# Rashda: System of Irrigation and Cultivation in a village in Dakhla Oasis[1]

Hiroshi KATO, Erina IWASAKI, Eiji NAGASAWA, Hisao ANYOJI,
Nobuhiro MATSUOKA and Reiji KIMURA



## *Introduction*

The two of cowriters (Hiroshi Kato and Erina Iwasaki) made a field study in Rashda village, Dakhla Oasis in the Western Desert **(Map)**, as part of the Mediterranean Studies Project, Hitotsubashi University from 2005 to 2008, and wrote a report on it, titled "Rashda. A Village in Dakhla Oasis", in *Mediterranean World 19* in 2008. That field study was concentrated on collecting data and information on the topography of the village residential area and the social life of villagers in it, while the preliminary field survey was only made on the economic life, especially agriculture, of villagers.

After that, the field study on Rashda was continued and expanded to be an inter-disciplinary one, a rare case in the field of the Middle East studies in Japan, in collaboration with natural scientists. The field surveys were also done in Rashda in March and August of 2008. The main theme in this occasion was the irrigation and cultivation system in the village.

---

1 This study was carried out under the Joint Research Program of Arid Land Research Center, Tottori University, and the Mediterranean Studies Project, Hitotsubashi University.

This report is based on the data and information which were collected during these two field surveys mentioned above.

However, this report is an interim one, whose main purpose is to provide the basic information on the irrigation and cultivation system in Rashda village through the presentation of tables and graphs, because the information is still being collected through the additional surveys. These information will be used to discuss on the subject more in detail in near future.

This paper is composed of seven chapters. Chapter 1 is the theoretical introduction for the paper. Chapters from 2 to 4 are the description on the natural and social environments of the oasis region in the Western Desert, in which the survey village Rashda is located. Chapter 5 is the overview of Rashda village, based on the previous report mentioned above. And Chapters 6 and 7 are the main part of this paper to explain the irrigation and cultivation system in Rashda village, referring to some tables and graphs[2].

## *I Issue, methodology and data*

### 1. Issue

Rural Egypt is administratively composed of Lower Egypt, Upper Egypt and Frontier governorates. Lower Egypt is the northern part, from Cairo to the Mediterranean. Upper Egypt is the southern part, from Cairo to the border between Egypt and Sudan. The Frontier governorates are two governorates in Sinai, one in Red Sea Coast, and two in the Western (Libyan) Desert (Matruh and Wadi Gedid (New Valley)).

The survey village Rashda is one of the villages in Wadi Gedid (New Valley). The Western oasis region, isolated from the Nile valley by sand and located on the periphery of the nation state of Egypt, has different ecology and culture from those in the Nile valley.

The differences between the oasis region and the regions of the Nile valley have been mainly caused by the way of access to water. The oasis region depends on the underground water, while the other regions rely on the Nile. The studies on the irrigation system in the Nile valley have been accumulated until now. However, the studies on the irrigation system in the oasis region have not been so. This paper will contribute to fill the lack of research on the subject.

### 2. Methodology

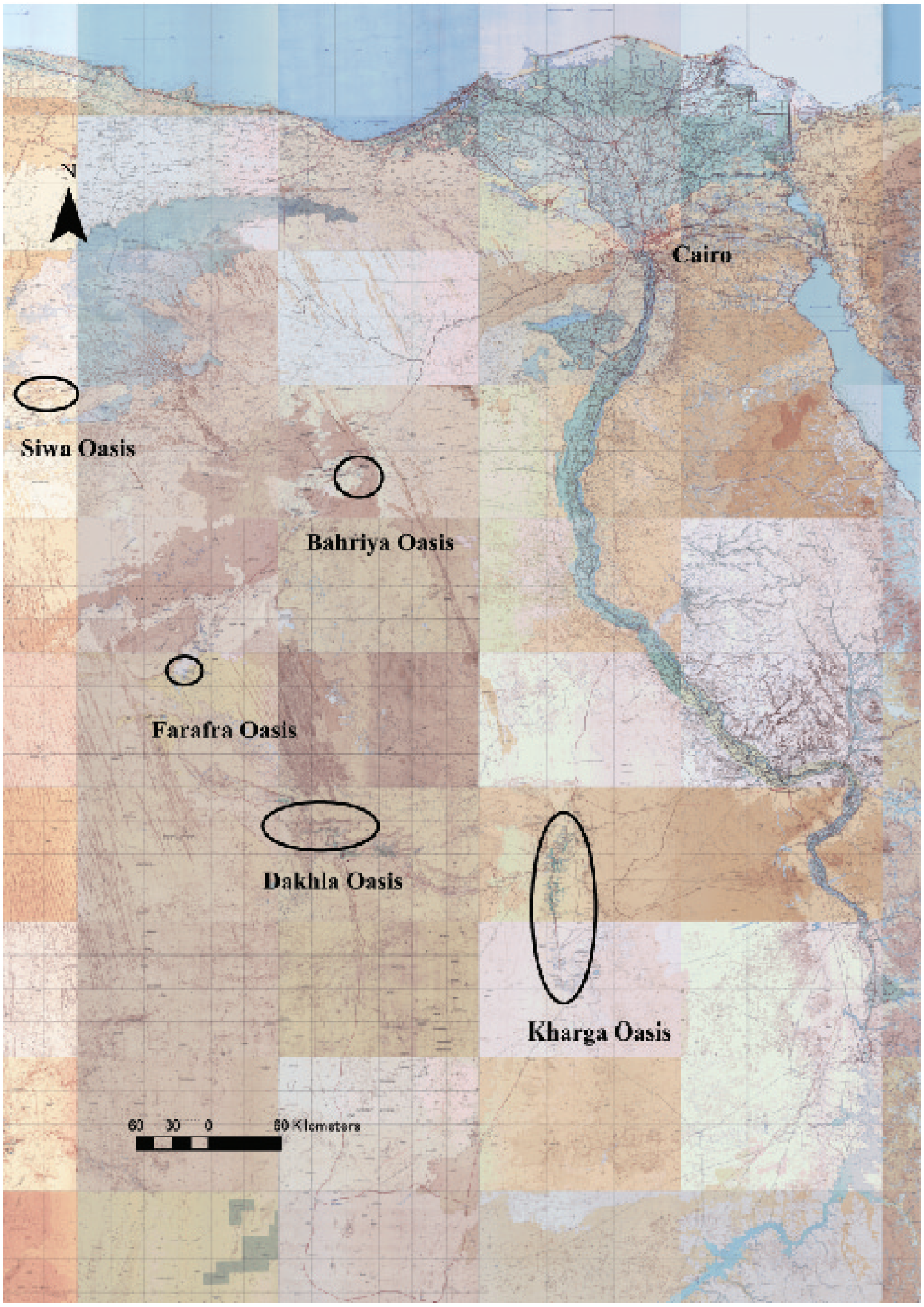
In this report, we take an interdisciplinary approach, using the following kinds of information.

(1) Statistical data on natural environment in one hand and on socio-economic circumstances in the other.

---

2 Chapters are written by the following authors: I, IV, V and VI by Kato and Iwasaki, Chapter II by Kimura, Chapter III by Nagasawa, Chapter VII by Anyoji, Iwasaki, Kato and Matsuoka.

**(Map) Oases in the Western Desert**




(Note) Maps used are 1/1,250,000 scale maps (1986) by Egyptian General Survey Authority.
(Source) Kato and Iwasaki, 2008.

Road to Rashda

Black Desert

White Desert

(2) Micro data collected through household surveys.
(3) Geographical information on irrigation and cultivation, including maps of cultivated land at the level of individual land holders.
(4) Quantitative and qualitative information such as water distribution, cultivate rotation and agricultural productivity collected by the informant and the interviews with village authorities, notables, and other residents.

The data in (2), (3) and (4) are original information obtained through fieldwork to gain an interdisciplinary view. The most important innovation in this report is the linking of the statistical data of (2) and (4) with the geographical information of (3) through the GIS (Geographic Information System) method.

**3. Data**

In detail, the main data and information, on which this paper is based, are composed of the following four.

(1) Data on irrigation and cultivation systems at village and plot level.
(2) Data on water use and cultivation collected from the households.
(3) Geographical information on irrigation and cultivation obtained by making and using the digital map.
(4) Information on irrigation and cultivation systems collected through the interviews with village notables and agricultural institutions.

The most important data and information collected and used in this paper is the list of all the wells in Rashda village (see **Appendix 1**) and its digital maps. The maps were elaborated following five steps below.

1. Collecting the maps made by the Irrigation Ministry (1/25,000 and 1/5,000 scale).
2. Collecting the information on the geographical locations of the wells and water way.
3. Digitizing the map and putting the geographical information of the wells on it.
4. Collecting the information of each well (name of well, year of digging, ownership, etc.)
5. Linking the information of each well on the digital map.

## *II Natural environment in the Western Desert*

Dakhla is one of the major oasis in the Western Desert of Egypt, and located on the low-level ground from 0 to 200m above sea level (surrounding altitude is above 200m). The aridity index used by the United Nations Environment Program (UNEP, 1997) indicates that this district lies in a hyper-arid region, that is annual rainfall is nearly 0mm and potential evapotranspiration estimated by Penman-Monteith and Thornthwaite's methods is 1950 and 1773mm using the data of Dakhla meteorological station (25.48°N, 29.0°E, 117m) **(Fig. 2-1)**. Surrounding area of oasis is consequently bare of vegetation except for very isolated clumps like *Acacia* or *Tamarix* survive on shallow moisture held in blown sand, and derived from dew, isolated showers, and frontal storms (Brookes, 2001).

The climate of Dakhla is mainly controlled by a harmattan wind which is a hot air blowing from Sahara high pressure. From 1990 to 2005, the mean percentage of possible sunshine was high at 87% (smallest 82% in January, largest 90% in June) in Kharga meteorological station (25.45°N, 30.53°E, 73m) 120km apart from Dakhla where solar radiation components were not measured (Robaa, 2008). Although wind direction frequencies were almost north, there were the slight westerly skewing of the maximum probably reflects topographic indraft of northern winds into the Dakhla depression (Brookes, 2001). **Fig. 2-2** shows the seasonal variation of average and maximum wind speed in 2008. Assuming that the threshold wind speed for dust outbreak is 6.5m/s (Tegen and Fung, 1994), there were some possibilities of dust storm through the year. Annual average, maximum, and minimum temperature was 24.5, 45.3, and –0.3°C in 2008, so annual range of temperature are large **(Fig. 2-3)** (the average diurnal range of temperature was 16.5°C). The annual temperature was increasing by 0.038°C per year since 1988 **(Fig. 2-4)**.

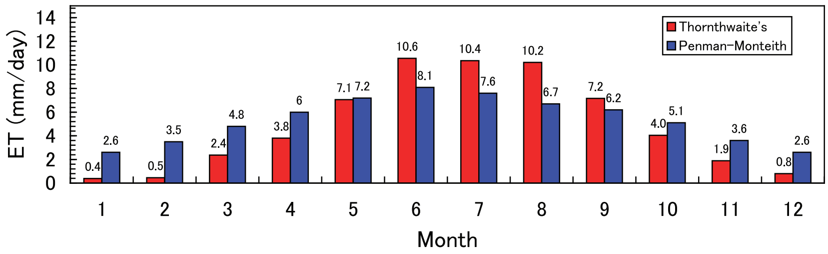
A distinctive climate is formed in oasis in comparing with surrounding desert, especially in the air humidity. Annual average relative humidity and vapor pressure were 36% and 10.7hPa **(Fig. 2-3)**. This means that Dakhla is humid because the irrigation farming has been plentifully conducting. Since 1988, there was almost no change in vapor pressure **(Fig. 2-4)**. For the human life or health, comfortable season was January to March, and November to December using the discomfort index estimated by monthly maximum temperature and averaged humidity.

## *III Irrigation land development in the Western Desert*

Irrigation development in the Western Desert officially started with the establishment of the Desert Irrigation District (Taftīsh Rayy al-Ṣaḥrā') in Kharga city in 1938, after some failed private projects such as by an English private company in the areas of Sharika and Mahariq in 1905. The District (*taftīsh*) supported the inhabitants of the oases for digging wells and dredging springs. The District strengthened its activities after 1950 by using more advanced excavators that had been used for digging oil wells [Husayn 1975: 92-93].

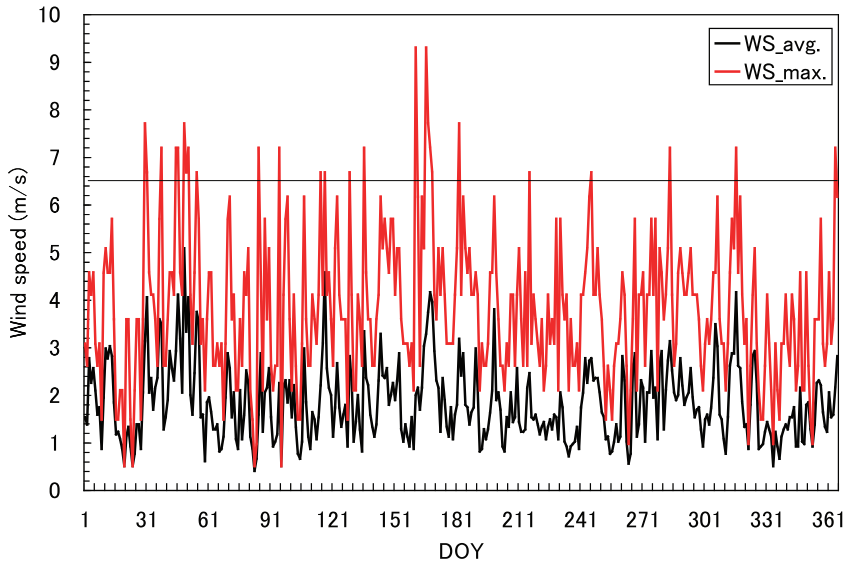
After the July Revolution, the Permanent Organization for Agrarian Reform (POAR; al-Hay'a al-Dā'im li-l-Iṣlāḥ al-Zirā'ī ) extended its activities into the Western Desert in 1957.

**Fig. 2-1 Seasonal change of potential evapotranspiration of Dakhla in 2008**



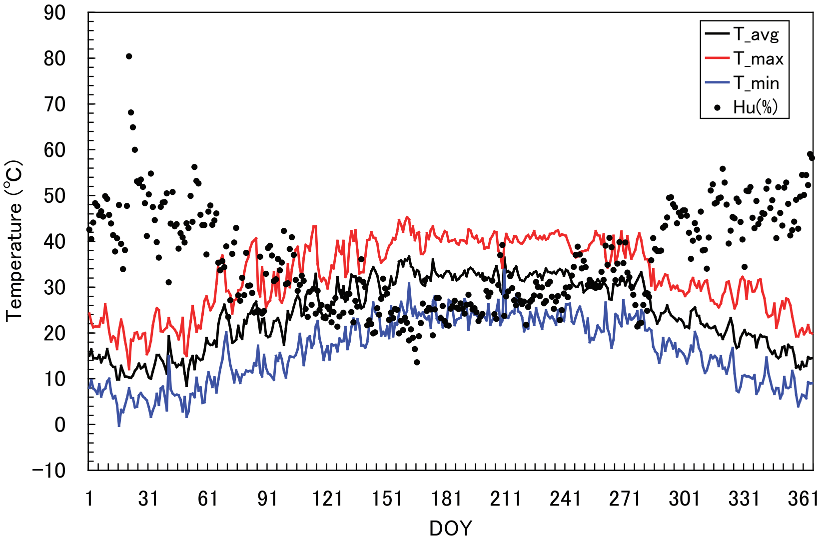

(Source) NNDC Climate Data Online.

**Fig. 2-2 Seasonal variation of average and maximum wind speed of Dakhla in 2008**



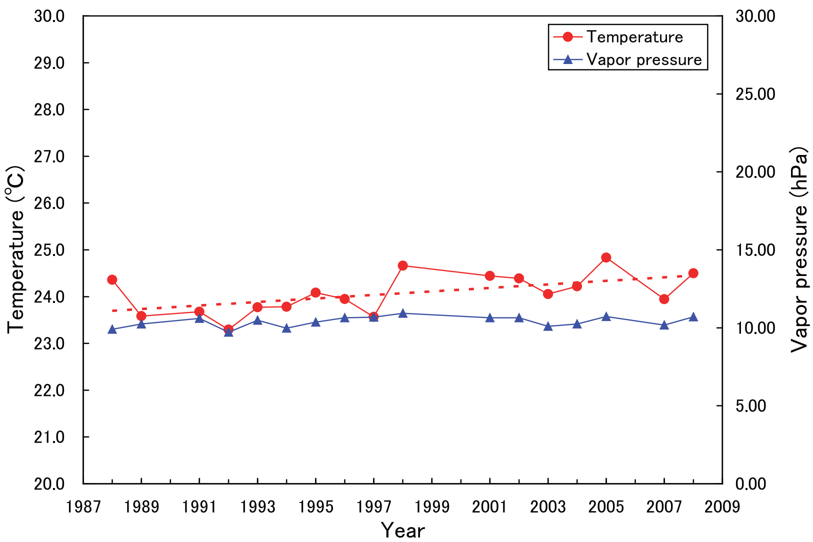

(Note) Line in the figure shows the threshold wind speed for dust emission (6.5 m/s).
(Source) NNDC Climate Data Online.

**Fig. 2-3 Time variation of average, maximum, and minimum temperature, and humidity of Dakhla in 2008**




(Source) NNDC Climate Data Online.

**Fig. 2-4 Annual change of temperature and vapor pressure in Dakhla**




(Source) NNDC Climate Data Online.

It engaged in land reclamation by using the new water resource provided by the irrigation projects of the District and distributed these lands for the inhabitants. The first area the Organization started its activities in the desert areas was the Tahrir (Liberation) Province in the western fringe of Nile Delta in 1953. In 1958 the Egyptian General Desert Development Organization (GDDO; al-Mu'assasa al-Miṣrīya al-'Āmma li-Ta'mīr al-Ṣaḥrā') was established.

Taking over the projects of POAR, GDDO started the New Valley Project (*Mashrū' al-Wādī al-Jadīd*) in October 1959 in the framework of the First Economic Development Plan (1959/60-64/65) [Husayn 1975: 93]. Along with the Aswan High Dam (its construction started in 1960), the New Valley Project constituted one of twin plans of remodelling nature by the Arab Socialist regime. It was an ambitious plan to create the second valley in the Western Desert in addition to the old valley, the Nile valley, in order to absorb surplus population in the latter into its new reclaimed lands. This project covered the vast area of about 458,000 square kilometers extending in Kharga, Dakhla, and Farafra Oases [Vivian 2000: 60].

Soon later, its preliminary surveys revealed over-estimation of water resource in the original plan. Further facing financial difficulty, the New Valley Project was obliged to revise its target of land reclamation. Eventually, the actually reclaimed area until 1966 was only 44,000 *feddans* (18,500ha). And 16,000 *feddans* (6700ha) of this land, its 36%, was not cultivated because of water problem [Husayn 1975: 101].

It is difficult to evaluate accurately the final performance of the New Valley Project because of lack of precise data same as other land reclamation projects since the Revolution. It is said that there were a number of failures in water management (over irrigation and salinization, in particular) resulted in the abandonment of many of reclaimed lands.

However, it is undeniable that the New Valley Project played as the starting point for socio-economic development in the Western Desert: transportation (paved roads and the Kharga Airport) and communication, basic infrastructure, immigration from the old valley, especially Upper Egypt, and industrial and commercial development.

After the introduction of the Open-Door policy in 1970s, New Valley Project, private investment (*istithmār*) sector began to participate in irrigation development in addition to the government's activities. The rapid irrigation development influenced the cropping pattern in the newly reclaimed land (introduction of new commercial crops in particular). It also urged the transformation of traditional land ownership system based on scarce water resources.

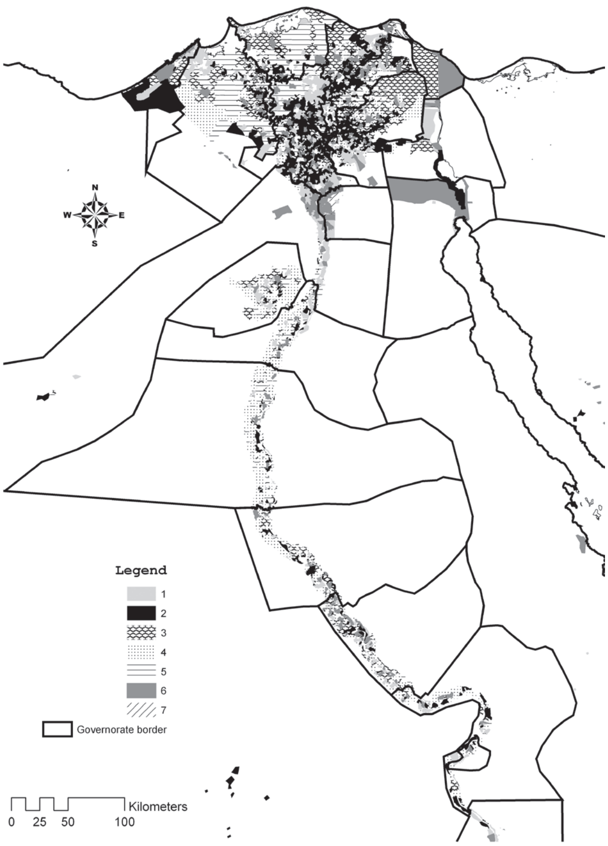
## *IV Western oasis region in Egyptian socio-economy*

Egypt has been studied as a hydraulic society totally dependent on the Nile, and has been described as a homogeneous society. One of the authors criticized this stereotyped image of Egyptian society and pointed out the regional diversity in Egypt in her previous papers (Iwasaki 2008a, 2008b).

The results of the analysis based on the agglomerated data at the smallest administrative unit (*qarya* for rural areas and *shiyakha* for urban areas) on income, employment, and educational level (1996, 1999/2000) show that Egyptian society is classified into 7 groups as follows **(Fig. 4-1)**.

Cluster 1: "Industrial workers"
Cluster 2: "Low status government workers"
Cluster 3: "Agricultural self-employed"
Cluster 4: "Agricultural waged workers with low income"
Cluster 5: "Large agricultural farms"
Cluster 6: "Mixture of industrial and commercial, and government workers"
Cluster 7: "Service workers with high income"

**Fig. 4-1 Result of cluster analysis (unit:*shiyakha/qarya*) (1996, 1999/2000)**




(Note) The data are from CAPMAS, 1996 Population Census dataset, Household Income & Expenditure Survey 1999/2000 dataset.
(Source) Kato and Iwasaki, 2008.

The villages in the Western Desert region is categorized as Cluster 1, just as most of the villages in the southern part of Lower Egypt, the center of the peasant economy. It seems, in a glance, a surprising fact, for it is far from the Nile valley and located on the periphery of the nation state of Egypt. In history, the people in oasis region in the Western Desert lived under unique ecological circumstances and raised the traditional culture peculiar to the oasis region.

However, the feeling of a surprise will be faded away, if the rapid transformation of both social life and lifestyle in recent years is taken into. The social change has been caused mainly by improvements in transportation, whether by regular liner or by car on asphalt roads, and the opening of new economic opportunities such as the tourist industry. Today, it takes only seven hours to travel from villages in Dakhla Oasis to Cairo directly via an asphalt road in the desert.

It is true that the life of oasis villagers should be conditioned by available water. However, the volume of water is partially dependent on the level of technology, and economic opportunities. The rapid transformation of oasis villages in recent years is supposed to offer the chances to get nonagricultural jobs, especially those in the government sector. The level of income in today’s rural Egypt is determined by whether people can find jobs other than agriculture.

## *V Rashda village*

The village called Rashda, the survey village in this report is one of the villages in Dakhla markaz, Wadi Gedid governorate. It is the administrative center, usually called the “mother village” of the Local Unit (*al-waḥda al-maḥallīya*) of Rashda, and is located 10km northwest of Mut town, the administrative center of Dakhla Oasis.

The Local Unit of Rashda, which is composed of Rashda village and four belonging settlements, is the biggest unit in Dakhla Oasis in terms of population. The total number of households was 1,331 and the total number of people 7,987 in 2004. The population of Rashda village itself is 5,361. Although Rashda village is the second most populous village in Dakhla, it is the new village that was formed in the modern age, after the 19$^{th}$ century.

The name of the village comes from the Roman spring called Rashda. Although its name can be traced back to the Roman Empire and can be observed in some written material from the Middle Ages, the present Rashda is a “new” village. The origin of the name implies the relative abundance of water. In fact, around 1800, the whole residential area of the present Rashda was agricultural land. The land was cultivated by peasants who lived in Qalamun, and they went to and from the fields in Rashda every day.

In the first half of the 19$^{th}$ century, there were no houses except some cottages where the peasants coming from Qalamun stayed at night in the busy farming season. They were located at the eastern side of the foot of a sandhill. However, by the second half of the 19$^{th}$ century, there was a settlement named Rashda. It was located in the “old” area of Rashda village on the sandhill, at the western side of the "new" area of Rashda village.

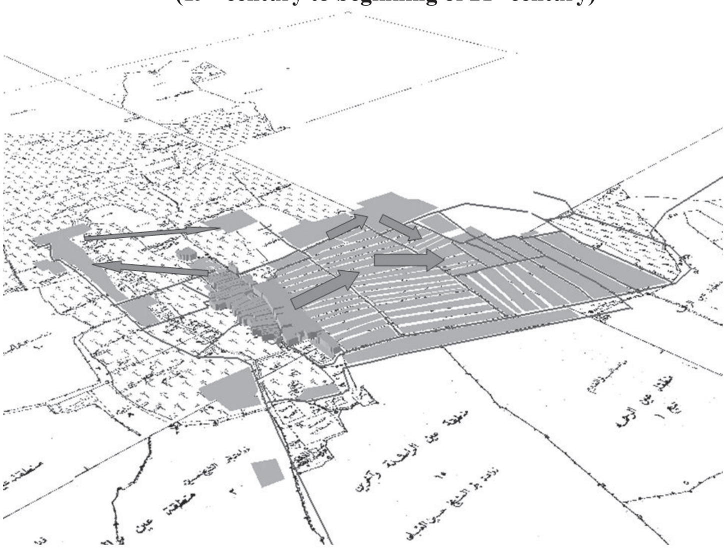
The settlement was built by the peasants who migrated from the village of Qalamun to Rashda. At the same time, some peasants migrated from the village of Balat. They also came there to seek land and water for their livelihood. The "old" area of Rashda is now abandoned and largely left as ruins.

Rashda in the 19th century was not an independent village. In fact, Rashda was a settlement belonging to the village Qalamun. However, Rashda was separated from the village of Qalamun and became an independent village in 1899. One-third of the households in the present Rashda are originally from outside the village. They came mostly from Balat, Mut or neighboring villages within Dakhla Oasis, along with some households from Upper Egypt such as from Asyut.

The 1960s was supposed to be a turning point after World War II in the development of Rashda. It was the age of "developmentalism" under the socialistic regime of President Nasser. The number of houses in the present Rashda, namely the "new" area of the village, rapidly increased in the late 1960s. This demonstrates that the residential space of Rashda has been shifted from the "old" area to the "new" area.

After the shift in residential space from the "old" area to the "new" area in the latter part of the 1960s, migration from outside to Rashda became insignificant, because almost all surveyed heads of household were born in Rashda. The history of the village could be summarized in a conceptual map **(Fig. 5-1)** of the development of the village of Rashda from its formation until today.

**Fig. 5-1 Conceptual map of the residential development in Rashda (19th century to beginning of 21st century)**



(Source) Kato and Iwasaki, 2008.

## *VI System of irrigation and cultivation in Rashda*

The basic information on the irrigation and cultivation system can be found in the previous report on Rashda. In this chapter, we will present more detailed view on the subject, adding to them the data and information collected during field surveys in 2008.

### 1. Irrigation system

#### (1) Water source

Water source in Dakhla Oasis and throughout the Western Desert is the Nubian Sandstone aquifer, which is the world's largest fossile water aquifer system. Therefore, the irrigation and cultivation system in Dakhla Oasis differs from that in the Nile valley which totally depends its water source to the Nile river.

Recharge area of Nubian aquifer are northwest part of Sudan and Uweinat Upland located in the boundary of Egypt, Libya, and Sudan. However, ground water of Nubian aquifer is the fossil water that was recharged in 14000 to 30000 years ago, and last rainy season related with the recharge is 8000 years ago according to the isotopic analysis (Dabous and Osmond, 2001). In the present, recharge water by the rainfall in recharge area is very few, so the irrigation water in Dakhla Oasis is mainly the fossil water having roots in ancient days (Nada, 1995).

In Dakhla Oasis, the underground water is extracted using a water well (*bīr*). Resource of exploitable groundwater is very large. However, since there is essentially no rainfall in this region and therefore water is not rechargable, the water wells are destined to dry up with time. The ground water level of aquifer is different according to the geological condition of underground, so new water wells continues to be exploited on one hand, and old water wells and the lands are abandoned[3].

#### (2) Wells and springs

In Rashda, the estimated number of wells and springs is 70. The information collected on these wells are their names, type of well, depth, year of drilling, mode of effusion, quantity of water flow at the time of drilling (square meter per day) for the government well, status of operation. The locations of these 70 wells are shown in **Fig. 6-1** and **Appendix 1.**

#### Type of well and spring

The inhavitants recognize following five types of water source according to the depth, that are wells (*bīr*) if the source had to be tapped by a drill, and springs (*'ain*) if the water bubbles

---

3 At the beginning of the twentieth century there were 420 ancient wells in Dakhla Oasis, known by the inhabitants as *'ain rūmānī*, and 162 modern wells, called *bīr*, or *ābār* in the plural. Rohlfs in 1874, reported that a Hassan Effendi, originally working with the French mining engineer Lefèvre, had drilled sixty wells in Dakhla in thirty years. See King (1917).

up naturallly and only needs to be cleared from time to time.

1. Government well (*bīr ḥukūmī*)

"Government well" is a well exploited by the government (Ministry of Irrigation), and owned and managed by the Ministry of Irrigation. It has generally 1200 meter depth, and supposed to last for 50 years. There are 12 wells of this type in Rashda.

2. Local well (*bīr ahlī*)

"Local well" is an artesian well exploited by the local cultivators, dug in the local, old way and owned and managed collectively by themselves. The depth is usually 85 meters or under. There is a leader of the well who holds the list of cultivators who have access to the watersource. The watersource is supposed to last for 20 years. There are 29 wells of this type in Rashda.

3. Investment well (*bīr istithmārī*)

"Investment well" is a well exploited by an individual under the scheme of Public Investment Organization (al-Hay'a al-Āmma al-Istithmarī[4]). An individual who wants to start up an agricultural business would be permitted to dig a well with the permission of digging from this organization. It has a depth of 500 meters or under, and supposed to last for 20 to 30 years. It is generally privately owned by an individual, and its irrigated lands would be privately owned after 10 years of rent from the government. There are currently 9 wells of this type in Rashda.

4. Surface spring (*'ain saṭḥī*)

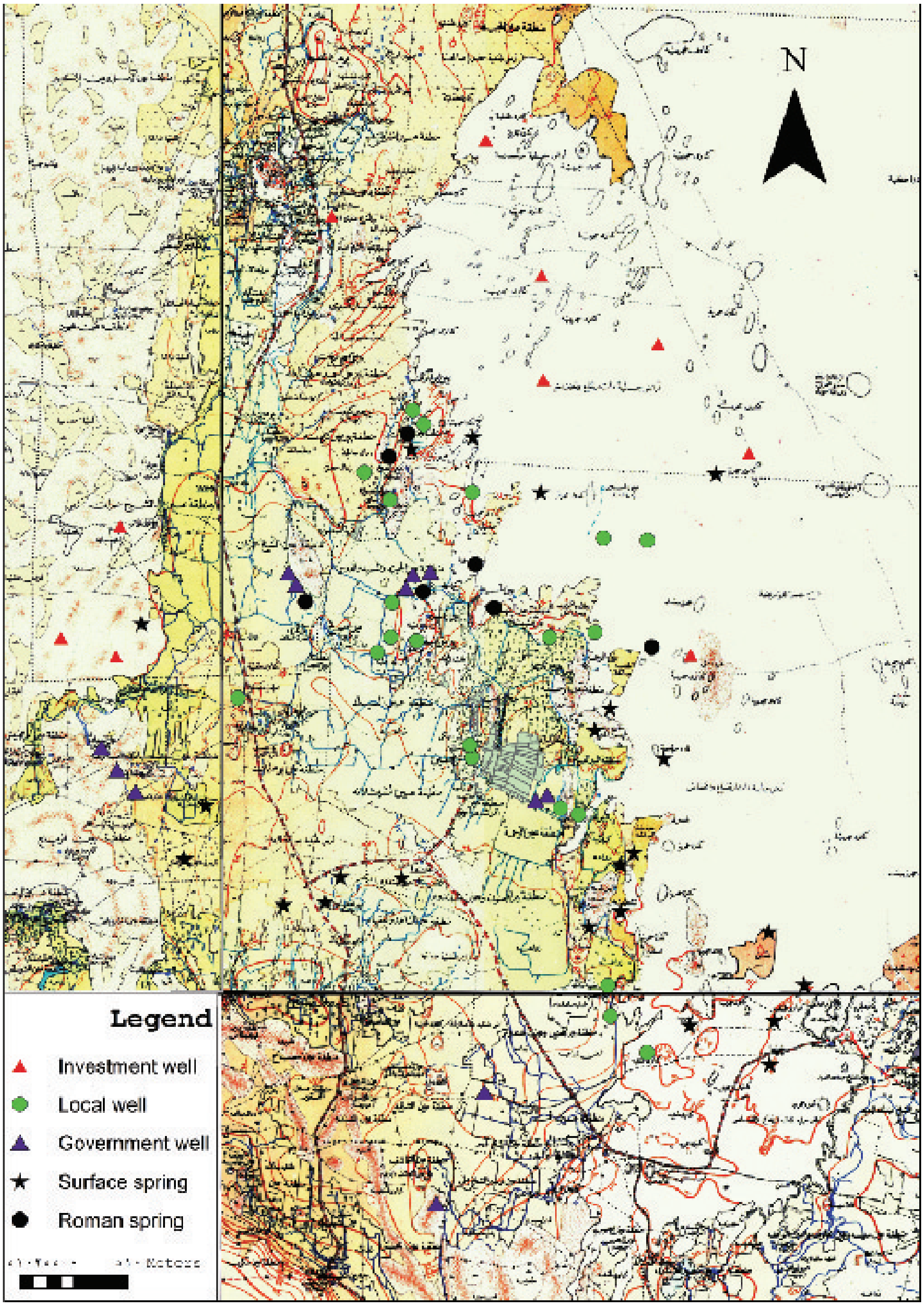
"Surface spring" is popularly recognized as a spring bubbling up by itself, although its depth is generally 120 meters or under. It is drilled with the permission from the Land Reclamation Fund. It is collectively owned and managed by the local cultivators. Its irrigated land is rented to the cultivators from the government, since the land belongs to the government. There are about 34 springs of this type. First one is 1998.

5. Roman spring (*'ain rūmānī*)

"Roman spring" is popularly recognized as dating back to the Roman era, although most of them are assumed to date 200 years or less. It has a depth ranging from 85 to 100 meters, and exploited by the local cultivators. As local well, it has a leader who holds the list of cultivators who have the water right, and manages the water schedule. There are 8 springs of this type, all of which are dried up now.

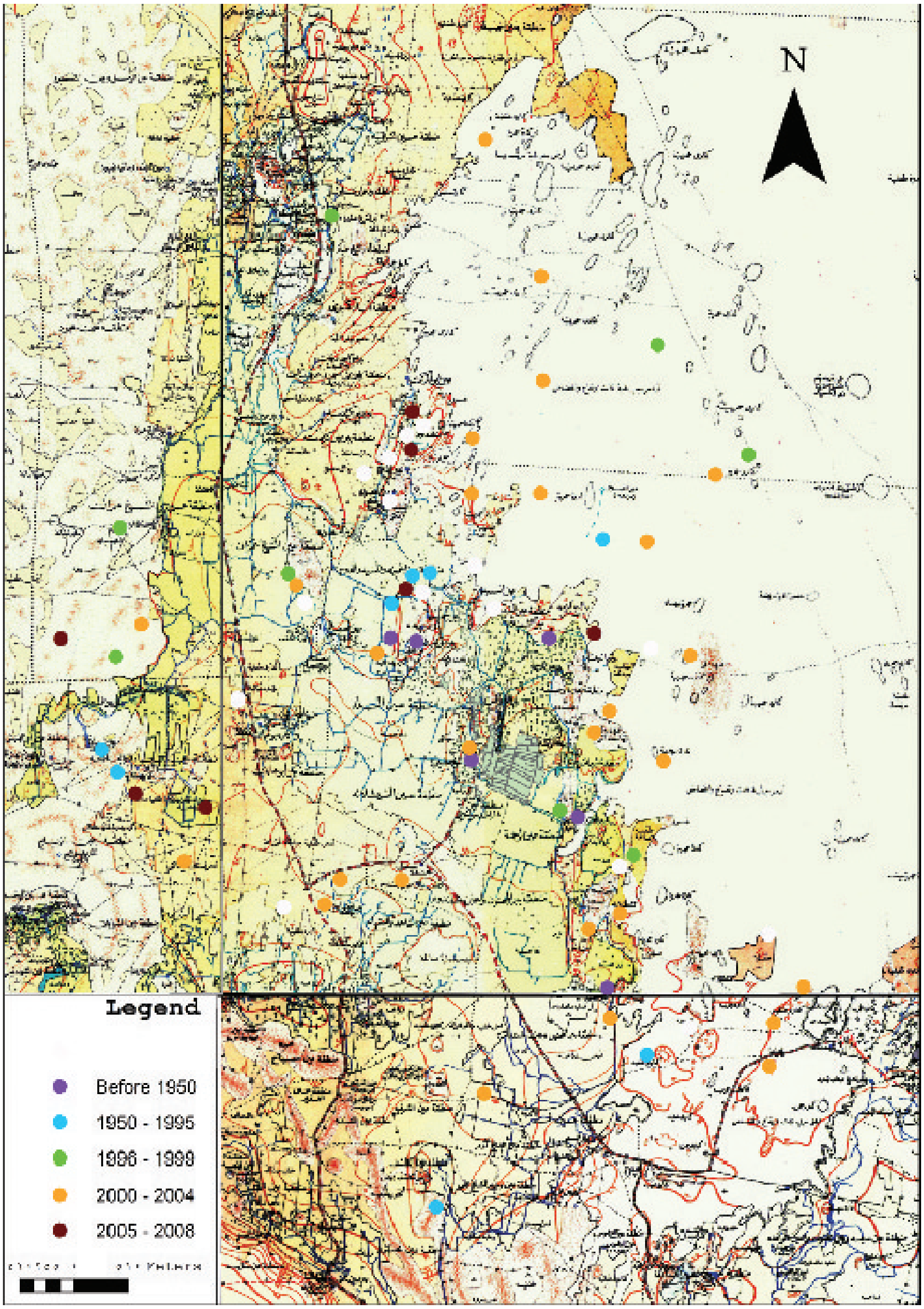
4 Public Investment Organization is an organization under the Ministry of Agriculture and Ministry of Investment.

**Fig. 6-1 Location of wells and springs in Rashda (2007)**




(Source) 1/25000 scale maps (1932), 1/2500 scale maps (1985), and fieldwork done in 2007 to collect the geographical location of wells.

**Fig. 6-3 Location of wells in Rashda by year of construction (2009)**




(Note) Roman springs and some wells whose year of construction are unknown are excluded.
(Source) 1/25000 scale maps (1932), 1/2500 scale maps (1985), and fieldwork done in 2007 to collect the geographical location of wells, and data on each wells collected through the informant.

**Construction year of well**

As for the history of wells, it begun with the beginning of construction and reclamation of Wadi Gedid in 1959[5]. Before the construction campaign in 1959, only two types of water source existed: the Roman springs, and the local wells dug in the traditional way. At the present time, all of the 8 Roman springs are dried up and abandoned. As to the local wells, the first one which exists until now was drilled around 1900. The second one was drilled in 1914, and 5 wells were drilled during 1920s. The rest of 5 wells were drilled in 1943 and 1950s. These wells are all dried up. The local wells which are currently in operation are those drilled 2000 and after.

As shown in **Fig. 6-2**, beside the local well and Roman spring, all of the wells in Rashda was constructed after 1960. In 1959, three wells were constructed. These are Well No.1 in Rashda west drilled by the Italian company that worked in the New Valley Land Reclamation Project, Well No.2 which is currently changed to a touristic site, and Well No.3 which were also drilled by the Italian company. All of these wells have 500 meters depth.

Many wells are drilled after 1996 in the outskirt of Rashda **(Fig. 6-3**). The first two "investment well" were drilled in 1996. These wells are drilled by the individuals, and have 500 meters depth. The rest of "investment wells" are drilled after 2000 also by the individuals.

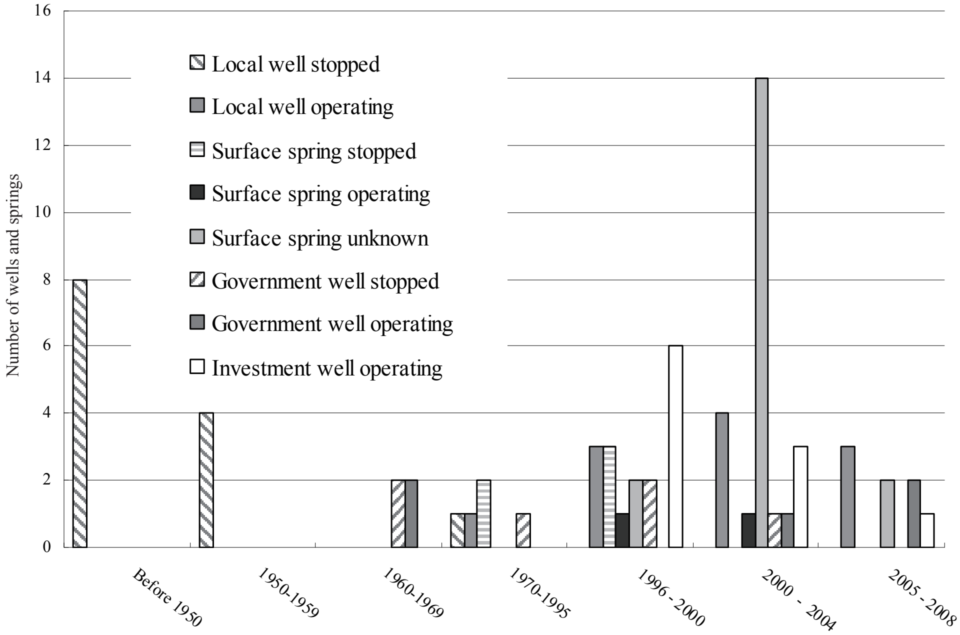
As to the "surface springs", the first one was drilled probably in 1996. And many of them were drilled in 2000 and 2002, collectively by the local cultivators. However, some the springs are out of operation now. For example, two wells drilled in 2000 are out of operation. The wells and springs are generally named after the leader of the cultivators who contributed to the drilling of the springs. For example, the "surface spring" drilled in 2003 is called "hajj Hasan", and shared by 12 cultivators.

As to the government well, many wells were drilled from the end of 1990s, because the three wells drilled in 1962 are out of operation now. These are two wells in the Well No.1 Irrigation District (Bir No.1 District) , one well in the Well No.2 Irrigation District (Bir No.2 District), four wells in the Well No.3 Irrigation district (Bir No.3 District).

Thus, the drilling of wells continues and accelerated in recent years, to keep the water supply and with the relaxation of the state control on the water source.

5 The governorate of Wadi Gedid itself was established in 1961.

**Fig. 6-2 Year of construction of wells in Rashda by type of well (2009)**




(Source) Data collected through the informant.

### (3) Distribution of water

### Methods of irrigation

Irrigation in Rashda is, as explained before, dependent on the water sources of wells or springs. The water flows from wells or springs through main and branch canals (*marwa*) into the parcels (*khaṭṭ*) of cultivated lands by the main and branch distributors (*muqassim*). Then, the irrigation is managed according to the three systems: Ghamr system, Bakiya system and Nahr system.

Ghamr system could be called "basin irrigation system for small basins (*ḥauḍ*)", in which the water from main or branch canal directly enters into the parcel through the distributor.

This system has two kinds of management. 191xhe first is called "*ghamr saṭḥī*", in which the water is dividedly irrigated into small basins for various crops. The second, called "*ghamr kullī* or *baṭī*", distributes the water collectively into a parcel composed of small basins. It is suited for the cultivation of crops such as rice which requires abundant water.

Bakiya system is another system, in which the water from main or branch canal directly enters into a parcel through the distributor. But, in this case, the parcels are divided into some divisions (*bākiya*) and irrigated by the private small canals (*qanāt taqdīm*) inside the parcel.

Nahr system is a system in which a parcel is composed of the nurseries (*masṭaba*), on which various kinds of vegetables and water passages (*nahr* or *khulayja*) between nurseries. It is used in case of land partition before cultivation.

The factors influencing the choice of the method are the following three. The first is the soil. The clay soil is preferable since it keeps the water for a longer time. The second is the capital. The third is the volume of water.

The Ghamr system has some advantages on this point. It, followed by the Bakiya system, is economical, since other irrigation methods require higher expenditure. It washes and adjusts the soil, in case of salinity, and is suitable for grain crops and alfalfa. It is also easy if the water is abundant. The Ghamr system is not economically apt except for a large project.

On the other hand, the Nahr system has the following advantages. It decreases the water consumption. The Nahr system is suitable for planting different crops, especially the vegetable crops which require special treatment.

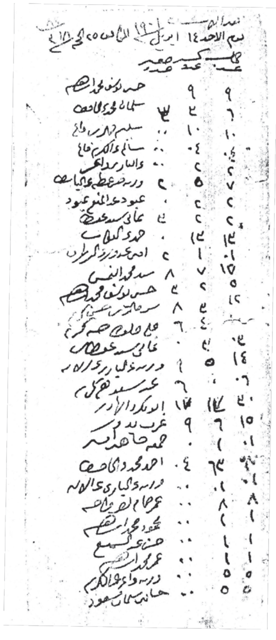
**Water distribution**

The water from each well or spring is equally distributed and irrigated among individuals who have the right of water use according to their registration. They are the participants in the first investment for the establishment of the irrigation equipment **(Fig. 6-4)**.

The water is distributed by time according to the rotation every 12 days. In each well or spring, a leader called *ra'īs al-mā'* (chief of water) keeps the register book (*kambūsha*), manages the rotation of water, and mediates troubles on irrigation.

The unit of measurement of the water quantity is as follows. *Amīla* = 12 hours=30 *qadam*. *Qadam* = 24 minutes. *Ḥabba* = 4 minutes = 1/6 *qadam*. In conclusion, 1 *amīla*=30 *qadam*= 120 *ḥubba*.

**Fig. 6-4 Document on water distribution in Rashda(1901)**



## 2. Cultivation system

### (1) Economic situation

#### Employment

The predominant feature of the employment structure in Rashda, which is measured by the questions on wage employment and nonagricultural self-employment, is that it is overwhelmingly dependent on the government sector. As mentioned in the previous report, 56.8% of those aged between 15 and 64 have a waged job. Among the waged workers, 79.5% work in the government sector. This percentage is higher than the average for Dakhla Oasis, or even that of the Wadi Gedid governorate (1996). Those in the government sector work either in the administration or education.

As to access to their current waged job, 71% of the waged workers got their jobs through the government (Employment Office). There are very few who obtained their current job through family or by direct contact with employers, while most of the waged workers in the surveyed villages in the Nile valley obtained their current job by direct contact with the employer..

Of the waged workers, 60.3% work inside the village. Others mainly work in the city of Mut (68.3% of the waged workers work outside the village), or in the villages in Dakhla. Another feature of Rashda is that agricultural workers, who are supposed to be the main component of rural poverty, are absent. Only 3.4% of the waged workers are in agriculture. This is similar to the villages in Lower Egypt. For example, Abu Senita village in Menufiya governorate has only 5% of waged workers in agriculture (Iwasaki 2006, p.141)

Only 9.5% of households have members who are involved in nonagricultural self-employment. This is also similar to the villages surveyed in the Nile valley. 83.3% of 45 self-employed currently work inside the village. Half of them (19 self-employed) work in commerce, and in the shops. Other self-employed people work mostly in transportation. Commerce and transportation are the most common economic activities in other surveyed villages in the Nile valley.

Labor migration away from the village is practically absent: 13.8% of the households declared that one of their members had resided outside Rashda for work either in the past or currently. Their destination was either Cairo or the cities of Kharga or Mut in Wadi Gedid.

#### Income

Although the agriculture has little importance as a source of employment, it has a large effect on the household income distribution. **Fig. 6-5** shows the household income distribution by income sources. Main income source in Rashda is the income derived from non-agricultural wage employment. Its share is half of the income in Rashda. Income derived from agricultural self-employment, on the other hand, occupies only 29.7% of total income in Rashda. However, when the income sources are classified according to the income class, it is noticed that the agricultural self-employment is the most determinant source of income for the richest income groups. Therefore, the agriculture is an important economic activity that determines income disparity in Rashda.

**Fig. 6-5 Household income distribution by income sources (LE, %)**

| | | Lowest | Second | Third | Fourth | Highest | Total |
|---|---|---|---|---|---|---|---|
| Average total household income (LE) | | 4,464 | 6,782 | 9,147 | 12,165 | 20,043 | 10,520 |
| Percent of total household income from | Agricultural self-employment | 13.7 | 20.5 | 33.6 | 40.4 | 40.3 | 29.7 |
| | Agricultural wage | 5.1 | 2.1 | 0.6 | 1.1 | 0.4 | 1.8 |
| | Non-agricultural wage | 53.5 | 56.8 | 53.5 | 39.1 | 39.2 | 48.4 |
| | Non-agricultural self-employment | 3.4 | 1.9 | 1.4 | 5.3 | 9.9 | 4.4 |
| | Real estates | 6.6 | 8.8 | 3.9 | 6.2 | 3.8 | 5.9 |
| | Transfer | 17.7 | 9.9 | 6.9 | 7.9 | 6.4 | 9.8 |
| | Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

(Source) 2005 Rural Household Survey data.

### (2) Irrigated land and cultivation

The types of water sources and their irrigated land areas in 2004- 2005 are shown in **Fig. 6-6** and **6-7**.

**Fig. 6-6 Number of surface well and investment well, and irrigated area (unit:*feddan*) (2004-2005)**

| | | Number | Irrigated areas (*feddan*) | Number of holders |
|---|---|---|---|---|
| Surface spring | Rashda | 20 | 344 | 152 |
| | Budukhulu | 9 | 150 | 141 |
| | Duhus | 14 | 326 | 70 |
| | Total | 43 | 820 | 363 |
| Investment well | Rashda | 8 | 475 | |
| | Budukhulu | 4 | 372 | |
| | Duhus | 1 | 45 | |
| | Ain Abu Othman | 1 | 200 | |
| | Total | 14 | 1,092 | |

(Note) No information is provided for the local wells.
(Source) Local Unit (administrative center of Rashda village)

**Fig. 6-7 Area irrigated by government well and their number of holder (2006)**

| | Well No.1 | Well No.2 | Well No.3 | Well No.4 |
|---|---|---|---|---|
| *Feddan* | 454 | 371 | 167 | 63 |
| Number of holders | 100 | 32 | 34 | 150 |

(Source) Agricultural Cooperative in Rashda (March 2006).

The cultivated land of the village is divided into two categories: *zimām* and *khārij al-zimām*. *Zimām* means the surveyed and recorded in the Survey Department Books and Registers of the Land Estate Boundaries, and became subject to the realty tax on agricultural lands, according to Law No.143 of 1981 Concerning Desert Lands. It is registered as agricultural land, belonging to the village.

*Khārij al-zimām*, which literally means outside of *zimām*, signifies the non surveyed and nonregistered land. In Rashda, the agricultural land that was registered as belonging to the village at the time of the construction campaign in the oasis region (Wadi Gedid) on October 3, 1959, is called the *zimām.* The areas outside zimam are originally owned by the government, and the cultivators there could get the right of possession for the lands which they cultivated for 10 years.

The cultivated land outside *zimām* is estimated to be 528 *feddan* compared to the area inside *zimām* which is 2500 *feddan* in Rashda[6].

**Land holding**

Information on landholding was collected by the questions in the household survey on the plots cultivated by the households. 40.6% of the households in Rashda practice cultivation. This proportion is similar to other surveyed villages in the Nile valley. The mean area of cultivated land in Rashda is 1.1 *feddan.* This is larger than other surveyed villages in the Nile valley.

And 87% of the cultivators have only one plot **(Fig. 6-8)**. There are 24 cultivators who cultivate two plots, four cultivators with three plots, and one cultivator with four plots. The number of plots in Rashda is smaller than in other surveyed villages in the Nile valley. In the Nile valley, there are more households with two or more plots.

Most of the cultivated lands are owned by the cultivators themselves, but 20% of them are rented **(Fig. 6-9)**.

6 Local Unit (Administrative center of Rashda village) estimates the outside *zimam* to be 161 *feddan*.

**Fig. 6-8 Holding of cultivated land (2005) (% of household)**

| | | % |
|---|---|---|
| Cultivation | Yes | 40.6 |
| | No | 59.4 |
| | Total | 100.0 |
| | (Number) | 549 |
| Land size (*feddan*) | 0.5-0.9 | 6.3 |
| | 1.0-1.4 | 14.8 |
| | 1.5-1.9 | 7.6 |
| | 2.0-2.9 | 25.6 |
| | 3.0-3.9 | 9.4 |
| | 4.0-4.9 | 24.2 |
| | 5.0 or above | 8.1 |
| | Total | 100.0 |
| | (Number) | 223 |
| | Average size | 1.1 |
| | Gini coefficient | 0.33 |

(Note) Data is from Household Survey 2005.
(Source) Kato and Iwasaki, 2008.

**Fig. 6-9 Ownership of cultivated land (2005) (% of cultivated land)**

| | % |
|---|---|
| Owned | 74.4 |
| Sharecropped | 5.0 |
| Rent | 20.5 |
| Other | 0.0 |
| Total | 100.0 |
| Average land size (*feddan* ) | 2.8 |
| (Number) | 223 |

(Note) Data is from Household Survey 2005.
(Source) Kato and Iwasaki, 2008.

## Crops

As other villages in Dakhla Oasis, the most prevailing crops in Rashda are wheat and Egyptian clover in winter, rice and maize in summer, and dates. The cultivated area of these main crops is shown in **Fig. 6-10**.

The quantity of production per year is in **Fig. 6-11**. Vegetables such as onions, eggplants, okra, green peppers and fruits such as melon and watermelon are grown, but there are no data on them. It is because the data collected at Agricultural Cooperative is only for the cash crops, and the vegetables as well as Egyptian clover are generally used for household consumption.

Dates are generally produced in the lands attached to local well and investment well (**Fig. 6-12**). The lands attached to governmental well do not have palm trees.

**Fig. 6-10 Area of cultivated land by main crop (2008) (unit:*feddan*)**

| Crop | | Governmental and local well | Investment well | Surface spring | Total |
|---|---|---|---|---|---|
| Winter | Wheat | 750 | 332 | 84 | 1166 |
| | Egyptian clover (*hijāzī*, alfalfa) | 360 | 285 | 200 | 845 |
| | Egyptian clover ("strenghtened") | 400 | 89 | | 489 |
| | Barley | 12 | 18 | 4 | 34 |
| | Broad bean | 6 | 20 | 3 | 29 |
| | Egyptian lupin (*tirmis*) | 3 | | 2 | 5 |
| | Pea (*bsila*) | 1 | | 2 | 3 |
| | Onion | 4 | 14 | 12 | 30 |
| Summer | Rice | 150 | | | 150 |
| | Cow-pea (*lūbiya*) | 35 | 35 | | 70 |
| | Maize "slim" | 50 | 10 | | 60 |
| | Maize (*shāmiī*) | 10 | 15 | | 25 |

(Source) Agricultural Cooperative in Rashda, information from the informant in November 2008.

**Fig. 6-11 Production of main crops (2007)**

| | | Area *(feddan)* | Average production | (Unit) |
|---|---|---|---|---|
| Winter | Wheat | 1129 | 15804 | *ardab* |
| | Barley | 35 | 280 | *ardab* |
| | Broad beans local | 89 | 979 | *ardab* |
| | Egyptian clover ("strenghtened") | 1200 | 27000 | ton |
| | Egyptian clover (*hijāzī*, alfalfa) | 800 | | |
| Summer | Rice | No cultivation by decree on rice cultivation last year | | |
| | Maize | - | - | |
| | Tomato | 5 | 53 | ton |
| | Potato | 5 | 60 | ton |

(Note) No information is provided for other vegetables. 1 *ardab* of wheat =150kg, 1 *ardab* of beans =155kg
(Source) Agricultural Cooperative in Rashda, information from the informant in November 2008.

**Fig. 6-12 Area cultivating palm trees and their number in local well and investment well (2005)**

| Name of well | | Area (*feddan*) | Number of palm trees |
|---|---|---|---|
| Local well | Bir Sheikh | 23 | 4,890 |
| | Ain al-Balad | 40 | 5,946 |
| | Ain al-Rahma | 100 | 1,268 |
| | Ain Shishlana | 8 | 9,558 |
| | Bir al-Zanjura | 29 | 4,253 |
| | Bir Nakhil | 52 | 8,878 |
| | Bir al-Qadim | 13 | 1,015 |
| | Bir 4 Rashda | 12 | 193 |
| | Bir al-Duma | 7 | 784 |
| Investment well | Mahmud Said | 200 | 8,000 |
| | Inherited from Ahmad Said | 10 | 494 |
| | Muhammad Abdallah & his partners | 5 | 179 |

(Source) Agricultural Cooperative in Rashda, information from the informant in November 2008.

## *VII System of irrigation and cultivation in Well No.3 Irrigation District*

This chapter uses the information gathered and maps drawn on Well No.3 Irrigation District. The maps are those showing the location of wells and plots. They are digitized to link with other maps shown in Chapter 3. The information gathered are the list of plots containing the information on names of owner, size of plots, crops cultivated, number of irrigation times, etc.

### 1. Irrigation system

#### (1) Location of Well No.3 Irrigation District

As mentioned in Chapter 3, there are actually four wells in Well No.3 Irrigation District. They are all governmental wells. The area irrigated by these wells, and is located in the north-west direction of Rashda village. The District consists of 3 sub-districts (*zimām*), North (*Zimām Baḥrī*), South (*Zimām Qiblī*) and West (*Zimām Gharbī*) **(Fig. 7-1)**.

Well No.3 Irrigation District is 170-180 *feddan*. The North, South and West sub-districts are 65, 65-66 and 55 *feddan*, respectively.

The areas surrounding this District are also agricultural land. It is a long and narrow lot and this lot is irrigated with local wells.

The area on the left of the road leading to sub-District West is part of the irrigation district. Its land is rented out to a farmer living near by this District[7]. However, because of its lack of water and high salt concentration, it has not been cultivated or irrigated since the 1970s.

There are also some plots neighboring sub-district North which are purchased by farmers in the 1980s.

#### (2) Development of the District

The first well in this District was drilled in 1959 by an Italian company, and was 500m deep and initially had a discharge volume of 3600$m^3$ **(Fig. 7-2)**. The Land Reclamation Office of Wadi Gedid chose this area for drilling the well, because it was a fallow land not owned by the farmers. As was mentioned before, the District was a fallow land lying in the outskirt of the land owned by the farmers and irrigated with the water from a local well.

After the first well was dug in 1959, the Egyptian government reclaimed the District for agricultural use in 1962[8]. In 1964, the Land Reclamation Office of Wadi Gedid sold a total of 5 *feddan* of land in the District to 34 farmers under 10 year repayment contracts. Under the Land Reclamation scheme of the office, the total of 5 *feddan* sold to each farmer consists of 3

---

7 The land in Well No.3 Irrigation District is administered by the Rural Development Project whose local office is in Mut. Renters of the land in the District must pay 40 LE every season (6 months) to the office. But if the amount of water flow is insufficient and therefore the land is not cultivated, the renters are exempted of paying the rent.

8 The first harvest was in 1963, and the first plowing of the fields in this District was in 1970.

plots each in different sub-district (the North, South and West sub-districts). The dispersal of agricultural land ownership at that time was designed by the office to regulate the planting of crops in each district.

The first well was dried up in 1995. Therefore, four wells were drilled by the Office of Irrigation in 1988, 1999, 2004 and 2008.

Well No.3-5 was dug in 1988. The well is 831m deep and the discharge volume of this well is 3413$m^3$. This is an artesian well. Well No.3-7 was dug in 1999. The well is 530m deep and the discharge volume of this well is 3413$m^3$. This is also an artesian well. Well No.12 was dug in 2004[9]. The well is 1046m deep and the discharge volume of this well is 218$m^3$. This was an artesian well. However, a diesel-powered pump with a discharge volume of 150*l*/min was installed to this well in 2006. Well No.3-17 was dug in 2008 and its depth is 739m. This is an artesian well. The photographs of these wells were taken in March 2009.

**Fig. 7-2 Wells in Well No.3 Irrigation District (2008)**

| Name of wells | Year of digging | Depth of well | Quantity of water flow at the time of digging ($m^3$ /day) |
|---|---|---|---|
| Rashda No.3 | 1959 | 500 | 3600 |
| Rashda No.3-5 | 1988 | 831 | 3413 |
| Rashda No.3-17 | 2008 | 739 | (under construction) |
| Rashda No.3-7 | 1999 | 530 | 3413 |
| Rashda No.12 | 2004 | 1046 | 218 |

(Note) Well No.3-17 was under construction in 2008, but is in operation since summer 2009.
(Source) Information collected by the informant.

### (3) Management of irrigation

Water Distribution in this District is under the control of Irrigation Office. One employee of the Irrigation Office and two farmers are appointed as managers of each well. Every year, the managers of a well and the farmers hold discussions to determine how much agricultural land can be planted with paddy rice. They take into consideration the flow of the underground water in Nubian aquifer, pumping tests at the well, and the hydrologic conditions around Lake Chad in efforts to anticipate the irrigation conditions for that year and to determine the area to be cultivated.

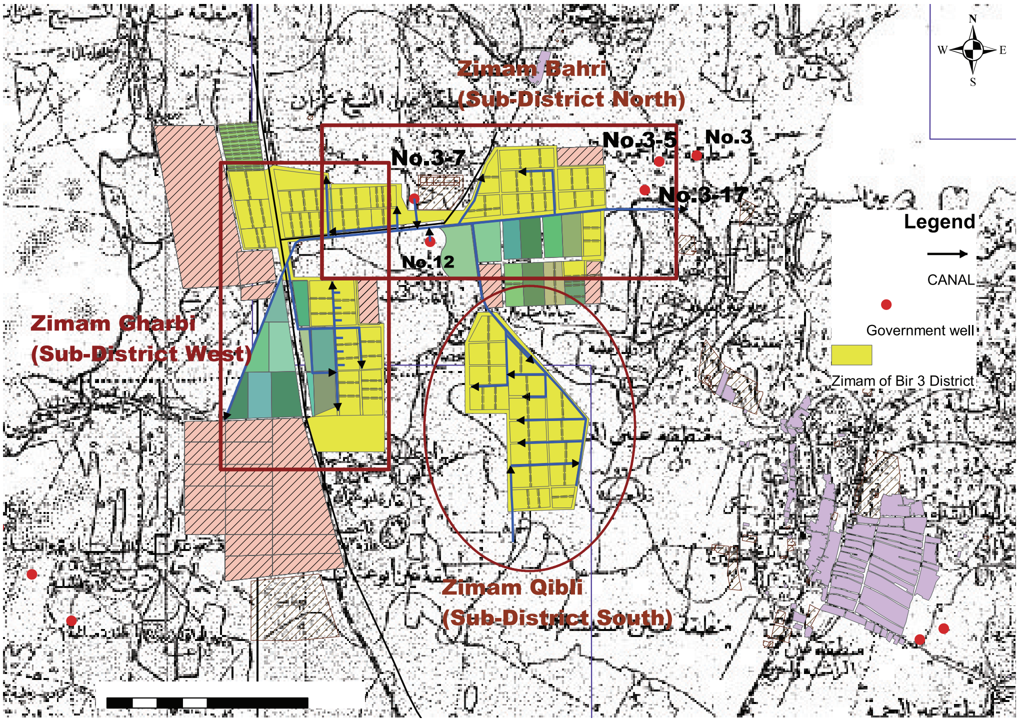
An engineer of Irrigation Department visits the wells every month to check the quantity and quality of water. Cleaning of the wells is also done at the time of visit.

### (4) Water distribution

The winter growing season is from October to April. During this season, 22$m^3$ of water

9 Well No.12 was dug in the land owned by a farmer. For this reason, this farmer has the right to get the water from Well No.12 to his land located outside the Well No.3 Irrigation District.

**Fig. 7-1 Location of Well No.3 Irrigation District**




(Source) 1/2500 Map, Information collected by the informant.

Well No.3 Irrigation District

**Fig. 7-4 Location of plots of the owners in Well No.3 Irrigation District (2009)**


(Note) Numbers in the map display the ID of each owner.
(Source) Information collected by the informant (2009).

Plot No.7 in Sub-District North

is irrigated to each 1 *feddan* of agricultural land once in every 12 days. The summer growing season is from May to September. During this season, water is irrigated to each 1 *feddan* of agricultural land once in every 16 days. The reason for the longer irrigation interval during the summer growing season is the scarcity of water for irrigation. Since the quantity of water is not sufficient during the summer season, the farmers cultivate only 60% of their land area[10].

It takes about one noon or night, or from sunrise to sunset or from sunset to sunrise to irrigate a plot of 1 *feddan*. This unit of time is called *amīla* as pointed out in Chapter 3.

The first question to be decided, in order that the owners can take their share of the water in succession, is the number of *amīla* that shall form a rotation. This varies according to the flow of the well and the number of men who share it. In Well No.3 Irrigation District, since the size of plots varies between 1 to 2 *feddan*, the number of *amīla* is distributed among the plots as in **Fig.7-3**. In general, each cultivator of 5 *feddan* receive 2 *amīla* and 8 *qadam* in one rotation. The quantity of water distributed to each cultivator is decided every season by the Irrigation Office.

While crop planting was deregulated in the latter half of the 1980s, cotton planting in the Nile delta remains under regulation. Furthermore, under current irrigation laws, the government can regulate the cultivation of paddy rice depending on the amount of water for irrigation.

At the time of the original land reclaimed to agricultural use, an orchard already existed in the sub-district North that had a claim to water for irrigation. Subsequently, part of the orchard was converted for cultivation of other crops. When we surveyed the site of Well No.3, all the surrounding area was date palm orchards. In the Well No.3 District, the cultivators prefer wheat than palm date because of the water scarcity. The cultivation of date palm requires an abundant water, but the Well No.3 District lacks water more than the neighboring private artisan well since the 1970s. Another reason for preferring the wheat is to secure the household consumption.

10 In the summer, 30m$^3$ of water per feddan is required because of the hot and dry climate. However, the actual distributed water is 22m$^3$ as in the winter season. Therefore, there are many plots left fallow during the summer season.

**Fig. 7-3 Size of the plots in Well No.3 Irrigation District (2008)**

| ID | East | | North | | West | | Total area | | Total quantity of water benificied in 3 plots (2007) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *qirat* | *feddan* | *qirat* | *feddan* | *qirat* | *feddan* | *qirat* | *feddan* | *qadam* | *amīla* |
| 1 | 23 | 1 | 15 | 1 | 14 | 1 | 4 | 5 | 8.0 | 2 |
| 2 | 13 | 1 | 3 | 2 | 2 | 1 | 18 | 4 | 15.0 | 1 |
| 3 | 2 | 2 | 11 | 1 | 15 | 1 | 4 | 5 | 8.0 | 2 |
| 4 | 2 | 2 | 11 | 1 | 8 | 1 | 21 | 4 | 4.0 | 2 |
| 5 | 6 | 2 | 4 | 1 | 12 | 1 | 22 | 4 | 4.5 | 2 |
| 6 | 13 | 1 | 21 | 1 | 2 | 1 | 12 | 4 | 29.5 | 1 |
| 7 | 21 | 1 | 14 | 1 | 16 | 1 | 3 | 5 | 7.5 | 2 |
| 8 | 22 | 1 | 16 | 1 | 13 | 1 | 3 | 5 | 7.5 | 2 |
| 9 | 12 | 1 | 5 | 1 | 20 | 1 | 13 | 4 | – | 2 |
| 10 | 13 | 1 | 17 | 1 | 15 | 1 | 21 | 4 | 4.0 | 2 |
| 11 | 13 | 1 | 19 | 1 | 5 | 1 | 13 | 4 | – | 2 |
| 12 | 2 | 2 | 14 | 1 | 16 | 1 | 8 | 5 | 10.0 | 2 |
| 13 | 4 | 2 | 11 | 1 | 16 | 1 | 7 | 5 | 7.5 | 2 |
| 14 | 20 | 1 | 18 | 1 | 3 | 1 | 17 | 4 | 2.0 | 2 |
| 15 | 7 | 2 | 12 | 1 | 13 | 1 | 8 | 5 | 10.5 | 2 |
| 16 | 0 | 2 | 13 | 1 | 15 | 1 | 4 | 5 | 8.0 | 2 |
| 17 | 0 | 2 | 23 | 1 | 5 | 1 | 4 | 5 | 3.0 | 2 |
| 18 | 2 | 2 | 14 | 1 | 5 | 1 | 21 | 4 | 4.0 | 2 |
| 19 | 2 | 2 | 13 | 1 | 5 | 2 | 20 | 5 | 6.0 | 2 |
| 20 | 1 | 2 | 11 | 1 | 12 | 1 | 0 | 5 | 3.0 | 2 |
| 21 | 1 | 2 | 0 | 1 | 18 | 1 | 19 | 4 | 3.0 | 2 |
| 22 | 2 | 2 | 14 | 1 | 2 | 1 | 18 | 4 | 28.0 | 1 |
| 23 | 20 | 1 | 16 | 1 | 14 | 1 | 2 | 5 | 6.5 | 2 |
| 24 | 18 | 1 | 17 | 1 | 13 | 1 | 0 | 5 | 6.0 | 2 |
| 25 | 16 | 1 | 13 | 1 | 18 | 1 | 23 | 4 | 6.0 | 2 |
| 26 | 14 | 1 | 13 | 1 | 8 | 1 | 11 | 4 | 29.0 | 1 |
| 27 | 14 | 1 | 13 | 1 | 15 | 1 | 18 | 4 | 3.0 | 2 |
| 28 | 5 | 2 | 4 | 1 | 5 | 1 | 14 | 4 | 3.5 | 2 |
| 29 | 5 | 2 | 2 | 1 | 5 | 1 | 12 | 4 | – | 2 |
| 30 | 6 | 1 | 21 | 1 | 15 | 1 | 18 | 4 | 23.0 | 1 |
| 31 | 5 | 1 | 2 | 2 | 14 | 1 | 21 | 4 | 19.0 | 1 |
| 32 | 9 | 1 | 16 | 1 | 15 | 1 | 16 | 4 | 1.5 | 2 |
| 33 | 8 | 1 | 15 | 1 | 17 | 1 | 16 | 4 | 1.5 | 2 |
| 34 | 8 | 1 | 10 | 1 | 19 | 1 | 13 | 4 | 15.0 | 1 |
| **Total** | **21** | **61** | **13** | **53** | **6** | **51** | **16** | **166** | **17.0** | **70** |

(Note) (1) 1 *amīla* equals 30 *qadam*.
(2) Since the agricultural lands were reclaimed in 1964, most of the owners are deceased except 6 owners who are alive now (in 2009). Therefore, actually, the lands are inherited to their sons.
(Source) Information collected by the informant in 2009.

## 2. Cultivation system

There are 34 cultivators in Well No.3 Irrigation District, and each cultivator owns three plots, each in different (sub-district) (**Fig.7-4**). This way of holding plots in different sub-districts was decided by the Land Reclamation Office at the time of purchasing the land when the first well was drilled. Since the rice cultivation requires permanent irrigation, and water flows for other crops must be controlled to avoid the overuse of water, crop rotation is necessary.

For this reason, the crops cultivated in each sub-district are rotated between them for 3 years and 6 months term. Currently until summer 2011, the sub-district South is mainly for alfalfa (Hijaz clover). Sub-district North is mainly fallow in summer, and in winter, wheat for one year and local (Egyptian) clover for another year. Sub-district West is mainly for rice in summer and local clover in winter. However, because of the water scarcity mentioned in Chapter 3, the maize was cultivated instead of rice in summer, in sub-district West.

Kinds of crops and their rotation are decided by the Department of Agriculture (Directorate of Ministry of Agriculture). There is no meeting held for deciding when and what kind of crops to cultivate, because it follows the same cropping pattern every year. However, in some circumstances which necessitate the agreement of cultivators, such as the prohibition of rice cultivation, the agricultural cooperative takes a role of informing and directing the cultivators. According to the informant, this rule of crop rotation among three different sub-districts is a system maintained in the areas irrigated by governmental wells. In the areas irrigated by local wells, this rule is not strictly applied. The cultivators have more freedom of deciding what kind of crops and when to cultivate.

Little field had been planted with paddy rice in the summer of 2009, because of the scarcity of water for irrigation. Many fields had been left for fallow. As a general rule, the irrigation interval in this district is once in every 12 days or 16 days. However, for paddy rice cultivation, continuous irrigation is necessary during a growing period. Therefore, the width of a division works was made narrow from the normal width and the discharge from the division works was reduced in order to ensure a continuous supply of water to a paddy field.

In other words, the narrowed width of the division works for cultivation of paddy rice was 1/12 or 1/16 of the normal width for ordinary crops. Photographs of narrowed widths of a division works were taken from the paddy field served by a local well, out of Well No.3 Irrigation District (**Appendix 2**). Paddy rice in this field was being illegally cultivated. In such cases, farmers will be fined.

## 3. Effect of irrigation for the growth of wheat in Rashda

Rashda village in Dakhla oasis has almost no rain in annual base and farmers there irrigate their farmland with the water from wells. As mentioned in Section 2 on cultivation system, they grow wheat, maize, rice, Egyptian clover and vegetables in case of enough allocation of water for irrigation in summer and winter cropping season. In case of no allocation, they will leave their farmland fallow. Therefore, it is indispensable to estimate the amount of irrigation water necessary for farming when discussing the agriculture of this oasis in the future. In the present study, we made the growth model of wheat by FAO scheme (Doorenbos and Kassam, 1979) and estimate the relation between the frequency and amount of irrigation. Concept of this scheme is shown in **Fig. 7-5**.

**Simulation of biomass by FAO scheme**

First, hearing survey was made to the farmers in 34 households who use the water from the wells in Well No.3 Irrigation District which includes the cultivation method, the irrigation method and amount, and the soil type of their farmland. This survey showed that wheat is the major winter crop in this village and is selected as target crop of this research. Based on this hearing survey, we made growth model of wheat by the FAO scheme. This scheme needs some parameters of crop such as amount of applied nutrient, manure day, weeding day, soil condition and so on. In this research, we adopted the parameters of this model for Jaza, which is cultivar of wheat grown in northern Africa.

Meteorological data used in this study were measured at Mut 4km away from Rashda and averaged into normals of daily values from 1986 to 2009. **Fig. 7-6** shows annual change of daily mean temperature and dew point. Based on these normals, the production amount of wheat was estimated for irrigation frequency by this scheme.

The result of the hearing survey showed that wheat was sown in the end of November to the beginning of December in 2008, and it was harvested in the end of April to the beginning of May next year. The farmers irrigate 3mm of water from 5 to 22 times during the cultivation period. The irrigation of 9 times in the cultivation period of wheat is recommended in Rashda village but half of wheat fields have insufficient irrigation water due to the shortage of the water from the wells.

Time variations of potential biomass (dry matter weight: g/m$^2$) of Jaza wheat calculated by the FAO scheme are shown in **Fig. 7-7**. We assumed that wheat was sown on December 1$^{st}$ and harvested May 1$^{st}$. It includes the cases with 5 and 22 times of irrigation which corresponds to the minimum and maximum frequency of irrigation in the farmland respectively, where we heard the survey. The dry matter weight that was calculated for the cultivation period for 22 times was almost the same amount of harvest (900g/m$^2$) as in Japan.

The mean harvest index for wheat in Rashda village for the 34 farmlands was 32%. This index is the ratio of amount of real production which is heard by survey, and potential harvest calculated by FAO scheme. The ratio is smaller than 60%, which is standard in Japan. The difference appeared to come from the difference of technique of cultivation and cultivars.

**Simulation of effect of irrigation to wheat growth**

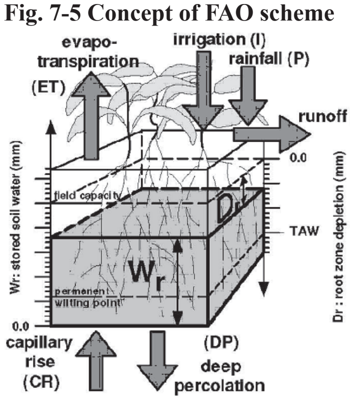
By employing FAO scheme with parameters above, we calculated yield of wheat in Rashda village with reference to irrigation frequencies. Although weather conditions and cultivation techniques is known to affect harvest index, we calculated the growth of wheat, as this index is assumed to be constant at 32%. The normal meteorological conditions are the same as those shown in **Fig. 7-8**. We, again, assumed that wheat is sown on December 1st and harvested May 1st.

**Fig. 7-8** demonstrates that an increase in the irrigation frequency brings an increase in the harvest. The 9 times irrigation during the cultivation period, which is recommended in this village, will bring 90% of potential amount of harvest and the 5 times irrigation will bring 75%. This means that increase of irrigation enables the increase of 15% harvest.

These results indicate that to increase of amount of wheat production in Rashda village, two methods are devised. One is the increase of harvest index and the other is that of irrigation amount. The increase of harvest index will be brought by development of innovated cultivars with greater productivity and/or improving of cultivation techniques. If these techniques are introduced, the harvest index will reach 60% of standards in Japan and production will become twice as much as present. The increase of irrigation amount also will be brought by development of water resources and improvement irrigation facilities. The irrigation water is supplied by ground water which came from Nubian aquifer. Recently, as the withering of the Nubia aquifer is worried, it is necessary to avoid development more than now to conserve this aquifer. Therefore, the alternative method is an improvement of irrigation facilities such as introduction of new irrigation techniques, repair of canals and so on.

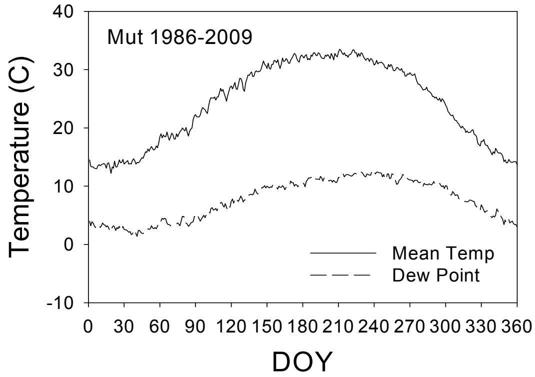
Fortunately, the improvement of the harvest index will bring greater increase in production than that of irrigation amount. Therefore, these considerations invite future investigation from the viewpoints of improvement cultivation techniques not from development of irrigation techniques.

**Fig. 7-5 Concept of FAO scheme**



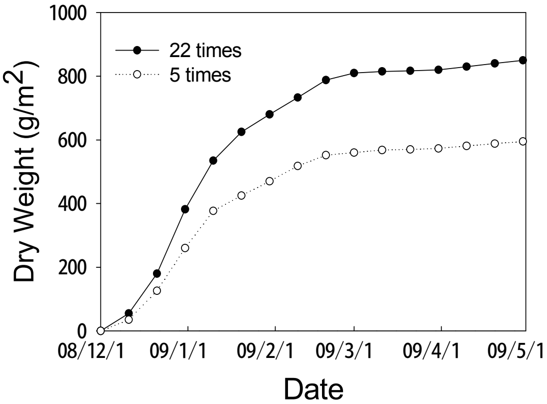

(Source) Doorenbos and Kassam, 1979

**Fig. 7-6 Annual changes of daily mean temperature and dew point**



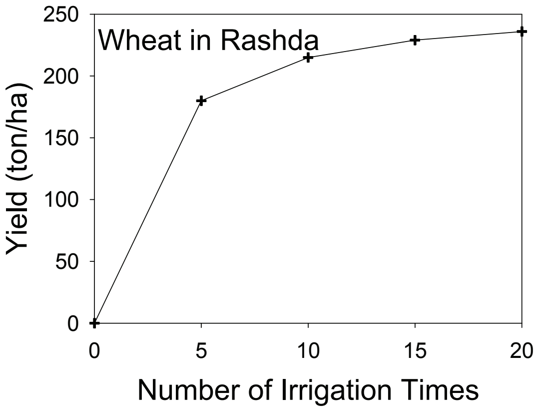

(Note) These temperatures are measured at Mut 4km away from Rashda village.

**Fig. 7-7 Growth of wheat in Rashda village**




(Note) Legends in this figure show irrigation frequency: 5 times and 22 times mean the minimum and maximum frequency for growing seasons in Rashda village.

**Fig. 7-8 Relationship between yield of wheat and irrigation frequency**



## *Conclusion*

This paper is an intermediate report of study on the economic life in Rashda village, focusing on the irrigation and cultivation systems. Although our study is still at an intermediate stage, and therefore it is too early to be able to give any assessment, some insights can be drawn from following three findings.

First, as anyone may easily recognize, the availability of water determines the economic life based on agriculture in the oasis village. Water is an essential factor for the agriculture in the Nile valley as well. However, the latter depends on the Nile so that the availability of water can be controlled and estimated in future. On the contrary, in the oasis region whose agriculture is totally determined by the underground water resource, it is hard to plan the use and management of water in mid and long-term, because the water flow from the underground water is uncontrollable.

Hence, the essential information to understand the agriculture in the oasis region is that on water wells and springs. The information on these wells, as shown in the list of 70 wells and springs in Rashda village (see **Appendix 1**), provides insights regarding the circumstances of agriculture, and the history of agriculture in the village as well, by looking at the year the wells and springs are dug. There are direct relation between the location of wells and springs and expansion of cultivated lands. In fact, the farmers' interest lies in the quantity of water, rather than in the size of land.

Following two findings are the corollaries of the first one. Second finding is that digging the well and obtaining sufficient water require large sum of capital and technology. Third finding is that the farmers have developed cultivation system to adapt the natural condition characterized by the scarcity of water resource.

This second finding leads us to understand the involvement of the state and private enterprises in irrigation agriculture. Use of water in agriculture leads to decline in underground water level. Therefore, digging the wells at deeper level is necessary to keep access to the water. This in turn requires a large sum of money. Thus, although the oasis region might appear as periphery, its survival largely depends on the political and economic regime in general at that time.

The third finding is related to the local cultivation customs in the village. In Rashda village, the farmers have been making the cultivation according to the way they developed with their experience, as is attested in the existence of historical documents on the water distribution. It is sure that the technical level is not high at least from the Japanese viewpoint. For example, the way water is drained has an important effect on irrigation agriculture and is necessary to avoid soil becoming too saline. Yet soil salinization is a phenomenon that appears here and there in the irrigated areas of the village.

However, it does not mean that the farmers are not conscious of the problem of salinization. Rather, the farmers consider the problem of soil salinization in relation with the expenditure. As is mentioned in Chapter VI on the methods of irrigation, the farmers consider the quality of soil, availability of capital, and quantity of water, so as to select the most efficient method of irrigation.

Thus, either their local way of cultivation is efficient or not, and has a room for improvement or not, are the matters to be assessed after an empirical and detailed examination, as the results in Chapter VII on the effect of irrigation on wheat growth suggest.

**Figures**

Fig. 7-7 Growth of wheat in Rashda village
Fig. 7-8 Relationship between yield of wheat and irrigation frequency

**References**

Brookes, I.A., 2001. “Aeolian Erosional Lineations in the Libyan Desert, Dakhla Region, Egypt.” *Geomorphology*, 39.

Dabous, A.A. & J.K.Osmond, 2001. “Uranium Isotopic Study of Artesian and Pluvial Contributions to the Nubian Aquifer, Western Desert, Egypt.” *Journal of Hydrology*, 243.

Doorenbos and Kassam, 1979. “Yield Response to Water.” *Irrigation and Drainage Paper*, 33, FAO, Rome, Italy.

Husayn, ‘Alaya Hasan, 1975. *Al-wāḥāt al-khārija, dirāsāt fī al-tanmiya wa al-taghayyur al-ijtimā‘ī fī al-mujtama‘āt al-mustaḥdathāt* [Kharga Oasis, A Study on Development and Social Change in Newly Created Societies]. Cairo: Al-Hay’a al-Misrīya al-‘Āmma li-l-Kitāb.

Iwasaki, Erina, 2006. “What is the Aila? A Comparative Study of Kinship Structure in Egyptian Villages.” AJAMES (Annals of Japan Association for Middle East Studies), 22(2).

Kato, Hiroshi, 2008. “Is the Egyptian Village a Community.” *International Journal of Public Affaires*, 4, Research Center on Public Affairs for Sustainable Welfare Society, Chiba University.

Kato, Hiroshi and Erina Iwasaki, 2008. “Rashda. A Village in Dakhla Oasis.” *Mediterranean World,* 19, 2008.

King, W. J. Harding, 1917. “Irrigation in the Dakhla Oasis.” *The Geographical Journal*, 50(7).

Law No.143 of 1981, 1981. “Law No.143 of the Year 1981 Concerning the Desert Land.” The Middle East Library for Economic Services, 1996.

Robaa, S.M., 2008. “Evaluation of Sunshine Duration from Cloud Data in Egypt.” *Energy,* 33.

Tegen, I., and Fung, I., 1994. “Modeling of Mineral Dust in the Atmosphere: Sources, Transport, and Optical Thickness.” *Journal of Geophysical Research,* 99.

UNEP, 1997. *World Atlas of Desertification*. London: Arnold.

Vivian, Cassandra, 2000. *The Western Desert of Egypt*. Cairo: The American University in Cairo Press.

## *Appendix 1 List of wells in Rashda (2008)*

| ID | Type of well | Name | Year of digging | Depth (m) | Quantity of water flow at the time of digging ($m^3$ /day) | Current status |
|---|---|---|---|---|---|---|
| 1 | Government | بئر 1 الراشدة الغربى (الأيطالى ) | 1962 | 500 | 3753 | Dried up |
| 2 | Government | بئر 1 الراشدة ( القرية الشرقى ) | 1964 | 298 | 668 | Operating |
| 3 | Government | بئر 1 الراشدة القرية الجديد | 2006 | 1000 | 1709 | Operating |
| 4 | Government | الراشدة 6/1 | 1996 | 535 | 3413 | Dried up |
| 5 | Government | بئر 2 الراشدة مؤسسة | 1962 | 500 | 1284 | Changed to touristic site |
| 6 | Government | بئر 2 استعواض / الخلط | 2002 | 827 | 1240 | Operating |
| 7 | Government | بئر 3 الراشدة (الإيطالى ) | 1962 | 500 | 3600 | Dried up |
| 8 | Government | بئر 3 الراشدة ااستعواض | 1988 | 831 | 3413 | Dried up |
| 9 | Government | بئر 3 الراشدة الجديد | 2008 | 739 | | Under construction |
| 10 | Government | بئر 3 الراشدة مدرسة المنصورة | 1999 | 530 | 3413 | Dried up |
| 11 | Government | بئر 3 الراشدة عين عثمان قبلى المدرسة | 2004 | 1046 | 218 | Dried up |
| 12 | Local well | البئر القبلى دهوس/هاشم | 1954 | | | Dried up |
| 13 | Local well | البئر القبلى مخيم | 2004 | 1050 | 160 | Operating |
| 14 | Local well | البئر القبلى معرف | 1929 | | | Dried up |
| 15 | Local well | البئر القديم | 1900 | | | Dried up |
| 16 | Local well | البئر القديم | 1923 | | | Dried up |
| 17 | Local well | البئر القديم | 2008 | | | Operating |
| 18 | Local well | البئر القديم كافورة | 1998 | | | Operating |
| 19 | Local well | الشيخ حسين القديم | 1914 | | | Dried up |
| 20 | Local well | الشيخ حسين دردير | 2003 | | | Operating |
| 21 | Local well | الرحمة الأعماق | 2006 | 1000 | 229 | Operating |
| 22 | Local well | حمام | 1943 | | | Dried up |
| 23 | Local well | الدولاب البحرى | 1977 | | | Dried up |
| 24 | Local well | بئر 4 الشرقى | 2003 | 1180 | 170 | Operating |
| 25 | Local well | بئر 4 الغربى | 1985 | 543 | 810 | Operating |
| 26 | Local well | عين الركن الجديد | 2005 | | | Under construction |
| 27 | Local well | الركن المخفوس | | | | Dried up |
| 28 | Local well | المنصورة البحرى | | | | Operating |
| 29 | Local well | المنصورة الشرقى | | | | Operating |
| 30 | Local well | الدومة أهالى | 2000 | | | Operating |
| 31 | Local well | الحرامية مسيد | 2004 | | | Operating |
| 32 | Local well | البلد | 1927 | | | Dried up |
| 33 | Local well | بئر عين البلد | 1927 | | | Dried up |
| 34 | Local well | عين عثمان | | | | Operating |
| 35 | Local well | الزنجورة الحالى بالغرد | 2000 | 748 | 170 | Operating |
| 36 | Local well | الزنجورة القديم | 1953 | | | Dried up |
| 37 | Local well | الشيخ الجديد/عرسة | 1953 | | | Dried up |
| 38 | Local well | بئر النخيل دريس | 1921 | | | Dried up |
| 39 | Local well | بئر عين البلد الوسطانى | 1958 | | | Dried up |
| 40 | Roman spring | عين الراشدة ( عين قارة برقس ) | | | | Dried up |
| 41 | Roman spring | عين الرحمة | | | | Dried up |
| 42 | Roman spring | عين الشيشلانة | | | | Dried up |
| 43 | Roman spring | عين المسيد | | | | Dried up |
| 44 | Roman spring | عين الجميزة | | | | Dried up |
| 45 | Roman spring | عين الدومة | | | | Dried up |
| 46 | Roman spring | عين المنصورة | | | | Dried up |
| 47 | Roman spring | عين صحصاح | | | | Dried up |
| 48 | Surface spring | عماد / عين رشدى | 2005 | | | |
| 49 | Surface spring | فقهاء | | | | Dried up |
| 50 | Surface spring | فقاء حاليا / هاشم | 2002 | | | |
| 51 | Surface spring | شعراوى / محمد شعراوى | 2000 | | | Operating |
| 52 | Surface spring | شندوم | 2000 | | | Dried up |
| 53 | Surface spring | العرب بالمخيم | | | | |
| 54 | Surface spring | مسعودمصنع | 2004 | | | |
| 55 | Surface spring | الأمل / منصور حسن | 2000 | | | Operating |
| 56 | Surface spring | عبد الناصر / منار | 2003 | | | |

| | | | | | |
|---|---|---|---|---|---|
| 57 | Surface spring | أبو يوسف | | | |
| 58 | Surface spring | عيد الناصر حمراية | 2000 | | |
| 59 | Surface spring | حج حسن / الشيخ حسن | 2003 | | Dried up |
| 60 | Surface spring | حج محمد / دردير | | | |
| 61 | Surface spring | عين الجديدة | | | Dried up |
| 62 | Surface spring | أبو هدية الصحابة | 1999 | | |
| 63 | Surface spring | فتحى / الإخلاص | 2004 | | |
| 64 | Surface spring | أولاد عبد المنعم / الأمل | 2002 | | |
| 65 | Surface spring | عادل / قناوى | 2003 | | |
| 66 | Surface spring | توءمان | 2002 | | |
| 67 | Surface spring | أحمد سيد قرية | 2004 | | |
| 68 | Surface spring | رويشد | 2002 | | |
| 69 | Surface spring | خضر / عبد العال | 2002 | | |
| 70 | Surface spring | ساويرس | 2007 | | |
| 71 | Surface spring | فوزى شعراوى | 2002 | | |
| 72 | Surface spring | ناهد | | | |
| 73 | Surface spring | رشيد | | | |
| 74 | Surface spring | عبد الظاهر | | | |
| 75 | Surface spring | دردير | | | |
| 76 | Surface spring | سلامة | | | |
| 77 | Surface spring | الغزال | | | |
| 78 | Surface spring | عبد النبى | | | |
| 79 | Surface spring | أحمد فاروق /الأصدقاء | | | |
| 80 | Surface spring | السعادة /أحمد حنفى | 2002 | | |
| 81 | Surface spring | محمد حسن // أسامة // السلام | 2003 | | |
| 82 | Surface spring | عادل عز/ فاضل | 2004 | | |
| 83 | Investment well | رفاعى البحرى | 1996 | 550 | Operating |
| 84 | Investment well | رفاعى القبلى | 1998 | 550 | Operating |
| 85 | Investment well | رفاعى الغرد | 2007 | 500 | Operating |
| 86 | Investment well | الزاهى | 2000 | 350 | Operating |
| 87 | Investment well | أحمد سيد الشرق | 1998 | 400 | Operating |
| 88 | Investment well | أحمد سيد الغربى | 1996 | 480 | Operating |
| 89 | Investment well | بيومى | 2003 | 500 | Operating |
| 90 | Investment well | حمودة | 2003 | 500 | Operating |
| 91 | Investment well | محمد سعد | 2003 | 500 | Operating |
| 92 | Investment well | رزق | 1998 | 500 | Operating |

(Source) Data collected through the informant.

## *Appendix 2 Photos of irrigation system in Rashda*

(1) Diesel-powered pump installed of water to the originally artesian well

(2) V-notch weir to measure the amount

(3) Artesian well

(4) Flow from an artesian well

(5) V-notch weir

(6) Flow from an artesian well

(7) Division works

(8) Concrete irrigation canal

(9) Division works

(10) Division works

(11) Earthen irrigation canal

(12) Field under surface irrigation

(13) Electric submerged pump

(14) Flow from an electric submerged pump

(15) V-notch weir to measure the amount of water

(16) Earthen irrigation canal

(17) Paddy field under irrigation

(18) Earthen irrigation canals to paddy fields

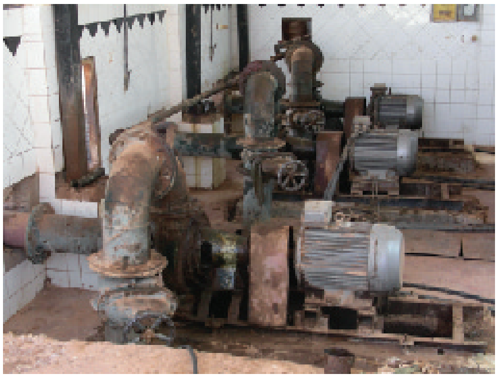
(19) Narrowed width of a division

(20) Sub-main drainage canal

(21) Main drainage canal

(22) Main drainage canal to a drainage pumping station

(23) Drainage pumping station (near Rashda)



(24) Drainage pumps (near Rashda)

(25) Discharge pipes to a drainage reservoir
(near Rashda)

(26) Drainage reservoir
(near Rashda)

(27) Salt accumulated field

(28) Water logged area
and salt accumulation works

(photos by Hisao ANYOJI)