CHAPTER 3

OUTLINE OF THE STUDY AREA

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3.1 Administrative Divisions

The administrative divisions of the study area are shown in **Table 3.1.1** and **Fig. 3.1.1.** The study area consists of 2 regions (Adrar and Tagant) which are divided into 7 departments (Moughataa). Under these departments, there are a total of 21 cities (Commune) and each city is composed of a couple of oases.

Table 3.1.1 Administrative Districts in the Study Area

1) Adrar Region

Moughataa	Atar	Aoujeft	Chinguetti	Ouadane
Commune	Tawaz	Aoujeft	Ain Savra	Ouadane
	Ain Ehel Tayaa	Maaden	Chinguetti	
	Choum	Meddah		
	Atar	N' Teirguente		

2) Tagant Region

Moughataa	Tidjikja	Moudjeria	Tichitt
Commune	Tidjikja	Moudjeria	Tichitt
	El Wahatt	N' beika	
	Tenssigh	Soudoud	
	Boubacar Ben Amer	Lekhcheb	
	Lehssira		

Source:MDRE

At present, a total of 123 oases have been identified by JICA Study Team. It is worthwhile to indicate that the number of oasis to have been identified is different by respective study because no universal definition on oasis has been presented. This may be explained by the existence of some small-scaled oases surrounding large-scaled oasis as well as settlements without date forest; furthermore, disunited alphabetical transcription for each oasis may have caused the said difference. The inventory survey of JICA Study Team was carried out bearing the said circumstances in mind and, as a result, the number of oases to have been recognized reached 57 in Adrar and 60 in Tagant, both of which have been identified as target oases under the present Study.

According to the Oasis Project, the number of oases where the associations hves been formed is 23 in Adrar and 18 in Tagant (Refer to **Table 3.1.2**).

Table 3.1.2 Number of Oasis with Association in the Study Area

Adrar	Atar	Aoujeft	Chinguetti	Ouadane	Total
No. of Oasis	7	11	2	3	23
Tagant	Tidjikja	Moudjeria	Tichitt		Total
No. of Oasis	12	5	1		18

Source : MDRE, Oasis Project

Number of AGPO members by oasis as of 2003 is shown in **Table 3.1.3**.

3.2 Population

With reference made to the national census 1988 and 2000 the population in the study area is summarized is shown in **Table 3.2.1**. As indicated in this table, the population in the study area decreased at a rate of 4.2% per year from 126,000 persons in 1988 to 78,000 persons in 2000. Decreasing rate is more remarkable in Tagant than in Adrar since the population dropped by almost half during the period. Especially in the department of Chinguetti and Ouadane in Adrar, Moudjeria in Tagant, their population was reduced less than half. The decline of agricultural production due to drought is considered the leading factor for the said decrease in population.

The urban population in two regions is shown in **Table 3.2.2**. The population also decreased (-2.2% p.a), but the rate is lower than that of the study area in general (- 4.2% p.a). The proportion of urban population in both regions increased from 27% in 1988 to 34% in 2000.

According to **Table 3.2.3**, the male population is less than female population in two regions and it is more conspicuous in Tagant. Especially, the department of Tichitt in Tagant has the female population twice as much as that of the male one. This can be explained by the fact that many men moved to the large cities for job hunting. The department of Ouadane in Adrar is the only department in the study area which has more male population than female one.

Table 3.2.1 Population in the Study Area

(Unit : person)

	1988*	2000**	A.G.R.(% p.a)
Aoujeft	16,217	12,396	-2.4
Atar	35,313	31,638	-1.0
Chinguetti	6,327	3,350	-5.6
Ouadane	3,186	1,997	-4.2
Adrar	61,043	49,381	-1.9
Moudjeria	27,995	9,298	-9.5
Tichitt	3,117	1,310	-7.6
Tidjikja	33,796	17,718	-5.7
Tagant	64,908	28,326	-7.3
Total	125,951	78,336	-4.2

Source: *) Annuaire Statistique 1998,

**) National Office of Statistics, National Population Census 2000

Table 3.2.2 Population in Main Urban Area

(Unit : person)

	1988	2000	A.G.R. (%)
Atar	23,166	20,710	-1.0
Tidjikja	10,904	6,061	-5.2
Total	34,070	26,771	-2.2
Regional share (%)	27	34	

Source: National Office of Statistics, National Population Census 2000

Table 3.2.3 Population Ratio by Sex and Age

(Unit : %)

	Adult		Child
	Male	Female	
Aoujeft	23	31	45
Atar	27	32	41
Chinguetti	21	26	53
Ouadane	28	25	47
Adrar	25	31	45
Moudjeria	22	35	41
Tichitt	21	50	29
Tidjikja	23	36	41
Tagant	23	36	40

Source: National Office of Statistics, National Population Census 2000

3.3 Regional Economy

The study team estimated the Gross Regional Domestic Product (GRDP) of the study area in 1998 as presented in **Table 3.3.1.**

This GRDP for Adrar and Tagant regions was estimated on the basis of the prices in 1998; the estimates are 2,356.1 million UM for Adrar and 834.3 million UM for Tagant. The share of these GRDP in the national economy is only 1.4% for Adrar and 0.5% for Tagant, respectively, which intimates that the two regions make an insignificant contribution to the national economy. On the other hand, the GRDP per-capita is estimated to be 47,713 UM for Adrar and 29,453 UM for Tagant, which each is equivalent to 71% and 44% of the national average.

The industrial mainstay in these regions consists of livestock farming and dates cultivation, which are followed by vegetables cultivation and handicrafts owing to the progress in establishment of organizations in many oases. The tourism is considered by foreign investors to be an attractive sector for development in the future. Nevertheless, the contribution of the sector to the regional economy remains at present insignificant because annual foreign visitors are as few as about 3,000 and many of them stay in the desert without lodging at hotel.

Table 3.3.1 Estimated GRDP in 1998

(Unit : Million UM, at 1998 price)

	Adrar*	Tagant*	Whole Country**
Agriculture	1,090.6	137.3	10,956
Livestock	821.7	410.9	27,391
Handicraft	54.8	42.3	8,501
Service	389.0	243.8	74,994
Total	2,356.1	834.3	168,879
Share (%)	1.4	0.5	100.0
GRDP per capita (UM / person)	47,713	29,453	67,552
Ratio (%)	71	44	100.0

Source : *Estimated by the Study Team **IMF Country Report, July 2000

3.4 Society

(1) Education

The education system of Mauritania consists of 7-year compulsory education (Primary education), 4-year secondary education and 3 to 5-year higher education. The advanced education at university is usually 3 to 5 years. Each department except for large cities in the metropolitan area has one secondary school and each region has one higher school. There is only one university throughout the country.

Table 3.4.1 shows a situation of primary schools in the study area compared with the country as a whole. In both Adrar and Tagant, the number of pupils per teacher is almost equal to that of the national average.

As for the number of schools, both regions have schools twice as much the number of oases, which hints that the primary education is properly spread in the study area.

Table 3.4.1 Condition of Primary Education (2000)

	No. of School	No. of Class	No. of Student (Male)	No. of Student (Female)	Total Student	No. of Teacher	No. of Student / School	No. of Student / Teacher
Adrar	124	365	5,902	5,439	11,341	340	91	33
%	4	5	3	3	3	4	76	76
Tagant	150	349	6,113	5,478	11,591	309	77	38
%	5	4	3	3	3	4	64	76
Study Area	274	714	12,015	10,917	22,932	649	84	35
%	10	9	7	6	6	8	70	76
National	2,798	8,002	183,641	172,181	355,822	7,826	127	45

Source: Direction de la Planification Scholaire et de la Cooperation, MEN

(2) Income

The income sources among population in Adrar and Tagant are shown in **Table 3.4.2,** together with per-capita and per-household income; the per-capita income is higher in Adrar than in Tagant. The people in Adrar earn more money from production of vegetable and dates, meanwhile the people in Tagant depend more money on non-agricultural activities and on remittance sent from their family members. This reflects the fact that the unit price of dates as well as its production is lower in Tagant than in Adrar.

In Mauritania, the poverty line is set at 53,841 UM of an annual per-capita income or at 147.5 UM of a daily per-capita income. The average income levels of the two regions are far below this poverty line accordingly. According to the "Poverty reduction strategy paper (IMF and IDA 2001)", the population who live in poverty account for 45 to 55% in Adrar and 55 to 65% in Tagant. On the other hand, the survey conducted in 2001 disclosed that the proportion of the households in poverty

jumped to 88% in Adrar and 90% in Tagant. Consequently, it is considered that the proportion of the household in poverty is in upward trend.

The result of the household survey is shown in **Table 3.4.3**. The people in Tagant earn less than the people in Adrar and the average income per-capita for both regions is far below the poverty line.

The comparison of income between male head of a household and female one reveals that the income of the latter is lower than that of the former in both departments; the difference of per-capita income is about by 5% in Adrar and about by 20% in Tagant. In so far as sources of income are concerned, the proportion of income from vegetables in female-headed households is about twice as much as that in male-headed households. By contrast, female-headed household earn far less income from livestock farming than that of male-headed households.

Table 3.4.2 Income by Source

	Handi-craft (%)	Non-agriculture (%)	Allow-ance (%)	Dates (%)	Live-stock (%)	Other agriculture (%)	Income/ household (UM)	Income/ person (UM)
Adrar	5.0	28.0	5.6	20.8	15.6	22.4	134,369	23,761
Tagant	10.5	48.3	10.1	8.5	15.8	6.8	80,116	14,073

Source: MDRE 1998

Table 3.4.3 Household Income

Head	Source of income (%)					Average Income
	Cereals	Dates	Vegetable	Livestock	Others	UM/Capita
Adrar						
Woman	7	42	39	3	9	36,719
Man	3	38	20	25	13	38,738
Average	4	38	22	24	13	38,296
Tagant						
Woman	5	50	18	17	10	18,453
Man	5	45	8	35	7	22,475
Average	5	46	10	32	7	21,615

Source: Household Survey by the Study Team

3.5 Agriculture

The agricultural sector is a mainstay within economic activities of the Study area. And the leading produces of the sector consist of dates, vegetables and livestock products.

According to IMF, an annual production of dates in Mauritania is in the range of 14,000 and 20,000 tons. An inventory survey conducted by the Study Team revealed that an annual production of dates in 2000 was 7,173 tons in Adrar and 5,670 tons in Tagant and these productions together account for about 65% of the national production; the production in Andar and in Tagant is equivalent to 36% and 28% of the national production, respectively.

The production of vegetables in Mauritania for the year 2000 was estimated to be 65,000 tons, of which 13,862 tons were represented by Adrar region and 50 tons by Tagant region. It is thus estimated that the production of vegetable in the study area represents 21% of the national production.
The production of cereals in the study area accounts for as few as 2% of the demand in Adrar and about 24% of the demand in Tagant.

In Adrar, the number of goats and sheep accounts for about 1.6% of the national total and that of camels about 1.3% of the national total, meanwhile, In Tagant, the same share represent about 2.1% for the former and about 0.6% for the latter. In comparison with other regions of the country, the study area has relatively more camels and fewer cattle.

At the national level, livestock production occupies 65% of the agriculture sector in GDP. In the study area, livestock production occupies 43% of the agricultural sector in GRDP in Adrar and 75% in Tagant, resulting in lower proportion in Adrar than the national average and higher proportion in Tagant (Refer to the **Table 3.5.1**).

Table 3.5.1 Number of Livestock in the Study Area

(Unit : 1,000 head)

	Camel	Sheep, Goat	Cow
Adrar	18.3	106.6	0.5
Share (%)	1.3	1.6	0.0
Tagant	8.7	142.4	16.3
Share (%)	0.6	2.1	1.3

Source : Annual Statistic in 2000

3.6 Natural Conditions

3.6.1 Meteorology and Hydrology

There are two meteorological stations under the control of ASECNA in the Study Area: Atar and Tidjikja, which have been undertaken since 1931 an observation of such data as precipitation, evaporation, air temperature, tension of vapor, relative humidity, pressure of the atmosphere, cloudiness, hours of sunshine, ground temperature, wind direction and wind velocity. The outline of each station is as follows:

Station	Coordination	Altitude	Period	Remark
Atar	20°31'N, 13°04'W	225,6 m	1931-present	Soil Temp. from 1955
Tidjikja	18°34'N, 11°26'W	396,0 m	1931-present	Rainfall from 1949, Soil Temp. from 1955

Source: SAM, Direction d'Exploitation Meteorologique

There are other local rainfall stations in addition to the said two meteorological stations under AGREMET, which is lower branch of MDRE, like: three in Chinguetti, Aoujeft, Ouadane in Adrar Region and four in Achram, Moudjeria, N'beika, Tichitt in Tagant Region. The data collected in almost all stations are incomplete and for a short period of less than 20 years.

The Study Area falls within the Taoudeni River basin which includes also parts of Mali and Senegal, but without the direct inflow of any of river system. Under the circumstances, there is no river system with permanent fluvial water. For that reason no river discharge gauging station has been installed in the Study Area.

Meteorological data for 30 – 40 years at Atar and Tidjikja stations are processed to get monthly mean meteorological data as shown in **Table 3.6.1** and **Fig. 3.6.1.** The outline and characteristics of the data from each station are described below:

(1) Rainfall

Meteorologically, the Study Area is divided into three different seasons: Rainy season with high temperature (July – October), Dry season with low temperature (November- March) and Dry season with high temperature (April-June). Annual mean precipitation in the period of 1960 – 2000 is registered to be 75.0 mm at Adrar and 118.1 mm at Tidjikja, and 80 to 84% of the annual precipitation are concentrated in the rainy season. Daily precipitation exceeding 15 mm usually forms surface water or puddles at wadis and occasionally causes flooding. Referring to the

existing data, the largest daily precipitation was 80.0 mm at Aoujeft in Adrar Region recorded on October 21, 2003 and 90.7 mm at Tidjikja in Tagant Region recorded on August 28, 1969 (Refer to **Table 3.6.2**).
The exceeding and non-exceeding probability analysis of rainfall data for various periods were calculated using the data of Atar and Tidjikja by means of the IWAI method and the result is shown in **Table 3.6.3**.

The evolution of annual precipitation during the period of 1960 - 2000 is shown in **Fig. 3.6.2.** As the chart indicates, there is no regular distribution pattern of annual precipitation over the period with an incident of rainy year and drought irregularly and with an outstanding fluctuation of annual precipitation year by year. Furthermore, there is timely and spatial concentration of rainfall caused by thunders, which is one of the distinctive weather features in arid area. The largest monthly precipitation is shown in September at Atar and in August at Tidjikja. Monthly rainfall fluctuation for 41 years is shown in **Fig. 3.6.3**. Monthly precipitation exceeding 60 mm has been recorded once four to five years at Atar in recent years. On the other hand monthly rainfall exceeding 100 mm was registered at Tidjikja during almost every year before 1970; however, the precipitation exceeding 60 mm has been recorded every three years recently. This fact reveals that rainfall pattern of both regions might change from 1970. It can be noted that a little difference of monthly rainfall and increase of drought months came to light in both regions.

(2) Air Temperature and Ground Temperature

Mean monthly temperature for both stations is calculated to be 28.4^{o}C and the highest one is 34.9^{o}C in July in Atar and 34.8 ^{o}C in June in Tidjikja. The recorded maximum temperatures were 48.0^{o}C and 45.8^{o}C at each station, respectively. The difference between the highest mean monthly temperature and the lowest one is 24.4^{o}C. in Atar and 22.3^{o}C in Tidjikja. On the other hand the difference between daily highest temperature and lowest one fluctuates from 18 to 26^{o}C, due to the fact that the sunshine is strong during the daytime and the land is subject to radiant cooling in the night.
The ground temperature is recorded regularly at 10, 20 and 50 cm below ground surface. This ground temperature fluctuates concurrently with air temperature, and its daily fluctuation is the largest at least depth point and the smallest at the deepest point.

(3) Hours of sunshine

The mean daily hours of sunshine is 8.3 hours in Atar and 8.0 hours in Tidjikja. Meanwhile, monthly hours of sunshine vary between 250 and 300 hours in Atar, 200 and 260 hours in Tidjikja. No remarkable monthly variation is observed.

(4) Relative Humidity

The annual mean relative humidity recorded at both stations is 28.5% and the highest values are in August (34.6% in Atar and 45.9% in Tidjikja) and lowest value in May (23.0% in Atar and 19.8% in Tidjikja). The monthly variation pattern is positively correlated to the precipitation and is inversely correlated to the evaporation.

(5) Evaporation

The mean annual evaporation is 4,704 mm for Atar and 3,949 mm for Tidjikja. The highest mean monthly evaporation falls in June and the lowest one in December.

(6) Wind

The mean monthly wind velocity is 3 m/sec or faster at both stations. Atar stands out among all the stations with a mean monthly velocity of 4.2m/sec in June. The dominant wind direction is from the north to the west in Atar and from the north to the east in Tidjikja. Twisters occur before and after thunderstorm raising a cloud of sandy dust.

(7) Sandstorm

A sandstorm is a phenomenon shifting sand particles by wind; wind carries sand particles very rapidly and bringing about remarkable transformation of topography in desert region. In Atar, the frequency of sandstorm is more during rainy and high-temperature season which falls in July through in October, whereas in Tidjikja more sandstorm takes place during the first half of a year (up to July).

The desertification progresses this way by forming sand dunes depending on the topographic feature/slope, floating sandy materials in the air, air humidity, vegetation, etc.

3.6.2 Geography

(1) Geographical Classification

From hydro-geographical point of view, the Study Area can be divided into the following five zones: 1) Plateau-Waved hills, 2) Alluvial fan、3) Flooding plane, 4) Sand dunes, and 5) Wadi. The characteristic of each zone is described as follows:

1) Plateau-Waved hills

This geographical unit is composed of plateau, waved hills, mountains, and lowland between mountains, pediments and cliffs with an altitude higher than 200 m. These features trend in a NNE (NE) – SSW (SW), NW-SE direction. The area has steep cliffs along the border of plateau and waved hills. The cliffs are 120-300 m high with development of unstable talus deposits. Platy beds crop out with detritus on the flat top of this zone. Low and dry-resistant trees are scattered in depressions or in waterways. As a result, rainwater quickly runs down the land surface without being trapped. This geographic unit acts as surface runoff area from hydrological point of view. It is presumed that it takes short time for rainwater to reach wadis.

2) Alluvial fan

Alluvial fans show extended fan-shaped and gentle sloped deposits formed by fluvial materials and develop commonly at the exits of large wadis between plateau-waved hills and gullies in cliffs. Although small-scale fans have developed in the Study Area due to little amount of deposits, the water resources in fans deposits are important for some oasis.

3) Flood plain

Surface water flows down reticularly, and transports a lot of fluvial materials during local heavy rainfall in the rainy season. Flood plains are located several meters above the actual wadi bed. It is normally located adjacent to wadi courses, and principally composed of poorly sorted coarse sediment, which makes it easy to obtain groundwater from the plain.

4) Sand dunes

The desertification progresses by forming sporadic sand dunes (Barchan) take place in varying topographic features such as recess in steep cliffs, undulations along valleys, and skirts of slopes, etc. Sand dunes tend to become higher towards the inland. Scattered groundwater sources are found at the front of sand dunes covered along wadi courses. In the lowlands between the sand dunes shallow aquifer is available.

5) Wadi

Wadis generally have only watercourse without consistent water flow throughout the year except flooding period and its sources. They are known as Oued or Batha in Mauritania. Wadis in the Study Area show linear or meander depression without clear natural levee. Scattered vegetation is found along waterway in the upper reach and wadiside in the lower reach. Large amount of surface water goes out widely during floods that normally occur once for several years leading to the flush of sandy materials deposited during the dry season and formation of pools in some sections of gently sloping wadi beds. Agricultural land is occasionally washed away by the excavation of undercut slope. Groundwater is available along wadi courses on account of the thick deposit of unconsolidated materials and regional faults. Groundwater level is commonly high in the farm zones which is convenient for the growth of dates and vegetables. After floods some wadi sectors are converted to the cultivated area of some crops such like beans, cereals and gourds.

(2) Drainage System

By means of interpretation of topographic maps and satellite images, it is revealed that the drainage systems in the Study Area generally extend N (NE) - S (SW) in direction in Adrar Region and NNW-SSE in Tagant Region. The wadis start from plateau or waved hills forming reticular, lattice and parallel streams in the upper reach and meander without clear riverbanks in the middle and lower reach. The majority of secondary streams disappear in concaves. In other words, the drainage system is a closed type in the Study Area. Therefore, the river flows of rainfall origin infiltrates and disappears in wadi course or concaves without flowing over long distance.

The surface water coming from plateau – waved hills infiltrates shortly in the wadi plane that makes possible to draw through wells. This fact reveals that wadis play an important role to recharge groundwater. Even though the surface water is not found

in wadis, the filtration of rainfall occurs in pools of the wadi depressions after heavy rainfall in a short duration.

Lineaments are recognized along straight or intermittent wadi course extending over a distance of more than 10 km, which may correspond to faults, lithological boundaries. The majority of cliffs are located in parallel with lineaments. A clear lineament along Oued el Abiod in Adrar Region where Toungad, El Maaden and other oasis are distributed in NW-SE direction over a distance of about 15 km. This lineament is considered an inverse fault. A 10 km-lineament along Oueds Soueiguiya-Amogjar wadi elongated can also be recognized. Many oases are sporadically distributed along NNE-SSW intermittent lineaments in Dahr de Chinguetti. In Tagant Region, lineaments parallel to the wadi in Taamourt en Naaj section, which extends along N'beika and Dakhlat el Fejhaoasis, elongates NW-SE in direction and parallel to the cliffs of the surrounding plateau. Detailed study of lineaments is indispensable for the development of deep groundwater such as fissure water.

From hydrological point of view, some hydrological basins are found in the upper reach, which is closed by rocky narrow exit and extended swamps especially during the rainy season. It can be mentioned that Beraka Ledheima located in the upper reach of Oued N'beika is the typical basin and develops suitable agricultural zone with abundant land and water resources.

3.6.3 Geology

National geological map on a scale of 1:1,000,000 has been edited in 1968 by Bureau of Mining and Industries. Detailed map (1:500,000) covers only some sectors of Adrar Region.

Lower Paleozoic formations, which are composed mainly of sedimentary rocks, form plateaus and waved-hills and overlay Basement Rocks of Pre-Cambrian formations, which are composed of metamorphic rocks (crystalline schist), granitic rocks (granites and migmatites), calcareous rocks, intrusive rocks (gabbros and dolerite). Quaternary no-consolidated sediment, which is composed of aeolian, wadi, flood, and fan deposits, is widely distributed over the said rocks except some plateaus and waved-hills. These non-consolidated sediments were accumulated largely in concaved area of paleo-geography and thinly in plateaus and waved hills.

Tectonic movement only gently affected these layers showing monoclinal dips with less

than 20^{o} of inclination and gentle folds.

In the context of geological history, Basement Rocks are derived from sedimentary rocks deposited in the inter-continental sea, which is presumably Taoudeni Syncline located to the south and the west of the ridge called Regueibat. The syncline extended with a bow shape down through Mauritania to the neighboring countries: Mali and Senegal. The inter-continental sea came to be bounded by faults due to a tectonic movement. Many deltas and fans were formed by wadis that opened to the tectonic depression during heavy rains. Simultaneously uplifting and subsiding movement formed mountains and basins, respectively. The accumulation of fine sediments evaporates and aeolian sediments took place in the basin.

3.6.4 Vegetation

According with the classification presented in **Fig. 2.1.1**, major portion of the Study Area falls under the area of "Desert"; to be more in detail, the areas surrounding Atar falls under the area of "Desert Shrub" and the southern part of Tagant Region is classified into "Shrub and Grass Steppe".

Zones of Desert, Desert Shrub and Shrub Steppe lie in the central and northern interiors of Mauritania where an annual rainfall is less than 100 mm. The dominant vegetation in this area is a grass called *Stipagrostis pungens*. Meanwhile, such drought-tolerant trees such as *Balanites aegyptiaca, Acacia tortilis* and *Acacia raddiana* are found in the Zones of Desert Shrub and Shrub Steppe.

Major natural vegetation species observed during field survey in Adrar and Tagant, are as shown in **Table 3.6.4**.

Table 3.6.4 Main Vegetation Identified in the Study Area

Area	Dominant Natural Vegetation		
Tagant	*Euphorbia balsemifers*	*Acacia senegal*	
Adrar	*Cassia italica* *Aristida pungens*	*Ziziphus mauritania*	*Tamarix senegalensis*
Both region	*Balanites aegyptiaca* *Acacia tortilis*	*Acacia raddiana* *Panicum turgidum*	*Leptadenia pyrotechnica*

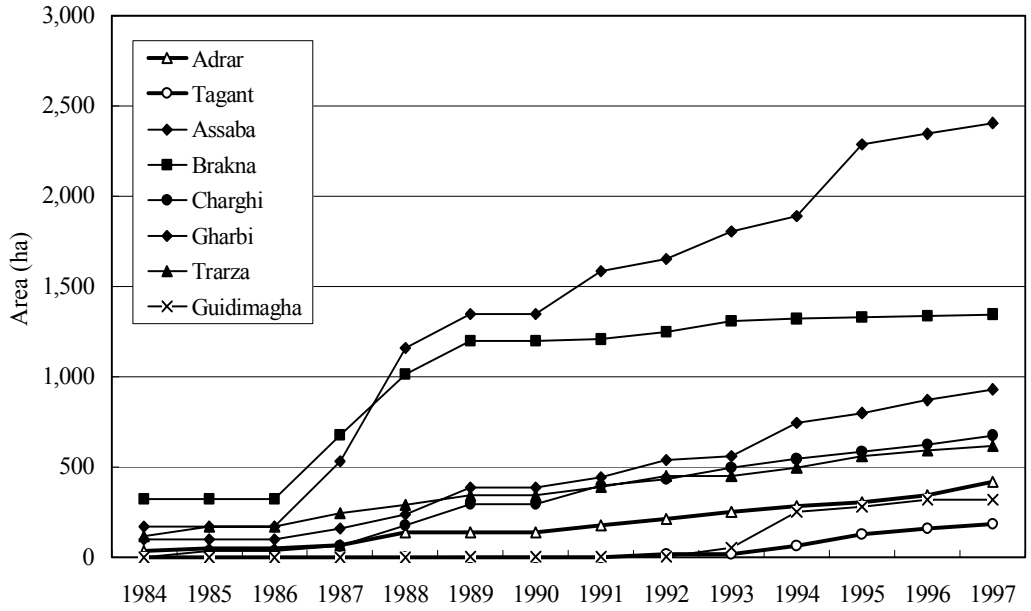
Source: The Study Team

3.7 Sand Stabilization

The first attempt to control sand in the study area was started by the Project of Fighting against sand Dune Invasion and the Development of Agriculture, Livestock and Pasture（Projet Lutte contre L'Ensablement et Mise en Valeur Agro-Sylvo-Pastorale (PLEMVASP) in 1983. This project aimed not only at sand stabilization and afforestation but also at pastoral management and increase in agricultural production. This project was implemented in three phases; in the Phase I, the major activities envisaged in this phase are to demonstrate and enlighten the rural people the importance of the sand stabilization project; in the Phase II, afforestation projects with the participation of oasis residents were put into implementation; and in the Phase III, the activities of the project were extended besides afforestation in such fields as to enhance the living standard of local people and to develop living circumstances of the people to be settled.

The Phase I (1983-1986) of the project was implemented only in Chinguetti and Azougui in Adrar Region within the Study Area.

The results of the project for each phase are shown **Fig. 3.7.1.** By the end of the project in 1997, sand stabilization and afforestation programs including new development activities were realized in 765 sites covering approximately 6,900 ha. However, most of the afforestation programs were carried out in the southern part of the country and the Study Area only represents 9% (6.1% in Adrar and 2.7 % in Tagant) of the share.



Source : Project UNO

Fig. 3.7.1 Area of Sand Stabilization Work by Region

After that, the sand stabilization and afforestation programs have been continuously implemented with aid rendered by FAO and other international agencies. Within the Study Area these programs are taken over to the Oasis Associations in Adrar, Tagant, Assaba and Hodhs. For the other regions where oasis association has not been established, the programs have been carried out by the Direction of Environment and Rural Adjustment of MDRE.

3.8 Hydrogeology

The geological composition relating to groundwater consists of hard Basement Rocks; calcareous, metamorphic and sedimentary rocks, and Quaternary aeolian and alluvial deposits located on concaved ancient geographical features. The groundwater is contained within unconsolidated sediments and hard rocks.

(1) Groundwater in Unconsolidated Sediments

This groundwater type is the most available water resources in the Study Area for daily use. Only localized heavy rainfall to be taken place from time to time during the rainy season of July through September leaves flooding plan inundated and form a large pool of water along the wadi. The cultivation of water resources to the aquifer is made in such incident of heavy rainfall. The aquifer is distributed along wadi courses and surrounding floodplains, and composed of permeable sediments of fluvial origin.

This groundwater type is also available at the base of large sand dunes and in inter-dune depressions. The groundwater is cultivated directly by heavy rainfall through percolation into sand dunes overlaying the wadi bed without evaporation once the water seeps under the surface layer of the dune. Wet surface sand layer is resistant to wind erosion. As a consequence, the low lands remain as they are retaining water underneath.

(2) Fissure water in Basement Rocks

Fissure water can be classified into two types: groundwater flowed within fractures, joints, stratifications, foliations, folding axes, schistosity and lithological boundary ; other one flowed in permeable zones along regional faults and shear zones in sedimentary and metamorphic rocks. Both types passed through long water cycle from rainfall.

The later fissure water is discharged through tube well made by boring works ranging from several 10 m to over 100 m in depth. The development began in the 1950's by the analysis of lineaments through satellite image and geophysical prospecting except for detailed hydrogeological survey. The development of this type of resources is expected to accelerate in order to supply drinking water mainly to urban and village areas. However, there still remain many problems to be solved such as high development cost, less precise geophysical prospecting methods and poor water quality.

3.9 Extension Services and Organization Activities in the Oases

3.9.1 Agencies and Projects relevant to Extension Services

The agencies in charge of agricultural extension services in the Study Area are the Ministry of Rural Development and Environment (MDRE), Regional Office of Oasis Development (URDO) and NGO. Activities of the each agency are as explained hereinafter:

(1) MDRE

MDRE has carried out three projects:

One of them is the PSA (Projet des Service Agricole) started in 1997 which was put into implementation in collaboration with the World Bank. The project, however, was suspended and the majority of the planned activities have left unexecuted.

PGRNP (Project for natural resources management in pluvial areas) is another project started in 1998. The principal target area of this project is the southern part of Mauritania that enjoys relatively large amount of precipitation and the Study Area is alienated from major target areas of the project.

Finally, the third project the Oasis Development Project, which is at present the most important project for the Oasis area of Mauritania including the Study Area. The project has been carried out development activities of oases by region. According to the White Paper Year 2000, the major activities of the project are as follows:

1) Support for organizing associations
2) Support to activities of associations

- Priority activities (commercial infrastructure, medical facilities and educational facilities improvement)
- Women's activities (vegetable cultivation, backyard animal raising, handcraft, sale of gas)

3) Infrastructure improvement (road, drinking water supply facility, pumping equipment)

4) Credit provision system

5) Afforestation activities

6) Improvement of hydro-facilities

7) Training and education

- Training of own staff, training for association and credit union members, maternity education and training for the maintenance of engine pumps.

8) Extension activities

- Enhancement of living standard among farmers, technical investigation of irrigation method on dates, extension of cropping techniques.

The operational fund of the Oasis Development Project is largely dependent on the financial assistance rendered by IFAD and FADES, and the Mauritanian government only shares 8 % of the expenditure. The budget for the year 2000 was UM 617 million and one-third of which is allocated to management of the project and the remaining amount was for direct cost of the project like: formation of associations, support to association activities, credit services, tree planting activities, training and education, extension services, etc.

In Adrar, a total of 10 persons (1 director, 4 experts and 5 members in charge of extension services) are engaged in the project and in Tagant 6 persons (1 director, 1 expert and 4 members in charge of extension services).

(2) URDO (Regional Representative Office of Oasis Development)

The URDO is the most active institution within the Study Area with an emphasis laid on development of the agricultural sector. In collaboration with the Regional Coordination Committee headed by Waly, the URDO is responsible for organizing associations, for planning such programs as water resources development, the environmental conservation, women in development, agricultural development, and for implementation of higher priority programs throughout the region. One of the focal activities of the project is the establishment of mutual credit system (MICO) for oases which envisage an appropriate management of the credit system under solo

responsibility of the oasis association. The policies of each activity are decided in conjunction with the Regional Coordination Committee that is usually headed by Waly.

(3) NGO and other agencies

In the Study Area some NGOs are carrying out small projects in several oases. These NGOs conduct self–financed projects and, at the same time, participate in the projects implemented by the government/international assistance agencies as a supporting member or dispatching required personnel. Leading NGOs and their main services are as mentioned below.

Targa (Morocco):	Extension of cropping technology, handicrafts and baking for women.
Tenmiya (Mauritania):	Extension of cropping technology of date and water-saved irrigation system and other unconventional agricultural technologies.

3.9.2 Constraints on Extension Services in the Oases

Association activities are more active in Adrar region than in Tagant region in such manner as to introduce new varieties of dates and to modernize irrigation system including its operation and maintenance. The reason for advance of Adrar region is that, besides enjoying geographical predominance (nearer to the capital city) traditional oasis community functions favorably there (availability of private investment by big names from the oases).

The Regional Coordination Committee is expected to coordinate with other relevant agencies in rendering extension services within the region, but it is regrettable that the field interview surveys disclosed that this coordination has been made in such inadequate manner as to be implemented similar programs separately by respective agency. Furthermore, deficient staff are filled with support requested to the NGOs and external consultant companies without making coordination in advance in assignment of personnel among concerned sectors.

3.9.3 Association Activities

(1) National Policy and Historical Background on Association Activities

The Mauritanian government announced a policy to establish Oasis Participatory

Management Associations (AGPO) aimed at vitalizing economic activities in the oasis regions. Although small and traditional water users' associations were found in the oasis regions in the past, this is the first attempt in terms of organizing large-scaled association in these regions. Fishery associations were organized retroactive to several decades and have been in operation in an attempt to improve marketability and to secure distribution network of fishery products. However, associations in other industries remain undeveloped.

The activities of the AGPO are not limited to crop production but cover a wide range of activities such as water use and management, environmental conservation, women in development and other aspects relevant to the oasis community. Its function is similar to that of a consumers' association and it pays more attention to the activities other than crop production.

(2) Outline of Associations' Activities in the Study Area

1) Activities of Oasis Projects and Activities of the Oasis Participatory Management Associations

A list of proposed activities to be carried out in the oasis regions are prepared annually by associations in collaboration with URDO. On the basis of this list, the fiscal budget for the subsequent year is requested by the URDO. The budget is prepared referring to the following six categories.

- Water use
- Environment
- Agriculture (dates, livestock, vegetables and others)
- Improvement of women's social status
- Infrastructure
- Priority activity for assistance of associations

2) Trends in Association Activities

An analysis on the activities of associations in the study area shows that the activities programs are forged within the context of the policies of the URDO (consequently that of the UCP) in view of the fact that the URDO's role in the process of their planning is indispensable. The activities carried out from 1997 to 2000 were emphasized mainly in such three areas as: water use and management (pumping of groundwater), assistance to women in development, and improvement of small businesses specializing in daily foodstuff (bread, fresh

meat). This trend is more the case in Adrar region where almost all of 11 associations which had been interviewed for analysis of their activities comprise these three activities in their programs for activities. In Tagant region, meanwhile, the activities were predominantly concerned with water use and management and assistance to women in development; the improvement of small businesses, on the other hand, were carried out at limited a couple of oases with smaller scale, in contrast to Adrar region, and the amount allocated to business improvements in Tagant region is considered to be large accordingly.

3) Collaboration with Relevant Institutions and Other Associations

Besides URDO, the groups concerned with association activities at the regional level include the regional offices of MDRE, the PGRNP, Ministry of Education, Ministry of Health, and so on. WALY, under the Regional Governor's office and the regional office of the MDRE coordinate with these organizations to implement projects as the need arises. In this connection, the associations must first submit their opinions and requests to the regional office of the URDO or MDRE and WALY for review their appropriateness; and later on they are distributed to the relevant ministry or offices according with their scope and characteristics. If the budget of the central government is required, the Ministry of Internal Affairs shall be responsible for distributing the documents to the relevant ministry or bureaus.

(3) Coincidence of the needs of local people with the activities of Oasis Associations

The interviews during the field survey revealed that the pressing demands of the oases residents are in general limited to development of infrastructure such as water resources development, road improvement, medical facilities, educational facilities. And, it is revealed furthermore that no outstanding difference was identified among demands of each oasis. On the other hand, the core strategy of the Oasis Development Project and PGRNP is to promote the development of the regions with emphasis laid on development and strengthening of institutional capability and human resources.

In view of the fact that construction of infrastructure and distribution of commodities still remains under-developed within the regions, it is needless to say that there exists disparity between the needs of the local people at oases and development policies of the agency in charge of extension services. Under the circumstances, the said agency aims at developing and building capability of associations in line with development of physical and social infrastructures

requested eagerly by local people.

(4) Promotion of Participatory Approach

The Oasis Development Project has been put into implementation under the slogan of participatory approach of beneficiaries, in due compliance with the participatory management of oasis associations legalized by the Government. In this connection, the establishment of well-organized implementation agency is considered to be a premise and indispensable factor prior to implementing projects. On the other hand, some projects hold meetings for exchange of opinions with participation of beneficiaries and relevant government staff in an attempt to have better understanding on the contents of projects and to make a modification of these contents, if necessary.

3.10 Tourism

In Mauritania, the development of tourism had been under control of the government in the past, putting only a few specific areas of interest into development. In 1994, the government forged a comprehensive national development policy on tourism and the following areas were selected as high priority areas for tourism promotion.

- Coastal Area
- Oasis area (site of attraction; oasis in desert and ancient cities)
- Eco-tourism-oriented areas (Banc d'Arguin, Jaurin)

Later on, in 1996, following the said policies, the government has tackled to foster the tourism development. In 1999, the tourism-related agencies were privatized, which has triggered further development of the sector.

Table 3.10.1 shows the number of foreign tourists visited in each region in Mauritania in 1999.

Table 3.10.1 Number of Foreign Tourists in 1999

Region	Number
Hod Chargui	320
Hod Gharbi	40
Assaba	605
Gorgol	224
Brakna	45
Trarza	2,768
Adrar	3,055
Tagant	156
Nouadhibou	4,048
Giri	23
Tiris Zemmouer	243
Inchiri	0
Nouakchott	12,295
Total	23,824

Source : MCTA

As an outcome of the privatization policy together with promotion for investment in the sector, the situation was improved considerably, especially in terms of access to major cities of tourism attraction. According to the Ministry, a remarkable increase in the number of foreign tourist was recorded in 2000; the total number of foreign tourist was increased by 30% reaching to about 32,000 in total. In particular, as for the regions of Adrar and Tagant, the growth in number of tourist is highly conspicuous than the national average; the former recorded a growth from 3,055 in 1999 to 10,000 in 2000, meanwhile the latter from 156 in 1999 to 800 in 2000. As indicated in the **Table 3.10.2**, the number of foreign tourist visited to Adrar has been increasing continuously.

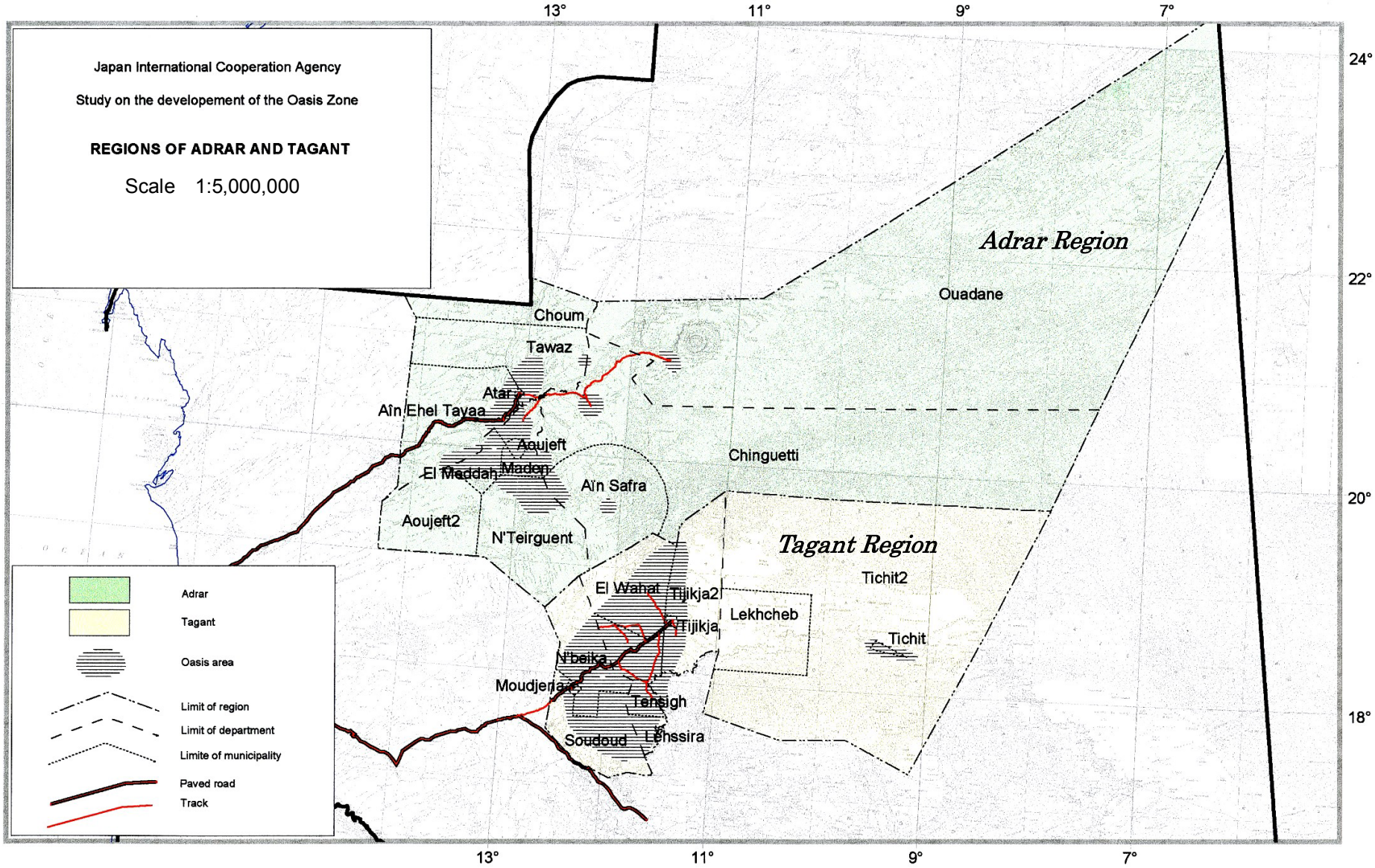
Table 3.10.2 Number of Flight and Tourist by a Charter Flight from Abroad to Atar

Year	No. of flight	No. of tourist
1996 - 1997	3	270
1997 - 1998	12	1,500
1998 - 1999	31	3,500
1999 - 2000	47	5,800
2000 - 2001	47	6,700
2001 - 2002	70	8,700
2002 - 2003	62	9,500

Source : National Office of Tourism

On the other hand, negative impact stemmed from tourism development is brought about like accumulated garbage left by foreign tourist; generally speaking, foreign tourists with

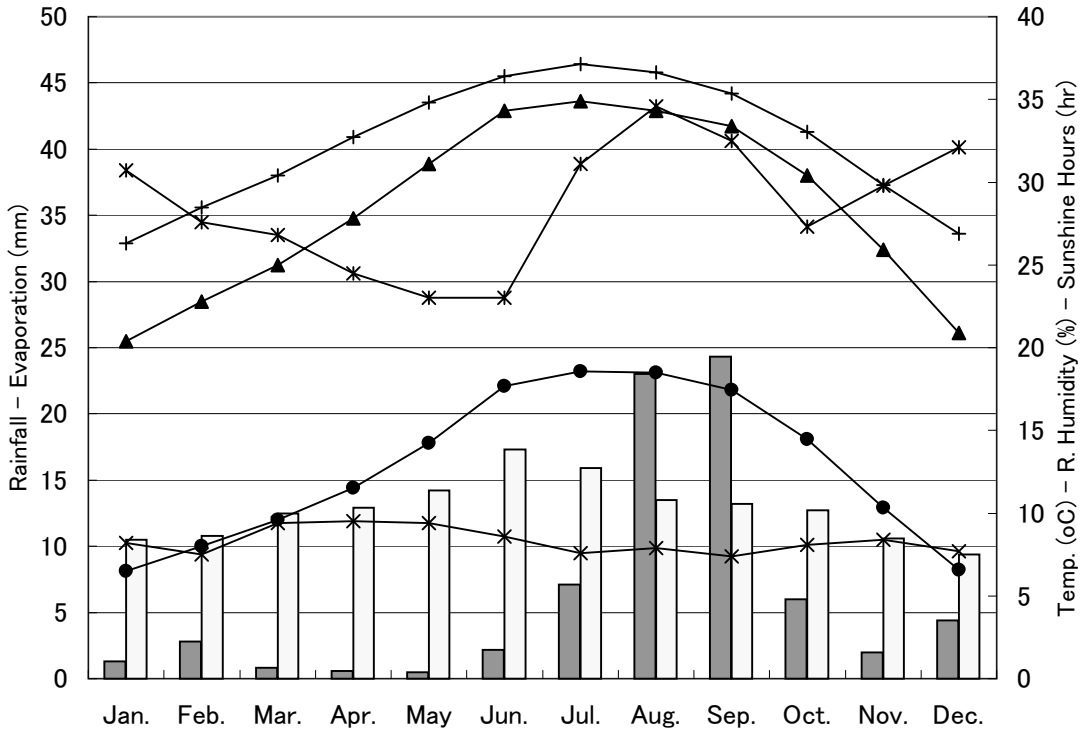
a purpose of camping at oasis or making an exploration into desert area visit the destination with foods and drinks brought from their own country and leave such derivatives as empty cans and bottles, plastic containers and packages, etc, and the environment in the areas in question are aggravated. Furthermore, contamination of water at narrow water spots like Terjite and others attributable to domestic wastes and wastes derived from livestock is observed. The field survey detected colon bacilli in water taken from water intake spot excavated near the small stream from which drinking water is taken. It is thus advisable that development of infrastructure within context of tourism development should be put into implementation paying attention to stem negative impact on water quality and surrounding landscape as far as possible; if necessary, introduction of environmental tax to be earmarked to take measures against environmental conservation should be discussed.



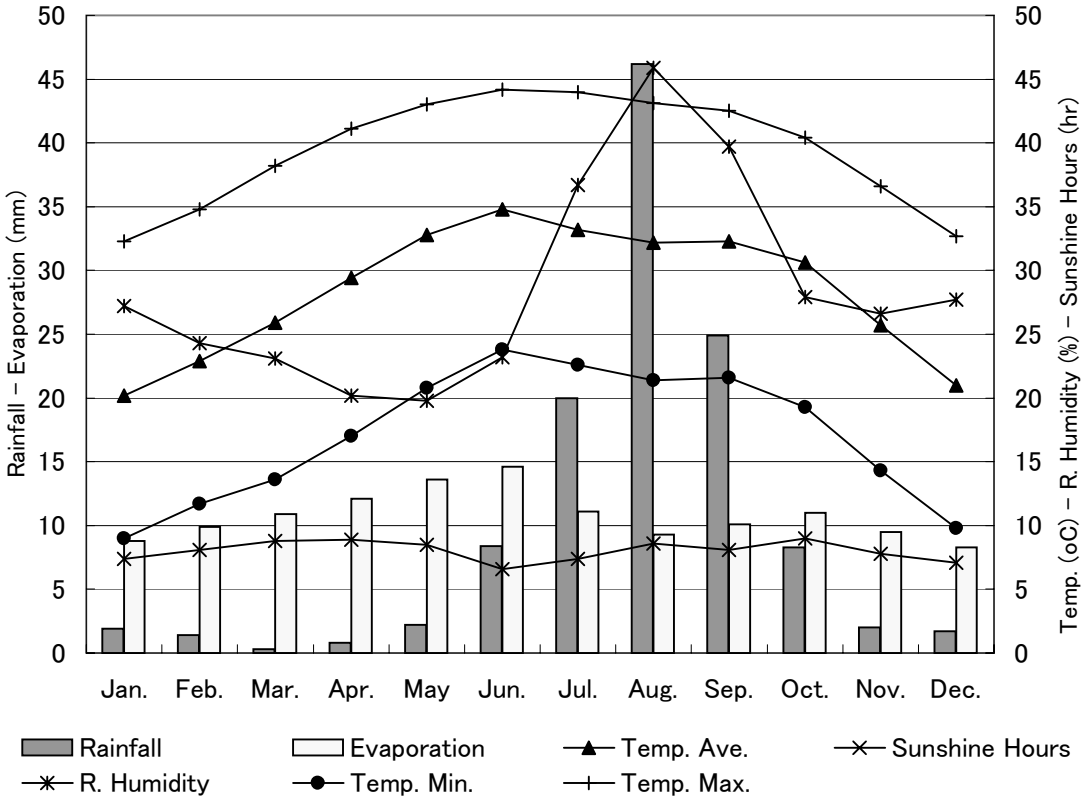
Source : MDRE

Fig. 3.1.1 Administrative Division

Atar

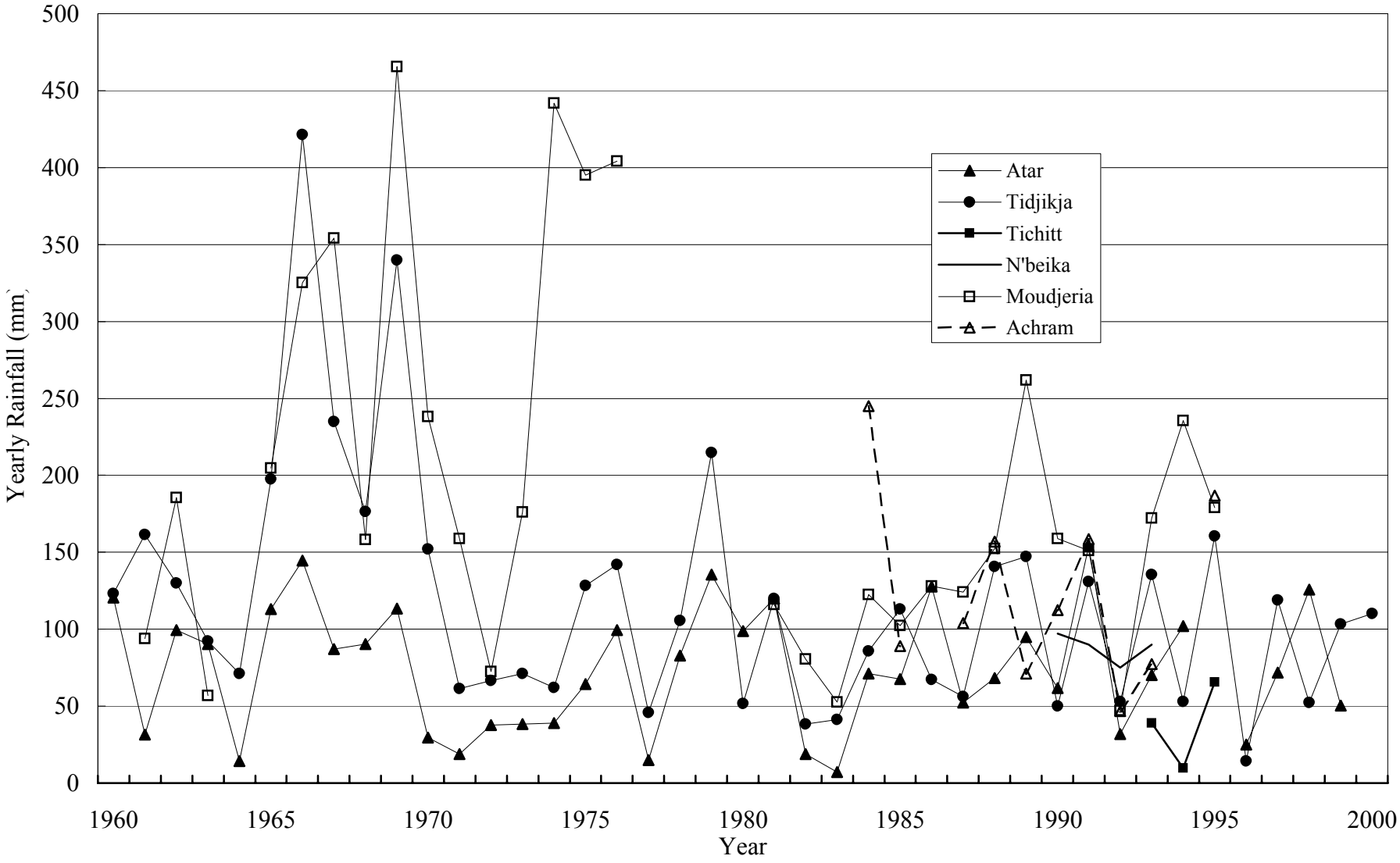


Tidjikja



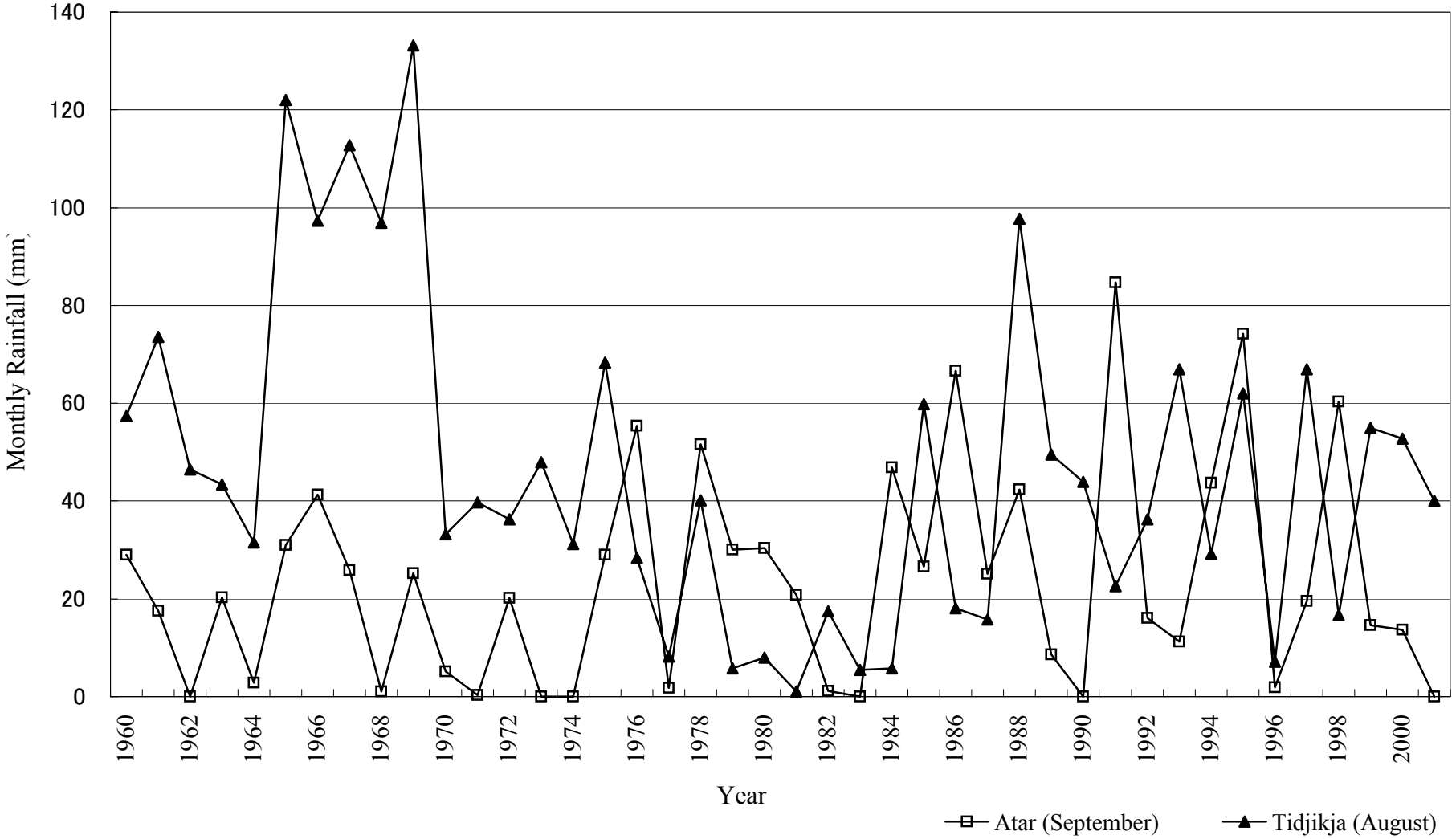
Source : ASECNA and SAM, Tableau Climatologique Mensuel

Fig. 3.6.1 Monthly Mean Meteorological Parameters in Atar and Tidjikja Stations



Source : ASECNA and SAM, Tableau Climatologique Mensuel

Fig. 3.6.2 Annual Rainfall Fluctuation in the Study Area



Source : ASECNA and SAM, Tableau Climatologique Mensuel

Fig. 3.6.3 Monthly Rainfall of Rainy Month in Atar and Tidjikja

Table 3.1.3 Number of AGPO Members

ADRAR				
Name of AGPO		Total*	Male	Female
1	Toungad	154	139	15
2	Azweiga	174	147	27
3	El Maaden	303	250	53
4	Meddah	324	206	118
5	Gleitatt	255	205	50
6	M'haireth	288	224	64
7	N'teirguent	168	134	34
8	Tirebane	154	120	34
9	Timinit	183	131	52
10	Wekchedatt	346	280	66
11	Loudey	177	124	53
12	Kseir Torchane	327	270	57
13	Taizent	151	107	44
14	Tawaz	370	291	79
15	Terwen	293	243	50
16	J'reif	195	152	43
17	Teyaret	264	245	19
18	Ain Ehl Tayaa	246	185	61
19	Chinguetti	204	186	18
20	Tenwemend	281	200	81
21	Ouadane	316	230	86
22	Tenllaba	185	150	35
23	Tenouchert	250	205	45
	Total	5,608	4,424	1,184

source: Projet Oasis Adrar in 2003

TAGANT				
Name of AGPO		Total*	Male	Female
1	Lekhdeima	126	102	24
2	El Housseiniya	156	101	55
3	N'titam	242	221	21
4	Aghlembit	123	112	21
5	N'batt	109	86	23
6	Tichitt	175	145	30
7	Aouenat Erji	126	97	29
8	El Wiaam (Tidjikja)	182	129	53
9	El Kheir Tenmiya (Tidjikja	186	122	64
10	Rachid	358	318	40
11	Nimlane	184	136	48
12	Ederroum	137	94	43
13	Lehoueitatt	214	125	89
14	Zouere	114	75	39
15	Echarim	166	88	78
16	El Gheddiya	119	92	27
17	Ksar El Barka	177	127	50
18	El Adala (Tidjikja)	153	112	47
	Total	3,047	2,282	781

source: Projet Oasis Tagant in 2003

*: Including group member

Table 3.6.1 Monthly Mean Meteorological Parameters in Atar and Tidjikja

Atar Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total/ Ave.	Observation Period
	Dry season low T°			Dry season high T°			Rainy season high T°				Dry low T°			
Rainfall (mm/month)	1.3	2.8	0.8	0.6	0.5	2.2	7.1	23.0	24.3	6.0	2.0	4.4	75.0	1960-'00
Temperature														
°C Minimum	8.1	10.0	12.0	14.4	17.8	22.1	23.2	23.1	21.8	18.1	12.9	8.2	16.0	1960-'67 1970-'00
°C Maxium	32.9	35.6	38.0	40.9	43.5	45.5	46.4	45.8	44.2	41.3	37.3	33.6	40.4	
°C Average	20.4	22.8	25.0	27.8	31.1	34.3	34.9	34.3	33.4	30.4	25.9	20.9	28.4	
Sunshine Hours (hour/day)	8.2	7.5	9.4	9.5	9.4	8.6	7.6	7.9	7.4	8.1	8.4	7.7	8.3	1960-'94
Relative Humidity														
Minimum (%)	17.1	14.9	14.8	13.1	12.9	13.0	16.6	18.0	17.5	15.2	17.4	17.9	15.7	1960-'67 1970-'00
Maximum (%)	44.8	40.7	40.6	37.6	34.0	34.1	46.5	51.7	48.7	39.8	42.6	46.4	42.3	
Average (%)	30.7	27.6	26.8	24.5	23.0	23.0	31.1	34.6	32.5	27.3	29.8	32.1	28.6	
Evaporation (mm/day)	10.5	10.8	12.5	12.9	14.2	17.3	15.9	13.5	13.2	12.7	10.6	9.4	4704.2	1960-'67 1970-'00
Wind Velocity (m/s)	3.6	3.6	3.9	3.8	3.8	4.2	4.0	3.7	3.5	3.1	2.9	3.2	3.6	1961-'67 1970-'00
Sand Stream (time/month)	6	7	9	7	8	9	11	10	7	4	4	6	86	1960-'62 1964-'67 1970-'99
Sand Storm (time/month)	0	1	1	1	1	1	2	2	2	1	0	0	14	1970-'99

Tidjikja Sta.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total/ Ave.	Observation Period
	Dry season low T°			Dry season high T°			Rainy season high T°				Dry low T°			
Rainfall (mm/month)	1.9	1.4	0.3	0.8	2.2	8.4	20.0	46.2	24.9	8.3	2.0	1.7	118.1	1960-'00
Temperature														
°C Minimum	9.0	11.7	13.6	17.0	20.8	23.8	22.6	21.4	21.6	19.3	14.3	9.8	17.1	1970-'00
°C Maxium	32.3	34.8	38.2	41.1	43.0	44.2	44.0	43.1	42.5	40.4	36.6	32.7	39.4	
°C Average	20.2	22.9	25.9	29.4	32.8	34.8	33.2	32.2	32.3	30.6	25.7	21.0	28.4	
Sunshine Hours (hour/day)	7.4	8.1	8.8	8.9	8.5	6.6	7.4	8.6	8.1	9.0	7.8	7.1	8.0	1970-'92
Relative Humidity														
Minimum (%)	15.9	14.4	14.2	12.1	11.8	13.2	21.6	26.9	22.3	16.6	16.2	16.6	16.8	1970-'00
Maximum (%)	38.3	35.1	33.0	29.0	27.9	32.0	52.1	64.8	58.3	39.0	37.9	39.6	40.6	
Average (%)	27.2	24.3	23.1	20.2	19.8	23.2	36.7	45.9	39.7	27.9	26.6	27.7	28.5	
Evaporation (mm/day)	8.8	9.9	10.9	12.1	13.6	14.6	11.1	9.3	10.1	11.0	9.5	8.3	3948.9	1970-'98
Wind Velocity (m/s)	3.3	3.5	3.2	3.0	3.2	3.5	3.3	2.9	3.0	2.8	2.9	3.2	3.2	1970-'00
Sand Stream (time/month)	9	8	8	6	6	8	7	5	5	4	5	8	80	1970-'00
Sand Storm (time/month)	1	1	1	0	0	1	1	1	1	0	0	0	8	1970-'00

Source : ASECNA and SAM, Tableau Climatologique Mensue

Table 3.6.2 Monthly Rainfall and Daily Maximum Rainfall in Atar and Tidjikja

Station : Atar (unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Daymax
1960	0.0	0.9	0.0	0.0	1.8	0.0	69.0	3.0	29.0	0.0	0.0	16.8	120.5	-
1961	0.0	0.0	0.0	0.0	0.0	2.3	9.0	2.5	17.6	0.0	0.0	0.0	31.4	8.2
1962	0.0	0.4	0.0	0.0	0.0	4.0	0.0	93.2	0.0	0.5	0.0	1.3	99.4	31.6
1963	17.0	8.9	0.0	0.0	0.0	0.0	8.5	34.6	20.3	0.9	0.0	0.0	90.2	14.0
1964	0.0	0.3	0.0	0.0	2.4	0.0	0.8	7.1	2.8	0.0	0.0	1.0	14.4	5.0
1965	0.0	2.6	0.0	0.0	0.1	5.2	6.9	16.9	31.0	34.1	16.2	0.0	113.0	18.8
1966	0.0	0.0	1.5	0.0	1.6	0.0	2.1	27.7	41.3	69.3	0.1	0.9	144.5	39.9
1967	0.0	0.0	0.0	0.0	1.9	2.9	13.6	26.5	25.9	0.0	16.2	0.0	87.0	16.0
1968	0.0	28.6	0.0	0.0	0.4	2.9	13.2	29.2	1.1	3.3	11.5	0.2	90.4	22.2
1969	12.3	0.0	0.0	0.9	0.0	1.7	7.8	20.4	25.2	20.1	0.0	25.1	113.5	23.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	1.7	18.0	5.1	4.2	0.2	0.3	29.5	16.3
1971	0.0	0.0	0.3	9.2	0.0	0.0	4.4	0.0	0.3	0.0	4.7	0.0	18.9	9.2
1972	5.4	0.0	7.2	0.0	0.0	2.2	0.0	1.0	20.2	0.0	0.0	1.8	37.8	15.0
1973	0.0	0.0	0.0	0.0	0.0	1.5	0.0	36.1	0.0	0.0	0.7	0.0	38.3	12.4
1974	0.0	0.0	14.1	0.0	0.0	0.0	7.1	12.6	0.0	4.5	0.0	0.6	38.9	8.5
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.4	29.0	0.0	0.0	0.0	64.4	20.7
1976	0.0	0.0	5.0	1.5	0.0	0.0	0.0	36.1	55.4	1.5	0.0	0.0	99.5	40.5
1977	0.0	0.0	0.0	0.3	0.0	0.0	1.5	0.0	1.8	2.5	0.0	9.0	15.1	9.0
1978	1.3	0.0	0.0	0.0	0.0	0.0	16.5	11.2	51.6	1.3	0.0	1.0	82.9	16.5
1979	4.5	0.0	0.6	1.2	1.5	0.0	28.3	25.1	30.1	39.2	4.8	0.2	135.5	25.0
1980	0.0	26.8	0.0	3.2	0.0	10.0	9.0	16.7	30.4	1.5	1.2	0.0	98.8	18.7
1981	0.0	0.0	0.0	0.0	0.0	21.1	10.1	67.8	20.8	0.0	0.0	0.0	119.8	50.8
1982	0.0	1.0	0.8	0.0	0.0	0.0	0.2	15.8	1.2	0.0	0.0	0.0	19.0	15.8
1983	0.0	0.0	0.0	2.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	7.1	5.1
1984	0.0	0.0	0.0	0.0	0.0	19.4	0.0	2.8	46.9	0.0	2.1	0.0	71.2	45.5
1985	0.0	0.3	0.0	0.0	2.5	0.0	26.2	11.9	26.6	0.0	0.0	0.0	67.5	24.8
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.2	66.6	0.0	0.0	0.0	127.8	54.2
1987	0.0	0.0	0.0	0.0	0.0	0.0	2.0	19.6	25.1	5.6	0.0	0.0	52.3	14.5
1988	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.9	42.4	0.0	0.0	0.0	68.3	29.6
1989	0.0	15.3	0.0	0.0	0.0	0.0	14.7	44.5	8.6	0.0	11.7	0.0	94.8	20.8
1990	2.0	0.0	0.0	4.8	0.0	0.0	23.8	31.1	0.0	0.0	0.0	0.0	61.7	16.2
1991	0.0	0.0	0.0	0.0	2.0	0.0	2.1	3.1	84.7	0.0	0.0	62.1	154.0	36.7
1992	1.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	16.1	0.0	0.0	1.2	31.8	10.3
1993	0.0	0.0	1.4	0.0	2.5	0.0	0.8	51.1	11.2	0.0	3.2	0.0	70.2	15.4
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.2	43.7	9.2	0.0	9.0	102.1	19.9
1995	0.0	0.0	-	0.0	0.0	0.0	0.0	18.1	74.2	0.0	5.2	37.7	-	28.5
1996	0.0	2.7	0.0	0.0	0.0	16.6	0.0	3.8	1.9	0.0	0.0	0.0	25.0	16.1
1997	0.0	0.0	0.0	0.0	0.0	1.6	0.0	38.3	19.6	12.3	0.0	0.0	71.8	12.3
1998	0.0	0.0	0.0	0.0	0.0	0.0	10.6	32.9	60.3	18.4	0.0	3.5	125.7	28.6
1999	8.9	0.0	0.0	0.0	2.5	0.0	0.0	10.6	14.6	8.3	2.8	2.5	50.2	7.8
2000	1.7	2.3	0.0	0.0	0.0	0.7	2.4	19.2	15.0	7.8	-	-	-	17.0
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.5		0.6			0.0		
2002	11.2	0.0	0.0	0.0	0.0	0.0	0.0	4.1	30.4	8.8	0.0	0.0		
2003	0.0	0.0	0.0											
Average	1.3	2.8	0.8	0.6	0.5	2.2	7.0	23.0	23.9	6.0	2.0	4.1	74.2	

Station: Tidjikja (unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Daymax
1960	0.0	0.0	0.0	0.0	9.2	10.7	30.9	57.4	14.0	0.0	0.0	0.9	123.1	14.6
1961	0.0	0.0	0.0	0.0	0.0	8.8	23.5	73.6	53.5	2.0	0.0	0.0	161.4	35.3
1962	0.0	1.0	0.0	0.0	0.0	49.8	12.0	46.5	12.3	0.0	8.4	0.0	130.0	43.5
1963	0.0	0.0	0.0	0.0	0.0	1.8	34.6	43.4	10.5	1.5	0.6	0.0	92.4	24.3
1964	3.0	0.4	0.0	0.0	0.7	3.1	2.1	31.5	29.7	0.0	0.0	0.5	71.0	15.3
1965	3.3	1.7	0.0	0.0	4.5	5.0	14.2	122.0	26.4	19.1	1.2	0.0	197.4	64.8
1966	0.0	0.0	0.0	0.0	26.3	5.5	18.7	97.3	91.7	145.9	23.8	12.2	421.4	40.5
1967	0.4	0.0	0.0	0.0	0.0	1.4	3.3	112.8	107.2	2.7	7.1	0.0	234.9	50.7
1968	0.0	33.3	0.0	1.2	0.0	7.0	8.1	96.9	28.8	0.0	1.1	0.0	176.4	60.5
1969	0.0	0.0	0.6	0.0	16.0	0.0	88.5	133.2	50.2	51.2	0.0	0.0	339.7	90.7
1970	0.0	0.0	0.0	7.3	0.0	0.0	0.0	33.2	110.5	0.0	0.9	0.0	151.9	46.6
1971	0.0	0.0	0.6	2.2	0.0	0.0	11.4	39.7	5.9	0.0	1.5	0.0	61.3	30.1
1972	8.8	0.0	0.0	2.0	0.0	6.3	0.0	36.3	6.7	5.8	0.6	0.0	66.5	23.5
1973	1.2	0.0	0.0	0.0	2.2	16.8	1.6	47.9	1.4	0.0	0.0	0.0	71.1	19.5
1974	0.0	0.0	0.0	0.0	0.0	8.7	10.6	31.2	9.8	1.6	0.0	0.0	61.9	17.9
1975	0.0	0.0	0.0	0.6	0.0	1.9	34.0	68.3	8.2	13.7	0.0	1.5	128.2	32.9
1976	37.3	0.7	4.5	1.9	13.4	1.5	0.0	28.4	41.3	0.0	5.5	7.5	142.0	27.9
1977	0.0	0.0	0.0	0.0	0.0	0.0	11.2	8.2	25.2	0.0	0.0	1.1	45.7	16.7
1978	0.0	0.0	0.0	0.0	0.6	0.0	54.0	40.1	8.0	1.0	2.0	0.0	105.7	44.7
1979	8.8	0.0	0.0	0.0	11.2	94.3	11.5	5.8	66.8	16.3	0.0	0.0	214.7	49.4
1980	0.0	4.2	0.0	0.0	0.0	1.6	38.0	8.0	0.0	0.0	0.0	0.0	51.8	36.7
1981	0.0	4.2	0.0	0.0	3.5	22.0	62.0	1.0	27.3	0.0	0.0	0.0	120.0	28.0
1982	0.0	0.0	0.0	0.0	0.0	0.0	20.8	17.5	0.0	0.0	0.0	0.0	38.3	14.7
1983	0.0	2.6	0.0	0.0	0.0	6.3	23.7	5.5	3.3	0.0	0.0	0.0	41.4	23.7
1984	0.0	0.0	0.0	0.0	0.0	27.2	4.7	5.8	46.3	1.9	0.0	0.0	85.9	41.6
1985	0.0	0.0	0.0	0.0	0.0	14.6	35.3	59.8	3.2	0.0	0.0	0.0	112.9	25.9
1986	0.0	0.0	0.0	0.0	0.0	2.1	1.4	18.1	25.3	11.1	9.4	0.0	67.4	13.4
1987	0.0	0.0	0.0	0.0	0.0	2.7	14.9	15.8	22.8	0.0	0.0	0.0	56.2	15.8
1988	0.0	0.7	0.0	0.0	0.0	6.8	4.0	97.7	31.6	0.0	0.0	0.0	140.8	35.7
1989	0.0	0.0	0.0	0.0	0.0	0.0	75.0	49.5	3.5	7.4	11.9	0.0	147.3	38.6
1990	0.0	0.0	0.0	0.0	0.0	0.0	3.3	43.9	2.0	0.9	0.0	0.0	50.1	25.6
1991	9.3	0.0	0.0	0.0	0.7	27.2	43.7	22.6	27.4	0.0	0.0	0.0	130.9	29.8
1992	1.5	7.6	0.0	0.0	0.0	0.0	0.0	36.3	0.0	0.0	7.6	0.0	53.0	15.5
1993	3.5	0.0	0.0	0.0	0.5	0.0	51.4	66.9	13.2	0.0	0.0	0.0	135.5	42.6
1994	0.0	0.0	0.0	0.0	0.0	0.0	4.2	29.2	16.4	3.1	0.0	0.0	52.9	19.8
1995	0.0	0.0	1.4	0.0	0.7	2.1	36.7	62.0	11.2	0.0	0.0	46.5	160.6	36.9
1996	0.0	0.0	5.6	0.0	0.8	0.0	0.8	7.1	0.0	0.0	0.0	0.0	14.3	4.0
1997	0.0	0.0	0.0	0.0	0.0	1.7	0.2	66.9	21.7	28.4	0.0	0.0	118.9	28.0
1998	0.0	0.0	0.0	0.0	1.1	4.7	0.0	16.7	27.9	0.3	0.0	1.5	52.2	16.1
1999	0.6	0.0	0.6	16.0	0.0	0.0	8.2	55.0	19.8	3.1	0.0	0.0	103.3	36.6
2000	0.0	0.0	0.0	0.0	0.0	1.2	20.1	57.2	9.7	22.0	0.0	0.0	110.2	24.8
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.5	2.7	0.0	0.7	0.0	44.9	
2002	16.3	0.0	0.0	0.0	0.5	0.0	0.0	37.8	11.9	3.5	0.0	0.0	70.0	
2003	1.4	0.0	0.0	5.2	4.8	3.7	14.6	58.2					87.9	
Average	2.2	1.3	0.3	0.8	2.2	8.4	20.0	46.2	24.1	8.0	2.0	1.7	117.1	

Source : ASECNA and SAM, Tableau Climatologique Mensuel

Table 3.6.3 Probability of Rainfall in Atar and Tidjikja

Station: Atar (unit:mm)

Exceedance Probability	2	5	10	20	30	50	100	200
Daily Rainfall	18.0	29.2	37.5	46.1	51.3	58.1	67.8	78.0
Annual Rainfall	66.9	107.4	133.9	159.2	173.8	191.9	216.6	241.4
Rainfall in July	0.6	8.8	36.7	119.9	221.9	453.9	1104.5	2491.1
Rainfall in August	15.0	37.3	59.0	85.6	103.8	129.8	171.0	220.0
Rainfall in September	11.8	43.3	84.4	146.0	194.0	269.7	406.2	590.5

Station: Atar (unit:mm)

Non-exceedance Proba	2	5	10	20	30	50	100	200
Annual Rainfall	66.9	37.0	24.7	15.8	11.6	7.1	-	-
Rainfall in July	0.6	0.0	0.0	-	-	-	-	-
Rainfall in August	15.0	5.3	2.7	1.3	0.8	0.2	-	-
Rainfall in September	11.8	2.8	1.1	0.3	0.0	-	-	-

Station: Tidjikja (unit:mm)

Exceedance Probability	2	5	10	20	30	50	100	200
Daily Rainfall	28.0	44.1	55.9	68.0	75.2	84.6	97.9	111.9
Annual Rainfall	96.2	168.3	226.1	289.0	328.3	380.9	458.3	543.0
Rainfall in July	8.3	33.3	68.1	122.6	166.3	237.0	368.1	550.3
Rainfall in August	36.2	70.9	98.5	128.3	147.0	171.9	208.5	248.4
Rainfall in September	13.0	40.4	72.0	115.8	148.1	197.0	280.8	388.1

Station: Tidjikja (unit:mm)

Non-exceedance Proba	2	5	10	20	30	50	100	200
Annual Rainfall	96.2	55.7	42.1	33.6	30.0	26.3	22.4	19.5
Rainfall in July	8.3	1.8	0.7	0.2	0.0	-	-	-
Rainfall in August	36.2	16.6	10.0	5.9	4.1	2.3	0.3	-
Rainfall in September	13.0	3.8	1.7	0.7	0.4	0.1	-	-

Source : The Study Team

CHAPTER 4

GENERAL CONDITIONS OF OASES

CHAPTER 4 GENERAL CONDITIONS OF OASES

4.1 Agriculture

4.1.1 Soil

According to the report entitled "Master Plan for the Struggle against Desertification, Phase II, 1989", soil distribution and its characteristics in the study area are as follows:

The dominant soil in Adrar is fine sandy soil accounting for 65% of the area. Other soils are rocky and sandy soil in the plateau area accounting for 15% of the area, rocky soil covered by dune sand accounting for 10%, the rest is thin desert soil in the plateau area.

In Tagant region, fine sandy soil occupies 40%, brown desert sandy soil originated from calcareous rocks is 30%, non-weathered rocky soil accounts for 30%. The brown desert sandy soil includes alkaline soil. On top of this, alluvial soil (which is important for agriculture) is distributed in some depressions in an area of 24,000 ha.

These soils do not contain nutrients that are needed for cultivation, nor do they have the capacity to retain them.

4.1.2 Land Use

The total land area in the study area is 30 million hectares. The inventory survey conducted in 2001 by the Study Team disclosed that the total area of land used for agriculture in the study area is only about 29,000 ha, which is equivalent to 0.1 % of the total land area of the study area. About 57 % of the cultivated land is occupied by farming land called as Dieri and Bas-fonds where water collected in ponds after a strong rainfall is utilized. However its available area is largely affected by the amount of yearly rainfall. The remaining area of the land is used for cultivation of dates and vegetable, which each account for 40% and 3% of the cultivated area, depending on groundwater (refer to **Table 4.1.1**).

By region, more area is used for dates cultivation in Adrar, while rain-fed farming area prevails in Tagant.

Table 4.1.1 Agricultural Land Use in 2000

(Unit : ha)

1) Adrar	Aoujeft	Atar	Chinguetti	Ouadane	Total
Dates	3,493	3,290	447	418	7,648
Irrigated*	269	582	35	64	950
Rainfed	1,594	2,196	500	1,140	5,430
Total	5,356	6,068	982	1,622	14,028

2) Tagant	Moudjeria	Tichitt	Tidjikja	Total
Dates	2,038	85	1,737	3,860
Irrigated*	16	-	28	44
Rainfed	4,395	-	6,750	11,145
Total	6,449	85	8,515	15,049

Source : Inventory Survey by the Study Team

* : Vegetables mostly cultivated in the area.

According to the inventory survey, the share of land used by absent landowner is 24% in Adrar and 6% in Tagant (Refer to **Table 4.1.2**).

Table 4.1.2 Share of Absent Landowner in the Farm Area

1) Adrar	Aoujeft	Atar	Chinguetti	Ouadane	Average
Share (%)	30	21	10	21	24
2) Tagant	Moudjeria	Tichitt	Tidjikja		
Share (%)	3	47	6		6

Source : Inventory Survey by the Study Team

4.1.3 Date Palms

Date is the most important agricultural product in the oases in terms of its contribution to the regional economy, but also its cultural value. The recurrence of droughts from the 60s to the 90s forced many oases residents to move to urban areas, resulting in decrease of cultivated area of date for having been left without proper cultivation practice.

The **Table 4.1.3** below indicates the change in number of date trees during 1995 – 2000, the number of date trees shows growing trend except for some remote departments.

Table 4.1.3 Change in the Number of Dates Tree During 1995-2000

	1995			2000			Growth rate %/Annum
	Immature (%)	Mature (%)	Number	Immature (%)	Mature (%)	Number	
Adrar							
Aoujeft	47	53	310,364	44	56	327,480	1.1
Atar	40	60	196,745	40	60	223,650	2.6
Chinguetti	41	59	35,700	36	64	31,500	-2.5
Ouadane	54	46	37,600	53	47	29,400	-4.8
Average	44	56	580,409	43	57	612,030	1.1
Tagant							
Moudjeria	9	91	142,200	10	90	159,505	2.3
Tichitt	31	69	25,575	35	65	25,029	-0.4
Tidjikja	20	80	83,360	24	76	179,638	16.6
Average	15	85	251,135	19	81	364,172	7.7

Source : Inventory Survey by the Study Team

Information on the planted area, production and yield by department are summarized in the **Table 4.1.4**. As the said table indicates, the yield in Tagant region is higher by about 50% than that in Adrar region; the yield in the departments of Chinguetti and Ouadane is inferior to that of other departments.

Table 4.1.4 Dates Production in 2000

Adrar	Aoujeft	Atar	Chinguetti	Ouadane	Total
Planted Area (ha)	3,492	3,290	447	418	7,647
Production (t)	3,888	2,805	287	193	7,173
Yield (t/ha)	1.1	0.9	0.6	0.5	0.9
Tagant	Moudjeria	Tichitt	Tidjikja		Total
Planted Area (ha)	2,038	85	1,737		3,860
Production (t)	2,510	324	2,671		5,505
Yield (t/ha)	1.2	3.8	1.5		1.4

Source : Inventory Survey by the Study Team

A young suckering sprout of date palm is raised separately in a facility for two years before it is planted. It is planted in a hole one meter in diameter and appropriate soil is brought to fill the hole.

Date palms are considered productive only from 10th to 60th years and are considered to reach their peak in terms of production in around 40th year. They normally grow 2 segments per year, which is equivalent to 40 to 60 cm in height.

What is important in date cultivation are proper irrigation, proper care of lower fronds, effective pollination and efficient thinning by picking. Details are discussed in the following paragraphs.

1) Care of lower fronds

   Regular removal of lower fronds or dying fronds will work as a protective measure against disease and also it makes it easy to do the work of pollination and picking of the fruits. This will ultimately save much energy required to do the work. In addition, the removed fronds can be utilized for roofing and hedging and also for material for handcraft.

2) Pollination

   The ratio of male and female palms planted in oases is usually from 1 - 50 to 1 - 100. Farmers cut off the ears of male palms into 15 cm segments and fix several of them on the tip of a leaf on the top of a female palm to ensure effective pollination.

3) Fruit picking for thinning

   The appropriate number of bunches is said to be 12 to 14 for a single date palm. When a palm bears too many bunches, some bunches have to be picked off. In the cases where some bunches bear too many date fruits, some fruits have to be removed to avoid getting smaller fruits. Although the unit production of one palm tree is said to be 30 to 50 kg in general, the actual production figures suggest much lower unit production of 22 kg/tree and 23 kg/tree for Adrar and Tagant respectively.

4) Planting density

   The optimum density of the palms is 7 to 8 m between any of the neighboring two palms. However, the planting density in the study area is extremely high, and 104 trees per hectare are planted in Adrar region (10 m intervals) and 602 trees per hectare in Tangant region (4 m intervals).

The varieties, morphological characteristics, taste, price, and other factors are shown in **Table 4.1.5**. The classification is made only on the basis of the production area and of color, size and shape of the fruit. The five varieties of dates that are commonly cultivated in the study area are listed in **Table 4.1.6**. The leading variety is variable by region; El

Homr represents 80% of the total varieties in Adrar region, meanwhile the varieties of Tentergal and El Homr account for respectively 49% and 47% in Tagant region.

It is important to select varieties that will raise the productivity and are suited to each region. The majority of the dates are harvested in Adrar region, but some dates harvested in Atar and Tagant regions are collected and sent to the market from Tidjikja.

Table 4.1.5 Characteristics of Main Dates Varieties

Variety	Color	Size	Form	Taste	UM/Kg	Distribution
El Homr	Y/R	Medium	Ellipse	Sweet	600	Both
Oum Areicha	Red	Medium	Ellipse		200	Tagant
Tentergal	Yellow	Medium			150	Tagant
Tijib	Pink	Big	Ellipse	Very sweet	300	Adrar

Source : The Study Team

Table 4.1.6 Ratio of Dates Cultivated Area by Variety

(Unit : %)

Variety	Adrar	Tagant
El Homr	79	47
Tijib	17	-
Tentergal	-	49
Lemdiha	4	-
Oum Areicha	-	4

Source: Inventory Survey by the Study Team

The price of dates greatly varies between the regions. The average unit price of dates harvested in Adrar was 217 UM/kg and for Tagant was 89 UM/kg. It is said that the climatic and other natural conditions in the region of Adrar are more favorable for date cultivation than those in the region of Tagant. As a matter of fact, the dates harvested in Adrar are traded at higher prices. The prices differ also from oasis to oasis. In Adrar the price ranges from 70 to 652 UM/kg while in Tagant it is between 20 and 173 UM/kg. The occurrence of damage by disease and insects or improper irrigation greatly affects the quality.

In recent years, the outbreak of the soil borne disease, Bayoud, in Adrar region has been a major problem. The details are unknown. The following diseases in date cultivation that have been reported globally are listed below.

1) Leaf blight (Mancha da folha)

Characteristics: Withering of fronds
Cause: Diplodia phoenicicola virus
Eradication method: Improve water discharge facility and improve ventilation and sunlight.

2) Black rot (Queima-preta)

Characteristics: Numerous black spots appear on the fronds and in many cases, they wither and die
Cause: Ceratocystis paradoxa parasite
Elimination method: Quickly remove and incinerate the affected fronds.

3) Fruit disease (Docenca dos frutos))

Characteristics: Fruit rot
Cause: Alternaria citei Ell & Pierce, a germ parasite
Elimination method: The parasite enters through broken surfaces of the fruit. Caution must be taken not to damage the fruit.

4) Others

Root rot, branch rot, mottling disease

Since adequate use of pesticides cannot be expected, effective disease countermeasures include improving the water discharge system and ventilation and sunlight in densely cultivated areas. Affected fronds and stems must be quickly removed and incinerated.

Most of the dates seeds are simply thrown away, but the seeds contain precious nutrition. A certain portion is used as animal feed at present.

Many traditional units have been used to describe things concerning dates. The units used in the two regions are the following ones.

1) Zeriba

It used to mean a small plot of land bordered by a hedge. Now it is a unit of land for cultivation owned by a household.

2) Hofra

The origin of the word is a hole. It now means a group of palm trees growing together in a hollow.

4.1.4 Vegetable Cultivation

Vegetable cultivation in the study area spread rapidly after the formation of oasis associations in many oases. A variety of vegetables are cultivated in every oasis, but carrot is the only vegetable that is cultivated in a large scale for marketing on commercial purpose; harvested carrots are sold to SONIMEX (Societe National d'Importation et Exportation) and some of them are stored at the storage facilities (50 to 100 tons) located in Nouakchott to be sold in April and in May. It is regrettable to report that the majority of the products purchased by SONIMEX are put to disposal. According to SONIMEX, the total production of carrot was 5,200 tons in 2002, of which 1,484 tons were purchased at the price of 45 UM/kg. On the other hand, the sales price at Nouakchott was 150 UM/kg.

The remaining vegetables are forwarded not only to adjacent cities but also to major cities of the country like Nouakchott and Nouadhibou. However, the farm-gate price of vegetables remains as low as one-fifths of their wholesale prices at markets of major cities because of elevated transportation cost together with superfluous supply of produces as a result of concentrated cultivation period which falls in March through May. This marketing situation constitutes leading constraint in promoting vegetable cultivation.

A list of the vegetable varieties that are cultivated in Mauritania is given in **Table 4.1.7**. and typical cropping pattern of major vegetables is illustrated in **Fig. 4.1.1**. The majority of the vegetables are cultivated from September to March except for Violet variety of onion that is cultivated from March to August and Chinois variety of beet and KK variety of cabbage which are cultivated from March to September. Generally speaking, cultivation period tends to be prolonged, because 1). Soils are dried up and hardened after application of irrigation water, 2) growth of plants is inhibited because of decayed roots, 3) harvest period is dispersed, etc.

Table 4.1.7 Main Vegetable Varieties Cultivated in the Area

	Variety	Cropping Season	Seed Price/kg
Tomato	Rome VF	Sep～Mar	18,000
	Henzel 1730	Sep～Mar	18,000
Carrot	Musca	Sep～Mar	7,000
	Nantaise Amelioree	Sep～Mar	7,000
	Japan Cross	Sep～Mar	25,000
	New Kuroda	Sep～Mar	13,000
Onion	Texas Grano 502 PRP	Sep～Mar	14,000
	Violet de Galmired	Mar～Aug	14,000
Turnip	Vertu Marteau	Sep～Mar	5,000
	Chinois Longo	May～Sep	12,000
Cabbage	Copenhagen Market	Sep～Mar	8,000
	KK cross	May～Sep	20,000
Lettuce	Battavia blonde de Paris	Sep～Mar	12,000
Melon	Charleston grey	Sep～Mar	9,000
Watermelon	Sugar Baby	Sep～Mar	9,000
Potato	Ajiba Calibre' ±35	Sep～Mar	600

Source : MDRE

Traditionally vegetable cultivation has been practiced in small plots under palm trees making use of the shade the palms provide and the surplus water used to irrigate palms. However, in recent years, there have been many cases where cultivation is done outside the palm grove making use of the water from a new well in the vicinity. This is because the farmers have problems with landowners, the density of palm trees is too high to use the land underneath, the palm trees are too young. Since date palms need much water in the period of blooming and bearing fruit, it is most efficient to do the vegetable cultivation during this season.

The irrigated area is shown in **Table 4.1.8**. The majority of irrigated area is targeted for cultivation of vegetables, although some portion is covered by wheat. Vegetable farming is growing outstandingly in recent years in Adrar region, headed by carrot, which is followed by tomato and turnip. Tawaz is a leading production department of vegetables with planted area of 280 ha, accounting for one-thirds of the total planted area of vegetables in Adrar region. A market-oriented large-scaled cultivation of carrot is carried out in Tawaz. By contrast, vegetables cultivation in Tagant region still remains in developing stage covering small area, with installation of limited motor pump and without extension of adequate cropping technology.

Table 4.1.8 Irrigated Area and the Production

Adrar	Aoujeft	Atar	Chinguetti	Ouadane	Total
Area (ha)	269	582	35	64	950
Production (t)	3,353	9,829	86	594	13,862
Yield (t/ha)	12.5	16.9	2.5	9.3	14.6
Tagant	Moudjeria	Tichitt	Tidjikja		Total
Area (ha)	16	-	28		44
Production (t)	5	-	44		49
Yield (t/ha)	3.2		0.6		1.1

Source: Inventory Survey by the Study Team

Excepting market-oriented carrot, the area of a plot for cultivation ranges greatly from 1 to 100 m^2. Since it is difficult to properly level a large plot, irrigation water flows into a slight hollow in the plot and stays there for fairly long time without being drained. This condition causes death of plants due to root rotting at the early stage of their growth, which ultimately lowers production.

The production cost of vegetables on the basis of interview survey is summarized in **Table 4.1.9**. As this table suggests, net profit is scarcely expected due to inferior yield level, if labor cost of family is taken into account.

4.1.5 Cereals

As explained in the previous chapter, cereal is cultivated in Dieri and Bas-fonds in the study area. The rain-fed farming area in 2000 accounts for 5,431 ha in Adrar and 11,145 ha in Tagant (See **Table 4.1.10**). The major crops are sorghum and millet. This type of land is a kind of alluvial plain and the soil itself is considered to be relatively fertile. However one of the problems is that the annual rainfall amount restricts the size of cultivation area and this leads to unstable production. As a measure to cope with this situation, many attempts to control running water by barrage have been made so that stable production can be achieved.

The difference in sorghum production in the year 2000 between natural cultivation area (Dieri) and cultivation area with barrage are shown in **Table 4.1.11.** The effect of the barrage is apparent. The production has greatly stabilized and the productivity has increased with the use of barrage.

Table 4.1.10 Change of Rain-fed Area during 1995-2000

Adrar	Aoujeft	Atar	Chinguetti	Ouadane	Total
1995 (ha)	1,858	2,366	500	1,160	5,884
2000 (ha)	1,595	2,196	500	1,140	5,431
Growth rate (%/annum)	-3.0	-1.5	0.0	-0.3	-1.6
Tagant	Moudjeria	Tichitt	Tidjikja		Total
1995 (ha)	3,775	-	4,735		8,510
2000 (ha)	4,395	-	6,750		11,145
Growth rate (%/annum)	3.1		7.3		5.5

Source: Inventory Survey by the Study Team

Table 4.1.11 Sorghum Production in the Study Area (2000)

		DIERI			Barrage		
		Area (ha)	Yield (ton / ha)	Production (ton)	Area (ha)	Yield (ton / ha)	Production (ton)
Adrar	Atar	12	0.30	4	260	0.45	117
	Aoujeft	27	0.31	8	100	0.50	50
	Total	39	0.31	12	360	0.46	167
Tagant	Moudjeria	2,216	0.37	824	3,079	0.60	1,847
	Tidjikja	2,497	0.35	873	1,083	0.60	650
	Total	4,713	0.36	1,697	4,162	0.60	2,497

Source:Division des Statistiques Agricoles/DPSE/MDRE

4.1.6 Other Crops

1) Henna (*Lawsonia inerma*)

Generally, it is grown in the corner of a field or by the side of a well for home-consumption. According to the inventory survey, the oases that are cultivating henna for the commercial market are 4 oases in Adrar region (7.5 ha) and 5 oases in Tagant region (2 ha). The leaves of henna are harvested, sun dried, manually ground, and marketed in powder form. These activities are a source of income for the women's associations.

2) Besappu (*Hibiscus sabdariffa*)

Its leaves and floral parts are consumed and generally, the floral parts are made into a slightly sweet and sour drink as well as jellies and jams.

It is not cultivated in volume as an oasis crop, but mainly for home-consumption in about 10 to 20 gardens.

3) Luzerne

This is a grass of the Astragalus or Torifolium genus known as alfalfa.
If grown under favorable conditions, it can be harvested in 30 days, 5 to 7 times per year. Although it is not grown in large volume as an oasis product, it is widely cultivated on a small-scale. There are three oases in the Adrar region (10 ha) and four oases in the Tangant region (3 ha) that cultivate the crop in large volumes.

4.1.7 Livestock

The **Table 4.1.12** contains information on the number of livestock and the share of female livestock. Within the study area, the proportion of camel and sheep is elevated in Adrar region, while that of goat and cattle is raised in Tagant region.
The diet of cattle and goat is grasses on ground, but goat and camel devour sprigs and leaves of shrubs in addition to grasses, that permit them to be raised commonly in arid region. Owing to abundant grass resources depending on higher precipitation than Adrar region, more cattle are raised in Tagant region.

Table 4.1.12 Number of Livestock and Share of Female in 2000

	Camel		Sheep		Goat		Cattle		Chicken	
Unit	Head	%	Head	%	Head	%	Head	%	×1,000	%
Adrar										
Aoujeft	5,079	64	6,552	84	19,785	82	24	83	7,056	68
Atar	10,549	83	11,060	85	23,745	73	453	77	499	74
Chinguetti	1,450	86	7,015	87	33,300	90	17	85	20	75
Ouadane	1,230	65	450	91	4,700	72	-	-	140	66
Sub-Total	18,308	77	25,077	86	81,530	82	494	86	7,715	68
Tagant										
Moujeria	2,418	78	38,632	90	35,435	71	4,117	83	2,425	67
Tichitt	1,000	75	-	-	300	93	6	67	50	80
Tidjikja	5,322	82	33,673	86	34,411	88	12,153	76	5,950	90
Sub-Total	8,740	80	72,296	88	70,146	79	16,276	78	8,425	83
Total	27,048	78	97,373	87	151,676	83	16,770	78	16,140	76

Source : Inventory Survey by the Study Team

According to the Oasis Atlas 1984, the income from livestock raising accounts for 16%

and 11% of the total income for Adrar and Tagant respectively. The data in 1998 shows the values are around 16 % for both regions indicating slight increase in the proportion of income from livestock in Tagant.

The household ratio of the farms engaged in livestock farming in the study area is shown in **Table 4.1.13**. The findings show that the majority of the households are engaged in livestock farming. The number of households raising cattle in Adrar region is small due to the low rainfall volume and limited feed resources such as pasture land (see **Table 3.5.1**).

Table 4.1.13 Ratio of Household Raising Livestock

(Unit : %)

	Camel	Cattle	Sheep	Goat	Chicken
Adrar	89	16	86	96	49
Tagant	88	79	88	91	45

Source: Household Survey by the Study Team

Table 4.1.14 shows the number of livestock animal head per household. Cattle breeding has decreased in Adrar region due to the lack of pastureland, which is also evident in **Table 4.1.13**.
Purchased feed and date seeds are used in poultry farming. Therefore the numbers of poultry farms in both regions are nearly equivalent, regardless of abundance in natural resources.

Table 4.1.14 Average Number of Livestock per Household

(Unit : head)

	Camel	Cattle	Sheep	Goat	Chicken
Adrar	8.7	0.1	6.7	21.7	2.1
Tagant	2.6	5.1	23.6	20.8	2.3

Source: Household Survey by the Study Team

Generally speaking, an economically efficient proportion of male livestock is said to be 5 to 10 %, but this proportion is elevated to around 20% in the study area. This may be explained by the fact that more young males are kept without being sold.

Generally, people breed animals for the purpose of home-consumption for special occasions or as a form of investment because they can be easily sold for cash.

The following three types of grazing patterns exist in the study area.

- Breeders herd animals outside the oasis from morning till evening, within a circular area of 4 to 5 km of radius. This type of breeding activity is suited mainly for small animals and cattle.
- Typical breeders herd their animals outside the oasis. This pattern of grazing is used for camels and mountain goats that are extremely well adapted to the dry climate. A base outside the oasis is set up in the grazing area and the livestock graze for the entire day. When the forage plants decrease, the livestock are moved to a different area around next base. The milk that is produced at the grazing area is carried back to the oasis and sold to individuals.
- Livestock are consigned to the care of nomads. They are paid in cash or in livestock that have been bred, which is divided between the owner and the nomads according to a prior agreement. In exchange for the care of the livestock, the owner may also care for the date fields of the nomad.

The average speed of movement is 1 to 1.5 km/hour for grazing of animals during the migration.

The amount of available plant resources in the surrounding areas of oases is closely related to the amount of rainfall. During and immediately after the rainy season, areas such as Dieri and Bas-fonds provide desirable conditions for watering animals. As the water recedes the areas are either used for farming or become pasture ideal for animal grazing. When there is ample plant resources for feeding, breeding of cattle will be possible.

Chickens are always kept close to residential areas because they easily enter cultivation plots and damage the crops. There is a need to supply farmers with fish powder and date seeds, inexpensive feed, to expand poultry farming in the future.

The following major livestock diseases are found in the study area.

1) Cattle
   Bolinus, parasites, skin tubercule

2) Mountain goat, sheep
   Enterotoxsomia, itch mite, digestive tract parasites

3) Camels
   Strongyloides, Trypanosoma, diarrhea, itch mite, pasturella

The same diseases occur in both regions and it is unclear as to whether these diseases have being treated.

4.1.8 Technical Extension

Presently, the following agricultural extension institutions are found in the study area:

- Delegue Regional de MDRE
- Regional rainfall natural resource management project (PGRNP)
- Oasis Project (Unite Regional de Project Oasis)

All suffer from an inadequate number of staff personnel and activities. This has been compounded by the lack of agricultural research and training facilities for the oasis. There are no facilities to train extension personnel.

The source of technical extension for each oases based on the findings of the inventory survey implemented in the study area is shown below. The source differs according to region. In Adrar region, nearly half of technical extension activities is provided through other farms and 26 % from the government and NGOs. In Tangant region, 57 % technical extension activities are provided by government organizations and NGOs and only 7 % from other farmers (see **Table 4.1.15**).

Table 4.1.15 Technical Extension by Source

(Unit : %)

	Government/ NGO	Other Farmers	Others
Adrar	26	54	21
Tagant	57	7	37

Source : Inventory Survey by the Study Team

NGO and government extension activities in Adrar region were concentrated in Aoujeft department and there was only one oasis where extension activities were found. Extension activities in Tagant region were mainly conducted at oases located along the arterial road.

4.1.9 Inputs

According to the findings of the inventory survey, there were 8 oases in Adrar region and 10 oases in Tagant region that utilized chemical fertilizers. The fertilizers were compound fertilizers (10-10-20), superphosphate and urea. Due to the lack of knowledge about their use in sandy soil, the effectiveness has been minimal. Animal manure is generally used in

vegetable cultivation.

The number of oases utilizing pesticides were 9 in Adrar region and 18 in Tangant region; and the number of oases using disinfectants were 3 in Tangant region and none in Adrar region. Sulfur is commonly used in Adrar region and various agrochemicals are found in Tagant region.

4.1.10 Marketing Organization

A governmental agency relevant to marketing of vegetables in the oasis region is SONIMEX (Societe national d'Importation et Exportation) that belongs to Ministere de Commercialisation and this agency is in charge of importation and sale of rice, sugar and tea, among others.

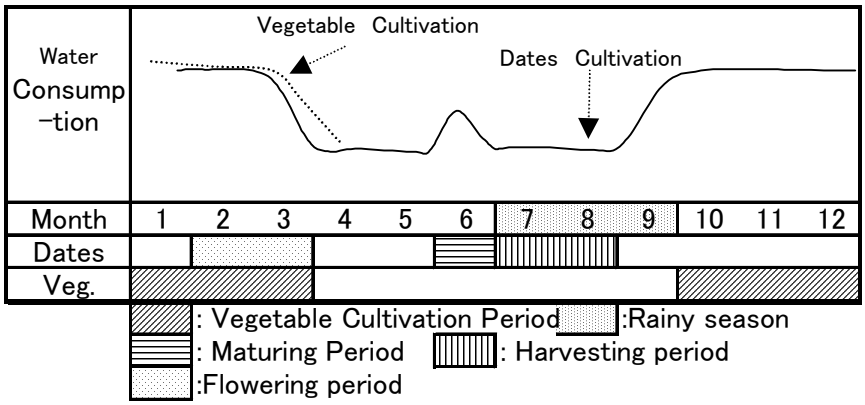
SONIMEX mainly purchase from farmers exclusively carrot harvested at the oases within Adrar region through the market in Atar in order to support them. Greater portion of the carrots thus purchased by SONIMEX are disposed as garbage due to the limited capacity of the storage facility, but some (50 – 100 tons) are stored in refrigerator for forwarding them to markets from the end of April to May.

National budget is earmarked to purchase of carrot by SONIMEX; 945 tons of carrot were purchased in 2001 at a unit price of 30 UM/kg and 1,484 tons in 2002 at 45 UM/kg; it is proposed to purchase 2,350 tons of carrot at 50 UM/kg in 2003.

4.2 Irrigation

4.2.1 Present Conditions in Irrigation

Agriculture in the oases is mainly centered on date cultivation and consequently, the water is mainly used for date cultivation. The oasis water usage patterns are shown in **Fig. 4.2.1**. In general irrigation for date palms is done only about 4 times a month during the rainy season. It is after the rainy season that the irrigation becomes intensive. It continues at a pace of 2 to 3 times per week for the following 6 to 7 months until the date palms bear fruits. The amount of irrigation water is gradually reduced after that.



Source: The Study Team

Fig. 4.2.1 Schematic Figure of Water Requirement

Generally speaking the water withdrawn from traditional wells is manually supplied to the farms or is distributed by gravity flow to the surrounding plots through earth channels. On the other hand, the water pumped from modern concrete framed wells is first stored in a reservoir and then distributed to plots through earth channels. This method of water withdrawal by engine pump seems to be widely adopted especially in Adrar region. However the study team observed that many pumps are left broken due to the unavailability of spare parts and sometimes fuel. In addition to these maintenance problems there is an economic problem. The farmers bought the pumps on loan and although the unit yield and production somehow increased, the increment in the unit yield and production was barely enough to pay back the loan and hasn't brought much benefit to the farmers.

The distribution of water is done through earth canals with a few exceptions. With this irrigation method water loss in the course of conveyance is considered as high as 30%. Therefore it will be indispensable to come up with an idea to the save water by either reducing infiltration or making use of the infiltrated water. This is going to be a critical issue in developing agriculture in the oases, since it affects the possibility of their survival.

The features of each withdrawal and irrigation method are presented in more detail in the following paragraphs:

1) Irrigation with manual water withdrawal

Water is taken manually from shallow wells with a diameter of 1 to 2 m and it is manually supplied to each plant. While the cost of maintenance is the lowest, the magnitude of irrigation is quite limited to 20 palm trees per well.

2) Irrigation with water withdrawal by balance (shadof)

This is a type of manual water withdrawal but uses a device called shadof (a large balance with counter weight on one end) to reduce the burden of withdrawal. Since the water is supplied to each plot manually, the magnitude of irrigation is quite limited to 20 palm trees per well.

3) Irrigation with wind pump

This type of irrigation can be found along some wadis where there is steady wind and water level is relatively low. The pumped water is stored in a tank and then supplied to each plot through earth channels. This method has the advantage of low maintenance cost and stable water supply, but lower pumping capacity leads to longer working hours. This system can supply water up to 50 date palms a day.

4) Irrigation with engine pump

This system can be used even if the water level of a well is very low. It is able to supply water to 50 - 70 date palms a day. However, proper maintenance of the pumps such as procurement of fuel and spare parts is critical in the long run.

5) Irrigation with solar powered pump

This system can also be used even if the well water level is very low. It is able to supply water to 70 - 120 date palms a day. However because of high initial cost and uncertainty of maintenance, this system is not used for irrigation in the study area. If this system is introduced, proper operation and maintenance system will be indispensable.

In addition to the 5 systems described above, the study team observed a drip irrigation system using PVC pipes in Toueikikt in Adrar region. This is a private system introduced by the landowner of the farm. Also, in Toungad, spring water is used to irrigate palm trees.

4.2.2 Water Quality for Irrigation

The findings on the water quality from the inventory survey are compiled in **Table 4.2.1**. The survey covered 62 and 77 irrigation wells in Adrar and Tangant regions, respectively.

Table 4.2.1 Water Quality of Irrigation Wells

(Unit : %)

Class	S1	S2	S3	S4
Adrar	50	11	10	29
Tagant	65	12	6	17

Source : Inventory Survey by the Study Team
S1,S2: Suited for irrigation, S3: Marginally suited for irrigation with some measures, S4: Unsuited for irrigation ,
S1:0-10, S2:10-18, S3:18-26, S4:26<

The inventory survey has revealed that the groundwater used for irrigation purpose in Adrar region is featured by from slight acidity to slight alkalinity with pH of 6.5 – 8.7. An average SAR value of irrigation water was 26, and 39% of the samples were classified as S3 and S4.

The water quality of the groundwater utilized by each oasis in Tangant region was in the range of pH 6.8 – 8.4, that indicates that the water quality in this region is featured by from slight acidity to slight alkalinity. A site with high EC water was also discovered, but an average SAR value was 14, lower that that in Adrar region. Of the total samples taken, only 23% of the samples were classified as S3, S4. The overall water quality was comparatively good.

Although there was no obvious sign of damage caused by high salinity in areas where saline water was found, the production and quality of dates were lower compared to other areas without saline water problems.

4.3 Water Resources

4.3.1 Groundwater

The only water resource that can be used for irrigation purpose in the Study Area is groundwater. Surface water, which is scarcely found with useless discharge, can not be considered as target water resources for development. Groundwater consists of two types: shallow groundwater to be taken through excavated wells and deep one to be pumped through pipes.

(1) Shallow Groundwater

Shallow groundwater is the most important water resource to be indispensable for

the human life in oases. The proportion of wells by purpose is as follows: for irrigation (71% in Adrar region and 47% in Tagant region), for dual-purpose (24% in Adrar region and 49% in Tagant region), for domestic use (4% in Adrar region and 2% in Tagant region) and for drinking of livestock (1% in Adrar region and 1% in Tagant region). In both regions, the number of wells is increasing year by year; in particular, the wells for irrigation use have increased by 41% for the last decade (1990 – 2000). As of 2000, the distribution of wells was 15,644 wells in Adrar region and 8,835 wells in Tagant region. On the other hand, private ownership of wells represent 82% of the total wells in Adrar region and 74% in Tagant region and the rest of the wells belong to local governments and the National Waterworks, with a share of 18% and 26%, respectively.

Shallow groundwater is widely distributed: i) along wadis, ii) in dunes, and iii) in basement rocks; i) is formed by infiltration of rainfall within the basin, ii) is cultivated through eliminating evaporation loss owing to dunes covering wadis, and iii) is composed of fissure water located along fragile line of geological structure and lithological boundary.

Wells installed within the Study area consist of concrete wells made of concrete walls and traditional ones made of mason work or with exposed sediment. Both of these wells are circular type with inner diameter 0.8 – 2.0 m and with depth less than GL – 10m (Refer to **Table 4.3.1**).

Table 4.3.1 Feature of Shallow Wells

Region	Well Type	Depth (GL-m)	S.W.L. (GL-m)	Discharge (m^3/day)
Adrar	Concrete Well	12.9 (3.4-27.5)	8.8 (2.0-21.3)	(2.0-3.0)
	Traditional Well	9.3 (3.2-23.4)	7.5 (1.6-19.1)	-
Tagant	Concrete Well	23.0 (4.6-43.0)	16.7 (4.0-35.0)	1.9 (0.6-4.0)
	Traditional Well	10.3 (6.0-18.0)	7.4 (4.0-13.6)	1.2 (0.2-2.5)

Source : MHE, Direction de l'hydraulique 2002 note : above values indicate Average (Range)

In Adrar region where groundwater within basement rocks is pumped, most of wells for pumping are located in parallel with complementary wells for installation of motor pump. The greater part of these wells are made of simple structure without frame, being surrounded with plain stones, and thus are subject to penetration of foreign materials like floating sand and organic substances. As maintenance task of wells, elimination of sediments or excavation works is carried out in case of deterioration of pumping volume as a consequence of penetration of floating sand or

clogging of aquifer.

A rubber bucket with rope, pulley and a balance system called “shadouf”, a traditional pumping method in Mauritania, are usually used to access the shallow water. Besides, in some cases people use motor pumps powered by gasoline, diesel and butane gas, submergible pump by solar batteries or wind-power pump. In the oases of Adrar Region where groundwater level is generally deepened, about 51 % of irrigation wells are equipped with motor pump, meanwhile in the oases of Tagant region where groundwater level is less deepened pumping of groundwater by means of shadouf prevails.

The groundwater level, which varies depending on hydrogeological conditions and groundwater type, ranges from GL-3 to -7 m in greater majority of wells in both regions. However, the groundwater level of wells pumping fissure water is generally deepened and some of these well have groundwater level deeper than GL-30 m. Although the shallow groundwater level shows slightly lowering trend in the long run, rising phenomenon is observed after rainfall. It is disclosed as an outcome of interview survey among local people at oases that many wells have decreased their groundwater level over the last 40 years; especially, the continuous drought years in the early 70s caused drastic decrease of groundwater level. 60 % of wells indicate declining water level in Adrar Region, while only 20 % of the wells indicate water level decrease in Tagant Region.

As the lowering of water level continues at many oases in Adrar Region, it has become difficult to access water manually and people have started using motor pumps starting in the 60s. This lowering trend of groundwater level is accelerated in the 70s when large-scaled vegetables cultivation was put into implementation and is continued up to date. Now, many pumping wells suffer from the decline in water head, and for this reason, inhabitants have placed pumps at complementary wells in lower levels and then replaced them with higher capacity pumps or excavated new wells nearby in Adrar Region. The situation negatively affects the water resources of the oases as a vicious cycle. After the introduction of motor pumps, limited groundwater resources are being used up and the water quality is getting worse.

(2) Deep Groundwater

Deep groundwater includes fissure water located along regional faults and shear zones, and confined water below wadis. This type of groundwater is distributed at intersections of several lineaments or along large wadi points and is pumped

through piped wells with a depth of from several tens meters to more than 100 meters, excavated by boring machine. The **Table 4.3.2** below resumes the feature of deep wells by region on the basis of inventory book compiled by Direction of Hydraulic and Sewerage, Ministry of Hydraulic and Energy.

Table 4.3.2 Feature of Boreholes

Region	Depth (GL-m)	Casing Diameter (cm)	S.W.L. (GL-m)	Discharge (m^3/day)
Atar	52.6 (6.0-220.0)	52.8 (10.0-203.0)	9.6 (0.3-44.6)	14.0 (1.0-50.0)
Tagant	45.0 (10.0-200.0)	19.7 (10.0-72.0)	13.3 (2.4-33.0)	8.5 (1.0-80.0)

Source : MHE, Direction de l'hydraulique 2002 note : above values indicate Average (Range)

All deep wells are equipped with a submersible motor pump that is usually powered by diesel or gasoline generator in Adrar Region, and solar panel in Tagant Region.

Deep wells had been exploited for supply of potable water to rural and urban sectors and most of them were constructed during the period of 1985 – 1987 within as a part of groundwater development project carried out by former Direction of Hydraulic or owing to foreign-aid program of the Kingdom of Saudi Arabia and other foreign donors.

According to the inventory survey, 54 boreholes in Adrar Region and 65 boreholes in Tagant Region were recognized. In addition to these boreholes, the European Union (EU) and the German Society for Technical Cooperation (GTZ) drilled several tens of boreholes. It is regrettable although that, of these boreholes, only limited ones have contributed to public benefit with production of target volume of pumping water.

From the 1950s the leading prospecting method of groundwater consists of the lineament analysis by interpretation of satellite images and geophysical prospecting and detailed hydrogeological survey has not been put into implementation yet. This type of groundwater production wells and investigation wells are already excavated within the Study area, most of which are located in Adrar Region. It is supposed that exploitation of fissure water resources should be promoted in the future, subject to easing such constraints on exploitation as elevated exploitation cost, less accuracy of geophysical prospecting method and inadequate water quality. Furthermore, it is recommended that responsible public services on prospecting behavior of water resources should be rendered with implementation of quantitative and qualitative

monitoring on water resources.

4.3.2 Hydrogeology

Three sheets of hydrological map on limited area of Adrar Region with a scale of 1/200,000 which were published by Ministry of Construction, Public Works and Transport are available. Geological structure of the oases is represented by crystalline basement consists of calcareous rocks, metamorphic rocks, deposits rocks, etc, as well as by Quaternary sediments accumulated in concaved area of paleo-geography and by alluvial sediments. Groundwater exists within basement rocks and non-consolidated sediment layers.

(1) Ground water within unconfined sediment layers

The most common groundwater is unconfined type distributed along the wadis in oasis area. Only localized heavy rainfall to be taken place from time to time during the rainy season of July through October results in surface water to be flown down and forms some large and small puddles at concaved lands. This rainfall – surface water contributes to cultivate groundwater resources. Aquifers are composed of permeable sediments stemmed from the wadi and are distributed along wadi and around flooding plains.

Making a reference to the geological column map elaborated as a consequence of observation of the Study Team on excavated columnar at a construction site of a new well, it is disclosed that fine and medium-grained sand layer ranging from 2 to 5 m in thickness and mixed with obvious laminas and slantingly intersected layers is distributed. This layer overlies the alternation of strata composed of silty fine sand, silt and occasionally coarse sand layers. The upper layer is a permeable layer formed by flooding, which is vulnerable to infiltration of rainwater. Groundwater is found in spots in unconfined aquifers lying over impermeable clay, silt, or calcareous hard clay layers. Groundwater is located principally in coarse-grained sand layers distributed at around GL –6m and it is presumed that thick sandy silt forming upper layer makes up impermeable layer. Judging from the distribution of basement rocks along the wadi, the thickness of unconfined sediment layer may range from several meters to ten-odd meters.

The groundwater along wadis comprises the groundwater in sand dune. It is found in the section in which wadi is covered with sand dune; in such section groundwater which is made of infiltrated rainfall is stored without being evaporated owing to sand

dune covering groundwater. On the other hand, wet surface sand layer among dunes is resistant to wind and the lowlands thereby remains they are retaining water underneath. This type of groundwater can be observed only at Toungad oasis in Adrar Region, which is located toward downstream from desert front in the narrow valley. In this area, date trees are grown densely not depending on irrigation but owing to higher groundwater table.

(2) Fissure water along fracture zone in basement rocks

Fissure water can be classified into two types: groundwater stored within fractures, joints, layers, flows, frilly curved axis and schistosity of alluvial rocks and metamorphic rocks, other one stored within permeable zones along regional faults and shear zones in basement rocks. Both types passed through long water cycle from rainfall.

The former fissure water stemmed from fractures, etc. of basement rocks can be observed optically its spring at wells; in Tawaz, Adrar Region along schistosity of pelitic schist and in Tidjikja, Tagant Region along fractures of sand stone.

(3) Water Quality of Groundwater

It is the duty of CNH (Centre National d'Hygiene) under Ministry of Health to ensure the water quality of wells. According to the water resources law, the authorities should regularly check the quality of water from wells and water from taps. Since the country has no national standard of water quality, they temporarily adopt the one prepared by World Health Organization (WHO).

Probably the gravest problem concerning water quality is high salinity of the groundwater (deep and shallow) in Adrar and Tagant Regions. Nothing but Electric Conductivity (EC) is investigated at the time of completion of wells. The oases with such problem are geographically scattered. During the field study, salinity problems were identified in Ain Savra of Chinguetti department, Gralet Lefrass and Azougui of Atar department, and M'haireth of Aoujeft department in Adrar Region, and Moudjeria, Yaghref of Moudjeria department and Tichitt of Tichitt department in Tagant Region. Some of them have wells with EC values over 5,000 μs/cm. In addition, shallow groundwater with higher EC value is observed at some wells for monitoring. According to CNH the groundwater with EC values inferior to 2,000 μs/cm is considered to be eligible as potable water in Mauritania. Salinization of groundwater is detected more frequently for shallow wells with relatively high

groundwater level than for deep groundwater. Also, even within a same oasis, different salinity was sometimes observed for a group of wells located nearby each other, depending its water on different aquifers. In many oases people have no other choice than to use the highly saline groundwater for irrigation, due to lack of other water resources. The salinization seems to have been caused by mixing highly saline fossil water in evaporate formations with freshwater as the water table descends. A study will be conducted from the hydrogeological point of view by site to propose appropriate countermeasures against this problem in the future.

Another quality problem is biological contamination by coliform bacteria. The contamination occurs when animal dung and shifting sand fall into a shallow well whose opening is at the ground level without well frame. The result of water quality tests at such sites indicate that some water samples are unsuitable for drinking. The Household Survey result shows that there are many cases of diarrhea among the residents of the Study Area and it is, in most cases, caused by the water contamination in wells resulting from the situation described above.

4.3.3 Artificial Recharge of Groundwater

Localized rainfall taken place during July – October results in forming large and small ponds and swamps at valleys and concaved lands along wadi. In Mauritania, a number of dams and weirs were constructed in the Study Area to store such excess surface water and to make it an effective use as well as to prevent flooding damage. In this country, dam is defined as a structure to store the surface water in a reservoir, meanwhile a weir is defined as a structure to dam surface water temporarily. Up to date, around 450 dams and weirs have been constructed nationwide benefiting total lands of 4,000 ha of land for agricultural production, prevention of flooding damage and retaining flowing surface water to promote recharge. These facilities are managed under the Direction of Environment and Rural Management of MDRE.

Actually, 16 dams in Adrar and 66 in Tagant Regions were constructed in the Study Area The structure of all the dams are filled type with trapezoidal section that is composed of impermeable clay core and cement facing or gabion pile for transition and filter layer around the core. Most of the dam bodies have overflow weirs and spillways in the middle of the crest. Water is trapped by the weir and becomes available only after heavy rainfall, which occurs every 2-3 years on average. It is presumed that about 10% of total reserved volume can be utilized and a single dam supplies water for 10-500 ha of irrigable area. After decreasing the water level, the reservoir is used for cultivation of sorghum and millet, and natural pasture. However, irrigated farming depending on the use of stored

water is not actively pursued.

In an attempt to brake discharge of water during flooding, to make gentle inclination of riverbed, to mitigate erosion of riverbed and to promote recharge of groundwater, weirs are constructed in the bottleneck section of wadis where outcrop basement rocks are on both banks, the width of wadi is relatively narrow and the sediment is thinly accumulated. There are 20 weirs in Adrar Region and 23 in Tagant Region. The structure of these weirs is that a ditch with a width of some meters is excavated to across at right angle to the river course and a geotextile in the narrow sense composed of geo-nonwoven made of permeable sheet-type macromolecular product is placed, and gabions or concrete walls are installed on the said geotextile sheet for forming a barrier in the wadi course. It is generally installed an apron downstream of these weirs. The width ranges from 10 to 100 m. Judging from the field observation of the growth of natural pasture along wadi course sedimentation of fluvial materials upstream of one of the weirs, they are considered to be working effectively. Nevertheless, it is reported that some of the weirs have never been operated in an absence of flowing surface water due to an inadequate selection of the site for their construction.

The dams and weirs are designed processing the design discharge values on the basis of precipitation data without availability of river discharge data actually registered. As a consequence, the designed dimension of these structures may be under-estimated due to the fact that about 38% and 20% of dams and weirs in Adrar Region and Tagant Region respectively were damaged; these structures are vulnerable to flooding damage as a consequence of inappropriate structural design based on under-estimated return period of flooding and unforeseeable flooding scale. On the other hand, it is reported that the dam body was easily destructed because river course of wadi was dug due to convergent small flows at the time of flooding. Furthermore, some dams have trees growing out of their bodies and are losing their structural stability.

4.4 Sand Stabilization

4.4.1 Shifting Sand Conditions in the Study Area

Shifting sand and sand drifts occur throughout the study area. It is the cause of agricultural damage and it impacts the daily lives of the residents. The following summarizes the types of damage and the areas affected based on the information collected from the field study.

1) Overall impact of sand drifts

   The sand from the surrounding vast sand-desert areas invades an oasis causing sand dunes to bury farms and buildings. (Rachid, N'beika, Aoujeft, etc.)

2) Influence on the farms

   The shifting sand dunes threaten to bury farmlands. (Chinguetti, Tidjikja, Rachid,etc.)

3) Influence on crop cultivation

   Blasting sand and its burial effect hamper crop growth, especially vegetable, in the study area. (Chinguetti, Oudei Mejbour, etc.)

4) Influence on houses

   The residential area is threatened by the problem of burial by shifting sand. (Tidjikja, Chinguetti, etc.)

5) Influence to roads

   Roads are being buried by shifting sands, which interferes with traffic flow. (Truck roads leading to Adrar and Tidjikja)

6) Influence to the living environment

   Blasting sand is causing some health problems such as eye or respiratory diseases. Sand also gets into food. (The Study Area as a whole)

The damage to farmland was especially great in Tagant region, and was observed throughout the Study Area. And, although specific trends pertaining to damages sustained by homes were not perceived, a relatively large degree of damage was observed at northeastern part of Nimlane, in N'beika and at the southern part of N'beika, meanwhile road damage was concentrated at Rachid and northward at the northern part of Tidjikja, and further north and in Acherim, Tidjikja located northeast from Nimlane.

Nearly 83 % of the farmland in the oases in Adrar region suffered from damage, a higher ratio than that in Tagant region; this damage is extended over almost all the oases in

Aoujeft, Chinguetti and Ouadane. In addition, 40 % of the roads and residential areas have reported damage; and damage due to shifting sand was greater than Tagant region. The oases that suffered from insignificant damage on farmland were Atar city and areas adjacent to Ain Ehl Tayaa, because these areas are rocky land areas surrounded by less sand dunes that are the source of shifting sand. Residential areas that have been suffered from damage of shifting sand are in the southern region of Adrar region (near Aoujeft) and Chinguetti. Damage in areas near Atar tended to be minimal. Road damage was prominent near Aoujeft, but a specific regional trend was not observed.

4.4.2 Process of Sand Dune Formation and its Impact

The mechanism that triggers damage from shifting sand in the study region can be largely defined into the following two categories according with sand movement.

1) Macro sand shifting

Mauritania is located to the western end of the Sahara Desert and sand dune in the country is formed by great amount of shifting sand coming from the Sahara Desert Sand driven by wind. It is observed that sand sediments have expanded as a result of reduced natural vegetation caused by droughts that have occurred in Mauritania in recent years, together with overgrazing by increased livestock and the changes in the natural environment stemming from growing population.

The eastern area of Adrar and Tagant regions is enveloped in a sand dune that is known as the Sand Sheet. The shifting sand that is blown in by the prevailing winds from this sand dune belt causes sand movement and sand drifts to occur.

2) Micro Sand shifting

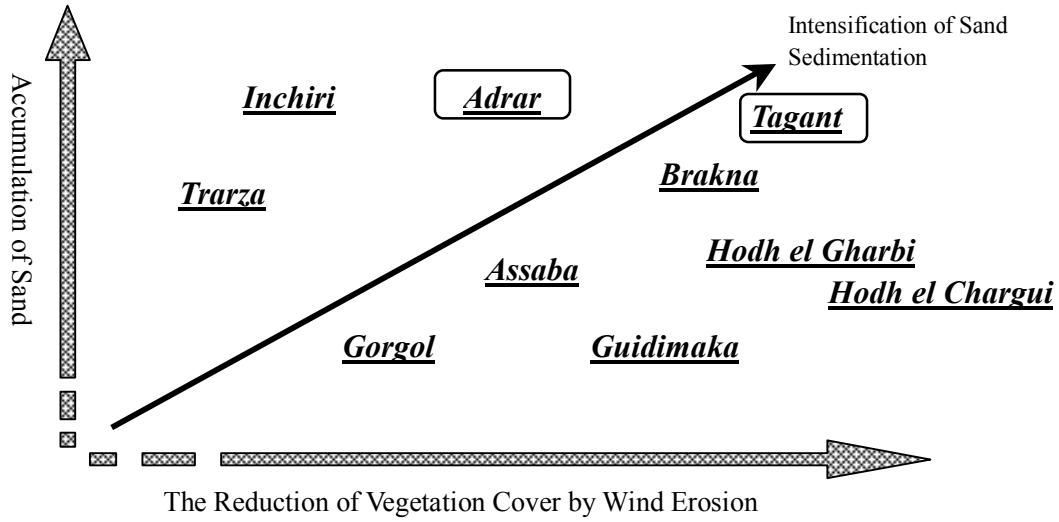
Sand drifts are caused by the micro shifting sand mechanism that stem from geographical conditions, small topographical features, and obstructive elements such as structures. Underlying factors include depressed areas, cliffs, and other topographical features where sand drifts are apt to occur; also roads, farmland, and obstructive man-made structures such as buildings. In the case of structures like buildings that impede the wind, the wind abruptly decreases due to the structure, which in turn creates sand drifts.

4.4.3 Need for Shifting Sand Prevention Measures and Methods

There are two methods for sand fixation and prevention of shifting sand; one is the

"mechanical method", which is realized by installation of facilities such as fences of dates fronds mat, and the other one is the "biological method" by plantation of trees and bushes. The two methods have been utilized as either a single operation or an associated operation depending on the environmental conditions at the site and on the purpose of the project.

As shown in **Fig.4.4.1**, Adrar and Tangant regions have been the hardest hit by damage caused by shifting sand in Mauritania. Hence preventive countermeasures there against wind and sand are extremely important.



Source: Manual de Lutte Contre l'Ensablement et de Fixation des Dunes en Mauritanie, MDRE1991

Fig. 4.4.1 Intensification of Sand Shifting and Sand Sedimentation in Different Regions

4.4.4 Methods to Prevent Sand Shifting

The sand shifting prevention methods commonly employed in Mauritania consist of mechanical method and biological method as explained hereinafter.

Mechanical method utilized by facilities to protect targeted areas, which otherwise will be damaged and/or be buried by sand sifting. Main facilities for the mechanical method are the fences (palisade) to interrupt the movement of sand and sand dunes. These fences are made by soil bricks, brushwood, palm fronds, and industrial materials such as polyethylene nets. In Mauritania, major materials are branches and leaves of trees and bushes. Plant materials such as *Calotropis procera* and *Prosopis juliflora* are used as the supports of fence. Branches and fronds are mainly collected from dates, *Acacia raddiana, Leptadenia pyrotechnica* and *Euphorbia balsemifers*. The palm fronds that are generally

used as fences are built at heights of 120 to 150 cm from the ground level. The fences that are set around farmland are generally built higher than the protective fence around planted trees.

The effectiveness of fences and other mechanical shifting sand prevention methods are temporary and last about two to three years after which renovation or repairs are needed.

On the other hand, biological method is the way to protect rather longer period by planting trees and bushes, target areas which otherwise will be damaged and/or be buried by sand sifting. The applied trees and bushes of biological methods are selected based on their effectiveness for sand stabilization and wind breaking, and on natural conditions such as soil and meteorology of the project site. The eligible trees and bushes shall be such ones as : i) growth of roots is realized, ii) tolerant to arid and high temperature, iii) being endowed with trunk and branches more effectively shaped for prevention of sand shifting, iv) renovation (regeneration) is easily done with sowing, and v) maintenance is without painstaking task.

The most common tree for biological method in Tagant and Adrar is *Prosopis juliflora,* which is an exotic species. This species has high ability of water absorption and can take root in the sand dune easily. Therefore, *Prosopis juliflora* has been applied in various areas. However, it has been recognized that the capability of water absorption of *Prosopis juliflora* is so high as to cause damage to neighboring palm trees. In addition its leaves are not suitable for feeding animals. In this context, people tend to avoid planting *Prosopis juliflora* near farmlands these days. On the other hand, it have been increasing for biological methods the applications of other indigenous trees and bushes such as *Tamarix aphylla, Balanites aegyptiaca* for wind-breaking woods and *Leptadenia pyrotechnica, Panicum turgidum* in addition to palm trees for fence.

The trees are used not only for prevention of wind and shifting sand but also for forage, firewood and construction materials, serving for the variety of the livelihood of local people.

4.4.5 Afforestation Programs in the Study Area

The first sand stabilization and afforestation project in Mauritania was put into implementation in Adrar apart from that carried out in Nouakchott; this project was implemented in 1984 in Toungad and Azougui with a benefited area of 35 ha and the benefited area was expanded to 429 ha with 39 sites in total by 1997 when PLEMVASP Project was finalized. After that, the oasis associations have implemented other sand

stabilization and afforestation. The rehabilitation of the existing facilities was carried out in 1998 and 1999 and there have been no new sand stabilization and afforestation projects since that time. In Adrar region, afforestation project aiming at mainly mitigating shifting of sand dune to farmlands are under implementation at 44 oases. Main tree introduced was *Prosopis juliflora*, and indigenous trees such as *Acasia tortilis*, *Laptadenia pyrotechnica* and *Tamarix senegalensis* were also applied. Main implementation agencies are rural communities and they are supported by rural associations. On the other hand, some projects have been also carried out by the governmental agencies and private sector.

Implementation of sand stabilization and afforestation project in Tagant was started in 1992. The first projects were carried out to benefit 20 ha in Tidjikja. During 1992 to 1997, the projects were operated under the PLEMVASP Project. By the time PLEMVASP Project was completed in 1997, total benefited area of sand stabilization reached 186 ha at 17 project sites. This project involved planting of approximately 70,000 trees and the installation of 71,000 m of palisades in total. After the establishment of oasis associations in Tagant, they have operated as executing agency of the implementation of sand stabilization and afforestation. The rehabilitation projects were implemented only in 1998 and 1999, and since then, no new development project has been realized. However, in 2000, eight sand stabilization projects targeting 36 ha of plantation were planned and seven projects benefiting 23 ha have been implemented using mechanical and biological sand stabilization measures with the budget of 5.6 million UM. Afforestation projects in Tagant region are implemented targeting 21 oases and *Prosopis juluflora* is planted at most of these oases. Of these 21 projects, 17 are implemented under responsibility of oasis body and others are by private sector. The leading target of these afforestation projects is protection of farmland but the projects also aim to protect houses, villages, roads, etc.

4.4.6 Sand Stabilization and Shifting Sand Prevention Procedures

The first step of sand stabilization and afforestation is to select the areas that need to be protected. The configuration, location of the sand dune, wind direction, and the location of the wind reduction area must be studied to effectively stabilize the targeted area. The type of stabilization measures (the combined or separate use of fences and afforestation) and installation location are selected.

In case of combined use of fences and afforestation, it is prerequisite to prepare an installation schedule of palisades and plantation paying special attention to afforestation timing and making effective use of water resources during rainy season. The operation

was started in early May. At first, wire fencing to protect the invasion of animals and production of seedlings are concurrently done followed by the installation of palisades and transplantation. Finally, the management and maintenance works are done.

The procedure of afforestation includes the design of palisade (spacing and material), acquisition of materials (palm fronds, pole and other materials) and installation. In the installation, the wire nets will be put around the site to protect it from the invasion of animals and this is followed by palisading. For afforestation works, the acquisition of seeds, production of seedlings, digging pits, transplantation and the management of cultivation is carried out successively in this order.

4.5 Oasis Society

4.5.1 Outline of the Oasis Society

According to the population census 2000, the following are the demographic features of the study area:

- The average number of people per household is 3.9 for Adrar and 5.2 for Tagant.
- The male-female ratio of adult population for the both regions shows higher proportion of females; 45 to 55 for Adrar and 39 to 61 for Tagant.

The greater female population especially that of adult can probably be explained by an exodus of male population to urban areas in search of working opportunities.

According to the interview survey findings of the Oasis Development Project in 1998, the ratio of households headed by women was 25 % in Tagant region and 16 % in Adrar region, reflecting the situation mentioned above. The income of women households is low due to the lack of employment opportunities and these households headed by women represent greater part of poor households.

In the oases, the dominant occupation is farming and livestock raising, accounting for 72 % and 61% of the total for Adrar and Tagant. Another remarkable difference between the two regions is the proportion of unemployed household. This is much higher in Tagant (16%) than in Adrar (7%).

The average household income seems to reflect the above mentioned situation. It is 23,762 UM per capita for Adrar and 14,073 UM per capita in Tagant.

The decision making process within each household is diverse and differs greatly according to the gender of the head of the household. The survey findings of the household decision maker on economic and social issues are shown in **Table 4.5.1**. Generally, decisions were made by all women householders in the Adrar region, while the mother was the decision maker in women households in the Tagant region. In male households in the Adrar region, the male head was the decision maker, while the father and the male householder were the decision makers in the Tagant region.

Table 4.5.1 Decision Making in a Household

(Unit : %)

Decision Maker / Householder		Father	Mother	Householder	Other Relatives	All family
Economic Issue						
Adrar	Woman	0	15	23	8	54
	Man	18	2	64	6	10
	Average	17	3	60	6	14
Tagant	Woman	22	59	5	8	5
	Man	43	3	40	5	10
	Average	38	17	31	5	9
Social Issue						
Adrar	Woman	0	0	8	23	69
	Man	2	5	48	6	39
	Average	2	5	45	7	41
Tagant	Woman	20	66	3	9	3
	Man	37	12	28	4	20
	Average	33	25	21	5	16

Source: Household Survey by the Study Team

4.5.2 Land Ownership

The traditional land ownership differs slightly from province to province. In the study area, the tribal chief has the right to give rights of land use. The chief collects the rent.

In 1906, France introduced a law to implement a system whereby those who develop the land can own it through registration. The system was supposed to replace the traditional system but it was not accepted by the population. As a result, the traditional system continued.

In 1983, the government of Mauritania passed a bill to legalize the private ownership of land (Ordinance No. 83.127 June 5, 1983). The act aimed at abolishing the traditional

land ownership system to assure private ownership of land for socio-economic development. A guideline for the act was set up the following year to put this act into effect. Later in 1990, the act was amended to describe that a piece of land can be legally owned after a certain period of use by a person.

However in the oasis areas, the situation hardly changed even after the introduction of the law. The traditional landowners remained in power making it difficult for those who didn't have land to obtain a piece of land. However, even under these circumstances some farmers somehow managed to buy land to become landowner despite the gradual breakdown of the traditional social hierarchy.

4.5.3 Traditional Institutions and Customs

(1) Traditional Caste System

There are as many as 16 tribes in the study area. Each of the tribes is further divided into sub-tribes which numbers way over 60. Traditionally these tribes served as strategic and political unit against invasion of other groups. Sub-tribe is a lower level of group in which people are tied more by economic interest and mutual support based on land ownership.

Within each sub-tribe there is a system of social hierarchy called caste which used to determine the occupation of a person according to his caste level. The following are the major castes:

Maalmin (black smith)	:	engaged in production of knives and other domestic tools. Female members engage in tanning.
Tolba	:	engaged in Islamic education (teaching Koran)
Chorva	:	descendants of the prophets
Aghzazir	:	engaged in dates cultivation and animal slaughtering
Iguawen	:	who sing and maintain traditional culture
Aznagua	:	engaged in animal breeding
Akumbi	:	engaged in digging wells

However, the system is gradually vanishing due to the following social changes that have occurred:

- Migration of oases residents to urban areas due to the recurring drought from

the 1960's.

- Establishment of an autonomous government led to an exodus of landowners from the oases to the urban areas to become government officials and their farms had to be sold or were left in the hands of other people.
- Many industrial tools and appliances were introduced in conjunction with modernization which produced occupational diversity and a shift from traditional occupations.

Consequently, a new class system comprised of landowners and tenant farmers was created under the new system of land ownership. The prosperous landowners, who generally reside in the cities, have used their capital and assets to obtain information and technology from external sources, which they have applied to their lands in the oasis. Consequently, they have contributed greatly to the development of the oases. For example, some farms have installed their own solar energy system or drip irrigation and other high cost facilities.

In contrast, the tenant farmers are employed by the large landowners and work in a relatively good environment if the landowner is prosperous. For example, the availability of irrigation pumps has alleviated the manual labor of drawing water.

The lower classes that had been employed as farm labor are freeing themselves from traditional employment practices. A modern employment system is evolving where work contracts are signed with the landowners and workers are paid in farm products or receive cash income. Moreover, an increasing number of cases can be seen where workers, who save their wages, become landowners themselves.

(2) Decision-making Process and Structure of Activities in the Oasis

1) Family level

Decisions in the family are basically made by the head of the household based on discussions with other family members, but in the case of marriages, children generally do not have a voice in the decision-making process. Moreover, the household survey findings show that the householder is the decision-maker in economic matters and the rest members are often responsible for deciding social matters in the family. Although the wife has very little authority in money matters, the husband often seeks the opinion of his wife in matters related to daily meals, the children's schooling, health and other issues.

2) Village level

Traditionally, the village chief (tribal leader of the oasis) is in sole control of the community. Decisions may also be made at meetings called by the village chief and attended by resident representatives from various areas of the oasis. In such cases, the decisions are then relayed and explained to all the residents. Regular meetings are held at the mosques for this purpose at some of the oases.

3) Oasis level

In addition to the decision-making process explained above, a resident-participation based oasis management association or AGPO exists at the oases, which has played an important role in organizing oasis residents. The organization is headed by an office that is generally under the control of the tribal leader or other traditionally influential personages of the oasis. The association is structured according to the traditional leadership system of that village. In oases with an AGPO, the majority of the residents are members and decisions are made at some oases based on preliminary interviews with residents. Although AGPO does not represent women's issues per se, a woman is often placed in charge of handling women's issues and opinions are collected.
The prominent official of the association office provides the explanations, raises the awareness of residents about the project that is implemented, and organizes residents.

4.5.4 Guetna

The word "Guetna" literally means "harvest festival" but in practical sense it is an important traditional event where families from an oasis get together and celebrate the harvest of dates. The period of Guetna is different from place to place but in general it is held between mid July to mid August for Adrar, and mid June to early August for Tagant. It tends to start earlier toward south.

The Study Team conducted a questionnaire survey with an aim of revealing the social role of date palm cultivated in the oasis region as well as of the oasis itself. The number of interviewees reached 317 in total, which are composed of the persons living in Nouakchott and coming from the oasis region and the persons of other regions visited the oases within the Study area at the opportunity of Guetna. The findings are as follows.

1) The purpose of going to oases during Guetna is to see their families and relatives (58%), to eat dates to maintain or enhance health (17%), to purchase dates (14%), to have rest (9%).
2) Their destination oasis is their home oasis (49%), the ones where their parents

live (21%), ones where the price and quality of dates are good (20%), ones with good surrounding environment (10%).

3) People go to enjoy Guetna with family and relatives (49%), alone (25%), with friends and acquaintances (the rest).
4) 75% of the people go to the same oasis and 65% of the people go to enjoy Guetna every year.
5) 72% of people visiting oases during Guetna are from the oases they visit.
6) The average period of stay in the oases during Guetna is 10.7 days and 65% of them stay more than 10 days.
7) The average amount of money people spend during their stay is 24,000 UM. 31% of people spend less than 10,000 UM, 40% spend 10,000 to 50,000 UM, 29% spend more than 50,000 UM. The money is spent on food including dates (41%), given to the family (29%), on dates to be sold in cities (9%), on handcraft items (7%).
8) 61% of the people visiting oases for Guetna are landowners.
9) The reason they left the oases are: to find a job for money (45%), to get education or to get married (36%).
10) It should be noted that 82% of people say they want to return to their home oases.

In sum, the above questionnaire survey revealed that dates cultivation plays an important role not only in terms of economic aspect of the oases society but also for maintenance of the oases society.

In the past Guetna was a once-a-year event as it was not very easy to return to their home oases. However with the improvement of roads and means of transportation, people can go visit most of the oases any time they want these days. In addition, there are many workers who can't go to enjoy Guetna because they can't take holidays or for other reasons. The importance of Guetna is fading in this way.

4.5.5 Gender Issues

The productive activities in the oases are cultivation of dates, vegetables and fruits, livestock raising and handcraft. These are mainly done by the family.

A survey conducted in 1998 indicates that the ratio of such households is 16% for Adrar and 25% for Tagant. These women-headed households are generally left in poverty because the husbands working in cities usually can't afford to send any financial support to them. This has become a major social issue of the oasis society.

In response to this situation, the Oasis Project started supporting female associations. By the end of the year 2000, the accumulated total investment in women managed projects amounted to 29 million UM. Major projects are increasing vegetable cultivation, small-scale animal raising, promotion of commercial activities and handicrafts. Usually associations bear one-third of the project cost. These projects revitalized women associations and has produced increased income and miscellaneous other benefits.

(1) Women's consciousness

According to the findings of the household interview survey, nearly 100 % of the women wanted to continue their lives in the oases with their families. The major reasons for this answer are:

- To live near their parents or their relatives (40 % Adrar region, 38 % Tagant region),
- Amenity of living environment (26 % Adrar region, 40 % Tagant region).

The major tasks allocated to women were harvesting activities, followed by weeding, irrigation, feeding and watering livestock, milking, preparing the meals, child rearing activities, and washing.
The tasks that women found the most difficult were harvesting, cropping, irrigation and other field work and preparing the meals (see **Table 4.5.2**).

The working hours for women exceeded 8 hours for 70 % of the respondents. In households headed by women, the ratio of women who worked more than 8 hours (46 % in the Adrar region, 51 % in the Tagant region) was higher than women in households headed by men (30 % in Adrar region, 24 % in Tagant region) (see **Table 4.5.3**).

Table 4.5.2 Main Duty Perceived the Hardest

(Unit : %)

	*Family	Water fetching	Food preparation	**POA	Livestock raising	Farm work	***OD
Adrar	14	18	27	1	5	23	12
Tagant	6	7	19	1	14	48	5

* Taking care of the family, ** Participation of oasis activity, *** Other domestic works
Source: Household Survey by the Study Team

Table 4.5.3 Average Working Hour per Day

(Unit : %)

	<3hours	3-5 hours	5-8 hours	8-10 hours	10<
Adrar					
Woman	8	15	31	15	31
Man	9	22	38	19	11
Average	9	22	37	19	13
Tagant					
Woman	3	5	40	24	27
Man	6	14	55	19	5
Average	5	12	52	20	11

Source: Household Survey by the Study Team

(2) Gender

Main women's role in agricultural activity of oasis is as follows:

1) Vegetable cultivation

- Although the role is a little different by oasis, main roles are seedling, fertilizer application, weeding, harvesting, processing and selling.
- In the case of an oasis running large-scale vegetable cultivation such as Tawaz, women are responsible for only processing but not for the cultivation activity.

2) Dates cultivation

Generally, women are in charge of yield and drying and selection of fruits. In a few cases, they transplant the nursery stock.

3) Livestock raising

Main role of women are feeding, supplying water, milking, milk processing and selling. They also are responsible for construction of a pen and cleaning of droppings in some oases.

Generally, men are mainly responsible for heavy physical works such as water drawing and tillage, and works of a high place such as pollination, branch selection and yielding of dates. Women mainly take charge of less heavy physical works such as handcraft, milk processing and livestock raising etc. Works by sex, therefore, is not due to religious reasons and sex discrimination, but rather physiological differences between man and woman.

(3) Cooperative

AGPO (the Oasis Participatory Management Association) is composed of individual man, woman and woman's association. At present, the number of woman's member of AGPO is 1,184 in the Adrar region and 781 in the Tagant region, which is equivalent to one fourth of total AGPO members.
Other main activity of the association is handicraft, kiosk and bakery etc. Oasis Project strongly assists these activities of women's associations.

(4) Education

The illiteracy rate of women is 75% for the French language. Most women are only educated in local Islamic schools. As shown in **Table 4.5.4 - 4.5.5**, the boy and girl ratio in primary education is nearly 1 to 1 these days. However, the proportion of male students is much higher in secondary education, although the ratio is decreasing.

Table 4.5.4 Share of Primary School Student by Sex (1998)

(Unit : %)

	Male	Female
Adrar	52	48
Tagant	54	46
Study area	53	47
National	52	48

Source : Annuaire Statistique 1998

Table 4.5.5 Share of Secondary School Student by Sex (1998)

(Unit : %)

	Male	Female
1998/1990	69	31
1994/1995	64	36
1997/1998	59	41

Source : Annuaire Statistique 1998

The lack of middle and high school education for women is affecting female professions such as doctors, nurses, midwives, teachers and nursery school teachers. In order for women to take more active and substantial roles in the society, fundamental education for women must be implemented.

The lack of basic knowledge in their daily lives sometimes causes the following problems.

- Many trials to grow vegetables by women did not succeed due to the lack of appropriate skill and knowledge.
- In recent cases where chicken raising was introduced, they don't have proper skills to raise chickens.
- For handcraft activities, the color of dyed items washes off easily and the tanning of leather products is not sufficient, leading to mediocre quality.

In order to improve these situations, specialists and field workers of the Oasis Project are working on the following measures:

- Educational activities on home life, child care, hygiene and disease.
- Workshop on vegetable cultivation, baking of coolies and on handicraft.
- Provision of public literacy class on Arabic language.

4.6 Health and Sanitation

4.6.1 Public Health Facilities

The medical facilities are part of a medical system hierarchy in the study area. There are region hospitals (Centre Hospitaliers Regionaux) in Atar and Tijdikja are at the top level. This is followed by clinics (Centre de sante) at the department level (2 in Adrar and 1 in Tagant). Under this is the medical care center (Poste de Sante) at the town level (17 in Adrar and 9 in Tagant). Finally at the bottom there are USB (Unité Santé de Base, 12 in Adrar and 4 in Tagant). The composition of the medical staff is shown in **Table 4.6.1.** For each clinic there are trained nurses and assistant nurses are posted to medical care centers. The top two institutions have medicine in stock, but the others do not. The ratio of physicians is one for every 3,730 people in the Study Area and the ratio of nurses is one for every 1,240 people in the rural areas; health care services are in short supply.

Table 4.6.1 Number of Medical Staff in 2003

	Doctor	Dentist	Technician	Registered nurse	Assistant nurse
Adrar	13	1	5	36	12
Tagant	8	1	5	27	13

Source: Inventory Survey by the Study Team

The ratio of the pregnant women who gave birth at a medical institutions is only 0.9% in

Adrar and 8.0% in Tagant. These figures are far below the national average of 18%. In the meantime the ratio of stillbirths is almost zero in Adrar and 133.8 per 1,000 in Tagant. This figure for Tagant is the highest in Mauritania. The principal reason for this high ratio of infant death is malnutrition but there are other reasons such as the lack of medical facilities, poor access to those facilities, and poor hygiene conditions.

4.6.2 Conditions in Food Intake

The staple foods that are consumed in the oasis region are wheat bread, corn, couscous, and rice. Rice is generally consumed during the day and couscous is prepared with the evening meal. Goats, sheep, and camels and dairy products made from livestock milk are the major source of protein. Fish and chicken are rarely consumed. Dates are a major food item, followed by melon and watermelon depending on the oasis. Major vegetables are carrots, onions, and potatoes and the consumption of other vegetables is increasing. However, this trend is seen only in the major urban areas of Atar and Tidjikja and in the oases where vegetable cultivation is conducted. Vegetables are not consumed at many of the remote oases. Fish and chicken meat is scarcely consumed, but its consumption tends to be greater recently in Tidjikja and Atar. Eggs also began to be used by women's group for making sweets.
The food intake volume based on the data collected from the household survey is shown in **Tables 4.6.2** and **4.6.3**.

In a review on the consumption of cereals and grains, the cereal intake of two-thirds of the households in both regions was inadequate. Households that consumed an adequate amount of cereals were only 11 % in the Adrar region and 6 % in Tagant. The ratio of households whose yearly cereal intake volume was inadequate was 19 % and 36 % in the Adrar and Tagant regions, respectively. The ratio of households with an adequate cereal intake volume was higher in Adrar than in the Tagant region.

The vegetable intake ratio of households was 36 % and 57 % in the Adrar and Tagant regions, respectively; and the consumption frequency of vegetables was low. The intake frequency of vegetables for women households in both regions was low.

The ratio of households that occasionally consumed meat was 69 % and 55 % in Adrar and Tangant regions, respectively; and the meat intake frequency was comparatively low.

Based on the findings, the consumption frequency of vegetables was high in the Adrar region, and the meat consumption frequency was high in the Tagant region. It was found that the food intake volume of the majority of the populace was inadequate.

Table 4.6.2 Dietary Conditions (Cereals)

(Unit : %)

	Sufficient as usual	Unusually sufficient	Unusually insufficient	Insufficient as usual
Adrar				
Woman	0	33	67	0
Man	13	11	55	21
Average	11	13	56	19
Tagant				
Woman	0	4	32	64
Man	8	7	56	29
Average	6	6	51	36

Source : Household Survey by the Study Team

Table 4.6.3 Dietary Conditions (Vegetable and Meat)

(Unit : %)

Housholder	Seldom	Sometimes	Often	Everyday	Others
Vegetable					
Adrar					
Woman	0	44	13	38	6
Man	22	13	14	42	9
Average	19	17	14	41	9
Tagant					
Woman	3	61	12	18	6
Man	17	38	12	30	4
Average	14	43	12	27	4
Meat					
Adrar					
Woman	29	14	57	14	0
Man	53	18	14	20	1
Average	51	18	19	19	1
Tagant					
Woman	26	32	21	21	0
Man	32	21	18	28	1
Average	31	24	19	26	1

Note : Seldom: 1-2 times a month, Sometimes: 1-2 times a week,
Often: 3-4 times a week, Everyday: 5-7 times a week
Source : Household Survey by the Study Team

4.6.3 Births

Data on births and the cause of infant deaths based on the household survey is given in **Tables 4.6.4** and **4.6.5.**

The average number of births per woman in Adrar region was 6.0 and 5.7 in Tagant region. Of this figure, the death rate was 1.4 and 1.2 in Adrar and Tagant regions,

respectively, which means that the number of child deaths exceeded the number of births by 20 %. This high death rate is due to disease (30 % in the Adrar region, 42 % in the Tagant region), followed by infectious diseases (26 % for both regions), and miscarriage (31 % in the Adrar region, 11 % in the Tagant region), malnutrition (7 % in the Adrar region, 5 % in the Tagant region).

Table 4.6.4 Average Child Birth and Mortality

(No./person)

	Birth	Death
Adrar	6.0	1.4
Tagant	5.7	1.2

Source : Household Survey by the Study Team

Table 4.6.5 Cause of Infant Mortality

(Unit : %)

	Miscarriage	Malnutrition	Infectious disease	Other disease	Accident	Others
Adrar	31	7	26	30	4	10
Tagant	11	5	26	42	5	10

Source : Household Survey by the Study Team

4.6.4 Disease

Data on three major health injuries (diseases) at each oasis together with their direct causes was collected through the survey and the findings are given in **Table 4.6.6**.

Table 4.6.6 Common Health Problems in the Study Area

Adrar		Tagant	
Disease	Number of oasis	Disease	Number of oasis
Diarrhea	47	Malaria	47
Eye problem	19	Diarrhea	43
Malaria	18	Pneumonia	12
Bronchitis	13	Tuberculosis	8
Flu	11	Bronchitis	6
Pneumonia	11	Anemia	6
Missals	3	Nyctalopia	4
Anemia	3	-	-
Tuberculosis	2	-	-
Others	20	Others	38
Total	147	Total	164

Source : Household Survey by the Study Team

The most commonly seen diseases in both regions were diarrhea and malaria, which comprised 40 to 50 % of all the diseases that occurred in the region. The reported incidence of malaria was highest in the Tagant region (29 %), followed by the Adrar region (12 %). This is due to the relatively high rainfall volume in Tagant which enables mosquitoes to breed during this season. Diarrhea is the most commonly found health hazard and often caused by drinking polluted drinking water. According to the survey findings. The other common diseases were respiratory and eye diseases. A high incidence of bronchitis and eye diseases caused by sand and dust was found in the Adrar region. Although eye diseases were not prevalent in the Tagant region, the incidence of respiratory diseases such as bronchitis and pneumonia was high, following malaria and diarrhea.

Other diseases characteristic to both regions were anemia and nyctalopia in the Tagant region, although the reported number of cases remains small. These diseases are caused by malnutrition and indicates a deficiency of specific nutrients such as vitamins and minerals.

4.7 Development of Oasis

4.7.1 Ongoing Projects

A total of 40 financial development assistance organizations and loan institutions of respective donor countries, donor institutions, or NGOs have provided assistance to Mauritania. The most important donor countries and institutions currently providing cooperation in the agricultural sector in the northern region of Mauritania targeted by this survey study are the EU and IFAD, FADES, which have invested in the Oasis Development Project, and World Bank. Details pertaining to the activities conducted by each of these three donors are given below.

(1) EU

The EU has conducted a feasibility study for the Adrar Region Development Project (master plan) aimed at road improvements, dam construction, and deep well excavations. Presently, two wells have been excavated. In addition, in accordance with the Tagant region development plan, dam renovations in six locations began in 2000, in conjunction with a PARP project aimed at regional development and agricultural improvements through usage of the water reservoirs of these dams. The dam renovations have been completed and there are plans to implement small-scale financing, to organize associations, to build schools, health clinics (USB), and

shallow wells by 2003. Solar panels have also been installed at 20 oases in the Tagant region under the PRS project that started in 1992.

Recent assistance by the EU has focused on large-scale projects aimed at infrastructural improvements; and the number of agricultural projects has decreased. Resident-level projects have become limited to supplementary projects related to these infrastructural projects which target the effective use of water. Nearly 85 % of the investments made in national-level assistance programmes have centered on road improvement works.

(2) Oasis Development Project

The Oasis Development Project has been implemented in Adrar, Assaba, Hod Garbi, Hod Chargi, and Tagant. The project implementing body is the Oasis Development Project Agency of the MDRE; and its objectives are to improve the living standards of the poor farmers in the oasis regions and agricultural and water resource development, environmental conservation, and strengthening associations aimed at achieving a stable food supply. Phase II of the project has been implemented with the financial assistance of IFAD and FADES and technical assistance has been provided by the FAO. Originally slated to be completed in June 2002, the project period has been extended to June 2003. The goals of the project in Phase II were to establish 70 associations at the oases, and this task has been nearly completed. The project is currently preparing to commence Phase III.

(3) World Bank

World Bank has implemented a total of 64 projects in Mauritania since 1960. In the agricultural sector, 12 projects have been implemented since 1971 and two major oasis related development projects have been implemented—the Projet des Service Agricoles (PSA) started in 1994 and the Project de Gestion des Ressouces Naturelles en Zone Pluviale (Programme to Manage Natural Resources in the Rainfall Region) (PGRNP) started in 1997. The former is concerned with strengthening the organization and personnel of the MDRE and SONADER and extension and research institutions. The former is a small-scale project concerned with developing the southern region, excluding the Senegal River basin, and utilizing the associations and providing small loans. Although projects have been implemented in the Tagant region and are under planning in the Adrar region, the targeted areas are the southern regions of Assaba, Hod Garbi, Hod Chargui, and Taraza.

4.7.2 Future Projects

Proposed projects to be implemented in the future are as follows:

(1) The rural area development for the oasis region of Adrar (EU)

The feasibility study for this project was completed in 2000 and the project is now selecting consultants for project implementation. Details of the projects have not been determined at this time. It will be decided after the consultants have been selected. An outline of the projects under planning is shown in **Table 4.7.1 – 4.7.2**.

Table 4.7.1 Improvement of Unpaved Road

Section	Length (Km)	Cost (Million UM)
Atar－Azougui－Choum	23	27.50
Chinguetti－Tawaz	7	15.30
Atar－Tawaz	22	42.13
Chinguetti－M'haireth	34	125.50
M'haireth－Aoujeft－Terjite	13	57.50
Aoujeft－Paved Road（via. Terjite）	46	192.50
Aoujeft－Toungad	9	145.00
Aoujeft－Tirebane－Maaden	20	
Total	174	605.43

Source : EU

Table 4.7.2 Weir Construction for Water Recharge

Moughataa	Basin	Tributary	Quantity	
			Gabion	Gabion and Soil
Atar	Seguellil	Tawaz (Upper stream)		1
		Tawaz (Middle stream)		2
		Touiderguilt	3	-
		Tawaz (Down stream)	1	1
		Touizic	3	-
		Tayart	2	1
		Tengharada	3	-
		Tarioufeta (Upper stream)	3	-
		Tarioufeta (Down stream)	-	1
		Seguellil	3	1
Aoujeft			4	-
Total			22	7

Source : EU

Excavation of a total of 12 deep wells (average 350 m deep) is planned for the recharge of the aquifer, but not for the exploitation of water resources. Two have been drilled thus far in Tawaz (Touiderguilt 210 m and Tarioufet 533 m). The remaining 10 wells are planned to be drilled in the following areas:
Ain Ehel Tayaa, Hamdoune, Tayaret, Ksar Torshane, Ziret, M'haireth, Toungad, Loudey, Aoujeft.

(2) Oasis Development Project

The activities implemented by the Oasis Development Project are aimed at improving the living standards of the oasis at all levels and large-scale activities are not planned. Some of the major activities or mini-projects that are currently underway are shown in **Table 4.7.3**. The figures in the table represent the number of activities or mini-projects.

Table 4.7.3 Planned Projects of AGPO

Category	Adrar		Tagant	
Hydraulic	Well Construction	5	Well Construction	7
	Well Maintenance	1	Pump Introduction	3
Project for Women	Food Processing	1	Literacy Education	2
	Gas Use	2	Small Animal Raising	2
	Sewing Machine	1	Handicraft	1
	Textile	2	Sewing and Weaving Equipment	1
	Clothing Making	1		
	Cuscus Making	3		
	Cane Products	1		
	Dying	2		
	Vail Making	1		
	Dried Vegetable	1		
	Flour Mill	1		
Agriculture	Fruit Growing	1	Pest and Disease	6
	Vegetable Growing	1	Material	4
Social Infrastructure	Storage House	1	Storage House	2
	Public Market	3	Kiosk Opening	3
	Meat Sales	7	Meat Sales	6
	Bread Making	6	Gas Use	1
	Preservation of Library	1	Bread Making	2
Environmental Improvement	Fencing Animal	1	Tree Planting	4
			Fencing	5

Source: MDRE, Oasis Project

The highest budget for these activities is 360,000 UM, but the majority of the activities has been budgeted at around 100,000 UM. In many cases, each resident

must shoulder several hundred to several thousand ouguiyas.

4.7.3 Coordination of Projects Between Donor Country and Institution

The assistance provided by each donor country falls under the jurisdiction of the Direction of Finance, Ministry of Economic Affaires and Development of the Mauritanian government. A government officer is assigned to each donor institution and country. Although the targeted region, summary, and cost of each project, as well as the cooperation system on the Mauritanian side are confirmed and existing projects in the same region are coordinated in terms of objective and summary content at this level, the coordination does not extend to the detailed content of each project.

The Commite Regional de Coordination under WALY (Region Governor) is responsible for coordinating projects at the regional level and provides the linkage between the project and the regional offices of the various national institutions. However, in reality, this committee has been unable to function effectively and the consultants have been left to carry out this task during the basic planning stage of the projects.

In addition, although coordination within the projects under the jurisdiction of the Direction of Finance is adequately conducted, the coordination of other financial donor country and institution projects has been left to the on-site project office where an informal exchange of information is conducted.

4.7.4 Needs of the Residents

The needs of the oasis residents, which are major elements in regional development, were surveyed using various approaches. The findings are given below.

1) On-site interview survey

- Group interviews and interviews of the oasis representatives were conducted at the project site to ascertain the problems and needs of the residents. The findings are compiled in **Table 4.7.4.**

- Group interviews of women associations at the oasis were conducted and the problems and needs of the women were confirmed. The findings are compiled in **Table 4.7.5**.

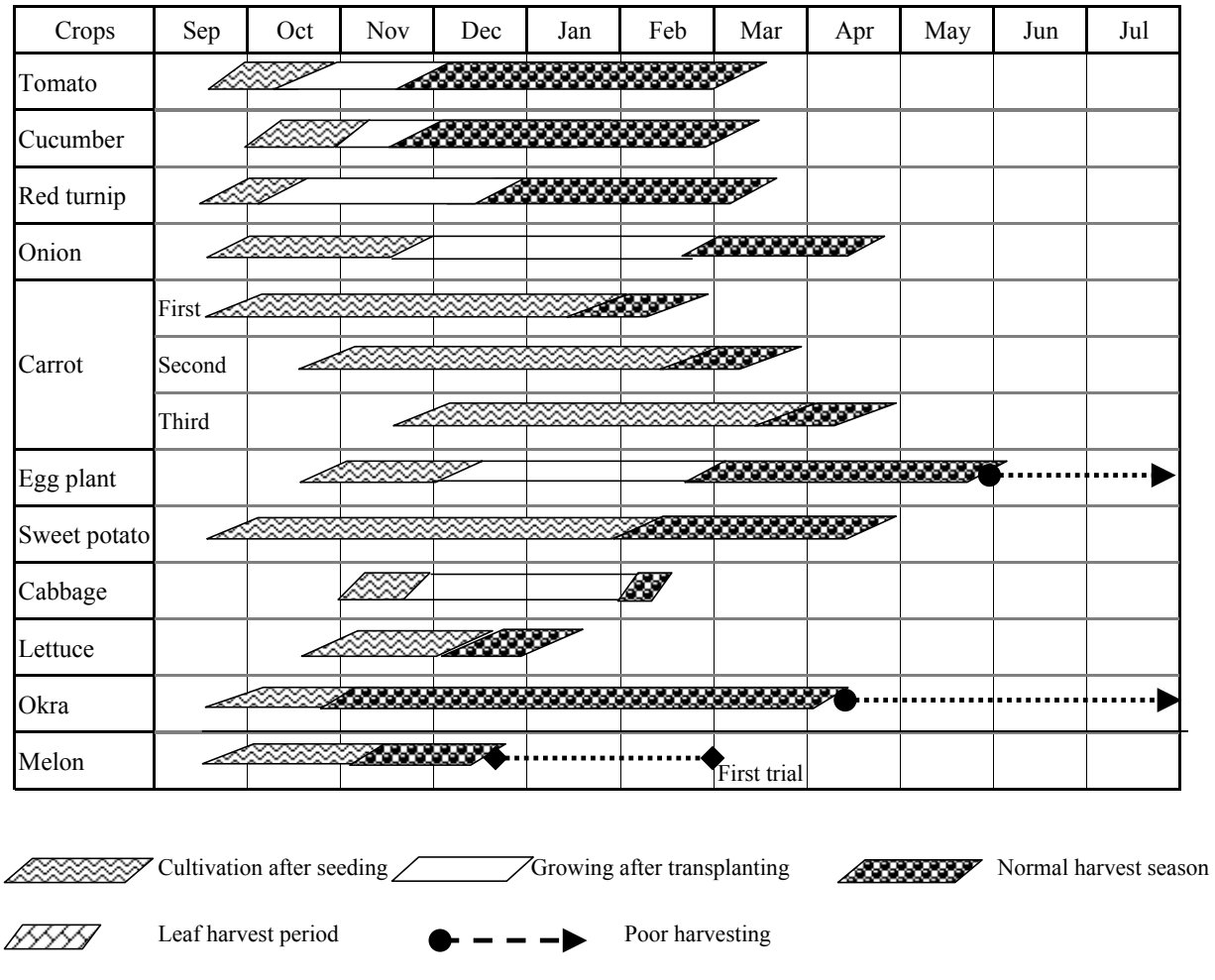
2) RRA survey

In the RRA survey that was conducted in tandem with the household survey, a

team of agricultural, health, and social experts pinpointed the problems and reform strategies of the oasis based on information collected at observation interviews that were revealed using the RRA approach. The findings are compiled in **Table 4.7.6**.

The needs of the oasis residents have been projected through the association activities of the Oasis Development Project. In addition, within the traditional system, the oasis chief and the Jemma have served as a spokesperson or body representing the needs of the residents. They hold meetings with the residents or individual interviews.

In general, the direct needs of the residents tend to be large-scale investments in facilities to improve productivity (well excavations, construction of vegetable storage facilities, dam construction to utilize rainwater, road construction in the oasis). The Oasis Development Project acts to reach a compromise with resident plans and decide which projects are implemented based on their goal to achieve sustainable development by strengthening resident associations. Hence the project's activities require only small investments that lead to modest improvements in the living standards of the residents.



Source : The Study Team

Fig. 4.1.1 Representative Cropping Pattern

Table 4.1.9 Representative Farm Economy with and without Pump (1/3)

Cultivation Area for Vegetable	ha	0.01 (without pump)								0.01 (with pump)								0.02 (with pump)							
Crops		Carrot		Tomate		Beat		Others		Carrot		Tomate		Beat		Others		Carrot		Tomate		Beat		Others	
Caltivation Period	month	4		5		3.5		3.5		4		5		3.5		3.5		4		5		3.5		3.5	
Caltivation Area	ha	0.004		0.002		0.002		0.002		0.004		0.002		0.002		0.002		0.01		0.003		0.005		0.002	
		Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value
Input																									
Seed	kg	0.02	120	0.10	1400	0.01	44	0.01	44	0.02	120	0.10	1400	0.01	44	0.01	44	0.05	300	0.15	2100	0.03	110	0.01	44
Fertilizer																									
Chemical	kg		-		-		-		-		-		-		-		-		-		-		-		-
Organic	kg	4	120	2	60	2	60	2	60	4	120	2	60	2	60	2	60	10	300	3	90	5	150	2	60
Agrochemicals																									
Insecticide	kg		-		-		-		-		-		-		-		-		-		-		-		-
Machinery																									
Pump	hour		-		-		-		-	2.2	480	1.3	280	1	220	1	220	5.4	1199	1.9	420	2.5	549	1	220
Miscelaneous	hour		-		-		-		-	2.2	108	1.3	63	1	50	1	50	5.4	270	1.9	95	2.5	124	1	50
Power																									
Fuel	l/hour		-		-		-		-	3.2	447	1.9	261	1.5	205	1.5	205	8.1	1118	2.8	391	3.7	512	1.5	205
Maintenance	hour		-		-		-		-	2.2	65	1.3	38	1	30	1	30	5.4	162	1.9	56.7	2.5	74.25	1	29.7
Labour																									
Family	md	4.8	3360	3.0	2100	2.1	1470	2.1	1470	3.2	2240	2.0	1400	1.4	980	1.4	980	8	5600	3	2100	3.5	2450	1.4	980
Hired	md	0.4	280	0.2	140	0.2	140	0.2	140	0.4	280	0.2	140	0.2	140	0.2	140	1	700	0.3	210	0.5	350	0.2	140
Total cost for production			3880		3700		1714		1714		3859		3641		1728		1728		9649		5462		4319.8		1727.9
Expense for sale			50		50		25		20		50		50		25		20		125		75		62.5		20
Total cost			3930		3750		1739		1734		3909		3691		1753		1748		9774		5537		4382		1748
Yield	ton/ha	2.5	0.010	5	0.010	2.5	0.005	2	0.004	2.5	0.010	5	0.010	2.5	0.005	2	0.004	2.5	0.025	5	0.015	2.5	0.013	2	0.004
Farm Gate Price	kg	150	1500	150	1500	150	750	150	600	150	1500	150	1500	150	750	150	600	130	3250	150	2250	150	1875	150	600
Gross Income			1500		1500		750		600		1500		1500		750		600		3250		2250		1875		600
Net Return by Crop			-2430		-2250		-989		-1134		-2409		-2191		-1003		-1148		-6524		-3287		-2507		-1148
(without family labour)			930		-150		481		336		-169		-791		-23		-168		-924		-1187		-57		-168
Total Net Return		-6,803								-6,752								-13,466							
(without family labour)		1,597								-1,152								-2,336							

Source: The Study Team

Table 4.1.9 Representative Farm Economy with and without Pump (2/3)

Cultivation Area for Vegetable	ha	0.05 (with pump)								0.07(with pump)								0.1 (with pump)							
Crops		Carrot		Tomate		Beat		Others		Carrot		Tomate		Beat		Others		Carrot		Tomate		Beat		Others	
Caltivation Period	month	4		5		3.5		3.5		4		5		3.5		3.5		4		5		3.5		3.5	
Caltivation Area	ha	0.02		0.01		0.01		0.01		0.03		0.01		0.02		0.01		0.04		0.02		0.02		0.02	
		Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value
Input																									
Seed	kg	0.10	600	0.50	7000	0.05	220	0.05	220	0.15	900	0.50	7000	0.10	440	0.05	220	0.20	1200	1.00	14000	0.10	440	0.10	440
Fertilizer																									
Chemical	kg		-		-		-		-		-		-		-		-	4	600	2	300	2	300	2	300
Organic	kg	20	600	10	300	10	300	10	300	30	900	10	300	20	600	10	300	40	1200	20	600	20	600	20	600
Agrochemicals																									
Insecticide	kg		-		-		-		-		-		-		-		-		-		-		-		-
Machinery																									
Pump	hour	11	2398	6.3	1399	5	1099	5	1099	16	3596	6.3	1399	9.9	2198	5	1099	22	4795	13	2797	9.9	2198	9.9	2198
Miscelaneous	hour	11	540	6.3	315	5	248	5	248	16	810	6.3	315	9.9	495	5	248	22	1080	13	630	9.9	495	9.9	495
Power																									
Fuel	l/hour	16	2236	9.5	1304	7.4	1025	7.4	1025	24	3353	9.5	1304	15	2049	7.4	1025	32	4471	19	2608	15	2049	15	2049
Maintenance	hour	11	324	6.3	189	5	149	5	149	16	486	6.3	189	9.9	297	5	149	22	648	13	378	9.9	297	9.9	297
Labour																									
Family	md	16	11200	10	7000	7	4900	7	4900	24	16800	10	7000	14	9800	7	4900	32	22400	20	14000	14	9800	14	9800
Hired	md	2	1400	1	700	1	700	1	700	3	2100	1	700	2	1400	1	700	4	2800	2	1400	2	1400	2	1400
Total cost for production			19297		18207		8640		8640		28946		18207		17279		8640		39194		36713		17579		17579
Expense for sale			250		250		125		100		375		250		250		100		500		500		250		200
Total cost			19547		18457		8765		8740		29321		18457		17529		8740		39694		37213		17829		17779
Yield	ton/ha	2.5	0.050	5	0.050	2.5	0.025	2	0.020	2.5	0.075	5	0.050	2.5	0.050	2	0.020	2.5	0.100	5	0.100	2.5	0.050	2	0.040
Farm Gate Price	kg	150	7500	150	7500	150	3750	150	3000	150	11250	150	7500	150	7500	150	3000	150	15000	150	15000	150	7500	150	6000
Gross Income			7500		7500		3750		3000		11250		7500		7500		3000		15000		15000		7500		6000
Net Return by Crop			-12047		-10957		-5015		-5740		-18071		-10957		-10029		-5740		-24694		-22213		-10329		-11779
(without family labour)			-847		-3957		-115		-840		-1271		-3957		-229		-840		-2294		-8213		-529		-1979
Total Net Return		-33,758								-44,796								-69,016							
(without family labour)		-5,758								-6,296								-13,016							

Source : The Study Team

Table 4.1.9 Representative Farm Economy with and without Pump (3/3)

Cultivation Area for Vegetable	ha	0.2 (with pump)								0.5 (with pump)								1 (with pump)							
Crops		Carrot		Tomate		Beat		Others		Carrot		Tomate		Beat		Others		Carrot		Tomate		Beat		Others	
Caltivation Period	Month	4		5		3.5		3.5		4		5		3.5		3.5		4		5		3.5		3.5	
Caltivation Area	ha	0.12		0.04		0.02		0.02		0.3		0.05		0.1		0.05		0.80		0.05		0.05		0.10	
		Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value	Q'y	Value
Input																									
Seed	kg	0.60	3600	2.00	28000	0.10	440	0.10	440	1.50	9000	2.50	35000	0.50	2200	0.25	1100	4.00	24000	2.50	35000	0.25	1100	0.50	2200
Fertilizer																									
Chemical	kg	12	1800	4	600	2	300	2	300	30	4500	5	750	10	1500	5	750	80	12000	5	750	5	750	10	1500
Organic	kg	120	3600	40	1200	20	600	20	600	300	9000	50	1500	100	3000	50	1500	800	24000	50	1500	50	1500	100	3000
Agrochemicals																									
Insecticide	kg		-		-		-		-		-		-		-		-		-		-		-		-
Machinery																									
Pump	hour	65	14386	25	5594	9.9	2198	9.9	2198	162	35964	32	6993	50	10989	25	5495	432	95904	32	6993	25	5495	50	10989
Miscelaneous	hour	65	3240	25	1260	9.9	495	9.9	495	162	8100	32	1575	50	2475	25	1238	432	21600	32	1575	25	1238	50	2475
Power																									
Fuel	l/hour	97	13414	38	5216	15	2049	15	2049	243	33534	47	6521	74	10247	37	5123	648	89424	47	6521	37	5123	74	10247
Maintenance	hour	65	1944	25	756	9.9	297	9.9	297	162	4860	32	945	50	1485	25	743	432	12960	32	945	25	743	50	1485
Labour																									
Family	md	96	67200	40	28000	14	9800	14	9800	240	168000	50	35000	70	49000	35	24500	640	448000	50	35000	35	24500	70	49000
Hired	md	12	8400	4	2800	2	1400	2	1400	30	21000	5	3500	10	7000	5	3500	80	56000	5	3500	5	3500	10	7000
Total cost for production			117583		73427		17579		17579		293958		91784		87896		43948		783888		91784		43948		87896
Expense for sale			1500		1000		250		200		22500		2500		5000		2000		100000		2500		2500		4000
Total cost			119083		74427		17829		17779		316458		94284		92896		45948		883888		94284		46448		91896
Yield	ton/ha	2.5	0.300	5	0.200	2.5	0.050	2	0.040	15	4.500	10	0.500	10	1.000	8	0.400	25	20.00	10	0.500	10	0.500	8	0.800
Farm Gate Price	kg	150	45000	150	30000	150	7500	150	6000	45	202500	150	75000	150	150000	150	60000	45	900000	150	75000	150	75000	150	120000
Gross Income			45000		30000		7500		6000		202500		75000		150000		60000		900000		75000		75000		120000
Net Return by Crop			-74083		-44427		-10329		-11779		-113958		-19284		57105		14052		16112		-19284		28552		28105
(without family labour)			-6883		-16427		-529		-1979		54042		15717		106105		38552		464112		15717		53052		77105
Total Net Return		-140,618								-62,085								53,485							
(without family labour)		-25,818								214,415								609,985							

Source : The Study Team

Table 4.7.4 Needs of Residents

Adrar	Tagant
Water Resources • Supply for drinking and irrigation • Motor pump by using alternative energies（solar、aeolian） • Drilling new shallow wells • Deep wells for deeper groundwater with collective irrigation network • Dams for recharging groundwater • Dams for recharge and protection in wadi • Deep wells for drip irrigation system • Installation in pastoral areas around oases • Dike construction in wadi • Dike for bank protection **Protection against Sand** • Fencing and fixation of dunes **Livestock Raising** • Fence installation against animal • Support for buying feeds • Veterinary service (assistant of veterinary surgeon, pharmacy, training) **Agriculture (Dates and Vegetables)** • Extension of agriculture techniques • Pest management • Facilities to conserve agricultural product for facilitating commercialization • Installation of public market **Transportation** • Means of transportation of agricultural products • Infrastructure for improvement of bad accessibility and general transportation **Health** • Construction of community clinic • Supply of ambulance • Supply of medicine **Education** • Expansion and rehabilitation of school • Professional Training (mechanic, carpenter, agricultural technology) **Others** • Central electrification • Gas supply program • Construction of modern mosque	**Water Resources** • Deep wells and collective canalizations • Deeper well drilling and new wells drilling (using compressor and dynamite) • Support for buying economical means of pumping (extension of solar and aeolian energy, and network) • Extension of potable water supply system network • Deep wells for stable irrigation • Weirs for slowing down or braking water and recharging groundwater • Deep wells for drip irrigation system • （in the area of 15～20km） • Dike construction in wadi • Arrangement of Small dikes for water deviation and for rain water agriculture **Protection against Sand** • Fencing and fixation of dunes **Livestock Raising** • Development technique of intensive animal raising by development of animal feeds and improvement of animal's health (sheep, cow, camel) • Need of pasture usable in the night • Fence installation against animal **Agriculture (Dates and Vegetables)** • Integrate pest management and tree nursery of various dates managed by the associations • Conservation equipments • Diversification of cultivation under the palm tree • Education and training for the farmers **Transportation** • Truck improvement between dates farms and oases **Health** • Construction of community clinic • Supply of ambulance **Others** • Introduction of long-term credit of investment by MICO

Source: The Study Team

Table 4.7.5 Needs of Women Residents

Agriculture

－Reduction of fetching labor (supply tools or pump).

－To solve the problem that donkey drinks a lot of water while pumping water.

－Reduction of farm work (supply tools).

－To obtain own lands (no land ownership at present).

－Possibility of introducing other products other than vegetable (fruits) < dates trees are men's property >.

－Education of technology and knowledge of vegetable cultivation.

Other industry

－Technique of food processing (dried vegetable).

－Promotion of animals skin products (bag, shoes, small goods) and technical training for craftwork (tannery and ageing, etc).

－Study of possibility for special products of the village.

Association

－Establishment of the women's association office.

－Training and support for administration and management of women's association activities.

－Opening of hotels, restaurants and souvenir shops managed by association to take advantage of proximity to sightseeing points.

－Examination of means of information transmission to the village (especially for women).

Market extension

－Establishment of market for selling agricultural products and handicrafts.

－Improvement of traffic network and means of transportation of agricultural products, information acquisition and buying vegetable seeds.

Medical treatment

－Existence of clinic without equipment, medicine, and water. No vaccination and no midwife in the village.

－There are many residents who complain of bad health during rainy season. Analysis of potable water and examination of method to solve this problem.

－Extension of health and sanitary education principally for women.

Education

－Literacy education (Arabic, French)

－Construction of junior high school.

Others

－Few men for marriage.

－Worries about children left alone at home during association activities and farm work.

Source : The Study Team

Table 4.7.6 Needs of Oasis Residents Revealed by RRA Survey (1/2)

Adrar

Activities	Problems	Solutions	Favorable Factors (+)	Unfavorable Factors (-)
Dates and vegetable cultivation	Lack of water	• Drilling wells (survey) • Regulation in water use • Construction of dam • Improvement of irrigation technique	＋Availability of population ＋Availability of local materials ＋Existence of AGPO and its mobilization	－Financial shortcomings －Irregularity of rain
	Disease and Soil deterioration	• Setting up of chemical treatment product unit • Training of veterinary technique	＋Use of traditional knowledge and earlier training ＋Possibility of extension of irrigation technique	－Lack of specialist －Lack of tools and materials
	Conservation and market	• Construction of packaging factory (dates) • Creation of new transformation technique • Installation of cold storage-facility	＋ Successful experience in Atar ＋Agreement to national production ＋Good system of collective organization ＋Existence of storage-facility（Atar and NKTT）	－Reduced stock capacity －Method transportation of products －Inactive market in the end of season (price drop) －Lack of products for conservation －Bad accessibility
Livestock raising	Dryness and draught	• Study and finance • (pastoral wells, sanitary infrastructure)	＋Private fund ＋Relation with exterior organizations ＋Existence of shallow groundwater	－Lack of means against dryness and draught －Lack of meteorological activities
	Disease	• Installation of veterinary unit • Vaccination	＋Training of veterinary assistant ＋Solidarity	－Financial problem －Lack of medicine －Lack of specialist
Environment	Desertification Influence by human and animals	• Afforestation • Protection against sand • Education of consciousness for environmental problems	＋Labor availability ＋Motivated technical contribution ＋Existence of more suitable species than prosopis	－Shortage of water and tree nursery －Raising cost of alternative energy －Lack of means
Handicraft	Lack of market for selling products	• Development of tourist zones • Promotion of local consumption	＋Tourist zone ＋Existence of women's organization	－Lack of raw materials

Source: The Study Team

Table 4.7.6 Needs of Oasis Residents Revealed by RRA Survey (2/2)

Tagant

Activities	Problems	Solutions	Favorable Factors (+)	Unfavorable Factors (-)
Dates and vegetable cultivation, Flood plain agriculture	Lack of water	• Drilling wells (survey) • Extension of potable water network • Increase in number of solar panels • Pumping equipment (motor pump) • Geological study about water resources availability • Construction of small dikes	＋Experience of local population in well drilling, maintenance of solar system, confection of small dikes	－Non-availability of water resources －Lack of funds －Raising price of local tools
	Dates sanitaries	• Fight against : Le Taka, la cochenille blanche (R'Meida), Le faraoun. • El Vaghnoun • (flood plain agriculture)	＋Experience of residents in fight against diseases and insects	－Information of damage by harmful insects, predators －Lack of products against various disease and insect
	Damage by domestic animals	• Protection of oasis, vegetable farm	＋Availability of wood post ＋Labor availability	－Big area for fencing －Fences concentrated in dunes.
	Lack of input	• Supply of equipment and mobilization of farmers	＋Existence of potential buyers of materials	－Bad accessibility －Non-availability of market to buy at
	Conservation and market	• Transportation and conservation technique • Equipment of cold storage (Tidjikja) • Production step by step	＋A number of production and quality ＋ Means of transportation and good road (Tidjikja, Nimlane)	－Undeveloped traffic network(Rachid, Lehoueittat and El Housseinia) －Vegetables rot quickly
Livestock raising	Lack of pasture land	• Protection of herding course • Gradual vitalization of pasture zones • Stock of feeds	＋(Tamourt N'aj) Zones suitable for development of livestock raising ＋Accessibility (Tidjikja , Nimlane). ＋Experience of population	－Rare rain －Conflict between breeder and farmer
	Disease of animals	• Local veterinary assistant and training	＋Availability of staff to train	－Lack of medicine
	Lack of meat and milk	• Stock of meat and milk	＋ Experience of population	－Lack of animals
Environment	Desertification	Afforestation Fixation of dune	＋Materials for fixation (animal skin) ＋Local species adaptable for afforestation ＋Labor availability	－Lack of water for plantation and tree nursery －Negative influence to the other culture by prosopis (dates)
	Water out flow	Blocking of branch of Wadi	＋ Population's consciousness of problem scale	－Raising price of local tools
Handicraft	Difficulties of commercialization of products	Important source of income	＋Available raw materials (animal skin) ＋Existence of skilled worker	－Raising price of materials －Reduced tourist activity

Source: Study Team