	140.20	-260	Jericho (Ariha)	1954	2003	Working	Full Automatic	PMD
8	0000017	161.20	190.40	160	'Anabta	1955	2003	Working	Manual	PMD
9	0000020	170	146	850	Al Bira	1958	2003	Working	Manual	PWA
10	0000022	185	178	520	Beit Dajan	1960	2000	Working	Tipping Bucket	PHG
11	0000023	157	202	100	Baqa ash Sharqiya	1962	2000	Working	Tipping Bucket	PHG
12	0000024	165	164	750	Farkha	1962	2000	Working	Tipping Bucket	PHG
13	0000025	161	190	170	'Anabta	1962	2000	Working	Tipping Bucket	PHG
14	0000026	182	188	165	Wadi Al Far'a	1962	1999	Working	Tipping Bucket	PHG
15	0000027	162	158	570	An Nabi Saleh	1963	2000	Working	Tipping Bucket	PHG
16	0000028	154	155	300	Shuqba	1963	2003	Working	Manual	PMD
17	0000029	145	99	480	Al Majd	1963	2003	Working	Manual	PMD
18	0000030	161	199	350	Seida	1963	2003	Working	Manual	PMD
19	0000031	148	107	460	Ithna	1963	2003	Working	Manual	PMD
20	0000032	162	185	420	Beit Lid	1963	2003	Working	Manual	PMD
21	0221970	169.50	214.50	180	Rummana	1963	2003	Working	Manual	PMD
22	0240150	178.50	207.50	138	Jenin	1966	2002	Working	Full Automatic	PMD
23	0240200	164.00	206.00	350	Ya'bad	1967	2003	Working	Manual	PMD
24	0240220	158.20	204.50	100	Qaffin	1968	2003	Working	Manual	PMD
25	0240250	169.10	201.50	340	Arraba	1968	2003	Working	Manual	PMD
26	0240350	186.50	199.30	500	Raba	1968	2003	Working	Manual	PMD
27	0240400	157.00	197.30	110	'Attil	1968	2003	Working	Manual	PMD
28	0240450	164.80	198.00	400	Kafr Ra'I	1968	2003	Working	Manual	PMD
29	0240480	157.00	195.00	190	Deir al Ghusun	1968	2003	Working	Manual	PMD
30	0240500	176.80	194.80	415	Meithalun	1968	2003	Working	Manual	PMD
31	0240501	176.00	194.80	410	Meithalun	1968	2001	Working	Manual	PMD
32	0240650	152.50	191.00	65	Tulkarm	1968	2003	Working	Manual	PMD
33	0240700	161.20	190.40	160	'Anabta	1968	2000	Working	Tipping Bucket	PHG
34	0240751	168.50	189.80	600	Burqa	1968	2003	Working	Manual	PMD
35	0240850	168.50	187.00	335	Sabastiya	1968	2003	Working	Manual	PMD
36	0240900	186.50	187.80	340	Tammun	1968	2003	Working	Manual	PMD
37	0240950	178.00	186.30	500	Talluza	1968	2003	Working	Manual	PMD
38	0240990	169.50	185.60	430	An Naqura	1968	2003	Working	Manual	PMD
39	0241030	163.50	181.00	400	Kafr Qaddum	1968	2003	Working	Manual	PMD
40	0241061	175.00	180.00	533	Nablus	1968	2003	Working	Full Automatic	PMD
41	0241140	162.50	178.00	350	Hajja	1968	2003	Working	Manual	PMD
42	0241150	185.30	177.80	520	Beit Dajan	1968	2003	Working	Manual	PMD
43	0241170	173.70	177.00	675	Burin	1968	2003	Working	Manual	PMD
44	0241200	162.50	176.30	430	Jinsafut	1968	2003	Working	Manual	PMD
45	0241250	155.50	175.90	260	Azzun	1968	2003	Working	Manual	PMD
46	0241300	163.40	170.80	432	Deir Istiya	1968	2003	Working	Manual	PMD
47	0241350	182.70	170.50	630	Aqraba	1970	2003	Working	Manual	PMD
48	0241400	157.50	169.00	315	Biddya	1970	2003	Working	Manual	PMD
49	0241415	172.00	168.00	600	Yasuf	1972	2003	Working	Manual	PMD
50	0241450	167.00	165.50	520	Salfit	1972	2003	Working	Manual	PMD
51	0241470	177.80	164.00	790	Qaryut	1973	2003	Working	Manual	PMD
52	0241630	169.00	157.00	500	'Atara	1976	1998	Working	Manual	PMD
53	0241900	164.20	151.00	600	Al Mazra'a al Qibliya	1980	2003	Working	Manual	PMD
54	0242400	166.00	143.70	810	Beituniya	1992	2003	Working	Manual	PMD
55	0246800	168.00	125.00	825	Bethlehem (Beit Lahm)	1998	2003	Working	Manual	PMD
56	0247430	162.70	115.70	860	Al'Arrub Camp	1998	2001	Working	Manual	PMD
57	0247920	151.00	109.00	500	Tarqumiya	1998	2003	Working	Manual	PMD
58	0248141	159.70	104.00	1005	Hebron (Al Khalil)	1998	2003	Working	Full Automatic	PMD
59	0248250	152.50	101.70	884	Dura	1999	2003	Working	Manual	PMD
60	0248280	158.50	95.00	820	Yatta	2000	2003	Working	Manual	PMD

Source: PMD: Palestine Meteorological Department, PWA: Palestine Water Authority,
PHG: Palestine Hydrological Group



Source: *PMD: Palestine Meteorological Department, PWA: Palestine Water Authority, PHG: Palestine Hydrological Group*

Figure 4.1.1 Location of Functional Rainfall Station in Palestine

According to the PMD staff in-charge, a lot of the equipment used for meteorological observation are very old and require urgent rehabilitation. PMD also expressed to the Study Team their willingness in establishing a modernized meteorological observation system with fully efficient observation equipment and data arrangement system.

Since the meteorological data, including the rainfall data, are essential for realizing the potential water resources, it is recommended that appropriate observation system is established as soon as possible.

(2) Availability of Hydrological Data

In general, the hydrological condition of the Study Area is very complex, being dominantly affected by groundwater movement in the catchment area and its adjacent basins, called “the Groundwater Area (GW Area)". In the Wadi Far’a basin, the GW Area exists in the catchment. Rainfall, which penetrates underground in the GW Area, moves towards the northern part of Israel. Thus, the groundwater in the GW Area vanishes from said catchment location. On the contrary, groundwater in the southern wadi basins, including Wadi Qilt, is augmented by groundwater from a catchment (GW Area) located outside the wadi basin, eastward.

Meanwhile, the TOR for this study specifies formulation of a storm water harvesting plan in the Wadi Qilt and Wadi Far’a basins. Basically, the present hydrological analysis has been carried out to facilitate the formulation of storm water harvesting plan on these two major wadis in the Study Area.

There are various structural methods on storm water harvesting that are implemented in the Jordan River East Bank area which are also proposed in the Study. These include construction of storage-type dam on wadi and the diversion of wadi flood runoff that will be retained in designated storage facilities. In connection with the hydrological analysis, it was noted that, in case construction of storage-type dam is implemented a corresponding monthly runoff data is required to adequately develop the plan. On the other hand, in case of a diversion scheme for wadi flood runoff is opted, it would be essential to utilize the hourly runoff data (hydrograph for each flood event) in order to accurately estimate the diverted discharges. In general, it is difficult to simulate an accurate flood hydrograph of wadi based on hourly rainfall data, even if said data are available for a relatively high density in the catchment area. This has been often experienced in East Asian countries where existing flood forecasting and warning systems (FFWSs) are installed in some basins to cope with the severe flooding.

In the course of data collection conducted during the first field work stage, it was found that hourly discharges are observed at stream gauges on the Al Far’a and Al Badan, the uppermost tributaries of the Wadi Far’a, under the EU-Najah University cooperative project. JICA Study Team could only obtain the hourly runoff data for two hydrological years, 2003/2004 and 2004/2005, which are shown in the interim report for the on-going project. At the end of the second field work stage, the additional runoff data for two years, 2004/05 and 2005/06, have been obtained from the concerned staff of PWA. As discussed hereunder, the annual mean discharges for the Al Far’a and Al Badan have been estimated based on the runoff data for the four years.

With regards to the flood runoff data on Wadi Qilt, continuous hydrological data could not been obtained so far, since the meteo-hydrological equipment at the stream gauge on said location, installed in 2003, were completely missing before the observation even started. On the other hand, JICA Study Team initiated a meeting with the personnel in-charge of the Joint Water Committee (JWC) on July 9th, 2007 in Tel Aviv, in order to request the runoff data observed on the Wadi Qilt. The flood runoff data on Wadi Qilt obtained from Israel and their availability are discussed in the following section.

Taking into account the very limited availability of flood runoff data on Wadi Qilt and Wadi Far'a, as well as the fact that the hydrological analysis is being carried out by the EU Engineer and Najah University, the present hydrological analysis has been carried out to estimate the flood runoff of Wadi Qilt, by applying the daily rainfall data to the simulation model called the "Tank Model".

4.2 Hydrological Analysis

4.2.1 General Climate

In Palestine, since rainfall rarely occurs in September, the hydrological year is taken as 12 months, from September to August of the following year. In this Study, the same hydrological year is considered.

The northern and western part of the Study Area is classified predominantly as a Mediterranean climate area, while a semi-arid climate prevails in the eastern and southern parts. In the Study Area, a comparatively large annual rainfall of 500 to 700 mm occurs in the mountainous regions, and gradually decreases to the east. In the southeastern area, where a wide lowland desert area including Jericho plain area spreads, the annual rainfall is as low as less than 200 mm, and becomes even lesser than 100 mm at the Dead Sea.

Furthermore, no rainfall takes place in the Study Area during the summer season of June to August, while it rarely occurs during September to May. The following table shows the annual mean monthly air temperature and relative humidity, monthly rainfall and mean monthly evaporation at Jericho and Nablus for the period from 1994 to 2007:

Table 4.2.1 Annual Mean Monthly Air Temperature and Relative Humidity , Monthly Rainfall and Mean Monthly Evaporation at Jericho

Item	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Annual
Air Temperature (℃)	29.5	26.0	20.1	15.6	13.9	14.5	18.5	22.5	27.3	29.7	32.2	31.8	23.4
Humidity (%)	48.5	54.3	57.1	69.4	70.0	65.2	56.6	45.7	40.2	43.1	42.9	48.8	53.6
Rainfall (mm)	0	7	22	33	36	31	25	10	2	0	0	0	166
Evaporation (mm/day)	7.2	4.9	3.1	2.1	1.9	2.5	4.1	6.2	8.4	9.4	9.8	8.7	5.7

Data Source: Meteorological office, the Ministry of Transport

Table 4.2.2 Annual Mean Monthly Air Temperature and Relative Humidity, Monthly Rainfall and Mean Monthly Evaporation at Nablus

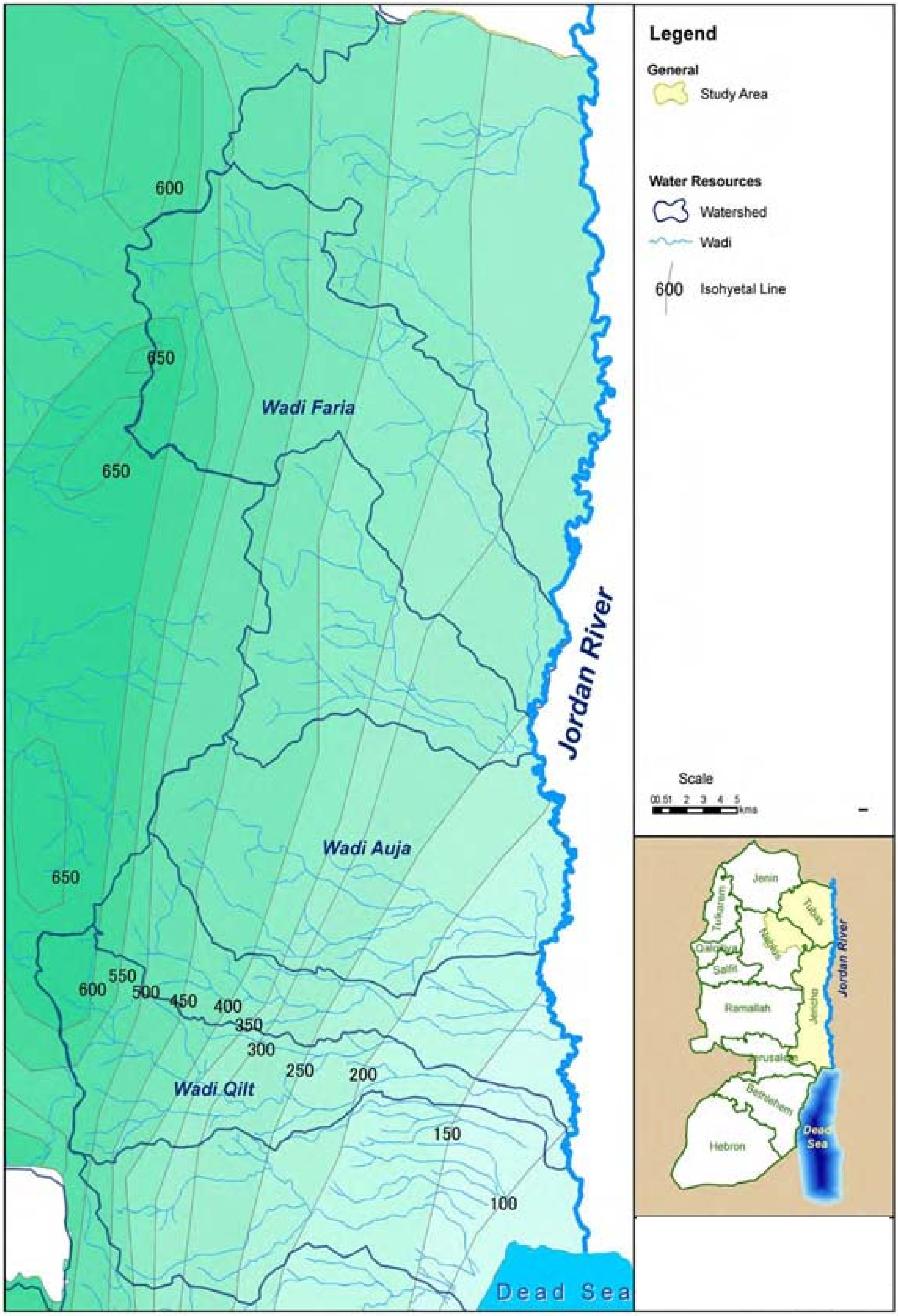
Item	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Annual
Air Temperature (℃)	23.7	21.0	16.9	12.4	10.1	10.8	13.5	17.0	21.0	23.5	25.0	25.0	18.3
Humidity (%)	63.2	61.7	58.9	67.2	70.2	67.8	62.5	54.9	50.2	57.8	59.2	65.1	61.6
Rainfall (mm)	2	21	77	141	142	147	104	20	8	0	0	0	660
Evaporation (mm/day)	6.3	4.6	3.5	2.4	2.3	2.8	3.8	5.3	7.4	8.2	8.2	7.2	5.2

Data Source: Meteorological office, the Ministry of Transport

As observed in the table above, the monthly rainfall at Jericho is considerably less than the monthly evaporation throughout a year. This implies that the rainfall in the desert hardly contributes to the supply in the water resources. Besides, the regulating ponds in the desert area that are examined as one of the options for storm water harvesting need to be planned in consideration of annual evaporation loss of 1,500 mm, which is equivalent to about 70% of the Pan-A evaporation amount at Jericho, unless any measure to mitigate water loss due to the high evaporation is taken.

The tables above show that the mean air temperature at Nablus at an altitude of about 500 m is about 5 ℃ higher than that at Jericho with an altitude of about -200 m. The difference between air temperatures at both stations justifies the theory that air temperature decreases by about 0.6 ℃ as altitude increases by 100 m.

The annual rainfall at Nablus is approximately four times larger than that at Jericho while annual evaporation at Nablus is about 80% of that at Jericho. Figure 4.2.1 shows an isohyetal map in Palestine, generated by PWA based on the annual rainfalls observed in the West Bank area, taking into account a general tendency that annual rainfall increases with altitude in the West Bank area.



Source: PWA

Figure 4.2.1 Isohyetal Map of the Study Area

4.2.2 Rainfall Analysis

PWA obtained the long-term rainfall data from the Meteorological Department of the Ministry of Transport and stored them in their database. Two excel files containing the rainfall data from all rainfall stations, observed between 1954 and 2005 in Palestine, are available. Prior to the hydrological analysis, the long-term daily rainfall data provided by the PWA are arranged in a yearly table format, viewed using a Fortran computer program developed in the present study stage. To utilize the excel files as input data, they are first converted into text files. Upon running said Fortran program, it was confirmed that the daily rainfall data at a total of 93 rainfall stations are stored in the PWA's database.

The annual rainfalls between 1953/1954 and 2005/06 at the whole of 93 rainfall stations, which are computed using said Fortran Program, are shown in Annex 1, while those at only rainfall stations in and around the Study Area are shown in Table 4.2.4. On the other hand, there exist only six rainfall stations in drainage areas of wadis covered by this study. The following table summarizes the annual rainfalls and availability the rainfall data at those rainfall stations:

Table 4.2.3 List of Rainfall Stations in Drainage Areas of Wadis Covered by this Study

No.	Code	Location	Wadi Basin	No. of Years of Complete Rainfall Data between 1953/54 and 2006/06
1	0000015	Jericho Met. Sta.	Wadi Qilt	34
2	0000022	Beit Daj.-PHG	Wadi Far'a	4
3	0000026	Al Far'a-PHG	- do -	2
4	0240900	Tammun P. Sch.	- do -	35
5	0240950	Talluza P. Sch.	- do -	38
6	0241150	Beit Dajan	- do -	39

Data Source: Meteorological office, the Ministry of Transport

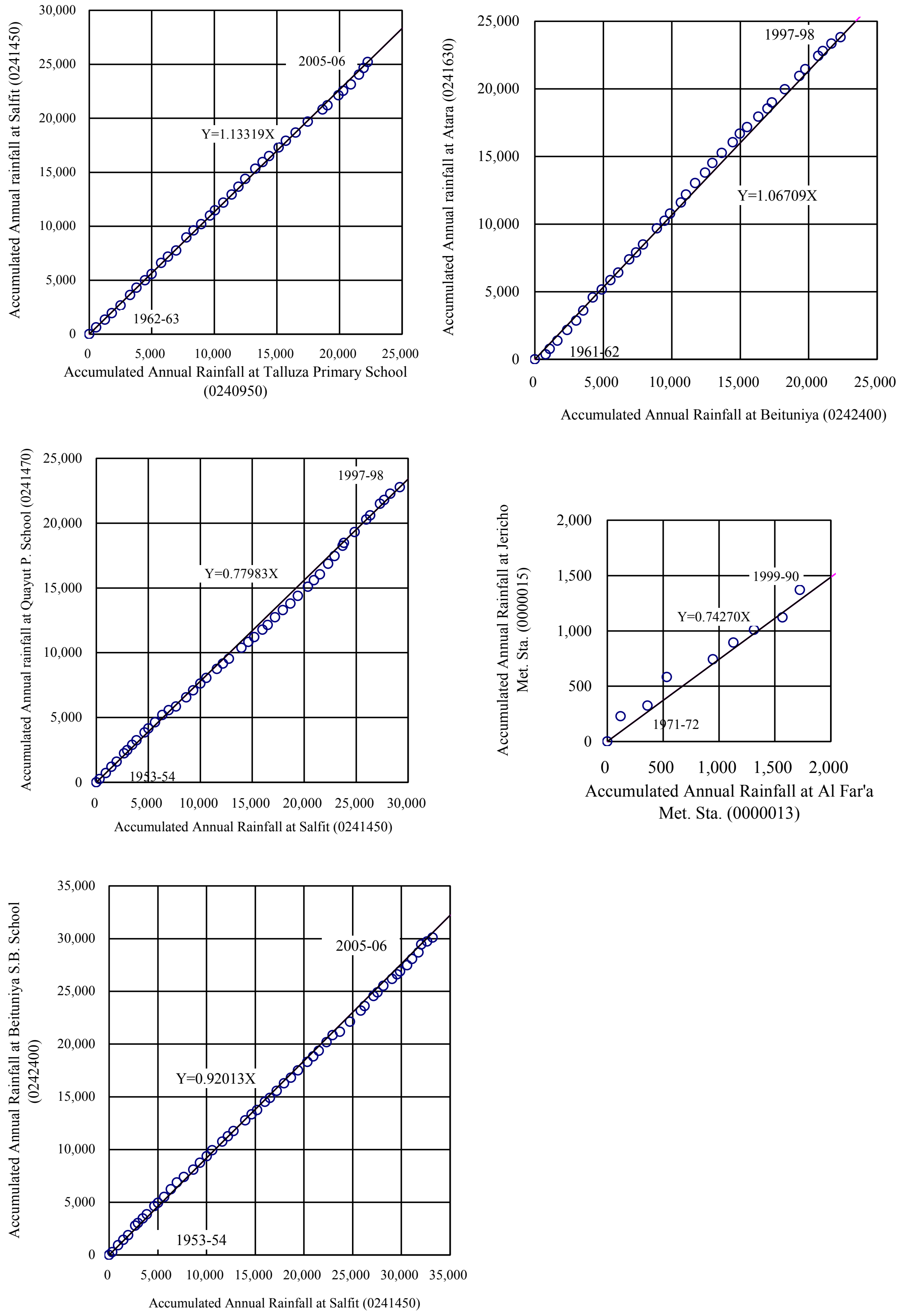
As shown in the table above, there is only one rainfall station in Wadi Qilt basin, but it is situated in the Jericho desert plain. Thus, no rainfall station has been installed so far in the main drainage area of the Wadi Qilt basin. This means that it is very hard to estimate the basin average rainfall in the Wadi Qilt basin, while there is a consistent tendency that the annual rainfall increases with ground elevation. On the other hand, there are five rainfall stations in the Wadi Far'a basin. Accordingly, it can be said that the Wadi Far'a basin is blessed with the number of rainfall stations, although there are a lot of interrupted periods of rainfall observation at those stations.

In general, there are a lot of interrupted periods of rainfall observation at these rainfall stations in Palestine. To interoperate the rainfall data for the interrupted periods of rainfall observation, a double curve method is adopted. Figure 4.2.2 shows the double curves between annual rainfalls in and around the two different rainfall stations in Wadi Qilt and Wadi Far'a basins. With the double mass curves, the complete rainfall data in and around both basins are derived for periods covering 1953/1954 to 2005/06.

Table 4.2.4 Annual Rainfall Records in and around the Study Area

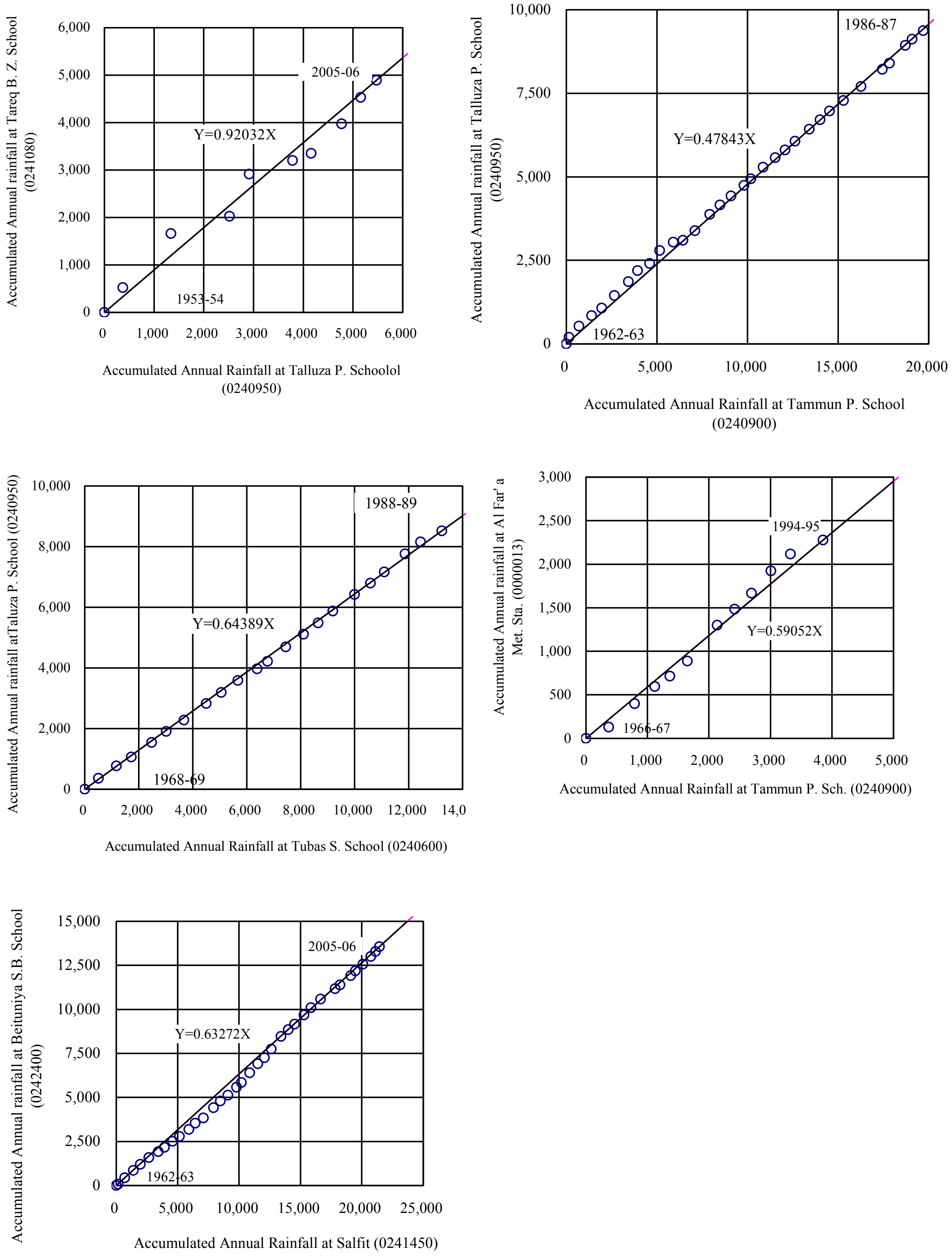
Code No.	0000003	0000008	0000013	0000015	0000020	0000022	0000026	0240350	0240500	0240900	0240950	0240990	0241150	0241170	0241350	0241450	0241470	0241630	0242400
Location	Bir Zeit	W. Bank W. Dpt. - Al Bira	Al Far' a Met. Sta.	Jericho Met. Sta.	W. R. and P. Dpt.	Beit Daj.-PHG	Al Far'a-PHG	Raba P. Sch.	Meithalun S. Sch.	Tammun P. Sch.	Talluza P. Sch.	An Naqura	Beit Dajan	Burin	Aqraba Sch.	Salfit	Qaryut P. Sch.	Atara	Beituniya S. B. Sch.
Place	Bir Zeit	Al Bira	Wadi Al Far'a	Jericho (Ariha)	Al Bira	Beit Dajan	Wadi Al Far'a	Raba	Meithalun	Tammun	Talluza	An Naqura	Beit Dajan	Burin	Aqraba	Salfit	Qaryut	'Atara	Beituniya
Region	Ramallah	Ramallah	Tubas	Jericho	Ramallah	Nablus	Tubas	Jenin	Jenin	Tubas	Nablus	Nablus	Nablus	Nablus	Nablus	Salfit	Nablus	Ramallah	Ramallah
1953-54	-	-	-	-	-	-	-	192.1	360.3	-	-	-	-	-	-	320.1	253.2	-	275.5
1954-55	-	-	-	-	-	-	-	323.9	625.4	-	-	-	-	-	-	601.2	464.5	-	651.1
1955-56	-	-	-	-	-	-	-	428.8	587.7	-	-	-	-	-	-	545.5	479.0	-	510.9
1956-57	-	-	-	-	-	-	-	306.7	409.5	-	-	-	-	-	-	488.7	398.0	-	458.8
1957-58	-	-	-	-	-	-	-	549.5	909.3	-	-	-	-	-	-	724.3	645.4	-	885.4
1958-59	-	-	-	-	-	-	-	233.0	267.1	91.4	-	-	-	-	-	284.8	243.2	-	250.1
1959-60	-	-	-	-	-	-	-	226.4	407.9	177.8	-	-	-	-	-	485.2	402.6	-	429.4
1960-61	-	-	-	-	-	-	-	275.1	512.5	116.5	-	-	-	-	-	416.1	349.8	-	398.2
1961-62	-	-	-	-	-	-	-	562.2	707.5	186.7	-	-	-	-	-	779.1	610.1	365.0	785.8
1962-63	-	-	-	-	-	-	-	329.7	508.3	198.2	146.2	-	74.0	-	*60.5*	373.0	313.6	407.3	299.6
1963-64	-	-	-	-	-	-	-	319.2	382.2	331.2	549.6	-	364.9	358.4	444.5	628.3	479.3	601.0	559.9
1964-65	-	-	-	-	-	-	-	434.9	677.4	319.0	700.5	-	415.9	824.5	575.5	702.8	564.4	797.1	721.2
1965-66	-	-	*45.3*	-	-	-	-	339.4	597.4	224.5	564.3	-	341.5	768.4	494.1	615.0	367.3	689.4	649.4
1966-67	-	-	130.8	-	-	-	-	521.6	640.3	371.1	690.9	-	392.7	665.3	568.9	706.4	272.4	741.8	525.9
1967-68	-	-	267.3	-	-	-	-	456.7	842.1	421.0	771.0	-	323.9	*79.8*	545.9	973.4	704.3	983.4	694.9
1968-69	-	-	196.8	-	-	-	-	435.4	580.6	325.8	510.1	-	252.2	646.1	565.9	675.1	552.6	578.8	647.1
1969-70	-	-	281.6	59.7	-	-	-	350.2	614.1	215.6	661.8	-	337.0	378.9	516.7	694.7	527.7	694.2	622.1
1970-71	-	-	-	158.0	-	-	-	329.8	543.6	388.2	553.2	-	284.8	-	474.1	564.0	426.8	551.4	582.0
1971-72	*247.6*	-	119.1	227.4	-	-	-	468.2	615.6	247.1	757.7	-	397.2	174.0	754.0	1,036.2	700.9	984.1	802.3
1972-73	429.5	-	240.1	96.0	-	-	-	361.6	424.2	*61.0*	534.2	-	356.6	357.9	462.9	579.0	411.0	510.0	504.2
1973-74	517.0	-	173.3	258.9	-	-	-	358.1	519.9	285.7	654.5	-	291.6	331.5	510.1	582.1	381.4	588.7	502.0
1974-75	981.5	*202.4*	412.3	160.2	-	-	-	455.7	749.7	483.8	826.9	-	578.1	628.5	794.8	1,190.1	832.5	1,192.6	1,015.9
1975-76	535.7	509.3	184.2	150.7	-	-	-	438.6	523.3	283.4	561.6	-	384.3	345.2	417.0	665.3	453.6	568.3	558.2
1976-77	340.5	464.9	184.7	115.5	-	-	-	568.9	616.3	272.6	610.5	-	335.7	311.1	407.4	567.9	375.7	519.8	412.3
1977-78	577.5	753.3	254.6	112.2	-	-	-	488.5	775.2	317.5	711.4	-	451.4	446.5	514.0	793.7	577.6	825.5	787.8
1978-79	433.0	491.4	*45.5*	109.6	-	-	-	307.3	406.7	192.8	386.3	-	270.0	107.5	375.2	506.5	360.9	578.6	371.5
1979-80	676.5	636.7	*65.4*	244.9	-	-	-	479.6	627.6	345.5	675.5	-	545.0	258.5	576.2	699.7	594.2	852.0	667.2
1980-81	569.5	819.2	-	199.7	-	-	-	400.5	624.1	291.4	663.1	-	516.8	-	500.0	748.1	553.1	768.2	712.1
1981-82	575.2	651.5	*33.5*	140.7	-	-	-	364.3	619.3	231.8	540.4	-	337.1	-	399.8	723.7	498.3	719.5	538.5
1982-83	559.5	807.2	-	219.0	-	-	-	411.4	584.7	256.0	549.9	-	499.7	-	596.4	725.8	588.9	739.5	690.6
1983-84	575.6	992.2	*77.6*	85.4	-	-	-	826.6	752.1	361.2	797.9	-	709.2	-	740.8	960.0	715.3	800.1	803.0
1984-85	476.8	642.6	-	150.5	-	-	-	586.4	535.2	283.5	590.9	-	385.1	-	478.8	593.9	496.4	636.8	510.9
1985-86	541.9	582.0	-	109.5	-	-	-	580.5	604.9	259.7	516.2	-	316.0	108.1	384.8	570.8	464.2	485.8	535.5
1986-87	645.5	780.1	192.6	-	-	-	-	516.5	752.9	319.1	769.6	-	526.2	322.2	721.4	798.4	803.9	771.0	824.0
1987-88	555.5	652.3	155.3	250.4	-	-	-	290.6	473.6	120.3	567.2	-	403.3	474.7	468.4	617.1	596.7	590.5	661.3
1988-89	474.5	868.4	294.1	167.2	-	-	-	267.2	672.3	-	790.0	-	500.0	104.0	751.0	761.2	786.4	457.0	321.5
1989-90	307.7	461.1	297.9	181.3	-	-	-	187.0	471.0	-	397.8	-	485.0	-	340.9	139.0	227.7	195.0	-
1990-91	-	514.6	-	110.9	-	-	-	242.5	378.1	*1.3*	370.4	*35.1*	355.0	*38.4*	297.0	*36.9*	*7.4*	426.0	*40.0*
1991-92	-	1,140.2	-	-	-	-	-	468.2	954.7	416.9	966.9	1,014.3	131.7	744.3	804.2	1,023.0	834.7	979.0	951.3
1992-93	-	1,225.7	-	119.0	-	-	-	828.6	1,173.1	513.8	1,182.1	1,065.7	583.5	886.9	865.5	1,109.5	964.4	989.0	1,057.1
1993-94	-	460.9	-	93.1	-	-	-	232.9	317.9	185.9	391.8	396.3	211.3	343.4	253.6	384.2	334.1	497.0	432.7
1994-95	-	1,057.3	161.0	-	-	-	-	617.9	838.0	528.3	872.0	892.1	526.7	812.3	662.9	935.8	878.0	989.0	958.1
1995-96	-	371.0	-	16.8	-	-	-	221.7	376.2	185.9	376.6	395.9	266.4	357.5	278.9	400.6	308.7	349.0	335.5
1996-97	-	640.8	*9.5*	140.1	-	-	-	380.6	561.5	254.0	610.7	557.3	393.0	565.0	427.0	602.7	471.2	546.0	627.0
1997-98	-	810.3	-	206.2	-	156.4	-	366.0	575.1	360.3	646.8	676.0	434.2	555.8	492.1	909.2	507.9	481.0	661.0
1998-99	-	507.3	-	91.9	-	312.0	429.0	-	-	-	-	-	-	-	-	489.8	-	-	430.4
1999-00	-	313.5	-	48.9	-	213.8	191.2	-	-	-	-	-	-	-	-	306.9	-	-	270.7
2000-01	-	714.4	-	154.1	-	241.2	-	-	-	-	-	-	-	-	-	725.0	-	-	596.3
2001-02	-	548.7	-	93.9	262.0	-	-	-	-	-	-	-	-	-	-	508.3	-	-	589.8
2002-03	-	645.2	-	137.5	601.6	-	-	-	-	-	-	-	-	-	-	657.7	-	-	627.8
2003-04	-	769.3	-	45.4	804.7	-	-	103.0	152.5	-	*99.0*	-	101.0	*84.4*	95.3	278.6	-	-	734.7
2004-05	-	-	-	129.6	330.0	-	-	363.7	464.0	-	386.8	-	278.1	348.4	305.1	613.0	-	-	291.5
2005-06	-	-	-	75.6	-	-	-	246.0	405.0	-	315.7	-	278.3	394.5	391.3	561.5	-	-	362.2
Mean	527.4	667.8	173.8	137.0	499.6	230.9	310.1	396.7	577.5	274.4	596.6	629.1	375.2	413.6	495.2	629.8	506.2	660.8	579.5

Data Source: PWA Database



Source: computed by JICA Study Team

Figure 4.2.2 Double Mass Curves between Annual Rainfalls (1/2)



Source: computed by JICA Study Team

Figure 4.2.2 Double Mass Curves between Annual Rainfalls (2/2)

4.2.3 Discharge Measurements Conducted by PWA on Wadi Qilt and Wadi Far'a

PWA conducted discharge measurements on Wadi Qilt and Wadi Far'a during occurrences of flood. Table 4.2.5 shows the discharge measurement results attached to the previous study report on storm water harvesting in the Eastern Surface Catchment of the Jordan River West Bank, which was prepared by FORWARD in September 1998.

Table 4.2.6 summarizes the discharge measurement results by PWA. However, these flood runoff data on are not deemed useful since they are instantaneous and sporadic. Nevertheless, it is confirmed from the data that flood runoff occurs on these two wadis on corresponding dates.

As shown in Tables 4.2.5 and 4.2.6, the large flood discharges of more than were so often measured on the Wadi Qilt by current metering conducted by PWA for the period from 1971 to 1994. The measured maximum discharge exceeds 30 m^3/sec.

As mentioned above, on the other hand, these were measured instantaneously when the hydrological monitoring team could visit the measurement site and continuous flow data on the flood events are not available. Therefore, it is considered that the actual peak discharges would be by far larger the measured discharges. Besides, it seems that the PWA monitoring team would not be able to proceed always to the measurement site because of the difficulty in staffing for the field works and budget, whenever the flood occurred on the Wadi Qilt.

As well as the current metering on the Wadi Qilt, the flood discharges measured by PWA on the Wadi Fari'a often exceed 10 m^3/sec. as shown in Tables 4.2.5 and 4.2.6. The maximum measured discharge on the Wadi Far'a reaches about 28 m^3/sec.

Unfortunately, the detailed data of current metering could not be found in the PWA office. Hence, it is hard to assess the accuracy of the current metering conducted by the PWA.

During the Field Work stages in this study, the JICA Study Team continued to observe visually flood flow on the Wadi Qilt. In floods of the middle of May 2007 and the subsequent floods on the Wadi Qilt, it is visually confirmed that the wadi water indicated a muddy condition, signifying an extremely high sediment concentration. During the flood, moreover, it was visually observed that the turbidity of the flood flow was especially high for the initial period of the flood. From these visual observations, it is estimated that a large amount of sediments are transported downstream during the occurrence of flood on the Wadi Qilt. Accordingly, the sedimentation condition will have to be taken into consideration in formulating the stormwater harvesting plan on the Wadi Qilt, although no suspended load data on the Wadi Qilt are available.

Table 4.2.5 Results of Current Metering Carried out by PWA on the Wadi Qilt (Extracted from the 1998 FORMARD Report)

(1) Wadi Qilt

No.	Date	Time of Meaurement	Flood Discharge Measured (m^3/sec)	Flow area (m^2)	Mean Velocity (m/sec)
1	Jan. 19, 1974	10:40	3.08	2.15	1.44
2	- do -	12:30	3.99	3.02	1.32
3	- do -	13:40	4.02	2.81	1.43
4	Jan. 21, 1974	10:00	16.02	6.16	2.60
5	- do -	11:20	21.28	7.07	3.01
6	- do -	12:55	30.28	10.64	2.85
7	- do -	13:40	33.77	11.21	3.01
8	Jan. 22, 1974	9:15	9.79	4.32	2.27
9	Mar. 03, 1974	11:05	3.81	2.85	1.34
10	Mar. 04, 1980	12;00	2.78	2.74	1.01
11	Jan. 16, 1992	14:10	1.93	2.67	0.72
12	Feb. 18, 1992	14;45	2.51	2.74	0.92

(2) Wadi Fara

No.	Date	Time of Meaurement	Flood Discharge Measured (m^3/sec)	Flow area (m^2)	Mean Velocity (m/sec)
1	Jan. 21, 1974	10:30-11:30	28.05	12.00	2.34
2	- do -	13:00	22.05	10.78	2.05
3	- do -	13:00-14:00	21.40	10.89	1.97
4	Jan. 31, 1974	12:50	4.25	3.26	1.30
5	Feb. 20, 1983	12:40	9.13	5.56	1.64
6	Feb. 21, 1983	13:25	10.34	5.88	1.76

Source: The 1998 FORWARD's Report

Table 4.2.6 Results of Current Metering Carried out by PWA on the Wadi Qilt and Wadi Far'a (Obtained from PWA in This Study)

(1) Wadi Qilt

No.	Date	Flood Discharge Measured (m^3/sec)
1	Apr. 18, 1971	0.89
2	Jan. 18, 1973	0.71
3	Mar. 03, 1980	2.36
4	Feb. 15, 1987	11.30
5	Feb. 03, 1988	18.11
6	Feb. 01, 1988	3.90
7	Dec. 02, 1991	6.48
8	Dec. 15, 1991	2.88
9	Jan. 07, 1992	7.60
10	- do - (after 4 hours)	8.81
11	Jan. 16, 1992	1.93
12	Jan. 25, 1992	1.93
13	Feb. 18, 1992	2.51
14	Feb. 06, 1992	18.48
15	Mar. 02, 1992	10.18
16	Dec. 20, 1992	17.45
17	Jan. 11, 1993	28.77
18	Jan. 11, 1993	15.21
19	Dec. 17, 1992	17.45
20	Nov. 24, 1994	1.40
21	- do - (after 3.5 hours)	5.29
22	Dec. 30, 1994	4.67

(2) Wadi Faria

No.	Date	Flood Discharge Measured (m^3/sec)
1	Feb. 20, 1983	7.99
2	Feb. 21, 1983	10.34
3	Dec. 02, 1991	7.65
4	Feb. 06, 1992	11.52
5	Mar. 02, 1992	7.22
6	Dec. 20, 1992	16.20
7	Jan. 11, 1993	22.50
8	- do - (after 1.5 hours)	15.21
9	Dec. 17, 1992	16.20
10	Nov. 24, 1994	17.20
11	Nov. 30, 1994	1.91
12	Dec. 03, 1994	6.12
13	Dec. 19, 1994	8.01
14	Dec. 20, 1994	2.67
15	Feb. 12, 2005	1.58
16	- do - (after 7 hours)	24.54
17	Feb. 06, 2005	22.09
18	Feb. 05, 2005	9.31

Source: PWA

4.2.4 Flood Runoff Data on Wadi Qilt, Provided by Israel

Flood runoff data on the Wadi Qilt provided by Israel consisted the following, for each of the flood event that occurred between 1967/68 and 1982/83 shown in Table 4.2.7:

(i) Time/date of beginning and end of flood;

(ii) Duration of flood;

(iii) Peak discharge and time/date of its occurrence; and

(iv) Flood runoff volume.

Flood runoff observed by Israel is at the same location as the existing stream gauge in Wadi Qilt, upstream of Jericho. According to the data provided, a catchment area at the old stream gauge, managed by Israel, is 135 km^2.

In total, 52 flood events on the Wadi Qilt were observed by Israel and it is reported by the Israeli agency concerned that there are no flood runoff data with the exception of the ones shown in Table 4.2.7.

The runoff data on said wadi are very useful for the runoff analysis. However, it seems that the estimated runoff volume of one flood event is very small at 0.001 to 0.436 MCM. It is noted that the annual flood runoff volumes ranges from 0.001 MCM in 1970/71, to 0.738 MCM in 1982/83. Besides, based on the data available no runoff was observed in five years covering 1969/70, 1971/72, 1972/73, 1977/78 and 1978/79. Hence, since runoff volumes seem significantly small, proposed development of storm water harvesting in the Wadi Qilt basin is deemed discouraging. In this regard, the runoff volume for each flood event is newly estimated using the following formula:

$$V_f = Q_p \cdot (T_1 + T_2)/2 \times 3600/10^6$$

Where,

V_f: Flood runoff volume on the Wadi Qilt (MCM)

Q_p: Peak discharge (m^3/sec)

$T1$: Time from beginning of flood to occurrence of peak discharge (hour)

$T2$: Time from occurrence of peak discharge to end of flood (hour)

The flood runoff volume for each flood event, estimated using above formula, is shown in the rightmost column of Table 4.2.7. Consequently, it is estimated that average annual flood runoff of about 1.41 MCM took place during the period of 1967/68 to 1982/83.

Since the detailed flood runoff data in the Wadi Qilt are insufficient, it would be difficult to confirm the accuracy of the data mentioned above, which are required for the preparation of storm water harvesting. Hence, it is essential to perform a flood runoff observation and measurement at the stream gauges that will be newly installed on the Wadi Qilt in the future, described in succeeding Subsection 6.4.6.

Table 4.2.7 Observed Flood Runoff at Station No. 46150 on Wadi Qilt, Provided by Israel

No. of Year	Hydrological Year	Time/Date of Beginning of Flood Runoff		Time/Date of End of Flood Runoff		Duration of Flood Runoff	Time/Date of Occurrence of Peak Discharge		Peak Discharge: Max. Stage Height	Peak Discharge: Peak Discharge	Flood Runoff Volume	Flood Runoff Volume Estimated Newly*
		Time	Date	Time	Date	(hours)	Time	Date	(m)	(m^3/sec)	(MCM)	(MCM)
1	1967/1968	4:30	15-Jan-68	12:00	18-Jan-68	79:30	6:32	16-Jan-68	11.53	2.485	0.028	0.356
	1967/1968	9:59	31-Jan-68	10:00	02-Feb-68	48:01	0:08	01-Feb-68	10.65	0.025	0.002	0.002
	1967/1968	15:29	19-Mar-68	19:59	19-Mar-68	04:30	15:53	19-Mar-68	10.44	0.007	< 0.0005	0.000
	1967/1968	12:00	27-Mar-68	0:00	28-Mar-68	12:00	12:41	27-Mar-68	11.44	1.732	0.004	0.037
	Yeraly Total										0.034	0.395
2	1968/1969	6:00	1969/2/9	21:29	1969/2/9	15:29	14:31	1969/2/9	10.58	0.018	< 0.0005	0.001
	Yeraly Total										0	0.001
3	1970/1971	10:19	1971/4/13	12:59	1971/4/14	26:39	11:25	1971/4/13	10.75	0.040	0.001	0.002
	Yeraly Total										0.001	0.002
4	1973/1974	9:30	1974/1/14	13:59	1974/1/16	52:29	10:04	1974/1/14	11.01	0.143	0.004	0.014
	1973/1974	20:30	1974/1/30	21:10	1974/2/1	48:39	19:13	1974/1/31	11.25	0.675	0.013	0.059
	1973/1974	6:00	1974/2/12	11:00	1974/2/13	28:59	7:18	1974/2/12	11.00	0.130	0.003	0.007
	1973/1974	16:59	1974/3/21	9:29	1974/3/22	16:30	17:33	1974/3/21	10.90	0.075	0.001	0.002
	1973/1974	21:49	1974/3/24	13:00	1974/3/25	15:10	22:37	1974/3/24	11.14	0.356	0.002	0.010
	1973/1974	12:35	1974/3/28	23:00	1974/3/31	82:24	20:14	1974/3/30	12.16	21.240	0.186	3.151
	Yeraly Total										0.208	3.242
5	1974/1975	22:00	1974/11/22	3:00	1974/11/24	28:59	23:22	1974/11/22	11.09	0.246	0.004	0.013
	1974/1975	14:30	1974/12/4	9:00	1974/12/6	42:29	14:43	1974/12/4	12.86	105.000	0.139	8.033
	1974/1975	15:49	1975/2/4	22:59	1975/2/5	31:09	16:22	1975/2/4	11.16	0.404	0.009	0.023
	1974/1975	3:50	1975/2/10	6:00	1975/2/12	50:09	4:11	1975/2/10	11.45	1.810	0.027	0.163
	1974/1975	3:20	1975/2/21	14:59	1975/2/22	35:38	21:10	1975/2/21	11.19	0.476	0.005	0.031
	1974/1975	5:20	1975/3/2	8:59	1975/3/3	27:39	8:05	1975/3/2	11.45	1.810	0.016	0.090
	Yeraly Total										0.199	8.352
6	1975/1976	22:00	1975/11/30	17:59	1975/12/1	19:59	3:49	1975/12/1	11.23	0.605	0.003	0.022
	1975/1976	16:50	1975/12/26	3:00	1975/12/27	10:09	17:23	1975/12/26	11.44	1.732	0.005	0.032
	1975/1976	2:00	1976/1/13	7:29	1976/1/13	05:29	3:50	1976/1/13	10.65	0.015	< 0.0005	0.000
	1975/1976	9:45	1976/3/12	9:00	1976/3/13	23:15	19:26	1976/3/12	10.98	0.109	0.002	0.005
	1975/1976	8:00	1976/3/18	10:00	1976/3/19	26:00	8:18	1976/3/18	11.05	0.190	0.004	0.009
	1975/1976	17:30	1976/3/21	5:00	1976/3/22	11:29	17:33	1976/3/21	11.10	0.260	0.002	0.005
	1975/1976	18:29	1976/4/6	11:00	1976/4/7	16:30	19:00	1976/4/6	11.03	0.162	0.002	0.005
	Yeraly Total										0.018	0.077
7	1976/1977	8:19	1976/11/28	19:59	1976/11/29	35:39	15:05	1976/11/28	11.09	0.246	0.006	0.016
	1976/1977	21:00	1977/2/8	0:59	1977/2/10	27:58	21:33	1977/2/8	11.12	0.308	0.006	0.016
	1976/1977	9:59	1977/3/4	17:30	1977/3/5	31:31	12:30	1977/3/4	11.54	2.580	0.020	0.146
	Yeraly Total										0.032	0.178
8	1979/1980	19:00	1980/1/5	0:00	1980/1/8	52:59	1:52	1980/1/6	11.81	7.430	0.124	0.709
	1979/1980	11:00	1980/2/17	0:00	1980/2/19	37:00	19:58	1980/2/17	11.42	1.576	0.026	0.105
	1979/1980	12:00	1980/2/20	1:59	1980/2/21	13:59	12:38	1980/2/20	11.17	0.428	0.003	0.011
	1979/1980	17:50	1980/3/1	17:59	1980/3/5	96:09	6:04	1980/3/2	12.30	30.200	0.502	5.227
	Yeraly Total										0.654	6.051
9	1980/1981	6:00	1980/10/14	7:30	1980/10/15	25:30	6:02	1980/10/14	10.66	0.016	0.001	0.001
	1980/1981	9:59	1980/12/11	23:00	1980/12/14	85:00	14:35	1980/12/11	11.33	1.021	0.035	0.156
	1980/1981	20:44	1980/12/27	20:30	1980/12/28	23:46	23:30	1980/12/27	11.10	0.260	0.008	0.011
	1980/1981	0:00	1981/1/4	13:59	1981/1/5	37:59	0:27	1981/1/5	11.02	0.148	0.006	0.010
	1980/1981	15:00	1981/1/13	0:00	1981/1/16	57:00	15:32	1981/1/13	10.96	0.098	0.008	0.010
	1980/1981	5:30	1981/1/28	18:00	1981/1/28	12:29	6:22	1981/1/28	10.99	0.115	0.001	0.003
	1980/1981	16:45	1981/2/1	5:58	1981/2/2	13:12	20:23	1981/2/1	11.05	0.190	0.002	0.005
	1980/1981	13:59	1981/2/10	4:00	1981/2/11	14:01	15:31	1981/2/10	10.97	0.104	0.001	0.003
	1980/1981	19:59	1981/2/13	7:00	1981/2/16	59:01	21:15	1981/2/13	10.91	0.070	0.006	0.007
	1980/1981	14:15	1981/2/27	1:59	1981/2/28	11:44	15:54	1981/2/27	10.95	0.093	0.001	0.002
	1980/1981	17:30	1981/3/14	22:00	1981/3/15	28:30	18:54	1981/3/14	10.95	0.093	0.003	0.005
	1980/1981	19:30	1981/3/18	1:59	1981/3/19	06:29	19:55	1981/3/18	10.68	0.018	<0.0005	0.000
	1980/1981	10:44	1981/3/26	22:00	1981/3/26	11:16	10:52	1981/3/26	11.00	0.120	0.001	0.002
	1980/1981	22:59	1981/3/27	9:59	1981/3/28	10:59		1981/3/28	10.96	0.098	0.001	0.002
	1980/1981	11:00	1981/3/30	16:59	1981/3/31	29:59	1:41	1981/3/31	11.11	0.284	0.008	0.015
	1980/1981	19:00	1981/4/1	13:00	1981/4/2	18:00	23:30	1981/4/1	11.14	0.356	0.003	0.012
	Yeraly Total										0.086	0.244
10	1981/1982	12:00	1982/2/1	6:59	1982/2/2	18:58	12:35	1982/2/1	11.06	0.204	0.004	0.007
	1981/1982	0:00	1982/2/4	5:27	1982/2/5	29:27	15:15	1982/2/4	11.20	0.500	0.009	0.027
	1981/1982	12:00	1982/2/15	2:27	1982/2/16	14:27	16:19	1982/2/15	10.99	0.115	0.002	0.003
	1981/1982	19:59	1982/3/5	4:59	1982/3/6	09:00	20:21	1982/3/5	11.03	0.162	0.001	0.003
	1981/1982	8:29	1982/3/14	20:59	1982/3/15	36:30	10:20	1982/3/15	10.97	0.104	0.002	0.007
	1981/1982	12:40	1982/4/6	2:00	1982/4/7	13:19	13:38	1982/4/6	11.24	0.640	0.004	0.015
	Yeraly Total										0.022	0.061
11	1982/1983	15:00	1983/1/1	12:58	1983/1/2	21:58	15:21	1983/1/1	11.13	0.332	0.008	0.013
	1982/1983	9:59	1983/1/15	22:00	1983/1/15	12:01	10:24	1983/1/15	11.08	0.232	0.002	0.005
	1982/1983	19:30	1983/1/18	15:01	1983/1/19	19:30	20:28	1983/1/18	11.26	0.710	0.015	0.025
	1982/1983	19:59	1983/1/23	19:58	1983/1/24	23:59	4:21	1983/1/24	11.31	0.907	0.017	0.039
	1982/1983	6:40	1983/2/3	3:30	1983/2/4	20:49	7:09	1983/2/3	11.10	0.260	0.007	0.010
	1982/1983	14:30	1983/2/17	12:00	1983/2/22	117:29	16:07	1983/2/20	11.68	4.630	0.217	0.779
	1982/1983	14:30	1983/2/26	9:00	1983/2/27	18:29	21:44	1983/2/26	11.09	0.246	0.007	0.008
	1982/1983	0:40	1983/3/5	18:59	1983/3/7	66:18	4:55	1983/3/5	12.26	27.480	0.466	3.280
	Yeraly Total										0.738	4.160

Note: *; Estimated by the JICA Study Team.

Data source: JWC

4.2.5 Preliminary Runoff Analysis on Wadi Qilt

On the basis of the hydrological and geological data collected so far, which include those provided by Israel, the flood runoff characteristics of the Wadi Qilt basin are assessed as follows:

(i) The flood runoff at Wadi Qilt is retained at its intake site for spring water, of which the channel runs to Jericho along the bank, up to a certain magnitude of the flood discharge. Hence, the only floods exceeding the maximum flood conveyed into the channel of the Wadi Qilt spring water, flows down as excessive flood flow of the Wadi Qilt; and

(ii) Although the runoff coefficient of the Wadi Qilt basin is higher as compared with that of the Wadi Far'a basin, the excessive flood does not occur every year. Thus, the total runoff volume during the dry years is either nor or significantly small.

With regard to the Wadi Qilt basin above the foot of mountain, there is no rainfall station as described in Subsection 4.2.2. Besides, the observed flood discharge data on the Wadi Qilt are hardly available for the present hydrological analysis as discussed in the foregoing Subsections 4.2.3 and 4.2.4.

In this study, attempt was initiated to further determine the runoff data of the Wadi Qilt through a runoff analysis considering a simulated model. Taking into account the availability of rainfall and runoff data on the wadi, the runoff analysis was carried out using the Tank Model method, in order to generate the required runoff information. The Fortran program executed for the Tank Model of the Wadi Qilt basin is adopted.

The Tank Model consisting of 16 tanks (4 steps x 4 ranks) is applied to the simulation analysis. The concept of the Tank Model is explained in Annex 1.

Trial simulations were carried out for the various combinations of the tank parameters to derive the adequate flood runoff for Wadi Qilt basin, using the available long-term daily rainfall data at Beituniya (Code No.02424000). From the isohyetal map shown in Figure 4.2.1, the average rainfall of the Wadi Qilt above the old stream gauge is derived to be 322 mm, which is equivalent to about 55% of the average annual rainfall at Beituniya.

The simulation is performed by utilizing the basin average rainfall derived from the long-term basin average daily rainfall data. These are derived by multiplying the data at Beituniya with the determined factor, as well as considering the average evaporation values of those at Jericho and Nablus.

As a result, the runoff data are derived on a daily data basis. The mean annual runoff volume of the Wadi Qilt between 1953/54 and 2005/2006 is derived as 1.67 (MCM).

The detailed data of the Wadi Qilt streamflow data that are worked out using the Tank Model are presented in Annex 1.

4.2.6 Preliminary Runoff Analysis on Wadi Far'a

The continuous discharge data at stream gauges on Al Badan and Al Far'a available for the winter seasons of 2003/2004 and 2004/2005 were obtained from the "Second Interim Report on Impacts of Global Changes on Water Resources in Wadis Contributing to the Lower Jordan Basin". The Al Badan and Al Far'a sub-catchments constitute the uppermost section of the Wadi Far'a and both its stream gauges are situated just upstream of their confluence. These stream gauges are measured to occupy total catchment area of 74.2 km^2 and 118.5 km^2, respectively, using 1 to 100,000 scale topographic maps, procured from the Survey of Israel.

From the concurrent floods observed at the stream gauges on the aforesaid two major tributaries of Wadi Far'a, it is judged that the flood runoff from the Al Far'a catchment is minimal, as compared to its large catchment area. It appears that most rainfall in the sub-catchment penetrates underground. Meanwhile, in the Al Badan sub-catchment, the noticeable runoff seems to take place after the sub-catchment is saturated to a certain level.

The mean monthly discharge records at Al Badan and Al Far'a stream gauges between 2003/2004 and 2006/2007 are tabulated below:

Table 4.2.8 Mean Monthly Discharges of Observed Flow at Al-Badan Stream Gauge

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
2003-2004	-	-	0.11	0.15	0.18	0.36	0.21	-	-	-	-	-
2004-2005	-	-	-	0.15	0.18	0.36	0.21	-	-	-	-	-
2005-2206	-	-	0.25	0.55	0.75	0.74	0.54	-	-	-	-	-
2006-2007	-	-	-	0.29	0.38	0.56	0.55	-	-	-	-	-
Mean			0.18	0.28	0.37	0.50	0.38					

Note: "-" means that no data are available.
Source: Second Interim Report on Impacts of Global Changes on Water Resources in Wadis Contributing to the Lower Jordan Basin

Table 4.2.9 Mean Monthly Discharge of Observed Flow at Al-Far'a Stream Gauge

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
2003-2004	-	-	0.09	0.12	0.15	0.20	0.10	0.04	0.03	-	-	-
2004-2005	-	-	-	0.04	0.08	0.23	0.16	-	-	-	-	-
2005-2206	-	0.04	0.04	0.09	0.16	0.18	0.14	-	-	-	-	-
2006-2007	-	-	-	0.04	0.08	0.09	0.11	-	-	-	-	-
Mean	-	0.04	0.07	0.07	0.11	0.17	0.13	0.04	0.03	-	-	-

Note: "-" means that no data are available.
Source: Second Interim Report on Impacts of Global Changes on Water Resources in Wadis Contributing to the Lower Jordan Basin

From the above runoff records, annual runoff volumes of the Al Badan and Al Far'a sub-catchments are derived as about 6.30 MCM and 1.76 MCM, respectively. Hence, the total annual runoff volume at the confluence of the two tributaries is estimated to be about 8.1 MCM.

4.2.7 Flood Analysis

Probable floods with various recurrence periods are necessary in order to determine the design flood in case a certain river structure is provided on any wadi. However, flood data on wadis in Palestine are hardly available. Hence, the flood data analyzed on the Wadi Kafrein in the area of the Jordan River East Bank are transposed to the Study Area by means of applying the Creager's formula, expressed as follows:

$$Q_p = 46 \times C \times A^{\alpha}$$
$$\alpha = 0.894 \times A^{-0.048} - 1$$

where, C: Creager's coefficient or C value
A: Catchment area (miles^2)
Q_p: Specific discharge (feet^3/sec/miles^2)

It is generally accepted that Creger's C value for basins with different catchment areas are almost of same value, provided that basin conditions including rainfall intensity and geologic conditions are similar. Also in the report on "Studies of Raising Kafrein Dam" (May 1992), the probable floods with various recurrence periods are estimated by transposing the Creager's C values which are derived through the frequency analysis for annual maximum peak discharges in the Wadi Wara basin in Jordan. Table below shows the probable floods for catchment of the Kafrein Dam and the corresponding C values derived using the Creager's formula:

Table 4.2.10 Probable Floods Estimated for Catchment of the Kafrein Dam in Jordan (CA=161 km^2) and Their Creager's C Values

Return Period	Peak Discharge (m^3/sec)	Creager's C Value
2-year	42	1.56
10- year	106	3.94
25-year	154	5.72
50- year	218	8.10
100-year	267	9.92

Source: JICA Study Team

Applying the Creager's C values estimated in the table above, the probable floods for catchments of the Wadi Qilt and Al Badan of the Wadi Far'a are determined as shown in the following table:

Table 4.2.11 Estimated Probable Floods for Catchment of Wadi Qilt and Al Badan

Return Period	Creager's C Value	Wadi Qilt (CA=103.1 km^2)		Al Badan (CA=74.2 km^2)	
		Probable Flood (m^3/sec)	Specific Discharge (m^3/sec/km^2)	Probable Flood (m^3/sec)	Specific Discharge (m^3/sec/km^2)
2-year	1.56	32	0.3	26	0.4
10- year	3.94	81	0.8	66	0.9
25-year	5.72	118	1.1	96	1.3
50- year	8.10	167	1.6	136	1.8
100-year	9.92	204	2.0	166	2.2

Source: JICA Study Team

Regarding Al Far'a, it is foreseen that specific discharges of the probable floods would be considerably small as compared with those of Wadi Qilt and Al Badan. In this study stage, it is advisable to apply the same magnitude of probable floods of Al Badan. On the other hand, it is strongly recommended to refine the flood analysis based on the runoff data observed at the new stream gauges at Wadi Qilt and existing ones at Wadi Far'a basin.

4.2.8 Sedimentation

In developing the storm water harvesting in the Wadi Qilt, one of issues concerned is the high sediment concentration of the Wadi streamflow, necessitating the installation of facilities such as desilting basin to detain sediments, and intensive operation and maintenance (O&M) works to remove sediments deposited in such facilities. This issue is attributed to the extremely poor vegetation in the Wadi Qilt basin which has easily caused soil erosion during occurrence of heavy rainfall. On the other hand, the sediment yield rate in the Wadi Far'a is considered to be smaller, taking into account the comparatively abundant vegetation in said wadi.

For the time being, no sediment data on wadis of Palestine are available. Hence, the sedimentation study results for the Kafrein Dam in Jordan were considered to assess the sedimentation of the wadi basins in the Study Area.

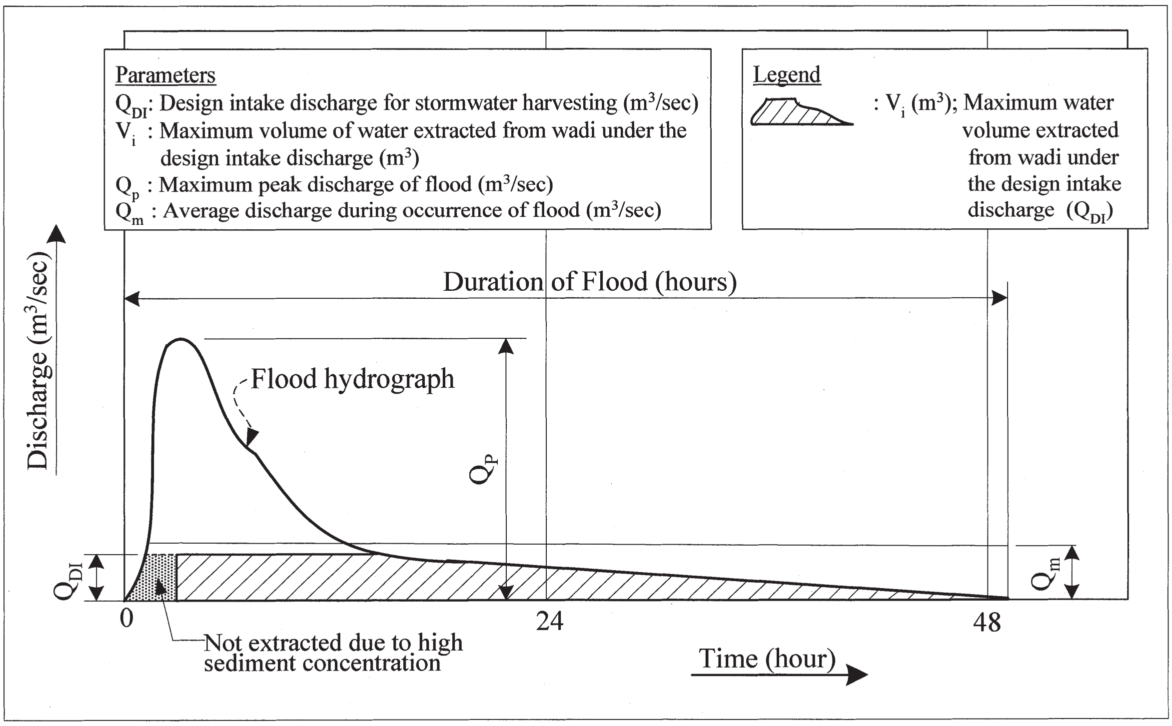
Until now, a lot of sediment studies on the Kafrein Dam have been performed so far in the various development stages of the dam project, based on the sediment survey, and with reference to the sediment studies on other dams in Jordan. According to the aforesaid report, the annual sediment yields of the Kafrein Dam catchment are estimated through the past studies, ranging from 0.08 MCM/year to 0.12 MCM/year. The annual sediment rates are equivalent to a denudation rate of 0.5 mm/year to 0.75 mm/year. From the past study, it is considered that the standard annual denudation rate in Jordan Valley would be 0.625 mm/year. In this study stage, it is tentatively determined that a standard rate is applied to the Wadi Far'a basin, while a high value of 0.75 mm/year is applied to the Wadi Qilt basin. To promote the storm water harvesting in the Study Area, the sediment survey including sampling of wadi streamflow during flood and analysis on concentration of suspended load contained therein is indispensable for setting up a relation between wadi discharge and suspended load concentration. Therefore, it is strongly recommended to carry out the sediment sampling and analysis on the new streamflow gauging stations, to be installed under this study as described in succeeding Subsection 6.4.6, as well as the existing streamflow gauging stations in the Wadi Far'a basin.

4.2.9 Assessment of Availability of Hydrological Data for Feasibility Study of Storm Water Harvesting Project

As described in Chapter 6 concerning the storm water harvesting on the Wadi Qilt, construction of reservoirs on the right bank of the downstream reach of the wadi are suggested as the prospective plan to store water extracted from the wadi. Moreover, in case of the Wadi Auja, the storm water harvesting plan including underground dam is assessed to be one of the prospective plans. To consistently carry out the Feasibility Study on these prospective plans of storm water harvesting in the near future, further field investigation and survey of various issues will have to be performed as shown in Table 6.4.7. With regards to the hydrological data to be considered in the Feasibility Study, a streamflow gauging station equipped with a water level recorder needs to be installed on the wadi in order to observe flood hydrographs with accuracy, although unfortunately it could not be installed during this study. In particular, the following data will have to be made available to carry out the Feasibility Study as explained in detail in the succeeding Subsection 6.4.6:

(i) Hourly discharge data on each runoff event of wadi; and
(ii) Suspended solid data on streamflow of wadi.

In the Feasibility Study, the development scale of the storm water harvesting will have to be examined based on the flood hydrographs and suspended loads observed at the streamflow gauging station, as described in detail in the succeeding Subsection 6.4.6. In case of the prospective storm water harvesting plan presented in Chapter 6, the whole part of every flood cannot be effectively utilized for this purpose. One of the issues is how to deal with a very high concentration of suspended loads contained in the wadi streamflow, during the O&M stage of the storm water harvesting project. In the Feasibility Study, therefore, the optimum intake discharge needs to be determined through a comparative study based on the flood hydrographs observed at the streamflow gauging station and suspended loads contained in wadi streamflow to be extracted The concept of extractable discharge from the wadi is shown in the following figure:



Source: JICA Study Team

Figure 4.2.3 Concept of Extractable Discharge from Wadi Considering Hydrological Data

For the time being, the available flood hydrograph data on the Wadi Qilt is limited to those provided by Israel. However, the data was recorded in discrete years before 1983 and contains incomplete hydrograph data which may seem to include underestimated discharges mentioned in Subsection 4.2.4. In principle, the latest hydrological data will have to be considered for the formulation of water resources development plan. Besides, in case of the wadis in the Study Area, no data on sediment is available.

The available hydrological data on Wadi Qilt remains insufficient for purposes of carrying out the Feasibility Study on storm water harvesting project in the Wadi Qilt basin. It is therefore recommended that the Feasibility Study and subsequent detailed design be performed after a sufficient hydrological data, including sediment data (5-years' data preferably), is obtained.