ESAP
Ecole Supérieure
d'Agriculture de Purapn

ENESAD
Ecole Nationale d'Enseignement
Supérieur Agronomique de Dijon

CNEARC
Centre National d'Etudes
Agronomiques en Régions Chaudes

AFD
Agence Française de
Développement

GDAR
General Directorate of Animal resources
Ministry of Agriculture and Irrigation
Republic of Yemen

Livestock performances depending more on investment level than on herd management

Report presented by : **ROUX LIONEL**

THOUILLOT FLORIANE

To obtain:
- DEGREE IN TROPICAL AGRONOMY
- « INGÉNIEUR » DEGREE-MASTER OF SCIENCE IN AGRICULTURE, ENVIRONMENTAL AND FOOD SCIENCES
- MASTER DEGREE OF AGRICULTURAL TECHNICS

Training supervisor: Delavente Jean-Pierre
Report supervisor: Boussou Véronique

September 28th, 2006

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Members of jury:

MR BANZHAF Matthias (IRAM)
MRS BOUSSOU Véronique (CNEARC)
MR JULLIEN Jean-François (AFD)
MR MOULIN Charles-Henri (CNEARC)
MR PILLOT Didier (CNEARC)
MR SCHEINER Javier (ESAP)

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RESUME

Le Yémen a connu d'important changement politiques et économiques au cours des 50 dernières années : démocratisation, croissance économique soutenue et développement du commerce extérieur. Cependant, il reste un pays pauvre avec de grandes inégalités. L'agriculture y est importante tel que la plupart de la population rurale en dépende.

Afin d'aider les populations rurales au travers d'appui à l'élevage, la coopération Franco-yéménite a mise en place le projet PADZEY. L'objectif général du projet est d'*"augmenter les revenues créés à partir de la production animale pour les petits agriculteurs."* Grâce à 4 mois d'étude de terrain, beaucoup d'informations ont été collectées et elles sont à présent disponibles pour le projet.

Wadi Mawr est une grande zone irriguée située dans le nord de la plaine de la Tihama. L'abondance de l'eau disponible, provenant des montagnes, fournit de l'irrigation de surface et remplit la nappe souterraine, ce qui permet le développement de l'agriculture, malgré les conditions climatiques arides. Les terres sont contrôlées par des propriétaires, et les plus gros d'entre eux gèrent des exploitations capitalistes ou patronales sur lesquelles ils ont des métayers.

Le gouvernement a mené des politiques de développement dans le pays à partir de 1970. La population s'est beaucoup accrue, qu'un fort soutien à l'agriculture et l'élevage, tourné autour du sorgho, a permis de nourrir. Grâce à des revenus exterieurs, des familles ont pu investir dans des terres ou des moto-pompes. Pourtant, l'accès à l'eau est toujours inéquitable entre les agriculteurs, écart que la construction du réseau d'irrigation en amont n'a fait que creuser. La guerre du Golfe, ramenant de très nombreux émigrants dans la zone, a entrainé une forte pression foncière mais aussi sur les patûres. La dépendance au sorgho fourrager s'est encore accrue, d'autant plus que le taux d'inflation a augmenté brusquement. De nouvelles difficultés relatives à une insécurité foncière et de l'accès à l'eau apparaissent de nos jours, affectant les plus petits agriculteurs et leurs revenus, et les menaçant de décapitalisation dans leur cheptel.

Au sein des systèmes de culture, le sorgho a la place la plus importante. Il est sujet aux aléas d'eau, et fournit du fourrage aux animaux. Les systèmes d'élevage, majoritairement gérés par les femmes et les enfants sont en conséquence fortement dépendants de l'accès au fourrage.

Mais l'importante combinaison entre les cultures et l'élevage au sein des exploitations est démontrée: aujourd'hui, la plus grande part de l'alimentation est constituée par le fourrage, produit sur l'exploitation aussi bien qu'acheté sur les marchés, par exemple après la vente du culure à plus forte valeur ajoutée.

Quelque soit l'accès à l'eau, les agriculteurs les plus pauvres sont limités par la terre. Ils sont ceux qui dépendent le plus des animaux, ceux qui ont les plus grandes difficultés à acheter du fourrage, et sont susceptibles de décapitaliser ou de quitter Wadi Mawr pour travailler illégalement en Arabie Saoudite.

Un soutien technique à l'élevage doit donc s'accompagner de plus larges mesures pour augmenter les revenus familiaux, focalisées sur les cultures.

ABSTRACT

Yemen has known very strong political and economic changes along the last fifty years: democratization, fast economic growth and development of the foreign trade. However, it remains a poor country with very strong inequalities. Agriculture stays important and the most of the rural population still highly depends on agriculture and livestock production.

In order to support rural population through the support of livestock production, Yemeni-French cooperation makes up the PADZEY project. The general objective of the project is to *"increase the incomes generated from livestock production of small farmers."* Thanks to a 4 months field survey, a lot of information has been collected and they are now available for the project accomplishment.

Wadi Mawr is a large irrigated area in the North of the Tihama plain. The high water availability coming from the mountains and supplying surface and underground water, allows the development of agriculture in spite of the arid climatic conditions. The lands are controlled by owners, and the biggest of them manage capitalistic or patronal farms and take share farmers.

The government starts development policies across the country in 1970. Population grows quickly, fed by a supported agricultural and livestock production, mainly around sorghum. Thanks to external incomes, some families buy land and motor-pump. However the water access is still unequal between all the farmers and the building of irrigation network upstream accentuates the issue. The Gulf Crisis, bringing back a lot of emigrated population, implies a high pressure on the land access but also on the pasture. Sorghum feeder dependence increases, all the more when inflation occurs. New problems relative to water and land insecurity appear nowadays for the smallest farmers, affect their cropping incomes, and threaten them to destocking.

In the cropping systems, the sorghum has the most important place. It is subject to the lack of water and supplies forage to animals. The animal husbandry systems, mainly managed by women and children are in consequence, highly dependent on fodder access.

Then, the important combination between crops and livestock within the farms are demonstrated: today, the biggest part of the livestock alimentation is realized with forage, either produced on the farm or bought on the market after the sale of higher valued crops.

Whatever water access they have, the poorest farmers are limited by the land access. They are those who depend the most on animals, those who have the biggest difficulties to purchase forage, and are likely to destock or to leave Wadi Mawr to work illegally in Saudi Arabia.

A technical support to livestock production has consequently to be accompanied by largest measures to increase family incomes, and to be focused on agriculture.

Key words: Yemen, Animal production, Irrigation, Wadi, Forage, Small ruminant, Oasis, Sorghum, Share farming, System

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أَنْزَلْنَا مِنَ ٱلسَّمَآءِ مَآءً طَهُورًا
لِّنُحْيَ بِهِ بَلْدَةً مَّيْتًا
وَنُسْقِيَهُ مِمَّا خَلَقْنَآ أَنْعَمًا وَأَنَاسِيَّ كَثِيرًا
(القُرآن الكَرلمي سورة الفرقان، ٢٥، ٤٨-٤٩)

And We send down pure water from the sky,
That We give life thereby to a dead land,
And We give to drink thereof many of the cattle and men,
That We had created.
(Qur'an, XXV, 48-49)

TABLE OF ABBREVIATIONS

ACF: Agricultural Credit Fund (ACF)

ACB: Agricultural Credit Bank (ACB)

AFD: Agence Française de Développement (French Bank Development)

CACBank: Cooperation and Agricultural Credit Bank

CNEARC: Centre National d'Etudes Agronomiques des Régions Chaudes (French Tropical Agriculture Training Institue)

CSO: Central Statistic Organization

CPO: Central Planning Organization

DPYR: Democratic and Popular Yemen Republic

EEC: European Economic Community

EU: European Union

GDAR: General Directorate of Animal Resources

GDP: Growth Domestic Product

HDI: Human Development Index

IDA: International Development Association

ITCZ: Inter Tropical Convergence Zone

KFAED: Kuwait Fund for Arab Economic Development

MAI: Ministry of Agriculture and Irrigation

PADZEY: Projet d'Appui au Développement des Zones d'Elevage du Yemen (Support to Livestock Production Development Project)

RSCZ: Red Sea Convergence Zone

RWDU: Rural Women Development Unit

RY: Ryal Yemeni

TDA: Tihama Development Authority

UN: United Nations

UNDP: United Nations Development Programs

YAR: Yemen Arab Republic

GLOSSARY

1 maad = 0,36 ha 1ha = 2,77 maad

wadi: this term designates a river in Yemeni Arabic. But it is also the name of the riverbed, of the irrigating spate, even of the water ("when the *wadi* comes"). The last definition is commonly used in the study.

Zeka: government tax

Murchidat: female extension agents, for the RWDU

GROSS RETURN : Output x Unitary market price

NET RETURN: Gross return – Inputs x Unitary market prices

LAND PRODUCTIVITY: Net return / maad

LABOUR PRODUCTIVITY: Net return / human.day

LIVESTOCK PRODUCTIVITY: Net return / cost of forage invested

NET FARM INCOME: Added Net returns – depreciation of fixed capital – (costs of external labourers + land rent + financial payments + taxes)

SURVIVAL THRESHOLD: Basic needs for a familial labourer in order to survive

SOCIABILITY THRESHOLD: Basic needs for a familial labourer to live into a society

SUMMARY

INTRODUCTION

Known as one of the oldest agricultural country in the world, Yemen is very different from the other countries in the Arabic Peninsula. This specificity gave to the country the name "Arabia Felix" thanks to its high agricultural potential, beneficiating from favorable climatic conditions. However, the era of the trade of incense and coffee, which made the Yemen reputation, is finished and the country is nowadays the poorest country in the Middle East, classified 151st over 177 countries for Human Development Index.

For thousands years, the Yemeni population has been mainly living from farming and this sector still represents in 2004, 12,9 % of the Growth Domestic Product, and 50 % of the active population. Done by 80 % of the rural population, livestock production represents a small part of the national agricultural production, but has an important economic and social function as a security to face uncertain climatic conditions.

Wadi Mawr is situated in the Tihama, which is a coastal plain along the Red Sea. Beneficiating from the high water resources coming from the highlands, this area has been settled by high population who irrigates the lands and grows among other crops, sorghum, vegetables and fruits. The availability in grasslands, forage and fodder trees, has also allowed livestock development, produced at low cost and very competitive on the regional market. Mainly managed as small familial herds, livestock is for the poorest population, a capital to deal with climatic or economic hazards.

While irrigated crops production has known intense support, with for example the construction of a large irrigation network through the Wadi Mawr Project, animal production has been less integrated by the previous development projects. Elaborated in cooperation between the Yemeni Ministry of Agriculture and Irrigation and the French Cooperation through the French Ministry of foreign affairs, the PADZEY project aims to reduce this deficit in two reference areas: Wadi Mawr and West Taez.

After 6 months of execution, the project stopped for administrative reasons. It restarts in April 2006 with readjusted objectives. One of the critical assessments of the first project proposal was the lack of sufficient preliminary field investigation. The present study aims to react to this trouble.

This report is the result of a 4 months field study which intends to give the basic data for the project implementation in one of the two areas: Wadi Mawr. It supplies general information about the biophysical environment and the main historical changes that the farmers have faced in order to understand the nowadays situation. The technico-economic approach provides the main information about the methods of farming and their results, as well as the standards of living of the farming population.

Thanks to a systemic approach, this study tries to point up the relationships at each level of organization of the society, its complexity and its diversity and to highlight the main problems that farmers face.

This study, through those different results, allows to make some suggestions, according to the main objectives of the project.

1 YEMEN AND CONTEXT OF THE STUDY

1.1 YEMEN

Official Name: Republic of Yemen (Al Jumhuriyah al Yamaniah)

Capital: Sanaa

Population: 20,7 millions (estimation 2005) (CSO Yemen, 2006)

Area: 528 000 km²

Political regime: Presidential democracy

President: Ali Abdullah Saleh, since May 22nd, 1990 (reelected in 1999)

1.1.1 Yemen, at the extrem South-West of the Arabic peninsule: the "Arabia Felix"

Yemen is located at the extreme South-West of the Arabic peninsula, in the south of Saudi Arabia and in the West of Sultanate of Oman. The country is situated near the African corn, between the Red Sea and the Golf of Aden, in the Indian Ocean.

Figure 1: Location of Yemen (© Google, 2005)

Yemen is a country geographically very diversified, with desert, coastal plain and, on the contrary to the neighboring country, high land, which furnish important rainfalls. The economy of Yemen is based on agriculture and the country is known in the entire region for its high potential for supplying alimentary needs. This advantage gave it the name of "Arabia Felix".

Figure 2: Physical map of Yemen (Unknown reference)

The country can be divided into three big areas (figure 2) from the East to the West (AL-HUBAISHI and MÜLLER-HOHENSTEIN, 1984):

- The desert plateau and the Rub Al Khali, which are desert areas (less than 200 mm) in the East of the country. Those plateau spread on the biggest part of the country and are dug by deep wadi oasis, which allow farming. Except in the wadis, the population density is very low. The most famous one is the Wadi Hadramout, where farmers are growing cereal and forge for the goats they breed.
- The highlands extend from Saada in the North to Taez in the South with the highest mountain, *Djebel Al Nabi Shu'ayb*, at 3770m asl. The high mountains create a micro-climate which leads to rainfall (up to 800 mm) digging wadis which go down to the East. As a result, people have settled here for thousands years and the biggest cities of the country are located in this area, between 1500 and 2500m (Sanaa, the capital, is at 2350m). They are beneficiating from the water resources by making terrace cultivation and they have traditionally very accurate water management. In these terraces, the crops are more diversified and farmers grow cereal, forage, but also vegetables, coffee and qat. Deeper in the wadis, where the temperature is warmer, mangoes, paw-paw and maize can grow.
- The last area spreads all along the Red Sea coast. This semi-arid coastal plain called Tihama, receives a maximum of 400 mm near the mountains. It is 50 to 70 km wide and goes from the Saudi border in the North to the strait of Bab El Mandeb in the South. In spite of the arid condition, 7 large wadis cross the plain and supply surface and underground water to agriculture. A lot of fruits, vegetable and even cotton are cultivated but sorghum, dedicated to human and animal consumption remains the dominant crop.

1.1.2 A widely differentiated society

Religion: Islam 98 % (50 % of Shiites Zaydites and 50 % Sunnites Shaféïtes)

Language: Arabic

Demographic growth: 3,45% (estimation for 2005)

(Microsoft Encarta, 2006)

1.1.2.1 A population with strong social and religious rules

Yemenis are mainly of Semitic origin, although African strains are present among inhabitants of the coastal region, the Tihama.

The population is divided in two principal Islamic religious groups: the Zaydites, in the north and northwest, and the Shaféïtes, in the south and southeast.

The *sharia*, which is the Islamic law, is strongly applied in the every day's life, and also in the Yemeni Constitution.

The population is divided in strongly established casts that condition all the relationships within the society. This casts' system has been existing for centuries, paradoxically combined with equalitarian principles of Islam.

Upper classes like the prophet descendants, notables, jurists have an acquired respect however rich they are. Then comes the tribal society, dominated by sheikhs who vouch for the very important customary right in Yemen. The middle class represents the craftsmen, the farmers, the merchants, and supplants a more modest class dedicated works such as hairdresser, barber, butcher… Finally, the lower class does not have the right to any social status and is condemned to degrading life conditions (GIROUD, 1997).

1.1.2.2 A rapidly growing population

Until the beginning of the 1970's in Yemen, the population was mostly stable due to the equilibrium between high birth and mortality rates (JOUBARI, 1999). But since 1975 with health and familial policies, the mortality has decreased while the birth rate is still very high. The population has grown by two and a half times, reaching his level of 20,7 million (CSO Yemen, 2006).

The current demographic growth is very high, 3,45%. The half of the Yemenis are less than 15 years old, what will imply in the coming years an increased pressure on economic development to provide jobs, food and basic services.

The Yemen is divided in 19 governorates other than the capital. The majority of the population is rural, and 74% live in numerous small population concentrations, through the whole country. The mountains are the most inhabited, according to the access to the main cities and basic services. But any inequalities persist and people living in rural areas are poorer and have less access to basic services including health, education, safe water and sanitation services.

A regular rural depopulation brings more and more people in the cities, which grow very fast. But the cities cannot provide sufficient jobs, what accentuate social inequalities, a lot of internal migrant lacking basic requirements to live decently.

The Yemeni government has implemented a regularly updated National Population Action Plan since 1991, what aims to slow down the population growth. In addition to the measures for health and better life conditions to decrease the mortality rate especially for children, the government fights to decrease the fertility rate and focuses its actions on the development of contraception actions.

1.1.2.3 The lack of education, an important issue for the wide young population

Illiteracy is an important issue in Yemen. The adult literacy rate is around 50%, while 65% of women are illiterate. There has been a noticeable physical expansion in educational facilities in recent years. Nevertheless, the educational system still suffers from shortfalls of enrolment capacity and favours males and urban areas. 59% of the school-age population is presently enrolled with large disparities in gender, between governorates and rural and urban locations.

1.1.3 A country where agriculture and trade has ever dominated the economy

1.1.3.1 10^{th} BC to 1^{st} AC centuries: Caravans Kingdom

Throughout the centuries, Yemeni population has been known as farmers, where the production is done by the family, usually cultivating on scattered mountain terraces.

The first important crop grown in Yemen was incense. This crop was grown in Hadramout and caravans were crossing all the country to go and sell it in the Mediterranean basin. This trade has made the wealth of several kingdoms, which the most well known in the *Saba kingdom*. At this time, Yemeni population was already managing water resource and controlling large irrigation systems, which allow to cultivate cereals, vegetables, forage … Later, after many conflicts, *Himyar Kingdom* becomes the most important empire and the economic centers move progressively to the highlands. The population builds up terraces everywhere it is possible and benefits from the rainfall by appropriate techniques. The wealth of the caravans' kingdom and the development of irrigation in terraces producing food for the big population gave the name "Arabica Felix" to Yemen.

1.1.3.2 15th to 18th centuries: Development of coffee

After incense, coffee, become an important crop for Yemen. Its development, coming from Ethiopia, occurs probably during the 15th century and it profit by the caravans' roads to reach the Mediterranean border to be sold in the European countries.

In the middle of the 17th century, trade between India and Europe intensifies. Yemen, in the middle of these commercial roads, profits by its strategic position to develop exportation, especially for coffee. Holland, then English and finally French interest in this trade and the port of Mokha, in the Tihama, grows up to become one of the most important Yemeni harbors. This trade prospers until the enlargement of the concurrence at the end of the 18th century.

During the same time, the development of the maritime trade is a problem for the ottoman, which risks to loose the benefit of the terrestrial trade. They conquer Yemen and take Sanaa in 1547. The Yemeni resistance develops from the proclamation of a new Imam in 1598 and in 1629 the Yemen is liberated.

1.1.3.3 Britain arrival and second ottoman occupation, 2 Yemen until 1990

The competition between France and England is high until English take the military control of Aden in 1839. Rapidly they control South and East governorates. It is the beginning of the Yemen separation in two parts.

In 1849 starts the second ottoman occupation in Sanaa, Taez, the Tihama and in the highlands. Like during the first one, the Yemeni population progressively builds up the resistance and with the Imam Yahaya the Da'an agreement accepts the Imam, but Yemen is under the Ottoman Suzerainty. Republican movements have increasing support in the population. They profit by the death of the Imam to make a coup d'état and to proclaim the Yemen Arab Republic, the 26th of September 1962. The royalists have to leave to the North and to Saudi Arabia but they resist and a civil war will take place in North Yemen for 8 years.

In the South, Northern rebellion inspires South Yemeni, who resists against English. With the influence from opposition parties, English decide to leave Yemen in 1967. With any resources, South Yemen finds quickly the help from the socialist bloc. In 1967, the Democratic and Popular Yemen Republic is proclaimed.

In the 1970's, the YAR develops. A part of the population takes benefit from the fast growth in Saudi Arabia following the oil crisis in 1974.

All times, conflicts between the 2 Yemen happen, but the same objective of the reunification, succeed in May, 22nd 1990.

1.1.3.4 From the reunification

When the Gulf crisis occurs in 1991, Yemen sustains Iraq, which results in the expulsion from Saudi Arabia of 800 000 Yemeni. This massive immigration leads to the instability and a very high inflation. In the same time, conflict between ex South and North persist until 1994, when the North take the control of Aden. Yemen is now really reunified.

Since 1994, Yemen is stable even if the government does not control all the country.

- 10th century B.C to 1st centuries A.C: Trade of incense and caravans kingdom

- 622: Exile of Mohammed to Medine, first year of Hegira

- 628-630: Beginning of Islam in Yemen

- 898: Beginning of the Zaydite imamate which will stay until 1962

- 1538-1636: First ottoman occupation of Yemen

- 17th century: Trade of coffee exported to Europe

- 1839: English forces seize Aden

- 1849-1918: Second ottoman occupation of Yemen

- 09-26-1962: Proclamation of the Yemen Arab Republic (North Yemen) and beginning of the eight years civil war between royalists and republicans

- 11-30-1967: Proclamation of the Democratic and Popular Yemen Republic (South Yemen)

- July 1978: Ali Abdullah Saleh becomes President of the Council of the Yemen Arab Republic

- 05-21-1990: Reunification of the North and South Yemen

- 05-22-1990: Proclamation of the Republic of Yemen

- Jan-Feb 1991: Diplomatic alignment with Iraq results in return of 800 000 Yemenis from Gulf Arab States

- 1990-1994: Conflict between ex North and South army, instability and high inflation

- June 1994: End of the conflict between ex North and South armies

- 09-1999: First presidential election with universal suffrage: Ali Abdullah Saleh is reelected

- July 2005: Increase of diesel price

(GIROUD, 1997 and Microsoft Encarta, 2006)

1.1.4 Economic current situation

Money: Yemeni Riyal (1$=198YR and 1€=250RY in July 2006)

GDP: 2 551 994 millions YR in 2004 (13 431 millions US$)

Growth of the GDP: 3,87 % (2003-2004 at constant price)

Agriculture in GDP: 12,9%

Services in GDP: 43,3 %

Industry in GDP: 43,8 %

(CSO Yemen, 2006)

Yemen belongs to the UN list of 50 countries classified as Least Developed Countries. In 2005 the UNDP ranked Yemen 151 among 177 countries of its Human Development Index.

Its economy relies especially on oil and agriculture. Indeed the industry, which is an important part of the GDP, is dominated by petrol refining and mining. But food processing, such as biscuits, and building materials are also contributing to this sector.

The total exports reach to 731 781 million of Yemeni Ryal, dominated by crude petroleum and refined oil products, but also by fish, fruits, vegetables, cotton, coffee, biscuits and plastic pipes. The major markets of the Yemen are Asian: Thailand, China, South Korea, and Japan.

However agricultural the country may be, it is highly importing food products, such as cereals (rice, wheat flour), feed grains, food stuffs, but also external machinery, petroleum products, transportation equipment. The imports are up to 736 533 million of Yemeni Ryal, what make Yemen very dependant on external suppliers, such as Japan, Saudi Arabia, Australia, EU countries, China, Russia, United States.

The high moonlighting and emigration of the population are escaping from the national economic assesses, and have to be estimated a lot higher than they are calculated. Those jobs and businesses are a real parallel economy that makes the economic development policies difficult for the government, but at least allow the country to stabilize the inflation, and to have an unemployment rate lower than the official one (GIROUD, 1997). The agriculture remains a pillar of domestic economy in such a rural society, but is regularly decreasing in the GDP, from 24,2% in 1992 until 12,9% in 2006 (CSO, 2006).

1.1.5 Agricultural sector, and rural development policies

Until the early 1970s, local cereal production covered almost all cereal requirements. The 1970's and the 1980s have been characterized by significant changes in the rural economy. The government has implemented wide rural development policies, thanks to decentralized public organizations in a lot of governorates, such as Ibb, or Al Hodeidah with the TDA.

It has resulted in effective economic growth, investment in agriculture and in irrigation means such as dam projects or well irrigation extension.

But in the same time it has led to the decrease of traditional rain fed cereal production, and has transformed the agricultural sector, now highly dedicated to market orientation and irrigation-dependant crops, and to the qat.

The *qat* (*Catha edulis*) is consumed by the wide majority of the Yemeni households, especially by the men. Overcoming the debate whether it should be considered as a drug or not, it has a real impact on relationships in the society, as it accompanies all the important discussions and reunions, and unites men in a peaceful atmosphere.

But in the mountains, it takes more and more the place of essential crops like cereals. And everywhere in Yemen, the part of the family budget dedicated to this consumption is

very high, and condemn some families to restrictions, particularly for food and household management.

(GIROUD, 1997)

The agriculture of Yemen is now dedicated to cotton, fruits, vegetables, cereals, livestock and poultry, hides, skins, tobacco, honey. The main production is sold on the market, while numerous families are still relying on partial auto consumption. But the first rank is given to the qat, which has taken the place of the coffee in the mountains.

Land use: Arable land (3 %), Permanent crops (13 %), Permanent pastures (33,5 %), Forests and woodland (4 %), Other (46,5 %)

1.2 PADZEY PROJECT TO SUPPORT RURAL DEVELOPMENT IN TWO LIVESTOCK PRODUCTION AREAS IN YEMEN

1.2.1 The PADZEY Project, a livestock-oriented project

The PADZEY Project is a project of the Yemeni-French cooperation, implemented by the General Directorate of Animal Resources (GDAR) of the Yemeni Ministry of Agriculture and Irrigation (MAI).

The main objective of the project is to contribute to the reduction of poverty in rural areas, through the development of animal production. More precisely, the project aims to:

- Improve animal production in the two areas of the project;
- Improve the processing and the marketing of animal products.

1.2.2 Origin of the PADZEY Project

In February 2002, Yemen entered into the priority zone of French aid (ZSP). At that time, the Yemeni government expressed the will to reduce poverty through the development of animal production. Thus, the French Ministry of Foreign Affairs (MAE) agreed to implement a rural development project focused on livestock.

And that was how the PADZEY Project was launched in February 2005, with an initial budget of 2 512 000 €, for four years. It was jointly managed by the GDAR and the French Embassy.

Six months later the launching, the project was transferred to the French Development Bank AFD, that led to a restructuring of French technical and financial cooperation. With regard to AFD principles, the project management and implementation authority had been completely transferred to the GDAR.

Then, several constraints, like the transfer of funds from MAE to AFD or even the change of organization of the PADZEY project, limited strongly the project actions. Besides the project was not yet functional one year after its launching.

Moreover AFD was preoccupied by the feasibility of the original plan action that seemed too ambitious. For all these reasons, the GDAR and AFD decided to update the objectives of the PADZEY Project, organizing a study-mission of the French Institute for applied research and development (IRAM), in April 2006.

1.2.3 The revised project approach and objectives

The original project was considered as a project focused on "the provision of services on a supply-driven basis". It did not take into consideration farmers' needs. Therefore the new project approach has been changed. The new setting-up of the project define the revised approach as follows:

- "The new set-up will clearly channel its support to ***livestock development***. […]
- The project will however use a ***holistic approach,*** taking into consideration the whole farm system […]
- The new setting will give a greater priority to ***direct grass root field activities*** that will be identified in close interaction with the farmers and that will be directly provided to them. […]
- The project will be ***demand driven***, thus adjusting its support according to the needs explicitly expressed by farmers […]
- Activities will be carried out on an ***action research basis*** […] Solutions will have to be tested on a basis of pilot action, carried out by pilot farmers with strong guidance provided by project's and partner's staff.
- The project will prioritize such ***investments that directly improve farmers' conditions*** for production (materials, small cheese processing units, etc.) and minimize "structural investments" […]" (BENZHAF, 2006)

In this way, the project should make farmers imply in the development of livestock production and in the increasing of their incomes.

Concerning the new setting up of the project, the main objective is redefined as follows: "increasing the incomes from livestock production of small farmers in the two areas of the project". More precisely, it comprises two main strategic objectives:

"The first component, related to the improvement of animal production, aims at increasing the technico-economical results of small farmers through the reduction of the constraints and obstacles limiting the development of their livestock activities. This will include (i) Improving animal health of small farmers' livestock, (ii) Optimizing small farmers animal feeding through intensified integration of livestock and agriculture, (iii) Improving small farmers herd management, and (iv) Improving sustainable management of open range resources.

The second component, related to the improvement of the processing and marketing of animal-products aims at increasing the added value of small farmers' animal products. This will include: (i) Improving cheese processing and marketing in Taez area, and (iii) Improving profitability of sheep fattening." (BENZHAF, 2006)

1.2.4 Why to carry out two field studies for the PADZEY Project?

The first step of the implementation of the PADZEY Project consisted in creating the largest possible data base on the current farmers' situation and on the role of livestock for farm households, as there were very few agricultural field studies that had been undertaken so far in Yemen.

Thus, the project required two field studies, including the training of Yemeni professionals as for the methodology implemented for those studies.

The activities required were(annex 1):

- Agrarian diagnoses of the two areas, that means the characterization of the different zones of the project areas according to natural features, population, agricultural and economical activities and so on;
- Diagnoses of the farming systems focused on livestock production;
- Diagnoses of water and land management in the two areas;
- Presentation of the main results to local officials and farmers implied in the study and to the PADZEY staff in Sana'a. (from Terms of reference)

That is why our two student teams from the tropical-agriculture training institute (CNEARC) were requested to undertake the two field studies, all the more because the CNEARC approach corresponds to the revised approach based on a holistic approach

1.3 COMPARISON OF THE TWO STUDY AREAS

MAIN CHARACTERISTICS		WADI MAWR	MAQBANAH AREA
Bio-physical characteristics	Altitude	From 10 to 130m	From 500 to 1200m
	Precipitation	From 70 to 250mm	From 300 to 650mm
	Geology	Alluvial deposits	Mainly volcanic basement rocks
	Relief	Plain	From high escarpment to plain
Size of the study area		1000 km²	300km²
Economic results	Feeder sorghum price	40 YR/packet in raining season	75 YR/packet in raining season
		80 YR/packet in dry season	120 YR/packet in dry season
	Sorghum grain price	70 YR/kg of grains	70-80 YR/kg of grains
	Goat price at 1 year old	7000 YR/dam	10000 YR/dam
	Sheep dam price	6000 YR/dam	
	Heifer price	45 000 YR/dam	100 000 YR/dam
	Survival threshold	250 000 YR/family	195 000 YR/family
	Size of the family	8	10
Main animal husbandry types		Small ruminants for meat Dairy cow for human consumption	Dairy cow and dairy goat for cheese processing

Figure 3: Comparative table of the two areas of the project

1.4 STUDY PROCESS: THE APPLIED METHODOLOGY OF THE AGRARIAN DIAGNOSIS IN WADI MAWR

1.4.1 Implementing an agrarian diagnosis survey

To fulfil the objectives described above, we have implemented an **Agrarian diagnosis survey** to define all agricultural activities at different scales. Indeed this method is a systemic and multidisciplinary approach that puts a stress on interactions between the different system components, from the regional to the specific situations.

Doing an agrarian diagnostic survey supposes to work at different scales of organisation (regional scale, farm scale and plot or herd scale). To each of these scales a system concept is associated:

At the plot scale, for a set of plots cropped in the same way in a given agro-ecological environment, a **cropping system** refers to specific spatial combination and temporal succession of crops and their management.

At the herd scale, the **animal husbandry system** refers to a set of animals bred in the same way for one or several end-products.

At this stage, we are still working at the scale of the plot or the herd. The analysis has so far taken little account of the overall production unit. At the farm scale the concept associated is the **farming system**, which is "a mode of combination between land, labour and capital in order to produce crops and/or herds, identical to several farms. A farming system is characterized by the kind of products, labour (qualification), means of production used and by theirs proportions" (Reboul, 1976).

At the regional scale, several farming systems together and the interactions between them constitute an **agrarian system**. The agrarian system is the sum of relationships between the farming systems and the general social and economic organisation of the whole society. M. Mazoyer defines the agrarian system as: "**a mode of exploiting the environment historically created and sustainable, a system of production forces adapted to the bioclimatic conditions of a given space and responsive to the social conditions and needs of that moment**" (In FAO, 2002. *Guidelines for agrarian systems diagnosis, FAO Land tenure service rural development division, 69p.)*

1.4.2 Applied methodology on the field

1.4.2.1 Meetings with the PADZEY project staff and bibliography

The first week in Yemen was spent in Sana'a. We met the PADZEY project staff and specifically the director of the animal resources department, the PADZEY project coordinator, and the technical assistant, to discuss about the field work, the methodology and to precise the objectives and the process of our study.

We took the advantage of our presence in the capital to search information about specific data of agriculture and breeding in Al Hodeidah Governorate, thanks to the help of several persons responsible, in main departments of the Ministry of Agriculture.

1.4.2.2 Work team

In Wadi Mawr, we have carried out all the field research in binomial; that allowed us to always crosscheck information or raise new questions. So we can say that it was best to work in binomial for a best understanding.

Moreover, we have worked separately so that we were able to understand two opposite worlds: women world and men world. It is right that, in such a traditional context as the Yemeni one, women do not discuss freely with men. As they play a key role in agriculture and breeding, therefore it was important that a woman interviews them in order to understand better their agricultural activities.

Thus, each of us has implemented the entire agrarian diagnosis survey with the help of one technical assistant of the TDA and also a female interpreter because the female counterpart speaks few English. That helped us to understand faster some local technical aspects but also to adapt our behaviour to different field situations.

On the other hand, we had carefully taught our Yemeni counterparts our methodology based on listening. In this way, they understood little by little how to formulate questions, how to let farmers feel comfortable and they also became aware of the relevance of farmers' answers. Consequently they felt implied in the study; that improved its efficiency.

1.4.2.3 Landscape analysis (2 weeks and half)

This step consisted in identifying the different types of ecosystems in the study area and the agricultural practices, including the management of natural resources developed by the different farms.

Most of the work effectuated at this stage was observations of the whole Wadi Mawr area, based on bio-physical characteristics: soils, spontaneous vegetation, water resources, but also agricultural and breeding activities. It consisted also with discussions with the farmers met in the fields or with their animals, asking them about their practices, about the local land and herd ownerships. An important part of this step was dedicated to the natural resources management, so to the specific subject of the pastures and water accesses for farmers and breeders.

During this period, we went daily over the large area, along the difficult roads and pathways to understand how the area is organized.

The technical assistants we worked with in our team, thanks to their engineer skills in animal production and rural development but also to their knowledge of the area, helped us a lot to better understand the area.

In the TDA office of Al Hodeidah, we met the persons responsible of water and soil department, of marketing department and of climatic department. They allowed us to obtain bibliography, maps of the area, and data about main physical factors such as climate, local population, agricultural prices. In the TDA office of Wadi Mawr, the manager and the engineer responsible for the extension section were kind to answer our questions (specifically about local crops in all the area).

1.4.2.4 Historical study (3 weeks)

The objectives of this step were to:

- look for the main evolutionary steps that the area has gone through and to focus on agricultural and socio-economic changes,

- identify the origin of the diversity of farming households and the foreseeable changes in agricultural systems.

To fulfil these objectives, we spent three weeks interviewing old farmers in different areas to know all the changes that occurred in the zone and that had an impact on agriculture. We carried out about 60 open-question interviews that allow us to crosscheck historical information and to build a first pre-typology of the current farming systems of the area.

At this step, it was difficult to have women point of view on agricultural changes because old women generally did not have chance to go out their villages during their lives so they were not aware of national events. Consequently the both team focused their attention on meeting old men or key resource persons, like sheikhs. The questions were focused on the global changes, through their personal experience of farm trajectories.

Little by little we became able to understand the main agricultural and socio economic evolution of Wadi Mawr, its issues, with special focus on social differentiation, water access, and livestock evolution in the families. This allowed us to define the farming activities realized in the area, to choose strategic ones to study, and to think of locations for a possible PADZEY future implantation.

Indeed, according to the situation we understood about the farmers and the difficulties they face, especially small farmers, we decided to study deeply two main areas with an important water access differentiation: an area with relationship between canal and rain fed area, an area depending completely on groundwater.

Originally we had planed to pass 4 weeks studying the agricultural history. A logistic problem occurred, and the car broke down for quite 2 weeks. According to the big size of the area, and the heat, it was not possible to work outside with the team, so we took the advantage of this time to think about the farming systems we would study, and begin the intermediate report.

1.4.2.5 Intermediate report writing

To make clear our first observations and data, we wrote a synthesis of the main results (regional presentation of the different agro-ecosystems, the different farming systems and households, main trends and problematic of agricultural development). Thus, we could discuss with the PADZEY project staff about the choice of farming systems sampling and chosen zones for the other steps of the study.

1.4.2.6 Technical and economical analysis of cropping and animal husbandry systems (4 weeks)

At this point we focused our attention on zootechnical and agronomic aspects, and economic performances of cropping systems, animal husbandry systems that compose each farming system of the two areas chosen according to PADZEY requirements.

To characterize the technical sequences of each system, we realized semi-structured interviews with farmers (open-questions not appropriated at this stage, especially with farmers

who are not used to talk about their activities with foreigners), preferably near a plot or the herd to have a look on practices and to understand their pertinences.

But in Wadi Mawr because of the heat, it was easier to find the farmers and their wives in the yard of their farm, and spend a lot of time for the interviews while checking with observations of the herds (especially in the end of the afternoon after the grazing time).

We carried out about 55 interviews, and were able to understand the main technico economic datas about the breeding activities focused on the forage and pasture access, and about cropping activities differentiated by the water access.

The female team met the TDA *murchidat* to discuss with them about their actions in the fields, and specifically about the women's role in the farms in order to get trails to better lead the female interviews.

In the same time as this technical study, we kept on trying to understand the difficulties for farmers in each of our two main areas. We then planed to focus the next step on the study of two villages where we went several times, to know better the farmers and have the time to see them more than once. The farming systems study would be limited to Al Rosfa and Al Nasheria.

1.4.2.7 Technical assistance from CNEARC (4 days)

At the beginning of the period dedicated to the analysis of cropping and animal husbandry systems, one teacher carried out a field mission in order to support and advice us on the technical-economic surveys of farming systems. Thanks to observations and open-question interviews, the teacher approved the identification of zones concerning their natural resources and types of management, types of agricultural and livestock practices; and the choice of farming systems sampling. In this way, we could continue our field study without ambiguity.

1.4.2.8 Farming systems analysis (2 weeks)

This step consisted in analysing, at the farm scale, the combination of sub-systems that farmers manage, their reason of being and performances. Indeed the economic analysis allowed assessing whether the farmers who manage a same type of farming system meets basic needs of his family and maintain his means of production.

At the same time, we tried to assess the survival level and the social level, interviewing poor families and also collecting food prices on main markets of the zone.

We also focused on the problems farmers meet, about technical aspects of their agricultural and breeding activities, but about the social differentiation and its impacts, and about the water safety.

1.4.2.9 Synthesis (1 week)

The aim was to formulate the diagnosis of the agrarian systems; the importance of husbandry in the agrarian system, the relations between agriculture and animal productions. It was then needed first to put together all the processed and collected data, to analyse them at the regional level.

At this step while analysing our data in the camp of the TDA in Wadi Mawr, we took the advantage of meeting several engineers and technicians working for several years. They helped us to precise some points of our field data, but we could exchange constructive

opinions that were very useful for our study. The persons responsible for extension section, agriculture, animal production, veterinarian section and North canal irrigation have contributed to those discussions.

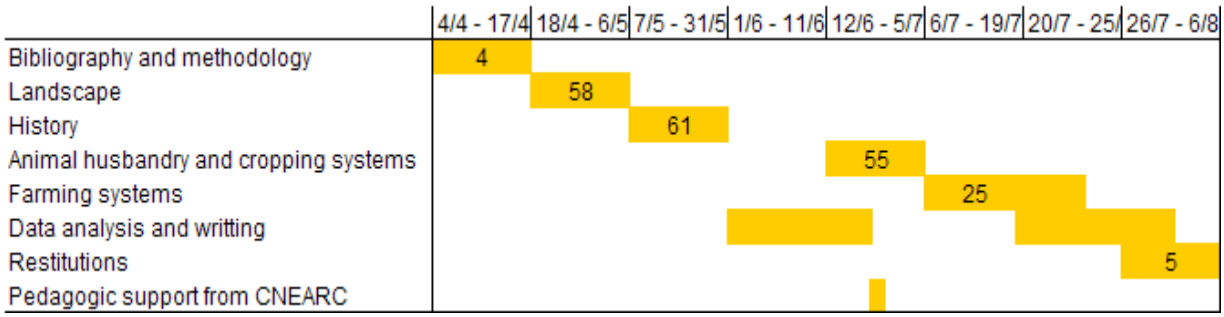
1.4.2.10 Local restitutions (1 week)

We organized a first restitution of our work to the local TDA staff, engineers and field technicians, but also *murchidat*. The main water differentiation implying the chosen farming systems has been presented, followed by very precise technico-economic results of three farming system examples. The aim was indeed to assess and correct our results thanks their field knowledge, and to have a debate with the staff about the issues of breeding and agriculture in Wadi Mawr. This restitution was prepared and led by the four members of our team.

Before leaving the field, we organized two local restitutions to exchange with farmers: one in Al Rosfa and one in Al Nasheria. We presented in each case the specific economic situations of the village, of its small farmers. We checked if our results were close to their reality, then debated with them about their problems and the solutions to face them. The two restitutions were presented only in Arabic by the Yemeni counterparts, to avoid interpreting waste of time and to allow better understanding from the farmers.

Then we also presented our results to the head quarter of the TDA in Al Hodeidah, in order to valid them, but above all to debate on new appropriate project strategies that the PADZEY project could implement in collaboration with the TDA.

Finally, we demonstrated our analysis to the whole project staff and to different representatives of the Yemeni Ministry of Agriculture and Irrigation.



1.4.3 Discussion about the study process

1.4.3.1 Limits of our study

The field study we have carried out permits to well describe qualitatively all agricultural activities of the studied area but does not give quantitative data as for concerned farm proportion. That could better validate our results; however we were not able to do that in such a relative short time (4 months).

1.4.3.2 Difficulties to carry out the field study

The team work represented a big challenge for us all the more because the team was heterogeneous. We had also to learn quickly an oral Arabic, to be able to check if the interviews with a lot of translation times were not modifying the farmers' words.

But the counterparts we worked with were well involved in the study, and it was a great experience to manage this warm team.

2 WADI MAWR: AN AGRICULTURAL IRRIGATED AREA BENEFICIATING ON FAVORABLE NATURAL AND ECONOMIC LOCATION, MANAGED BY STRONG TRADITIONAL RULES

2.1 LOCATION OF THE PROJECT AREA

The 60 km long and 20 km large project area is situated in the North of the Tihama plain, along the wadi Mawr, the largest wadi of Yemen. In the West the area spreads until the Red Sea, while in the East a big highway serves Saudi Arabia in two hours by car, and the big Al Hodeidah city as fast. The area profits by the favorable wadi and an interesting economic location, allowing high agricultural production and large outlets.

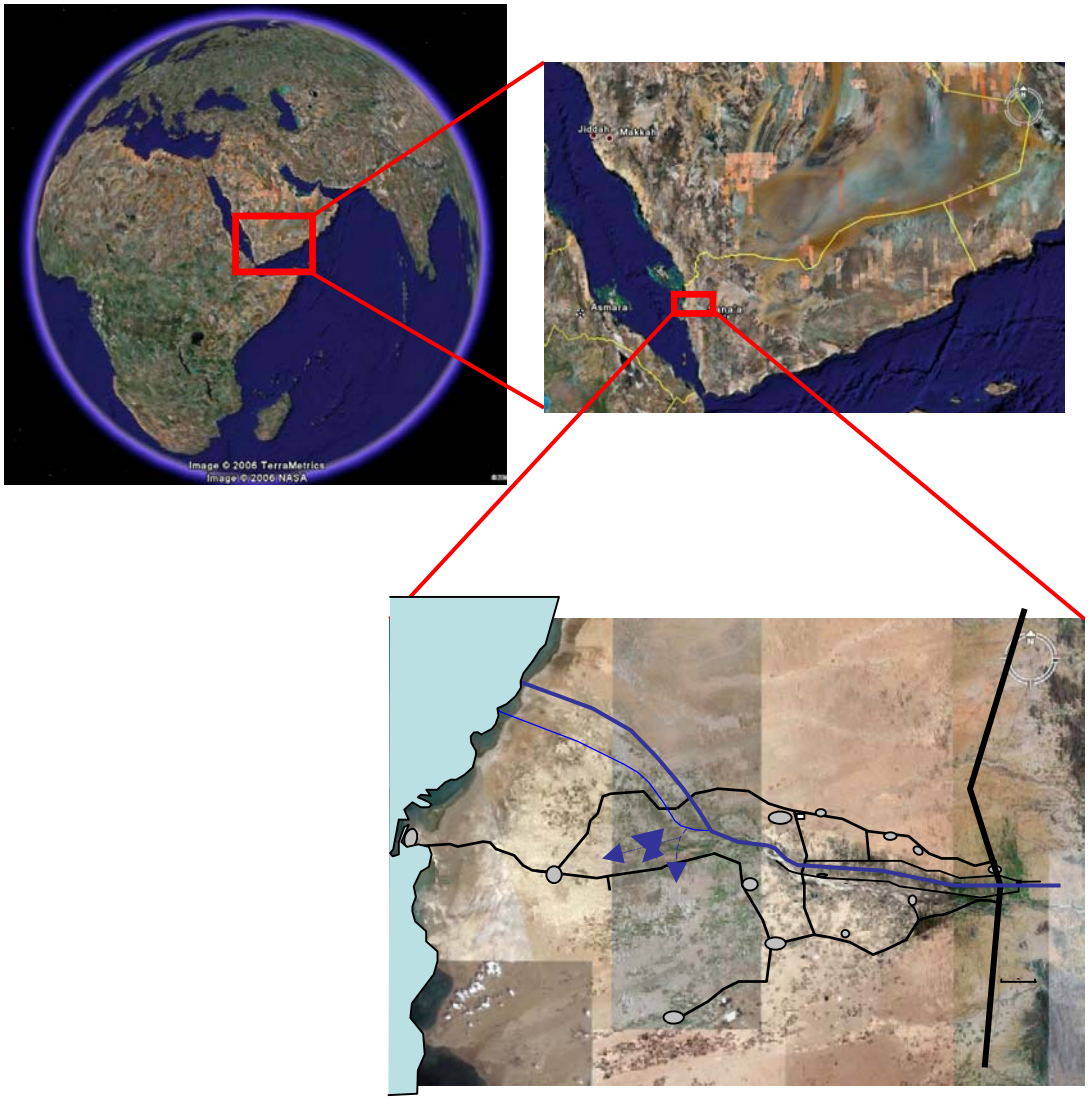


Figure 5: Location of the project area (© Google, 2005)

2.1.1 A growing population concentrated along the best irrigated areas

People have settled where the living conditions are the more welcoming for their activities, in the East and all along the wadi until the see. The road linking Al Marras to Al Luhaya allows an easy access to all the area, and concentrates a lot of villages and facilities.

As the health services are available and according to the little control of births (JOUBARI, 1999) the population knows continuously a big and fast growth and the villages are very inhabited and extending.

The Wadi Mawr villages are politically gathered in sub-districts, and the sub-districts in two main districts The East irrigated area depends in majority of the Al Zuhra district, which has 137 000 inhabitants in 2004, whereas it had 112 000 in 1994 (TDA source). Al Zuhra city has the highest density of population, followed by cities like Al Motared or Al Marras and a lot of villages on the two sides of the wadi. This area is indeed the most suitable to develop agriculture and breeding.

The studied area in the West depends on Al Luhaya district, counts around one third of the Wadi Mawr population, with approximately 30 000 inhabitants. The water is less abundant compared to the East, but it is quite densely inhabited and dynamic especially along the road. As for the far West of the area, the water is very rare, but some non agricultural activities maintain a population there.

Eventually the rainy area counts few and very sparse villages, where there is not a big density of population, as the environment is exploitable with difficulty.

2.1.2 An organized agricultural area providing services and access to markets

2.1.2.1 A transport network allowing numerous exchanges

The Wadi Mawr area is organized from East to West, along the wadi. In the East, the dam starts the irrigated perimeter and the water follows the canals or the riverbed until the see. The main communication network is structured the same way, with principally the Eastern highway between Al Hodeidah and Jizan, Saudi Arabia, and the East-West road between Al Marras and Al Luhaya. The biggest cities as Al Marras, Al Zuhra, Al Luhaya, and the main markets are available along those axes.

All the villages have a quick access to this network thanks to other numerous roads and ways, and are quite easily linked to services. Transport companies of cars and motorbikes are serving all the area and also linking the area to other national cities, like Al Hodeidah.

2.1.2.2 Fundamental services dedicated to the population

The Wadi Mawr villages generally do not have electricity, except in Al Marras, Al Zuhra and Al Luhaya, and are relying on petrol lamps. The telephone cabins are only available in those same cities, but mobile servers are covering all the area.

Almost each sub-district has a school and public hospitals but also private dispensaries are insuring health services to inhabitants in all the area.

Some villages have water supply facilities, thanks to wells either built by the government project or by the village community. But in some cases close to the sea the water is not drinkable since it is too salty, or the wells are not enough maintained and are only used

for housework and animals. So for the drinkable water, people take it in private wells of farmers for free according to the Charia, the Islamic law.

2.1.2.3 Public support of rural development through TDA

Tihama Development Authority (TDA), the public organism for rural development in the large plain, is working in several wadi areas of the Tihama for three decades, including Wadi Mawr.

It is the cause of the dam and the big irrigated perimeter of the area, encouragement for underground water use, or rural women development. Researches, training of workers but also technical supports to farmers, are conducted through the agricultural and the veterinary domain, and extension activities are developed to perpetuate the results.

The main office is located in the camp of Al Zuhra, where the main agronomic engineers and technicians are also living, and several centers are spread in the whole area, where technicians are available to advice farmers.

2.1.2.4 Great marketing facilities

Four big weekly markets take place in Wadi Mawr area. All products can be found: food for the families, handicraft as basket work and pottery, but also tools for farmers, concentrates and drugs for animals, sorghum feeder and animals.

MARKET DAY	Saturday	Sunday	Tuesday	Thursday
PLACE	Al Marras	Al Zaher	Al Rafi	Al Khamis

Figure 6: Weekly markets in Wadi Mawr

In addition to the weekly markets, small daily markets take place in six villages: Al Zuhra, Al Motared, Al Marras, Mawr, Al Luhaya and Deir Akhrach. Only basic food products and sorghum feeder are sold.

2.2 WADI MAWR: AN OASIS IN THE ARID TIHAMA PLAIN

2.2.1 The arid climate of the Tihama

In the project area, like everywhere in Tihama, the climate is hot and arid. Monthly mean temperatures range from 26°C in January to 34°C in June and Annual rainfalls are very low. The precipitations increase progressively getting away from the sea. The extremities of the project area get annually in the West and in the East respectively 75 mm and 260 mm (Annex 2). Those very few rainfalls make rain-fed cultivation nearly impossible in the West and hardly suitable in the East, especially because of there annual repartition and the high temperatures.

A slight rainy season occurs in April and May influenced by the Red Sea Convergence Zone (RSCZ). But the most important rainfalls occur from July to October, corresponding to the monsoon of India and East Africa and depending on the mechanism of the InterTropical Convergence Zone (ITCZ).

Then, the year is divided in four seasons:

- Summer, locally called *Seif* - from March 20th to July 20th – few rains in May and April and warm temperature.

- Autumn, locally called *Kharif* - from July 21st to November 20th – rainy season with most of the rains and temperature colder than summer.
- Winter, locally called *Mosemi* - from November 21st to January 20th – beginning of the dry season with very few rainfall and the coldest temperature.
- Spring, locally called *Shubat* - from January 21st to March 20th –dry season with nearly no rainfall and temperature warming up.

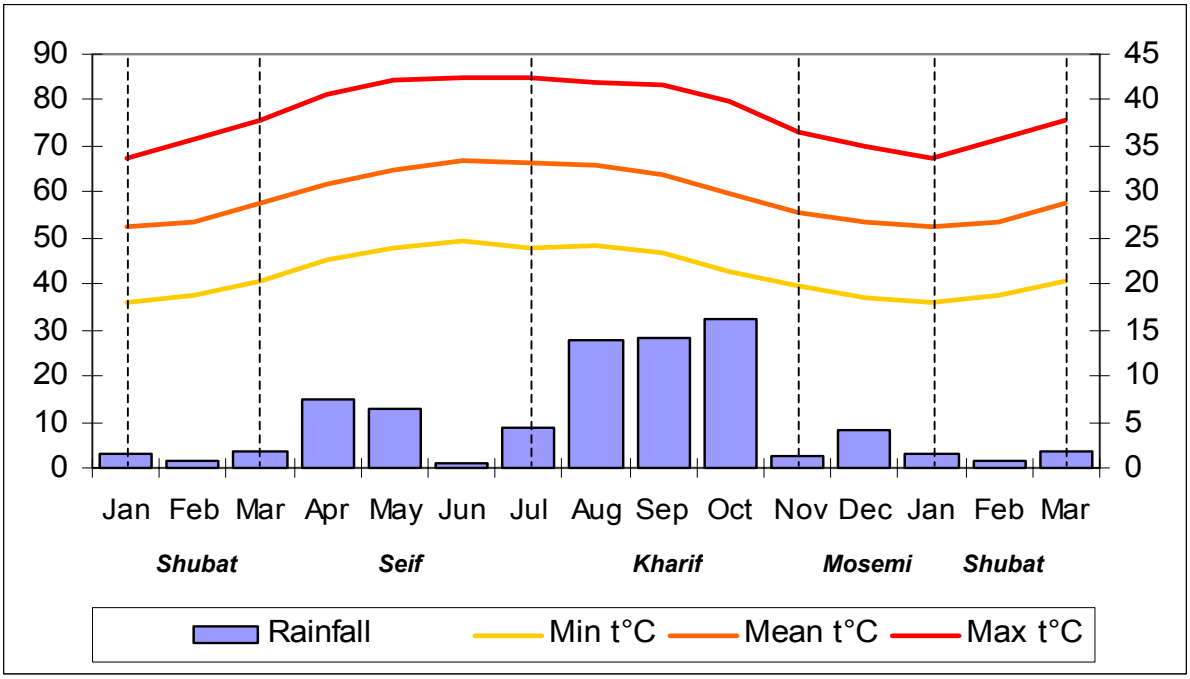


Figure 7: Ombro-thermic diagram in Al Zuhra (Annex 2)

Because of this repartition, only *Kharif* has sufficient rainfall to allow rain-fed cultivation in the East. Indeed, the average rainfalls in Kudmat Marraryh, near Al Marras, Eastern end of the project area, are a lot higher than in Jabal Al Milh, Wester end.

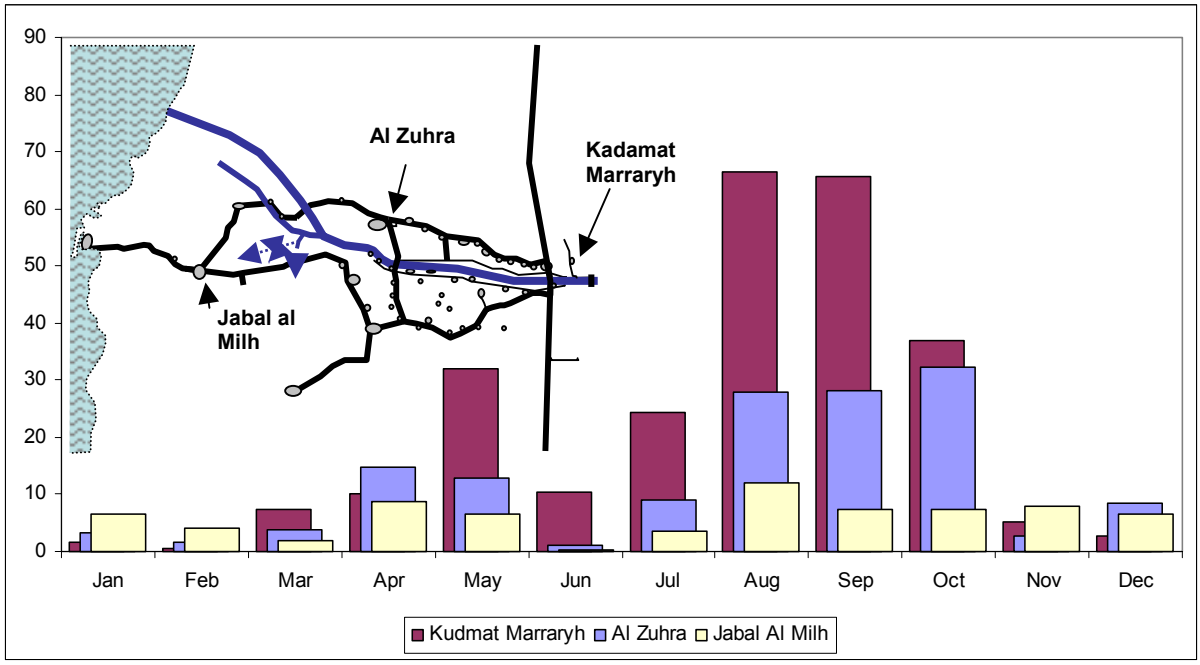


Figure 8: Rainfall distribution across Wadi Mawr (Annex 2)

2.2.2 Between mountain and sea, a plain crossed by a large wadi

In spite of the very few rainfalls which hardly allow rain fed cultivation, Wadi Mawr benefits from a big quantity of water coming from the mountains arising more than 3000 m above sea level, at the East of the project area. Those highlands constitute a big catchments area of 7912 km² for the wadi Mawr. The average annual rainfall in the mountains is about 520 mm, and the estimate long term average annual runoff volume is 210 millions of cubic meters (Mm^3).

This high water availability supplies surface water and recharges the underground storage.

2.2.2.1 High water resource thanks to the wadi

Like for the rainfalls, the wadi flow repartition is irregular during the year and across the project area. During *Mosemi* and *Shubat*, in spite of the very low wadi flow, water is available in the Eastern part of the project area but rich people, growing fruit tree in this area, take all the water. Then, during the year, the influence of both RSCZ and ITCZ make a lot of rainfall occurs in the mountain bringing big amount of water in the wadi during summer and autumn.

For centuries, people have taken benefit from this water and irrigate their land by deviating the wadi with dams and flooding their field to grow crops under conditions as good as possible.

Most of the water in the wadi comes in *Seif*, 45% of the annual flow, then, farmers grow a lot of crop in this season. But even if the annual wadi flow repartion make *Seif* having most of the water, the rainfall and the colder temperature, deacrising the evaporation, in *Kharif*, allow to cultivate the land and even to have better yields. Moreover the high water storage capacity of the soil, that we will present later, lets crops like sorghum to grow during *Mosemi* and sometime until *Shubat*.

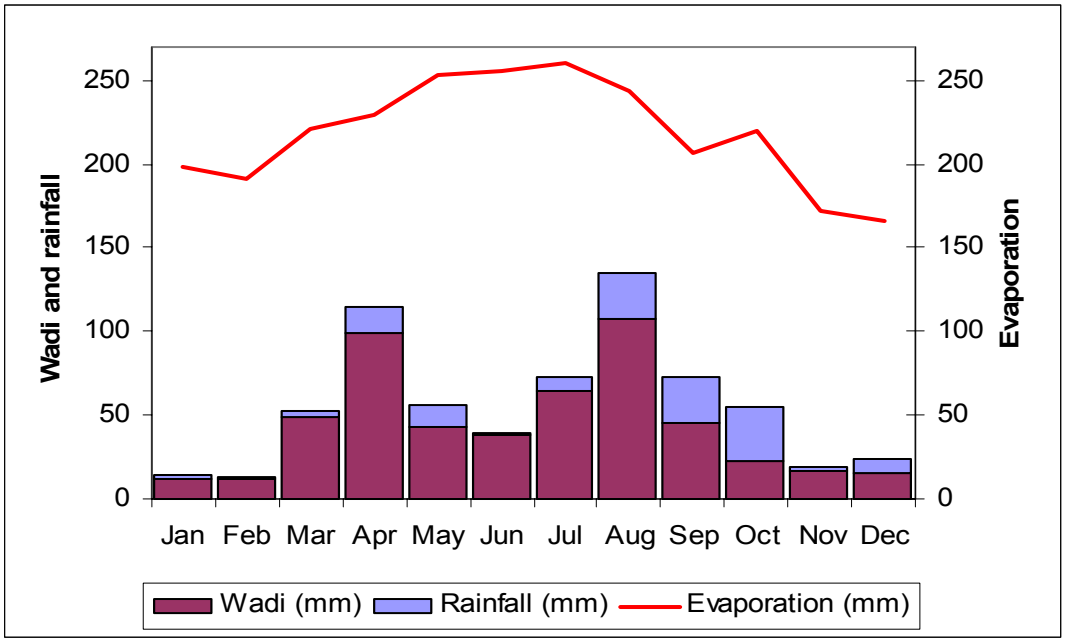


Figure 9: Water availability for the 40 000 ha pontentially irrigated by wadi (Annex 2)

Although the water from the wadi is available in big quantity, the above graph shows that it is not enough to irrigate the 40 000 ha potentially cultivable. Indeed, the irrigation system, described in chapter 2.4.1, make that the farmers living in the West and South-West of Wadi Mawr do not get the water as much as those in the East and in the North-West. The wadi has not even reached the western end for more than 20 years. Consequently, farmers in west area try to use another resource of water, the underground water.

2.2.2.2 Micro-relief and unequal access to underground water

Wadi Mawr is a very flat area extending from the sea to the mountains. The project area elevates from 10 m above sea level to 140 m going to the East, which does not imply any difference upon the climatic conditions. However, the natural discharge of the groundwater and the micro-relief make access to this resource of water different according to area.

The underground water is a very important resource of water for agriculture, especially where there is no wadi. The aquifer natural discharge occurs throughout the year along the seacoast and recharges thanks to the wadi and the deep percolation losses from the canals and the irrigated fields. Because of the natural flow of the groundwater, the elevation above the sea level of the top of the aquifer decrease going away from the wadi. As the soil surface is flat, the water depth increase going to the north or to the south. However, even if most of the project area is relatively flat, the micro-relief exposes a hill all along the Northern side of the wadi. This mount increases the depth of the groundwater and natural trees grow with difficulty in this area. On the contrary, in the south, just after the area irrigated by canals, the semi-shallow groundwater allows a lot of trees to grow, which furnish forage for goats.

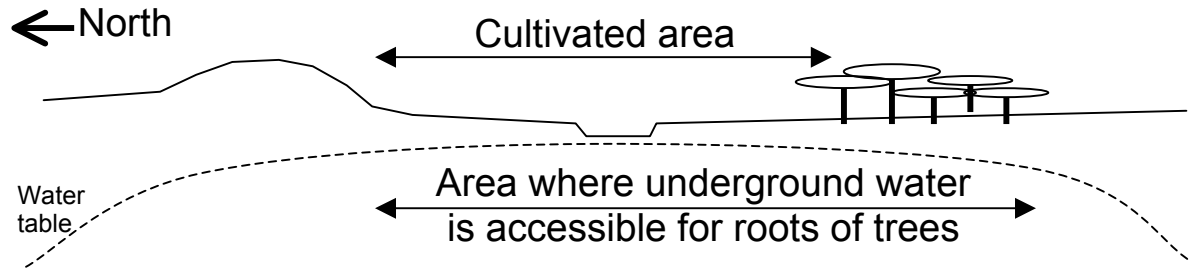


Figure 10: Availability of underground water from North to South

Then, going to the west the groundwater is shallower and shallower, which make irrigation by well more suitable. However, the salty water from the sea makes groundwater use unsuitable for agricultural purpose in the Western end of the project area.

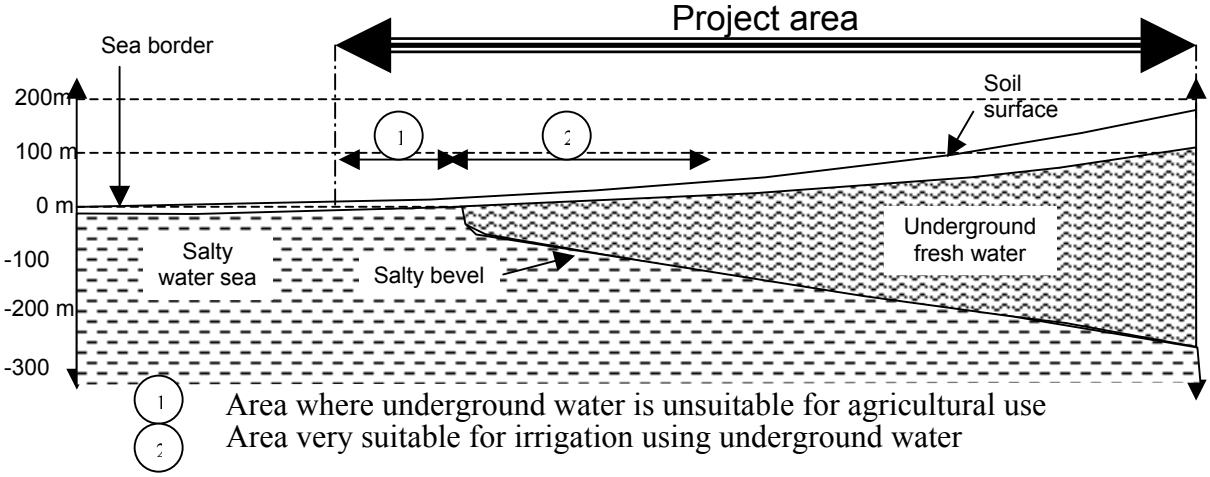


Figure 11: Underground water salinity

2.2.3 Alluvial sandy-loamy soils annually renewed in the overflowed area

2.2.3.1 A complex geology

Tihama is a sediment filled portion of the Red Sea depression. Alluvial sands, sandy silts, sandy clays and silty sands, coming from the erosion of the mountain in the East and deposited by the wadi Mawr on unknown depth, form the parent material from which the soils of the area have developed.

The mountain forming the Eastern border of Wadi Mawr are largely a complex of pre-Cambrian granites, diorites, syenites, andesites, Jurassic limestone with tertiary intrusions. The erosion of these rocks gives, in the project area, soil generally nonsodic with low nitrogen content (0,02 to 0,8%) and low soluble salt. (MIAN and al, 1979)

Moreover, in the city called Jabal al Milh, which means salty mountain in Arabic, a very young salt dome allows mineral extraction and a salt mine is presently operated.

2.2.3.2 Very young and non-differentiate soils

In the rainy area, North and South of Wadi Mawr, the soils have non-differentiate profile, because of the aridity, which slow down the pedogenesis, and the vegetative cover is sparse implying low organic content. The massive structure originates from a sandy soil with a very low organic content developed on a too sandy parent material, which does not allow

the formation of an aggregate structure. This sandy soil is draining and the water storage capacity is very low.

The area which has been irrigated for centuries by the wadi exhibits the accumulation of clay deposits yielding medium to fine textured. The massive structure originate from very young and little or non-differentiate profile with low organic matter content. On the cultivated land, the density of the surface layer, 10 to 20 cm, is less than underneath because of the plowing and other agricultural operations during the crop sequence and the structure is particular. The fertility and the water storage capacity are a lot higher in this soil than in the sandy soil in the rainy area.

As the wadi deposing successively the bigger and the smaller particles; the quantity of clay increases gradually going to the West. This difference hardly reduces the difference due to the lake of water supply in the West.

2.2.4 Spontaneous vegetation adapted to dry conditions and alluvial soils

2.2.4.1 The area supplied by wadi water, in the oasis

In the wadi area, the soil is rich with clay and mineral elements, and regularly renewed. But the hot and arid climate implies that the environment is difficult for any vegetation implantation and so for a micro-organic life. The plants found are mostly grasses and shrubs but also some scattered trees, all adapted to dry conditions, and the Western the observations are and the rarer the vegetation becomes.

In the riverbed exclusively, the Eastern water flow is fast and the soil is little sandy. *Salvadora persica* groves*,* cut and used to make toothbrushes to be sold, and the evergreen microphyllous tree *Tamarix nilotica,* to make the houses roofs, are widely represented. In the West, the water flow slows down, the soil is more clay, and in the large spate irrigated area those same trees alternate with the low layers of the cultivated lands. But the arid conditions, the marine deposits and the salty underground water make the trees and grasses decrease progressively going further to the West.

In the oasis, out of the riverbed, the tree *Ziziphus spina christi* (AL-HUBAISHI, MÜLLER-HOHENSTEIN, 1984) is widely spread in the area, very used by goats and giving the Wadi Mawr honey. Two kinds of acacias are present, also eaten by the small ruminants (*Acacia tortilis*, *Acacia ehrenbergiana*). *Salvadora persica* and *Tamarix nilotica* are also regularly colonizing the area. Finally, there are the palm tree *Hyphaene thebaica* used in handicraft, or the *Azadirachta indica* and the rare *Dober glabra* used in woodwork. Their density decreases while going away from the irrigated area.

The *Prosopis juliflora* (ABDURAHMAN *and al* 1989), another thorny tree implanted in the area after a feeder tree project in the 1980's, has invaded the landscape and causes some problems. Even if the leaves are eaten by animals and the branches used as barbed wire in villages, the long roots are pumping severely the underground water, it is spreading very quickly, the pods are little toxic and the animals remain preferring the acacias.

Moreover, the water ways of the irrigated area are invested by an herbaceous vegetation (canal or spate area, or wells area). The water feeding the fields infiltrates and the borders of the little canals are more colonized by grasses, with annual herbs like poaceaes (*Echinochloa colonum*, *Zingeria trichopoda*), cyperaceaes (*Cyperus rotundus*) (CHAUDHAR, REVRI,

1983). Those herbs are also found spontaneously in the irrigated fields, between the crops or on the resting lands, as well as perennial grasses like fabaceaes (*Tephrosia appolinea*) or small shrubs like *Cassia italica.*

All the wadi area, and specially its banks, is invested by the majority of the breeders for the water and pasture availability. They allow the grazing of goats thanks to trees and shrubs, but also sheep and cows thanks to the herbaceous vegetation.

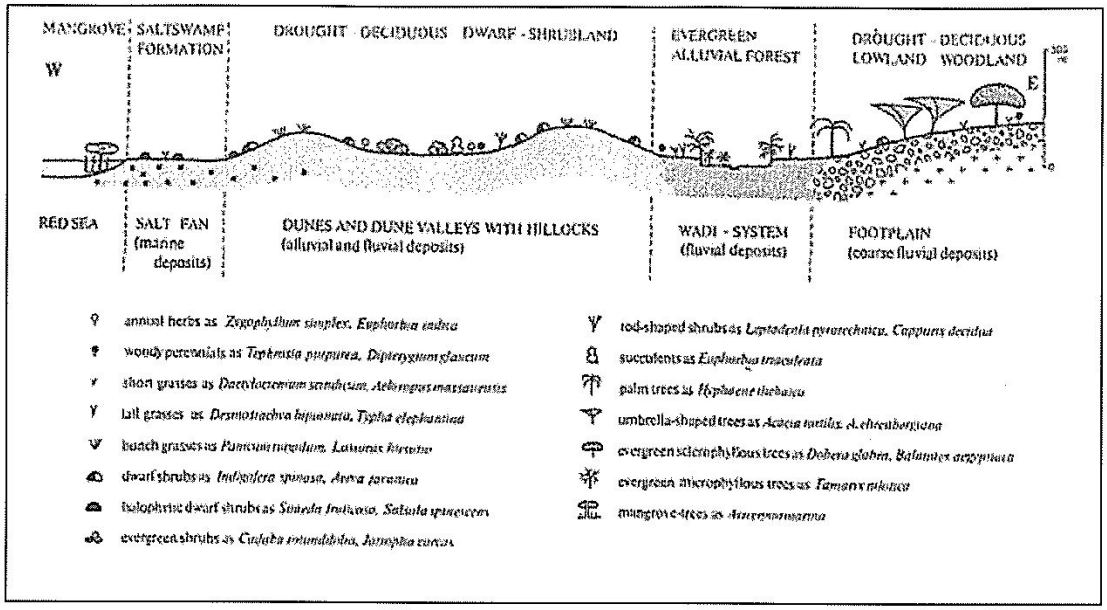


Figure 12: Ecosystem of Wadi Mawr and its spontaneous vegetation (AL-HUBAISHI, MÜLLER-HOHENSTEIN, 1984)

2.2.4.2 The rainy area, a dwarf shrub land

In the North and the South of the project area, the soil is sandy and the underground water is deep, so the vegetation is very rare and sparse and the ecosystem is semi-desert. The species are mostly thorny shrubs with deep roots systems, adapted to the lack of water.

Characteristic shrubs of the Tihama plain are represented (**AL-HUBAISHI, MÜLLER-HOHENSTEIN**, 1984), rod-shaped shrubs as *Capparis decidua*, evergreen shrubs as *Cadaba rotundifolia,* or dwarf shrubs as *Indigofera spinosa.* Perennials grasses like *Dipterygium glaucum*, or *Aerulopus massauensis* are also observed. Some toxic herbs are also present (such as the local named *sanafi*), what cause problem for the grazing herds.

The trees are the same thorny trees found in the wadi area, but very rarely observed, except in the South East where the underground water is less deep: a small forest of trees dominated by *Acacia ehrenbergiana* is invested by goats.

This area is very poor in available pasture, the animals can with difficulty graze, and those areas are very dependent on provided forage.

2.2.4.3 The West salty area

The Western area is only colonized by shrubs, adapted to the salt swamp formation. Halophytic shrubs like *Suaeda fructicosa*, *Salsola spinescens* and some *Hyphaene thebaica* are observed, to give then rise to very salty sterile soils, during the last kilometres until Al

Luhaya. The coast is finally boarded by a lagoon of mangrove trees, with *Avicennia marina* (**AL-HUBAISHI**, **MÜLLER-HOHENSTEIN**, 1984).

This area is not interesting for pastoral activity, unless for some few big dromedaries herds.

2.3 AGRICULTURAL SOCIETY REGULATED BY TRADITIONAL RULES AND HABITS

Wadi Mawr, as part of the Tihama plain, is influenced by both the Arabic and African worlds and is characterized by ethnic diversity and old mixed traditions (**GIROUD**, 1997). The society of the area is mainly rural, and its big agricultural population is divided in casts with specific roles and access to lands. Even if the Islam and its principles are as strongly implanted as in the rest of the country, the common way of life is also connected to African habits, like it is noticed with the villages made of little huts and the colored clothes of women. But those traditions are now more blended with Saudi and occidental customs, since a lot of inhabitants of the area have been working regularly in the neighboring country for decades.

2.3.1.1 Rich sheikhs dominate a middle class agricultural society

The Wadi Mawr society is characterized by an important place to customs and hierarchy between citizens. In this very agricultural population divided in casts, the main people are from middle class, with honorable activities like farming handicraft, marketing, and have the right to land ownership. This cast is living in villages with people of inferior casts, the *Akhdam* and *Abid* (PELAT, 2000).

The *Akhdam* are black people with African origin, descendants of Ethiopian invaders of pre-Islamic epoch and condemned to bad life conditions from generations. Most of them live in Tihama or in peripheries of big cities, predestinated to dishonorable works, and cannot have access to land ownership. In the Wadi Mawr area however, they can have activities of middle class people, like share farming or agricultural working, but stay living among themselves in the villages.

The *Abid* are also original from Africa, but are descendant of slaves who had most of the time an important position in their country. The official abolition of slavery occurs in 1962, but some of them have even managed to get free before by themselves, and this cast is respected and living with the same rights as the middle class.

Generally the villages, the sub-districts, and the districts are at each level directed by a chief, a middle class man designed by the people and who has a local authority for the management of conflicts and the functioning of the unity. Those chiefs are often land and animals owners, richer than the usual farmers of the villages, which are small owners or share farmers.

Above the whole area, some few *sheikh* families are among the richest people. They are very big owners of land and animals, with their personnel and numerous share farmers working on their lands. But they focus also the security of the unwritten law, and are the referee in the case of any problem between persons of their area. Designated by the population of the area, the *sheikh*s keep their power, unless they do not give satisfaction to the people.

2.3.1.2 Traditional way of life influenced by Saudi Arabia and occidental habits

Islam is the exclusive religion in Wadi Mawr and the *Sharia,* the Islamic law and part of the Yemeni Constitution, is always followed for every activity. For the water example, every owner is to give water for free to poor people for any purpose, housework, livestock or drinkable water. As the fields' irrigation is done at night because of the heat, women or children of the villages can go and take water in the day in any well.

The average nuclear family counts 8 members, generally based on monogamy. In those families the tasks are clearly divided between men and women. Men are usually working outside, in the fields or on the markets to sell animals, and are responsible for the family decisions, while young boys are schooled or requisitioned for the herds grazing. Women are managing the house, the children, the animals' feeding and care at home. The girls are still few sent to school, and are dedicated to help their mothers to the search for water on the wells or to manage the house.

The traditional Tihami habits are strongly implanted, although the emigrants to Saudi Arabia contribute to mix them to external influence. The original food descended from auto-consumed local production and based on sorghum meals, is less eaten compared to rice, wheat and tea from abroad. As for the habitat, the villages are dominated by round or square houses, made of branches roofs and walls of clay, straw and organic dejections, but permanent concrete houses are being built everywhere.

Eventually the *qat* (*Catha edulis*) consumption has to be underlined, almost all the masculine population of Wadi Mawr chewing the leaves of this tree from the beginning of the afternoon to the night.

2.3.1.3 An area dominated by agricultural activities, complemented by external jobs and emigration to Saudi Arabia

Wadi Mawr constitutes a dynamic area depending essentially on primary sector, and agriculture and breeding of small ruminants and cows are the main economic activities for the population.

The wood cutting for houses and beds building is also important, and in the Western area, the salt extraction career of Jabal al Milh and the fishing company of Al Luhaya for shrimps and very diverse fishes are developed.

Other sources of incomes are services such as transportation, some farmers own small taxis. On the markets, they also make small business of buying and reselling various things.

But the main source is the external jobs thanks to emigration to Saudi Arabia.

2.4 REGULATED ACCESS TO WATER AND FREE RIGHT TO USE PASTURES

2.4.1 Social management of water access

The arid climate balanced by the abundant of water resources in Wadi Mawr and the big population needing a lot of water make investments and a strong management for water use necessary. In the project area, we find three resources for agricultural water. The first one and traditionally the most important in this arid plain, is the wadi. It has been use for a long time and the irrigation network has been recently improved by the government. The second supply

for water is the groundwater, available in big quantity. Finally, even though the climate is arid, some farmers do rain-fed cultivation.

2.4.1.1 Traditional customs for water use

For hundreds of years farmers have taken benefits from the wadi by diverting it and flooding the fields. Fortunately, the entire catchment area and course of the wadi are located within the YAR (Yemen Arab Republic) and therefore no international riparian issues are involved. However, within the country, there is traditional customs of water allocation giving the priority to the upper riparian. These traditional rules did not implicate any problem when the population and the number of users were limited. But, the increasing cultivated land implies some unequal distribution of the wadi's annual flow.

During the project in the 1980's, the Government tried to change these rules in order to benefit as much as possible from the construction of the irrigation system. An assurance was obtained during negotiations, that the Government, through its agency TDA (Tihama Development Authority), would control water deliveries to the various canals in the system. However, with the influence of upper irrigators on TDA staff, this control is today not ensured and the traditional rules are back in practice.

This unequal distribution of the water is even bigger comparing the area irrigated by the Government project in the East and the traditional wadi diversion and spate irrigation in the West. Indeed, because of the increasing irrigated land, a lot of water is used in the Eastern part of Wadi Mawr and in the West some area have very limited or even no access to water.

The application of these traditional rules for water distribution makes the access to water decrease going to the West.

2.4.1.2 Irrigation by canal: scheme in the East

Within the Wadi Mawr Project started in the early 1980's to enhance the potential for agricultural production in the area, one mission was to provide an assured and controlled water to the farmers.

This project concerns mainly the Eastern half of the studied area. A weir and a first diversion structure supply the water in a main canal on the Northern side of the wadi, at a point approximately 4 km east of the Jizan-Hodeidah highway. Then a division structure and a siphon separate the water flow in Northern and Southern canals, 1 km before the highway. Those two primary canals are respectively 19,2 km and 24,4 km long. To permit the transfer of water in the fields, cross regulators and lengths of secondary canals have been constructed, and are supplying the traditional canals.

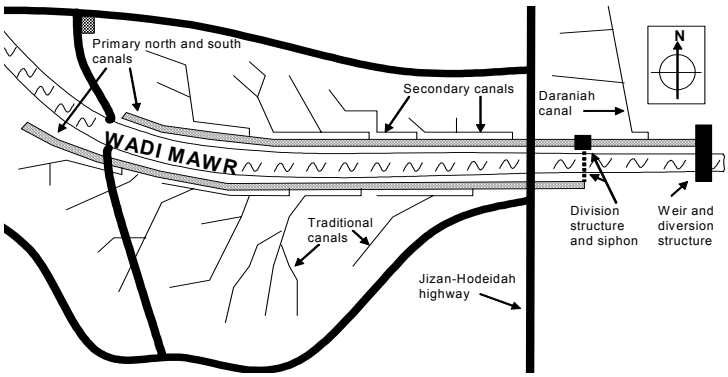


Figure 13: Irrigation scheme in the Eastern area

The traditional sandy canals have existed for generations in the East of the project area. Each time water flow arrives in the canals, the farmers get water in turns. According to the traditional customs, the first eastern secondary canals of each main primary canal are filled of water and irrigate the fields from the closer to the further one. After that the following secondary canal gets water, etc. Then, the next time the wadi comes, the following secondary canals should get water, as the first ones have already been irrigated. However, according to the traditional rules, if the upper farmers need to irrigate his crops, he has the priority.

Consequently, in spite of the government project and the big infrastructures, the access to water is considerably unequal in the East and the West of this area. Indeed, in the Western end of this canals area, some farms did not get water for several years.

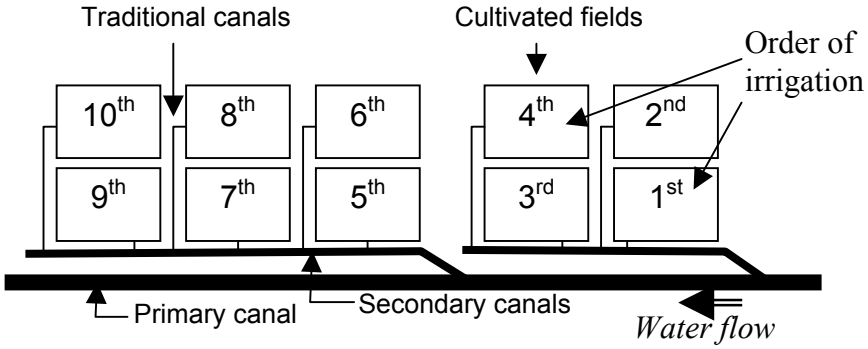


Figure 14: Water use in the irrigation network

Moreover, a main secondary canal, Daraniah, is directly linked to the main canal before the Northern and Southern canals division. This area, mainly owned by rich people, is the only one having water all the year. It is very productive and mango trees are dominating.

In the case of the secondary canals, there are managers for each of them. Chosen by the farmers, they supervise the distribution of water, compound the problems between farmers, and maintain the secondary canals. The only source of incomes for them to do this is the 5% of the harvest that farmers using water have to pay. The farmers are also responsible of the maintenance of the small canals and have to organize themselves for it.

During irrigation, the water is going through the primary, secondary, and then traditional sandy canals. The farmer breaks the border of those small traditional canals for the water to enter in the fields. When, there is enough water, between 15 and 20 centimeters, the farmer closes the canal to allow the next field to be irrigated.

2.4.1.3 Spate irrigation in the West

The structure described above to irrigate the canals area has a capacity of 40 m^3/s, the additional water is going directly downstream to the spate irrigated area. The average wadi flow is most of the time higher, which supply big quantity of water to the Western half of the project area, where the wadi is naturally less deeply embanked and where farmers swerve the wadi course to flood their field by spate irrigation. This big irrigated area was before spreading from the area actually irrigated by canals, until the sea. Because of the increasing uptake of water in the East, it has decreased considerably.

Traditionally, the wadi course is swerving thanks to big sandy dam in four different ways, making four different irrigated areas: two in the North, one in the South, then in the

West. According to the traditional rules, the water was going firstly to the upper irrigators, and then people brake off the sandy dam to let the wadi go to the next area.

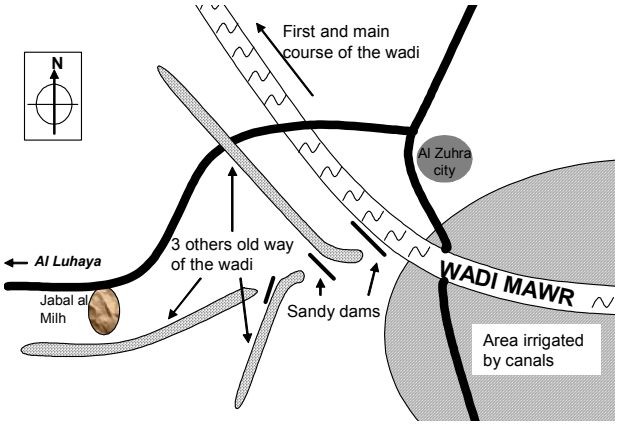


Figure 15: Traditional irrigation scheme in the Western area

This traditional organization for the water use is still used nowadays. However, the growing uptakes upstream decrease the availability of water for agricultural use and the wadi cannot reach all the areas like before. Indeed, the fourth way of the wadi has not get any water for about 20 years and the third one has been considerably reduced. Nevertheless, the two other areas receive sufficient water for *Seif* and *Kharif* cultivation.

When the water is coming, a big sandy dam swerves the wadi to the first way. Then, dikes split the wadi flow, which goes directly to each field of the area, successively upstream to downstream. Every field separates from the others by dike to stop the flow and allow water infiltrate. When the entire first area is irrigated, people break the dam to let the water go in the following irrigated area. Because of the traditional rules, the upper irrigators can, any time they want, make the dam again if they need.

This organization gives favorable conditions to farmers cultivating from the first water way and they have even more water access than people living in the West of the canals area. However, in the others water ways, the water supply is a lot lower and farmers have developed irrigation from underground water.

2.4.1.4 Irrigation by well

For about 35 years, farmers who had enough money have built wells nearly everywhere it was possible and profitable, as there is no regulation for underground water use.

However, it has not been possible to build well in the Western end of Wadi Mawr because of the water high salinity. People living and farming in this area before, has either moved to other place in Wadi Mawr or started non-agricultural activities. Moreover, in the rainy area, even if some farmers have built few well, because of the low water storage capacity of the sandy soil, the crops need more irrigation. The costs, mainly diesel, are consequently higher and it is not very profitable to use well. Finally, the area irrigated by Daraniah canal having water availability all the year, does not need any other water resource.

Anywhere else in Wadi Mawr, people have built wells in different situations. In the South-West they develop a lot this irrigation because it is today the only resource of water for agriculture. In the Northern area, still irrigated by wadi, farmers are using wells to ensure irrigation when the wadi does not come or to allow cultivation in *Mosemi*. In both of those areas, farmers are using big diesel engine to irrigate from 15 to 100 maad (5,4 to 36 ha) with

one motor pump. Finally, other farmers are using small motor-pumps to irrigate 1 to 5 maad (0,4 to 1,8 ha) grown in tomatoes, okra or any other vegetables. Those crops need a lot of water and the small investment, small motor-pump and a well few meters deep, ensure the production.

The use of the well can have different organization. Share-farmers exploiting the well of big owners give them ¼ of the harvest. They pay the diesel and the oil when they use the pump, while the owner is in charge of the maintenance. The use of the well is in turn according to cultivated land area, but the owner of the well has the priority. Moreover, few smaller farmers have got organized to build a well and buy a motor-pump together. Finally, the small farmers using motor-pump to irrigate vegetables work individually.

2.4.1.5 Rain-fed cultivation

In the North and South of Wadi Mawr farmers are doing rain-fed cultivation. Indeed, rains are the only supply of water in the areas which neither have access to wadi nor to the groundwater. Rather than having any rainfall storage infrastructure for drinkable water, people take benefit from the proximity of the wadi.

Because of the very sparse rainfalls, farming activities do not supply sufficient incomes and people often work in canal area are do non-agricultural jobs.

2.4.2 Free access to grassland, feeder trees and remains of crops

The area is completely divided in ownership; there is no collective land. The access to grassland and feeder trees is very easy for the breeders, as most of the land owners allow them to make their animals graze for free on the fields which are not occupied by crops. This includes the natural pastures and the resting lands. It includes also the remains of crops when they are not important and consequently not only valorized by the owner of the land. The breeders have to look carefully after their animals not to enter in cultivated fields, on pain of a fine.

The resting lands and the remaining of crops are essential for the breeders as the project area is widely cultivated. Indeed in the East the banks of the wadi are a lot invested by crops, and the dam allows a wide irrigated area. A small wet area along the wadi is still not cultivated because crops would be broken every time the wadi comes. As a result, this entire area provides abundant pasture and forage to every breeder of Wadi Mawr who comes to make the animals graze in the morning.

In the West there are fewer natural pastures, as the crops occupy large superficies. In addition to that, the whole area is dry and the pastures are a lot less abounding in natural plants. There also, the remaining of crops has become a much more important resource of food for the herds, to substitute the lack of vegetation.

So, it is usual to see several herds occupying the same pasture or field. But because of the increase of population and consequently of the total livestock, and because of this little control of grazing activities, the amount of pasture is affected and the landscape is mostly overgrazed. The breeding systems are much more dependant from the supply of forage, less moving to look for pasture, and some enclosed systems are appearing.

2.5 AGRICULTURAL AND BREEDING ACTIVITIES ADAPTED TO NATURAL AND SOCIAL ENVIRONMENT

The agricultural and the breeding activities that can exist in Wadi Mawr are depending on different factors, such as the water access of the wadi or of the underground water, the soil quality, the natural vegetation, and also socioeconomic aspect as the size and the status of the farms. However, water access is the main constrain in such arid area and it is the main differentiation factor from an area to the other.

According to the water supply, farmers have adapted their agricultural activities:

- Daraniah area: the area irrigated by the Daraniah canal has water supply all the year. Mango (*Mangifera indica*) is almost the only crop grown there, with vegetables or grain sorghum (*Sorghum vulgare*) underneath when the trees are small. Share-farmers are fattening small sheep and goats owned by rich people living in the area.
- Canals area: the area irrigated by North and South canals has high water supply in its Eastern part progressively decreasing going to the West. Without considering the western end, this canals area has high water supply and is mainly cultivated in sorghum sometimes in rotation with vegetables: okra (*Hibiscus esculentus*), tomato (*Lycopersicon esculentum*), radish (*Raphanus sativus*), jaws mallow (*Corchorus olitorius*)… Watermelon (*Citrullus lanatus*) and sweetmelon (*Cucumis melo*) are also cultivated in rotation with sorghum.

  - Some people are growing jasmine (*Jasminum sambac*), henna (*Lawsonia inernis*) and fruits trees (mango, banana (*Musa textilis*)) with big motor-pump. In this area, every family has cows, sheep goats and donkeys, which are going grazing along the canals.
- Spate area: this area is mainly grown in sorghum, sometimes in rotation with watermelon or sweetmelon. As the water supply is decreasing to the West, more and more farmers own well going to the West. This area is densely cultivated and the cows, sheep, few goats, donkeys and dromedaries bred here, do not have pasture and a lot stay enclosed all time. The production of sorghum feeder is largely sold to farmers living in the mountain.
- Wells area: this area, cultivated all along the year, is almost only grown in sorghum with very few farmers cultivating cotton (*Gossypium hirsutum*), sesame (*Sesamum indicum*). In this area, sheep and goats are grazing along the small canals. Like in the spate area, the production of sorghum feeder is largely exported to the mountains.
- Rainy area: this area is only cultivated in *Kharif*, with sorghum or pearl millet (*Pennisetum glaucum*) associated with cowpeas (*Vigna sinensis*) or math beans (*Vigna aconitifolia*). Those crops do not supply enough forage for the animals and farmers need to buy sorghum feeder produced in the areas of Wadi Mawr where water is more available.
- West area: this area is nearly not cultivated because of the sparse rainfall. Most of the population does not live from farming and all the remaining farmers have non-agricultural activities.

In each of these areas, cropping and animal husbandry systems made by farmers not only depend on natural conditions, but also on social situation: the size and status of the farm. According to their situation, farmers have different strategies. Richer farmers grow crops, watermelon for example, with higher value but with very fluctuating prices; while almost all small farmers grow only sorghum to insure incomes.

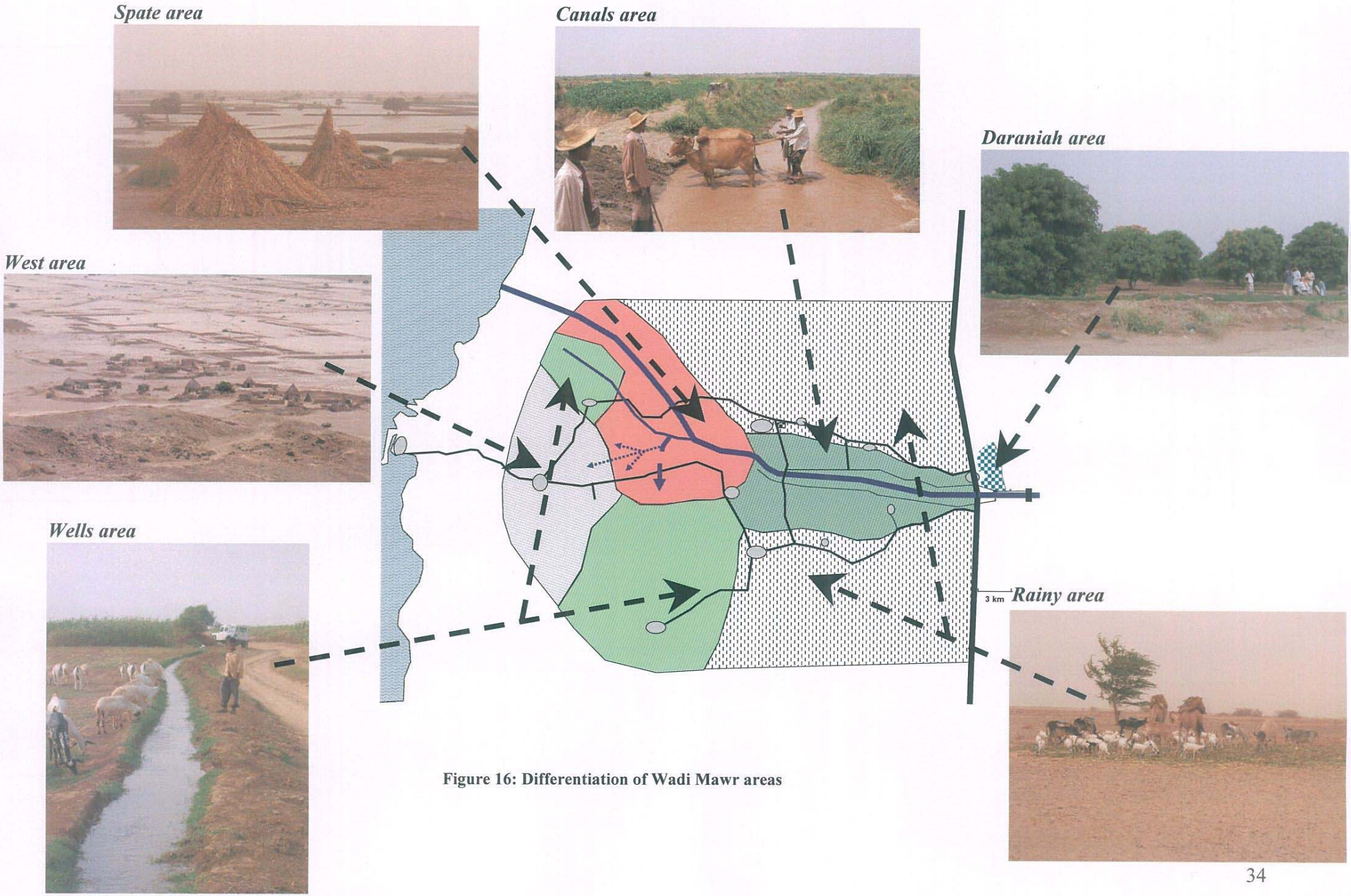


Figure 16: Differentiation of Wadi Mawr areas

3 IN STRONG SOCIAL ORGANIZATION, THE WATER REDISTRIBUTION MAKE BREEDING AND EXTERNAL JOBS MORE STRATEGIC FOR POOR FARMERS

Situated on the crossroad of one of the most important market roads of the world, between Asia and Mediterranean basin, the strategic position of Yemen gives the opportunity to a high economic activity.

Wadi Mawr, an oasis of the Tihama plain, has been settled for a long time by different people, organized with a strong social differentiation. The majority of the farmers are share farmers cultivating for big land owners, and the agriculture is mostly dedicated to family subsistence, while the animals are exported.

The last fifty years lead to important politic and economic changes, Wadi Mawr turns little by little to a general agricultural market orientation led by family farms with higher land and labor productivities.

But numerous farmers are still limited concerning the land access. An unequal water redistribution strengthens the situation, and nowadays' farmers face difficulties to insure their incomes and to feed their animals.

3.1 BEFORE 1970: AN AGRARIAN STRUCTURE BASED ON CHIEFFERY OWNERSHIP, AUTOCONSUMING CROPS AND SELLING SMALL RUMINANTS

3.1.1 Until the 1930's, a wide irrigated area known for breeding

In the early 20th century, the situation of Wadi Mawr, on the ways from the Southern Yemen to Saudi-Arabia, makes it as an important area and the two main cities, Al Luhaya on the Red Sea border and Al Zuhra inland, know a high activity with big markets, exporting a lot of sea and animals products. Indeed, at that time Al Luhaya is one of the most important ports of the Red Sea and the fisheries feed all the North Tihama in sea products. Moreover, the important spontaneous vegetation, especially trees, due to the shallow underground water, allows to breed goats at low costs. This comparative advantage makes the price of goats very low and people come from all Yemen and Saudi-Arabia to buy the very famous goats of Wadi Mawr.

At this time, except for some fishers, living on the sea border, and few merchants, the entire inland population is farming, benefiting from the water of the wadi for many years.

The area is strongly controlled by people of high social class, sheikh, and completely divided in huge land ownerships. Their lands are cultivated by many small share farmers of middle class, but also *Akhdam* or slaves, the *Abid*.

Not only for its strategic location on the Red Sea but also for big irrigation possibilities, Wadi Mawr is subject to many politic clashes and land tenure changes especially after the end of the Turkish occupation in the Tihama.

3.1.1.1 Land ownership kept by few rich people

3.1.1.1.1 From a big owner to another

One of the first important steps in the agrarian history of Wadi Mawr goes back to the 1920's when the Turkish presence in the area finished.

The end of the Ottoman occupation:

After a first invasion of the country in the 17th century, the Ottoman Empire comes back in Yemen in 1849 to take control of the mountains and the Tihama plain. Facing many years of conflicts, the armies of the Imam Yahaya attack Turkish forces in the whole country in 1911 and take back the control of Yemen. An agreement is signed the same year and the Turkish troops progressively leave: in 1919 the country is definitively free.

Al Ashraf family, who is one of the descendants of prophet Mohamed, owns a lot of land in the Arabic peninsula, in Saudi Arabia and Yemen like in Wadi Mawr. While during the Turkish occupation, the land owners kept their property, particularly Al Ashraf family, the situation changes after the Imam victory.

In 1919, the Imam Yahaya puts governors in each region of Yemen to control the country. Sheikh Hadi Heyg, is in charge of controlling Wadi Mawr area. Helped by the Imam authority, he buys progressively nearly all the irrigated area to Al Ashraf family, who is forced to sell most of the lands.

After having lost a lot of their good lands, most of Al Ashraf family members leave Wadi Mawr and sell the few of lands they still have. Sheikh Hadi buys some, and few other rich men, as well as small farmers, do the same.

Few years later, thanks to the Imam, sheikh Hadi becomes owner of about 40 000 maads (14400 ha) in Wadi Mawr and the other lands are divided between big land owners and very few small owners.

3.1.1.1.2 A capitalistic farming based on the work of numerous share farmers

At this time, the great majority of the lands of the oasis are kept under the control of few rich and powerful owners. They have big capitalist farms: the share-farmers insure all their production costs and have to give the half of their production to the owner.

The family farm owners are very few, particularly in the canal area. The wide majority of the agricultural population does not own any lands: they are share farmers, seasonal workers for the sheikh, or breeders without land owning and/or sharing big livestock (half of the animal production dedicated to the owner, except the milk). But usually they all have their own animals.

3.1.1.2 Social control on water management in irrigated area and free access to pasture land

The oasis knows centuries of water planning.

Upstream, big transversal dams have been built in the riverbed to deviate the water in canals, what allows a first irrigated area. Canals of the traditional irrigation system were fed by rudimentary earthen dikes. But the strong *Seif* flow regularly destroys the dams what sometimes prevent the farmers from cultivating at this season, and forces the farmers to cultivate only once a year in *Kharif*. And in the case of a possible *Seif* cultivation, the farmers rarely cultivate in *Kharif,* because the *Kharif* wadi

flow may not be sufficient, or to destroy again the dams. Consequently this irrigation system is with difficulty insuring water safety to the farmers, and a large amount of water is going to the sea.

After this canal area, some dams direct the wadi flow in order to irrigate the wide downstream area where there is the most water available for farmers (figure 17). The wadi flow is indeed weaker on this large and flat riverbed, and the farmers can take the advantage of the two wadi seasons.

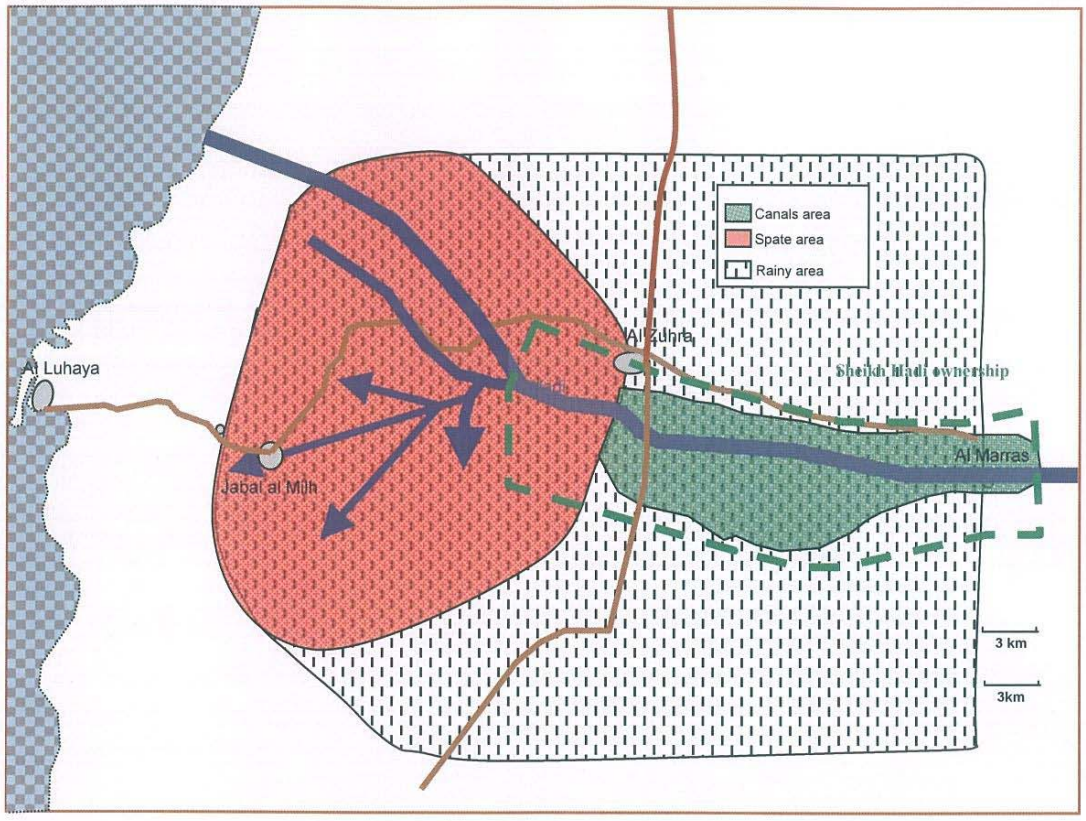


Figure 17: an oasis irrigated thanks to surface water

Thanks to his sheikh position, he makes the rules of using the lands and the water resources of the wadi, in order to cultivate the area. He is indeed responsible for the maintenance of the dams in the wadi bed, and the traditional canals, to distribute the water to the lands.

He imposes to the share farmers the way of using the water of the canals, following the existing custom of water allocation which gives priority to the upper user. Some managers working for him are responsible for this functioning, and ask special taxes to the farmers and share farmers for the canals use, that they have to pay in kind.

He also decides that the first lands situated right along the wadi, especially in the canal area where the riverbed is with steep sides, would not be cultivated. This avoids crop destructions when the wadi comes, and those lands are dedicated to animal use, for the grazing of spontaneous plants.

For the drinking water of the animals, everybody goes to the wadi or uses the wells of the villages for free.

Acacia tortilis, *Acacia ehrenbergiana, Ziziphus spina christi* (spontaneous plants, part 2.2.4.1). This kind of forage constitutes an important fraction in the animals' alimentation. As for the other forage shrub or grass resources, because of the high space availability the access to all non cultivated lands is free for everybody and his animals, and this is the same for the crops remains. The fields are never fenced, so the animals are always supervised by a breeder while going grazing.

3.1.1.3 Farms combining crops and breeding

3.1.1.3.1 Crops intended for farm consumption and commercialization for sheikhs

At this time, as JOUBARI explains in 1997 about the Yemen demographic situation before the Revolution, the population is relatively stable, thanks to the equilibrium between high birth and mortality rates. In Wadi Mawr, the large irrigated perimeter is mostly sufficient to feed all the population and the rain fed area is consequently few cultivated.

The population of Wadi Mawr is few moving outside of the area, and cultivates crops firstly for its own consumption. The sorghum is the main crop and the base of the local alimentation, and is auto and intra consumed in the farms: it is firstly grown for the grain for the families, and then the residues are used as forage for their animals.

The sorghum is adapted to loamy-clay soils, and does not require a lot of water to be cultivated. Consequently it is spread in all Wadi Mawr, and especially in the whole irrigated area where it can give good yields.

In the irrigated aera, the big amount of wadi water coming in *Seif* and *Kharif* allows the farmers to sow sometimes twice a year on the same land and to harvest several times grain in each season (until 5 harvests of grain, 2 in *Seif* and 3 in *Kharif*). At this period, the time between a harvest and the next sowing was longer, and the work with bulls was possible on bigger surface.

In the spate irrigation area, the two sowings are always realized on small surfaces to increase land productivity, while on middle and big lands the work is too important and the farmers sow once a year, alternating one year in *Seif* and one year in *Kharif*.

In the canal area, the lack of water safety makes them generally sow once a year in *Kharif*.

Moreover some other crops are cultivated in specific conditions, according to the water supply of the different areas. Those crops are consumed on the farm but they are mostly sold on the market.

- In the Eastern area, crops like vegetables are sowed in *Kharif*. Traditional perennial products like henna or jasmine, for weddings and fêtes, are also irrigated by the canals.
- In the whole irrigated area, East and West, some crops needing more water than sorghum can be integrated in the crop rotation: some watermelon, and sesame are grown. Some cotton is also produced on lands of the sheikh Hadi who is the only one to have outlets. It is cultivated by share farmers and sold to the Imam government
- The people living in the rainy area are few cultivating in their villages, and most of them are working on lands in irrigated area by share farming. In this rainy area, crops which do not need a lot of water are grown once a

year, when the rains come in *Kharif*: few sesame sometimes, millet, and sorghum associated with cowpeas and math beans to increase the yields but also the fertility in this non renewed soil.

All the fields are cultivated thanks to bulls and a swing plough, owned by every farmer. No one is using organic fertilizers: in the irrigated area the soils are very rich thanks to the wadi and its alluvial deposits.

3.1.1.3.2 Animals for draught, family consumption and for monetary incomes

According to the availability of a lot of trees, farmers have developed goats breeding as the main animal production, using the milk for the families and exporting the young animals to other Yemeni regions or to Saudi-Arabia. However, almost every family has also cows for the milk, bulls to work in the fields, donkeys or dromedaries for the transport and even some sheep that they export or consume for Muslim fêtes.

The animals are mostly fed thanks to pasture and trees in the day, particularly on the lands along the wadi, and are eating the remaining crops after the harvesting seasons. They are given sorghum feeder in the evening particularly in dry season.

The animals are generally led to graze by a member of the family. If the livestock is more than 100 animals, this person need help from the family, or to hire someone. If on the contrary the livestock is very few, several families can join themselves and hire someone to lead the animals.

3.1.1.4 Farming categories according to their location

Wadi Mawr is at this time characterised by a great social differentiation between on one hand the rich owners who do not work on their land but manage a capitalistic farm, and on the other hand the share farmers who have to maximize their land productivity to live and who depend on the big owner for their land security. The cropping activities depend essentially on water access, but the wide availibility of pasture allows everybody to manage animals easily, especially big specific breeders, and share breeding is widely spread.

<table>
<tr><th></th><th>Size of the farm</th><th>Location</th><th>soil</th><th>Main water resources</th><th>Cropping activities</th><th>Herding activities</th></tr>
<tr><td>Very big land owner</td><td>More than 500 maad</td><td>Wadi and canal zone</td><td rowspan="6">Loamy clay soils</td><td rowspan="6">Wadi</td><td>Lands given to share breeding</td><td>Herd given to share breeding</td></tr>
<tr><td>Big land owner</td><td>30 to 150 maad</td><td rowspan="2">Wadi zone</td><td>Sorghum, sesame and watermelon</td><td rowspan="3">Breeding 10 to 50 goats with some sheep, 3 to 10 cows
Using 2 bulls to work
Using 1 to 3 donkeys and sometimes 1 dromedary for transportation</td></tr>
<tr><td>Middle land owner</td><td>5 to 30 maad</td><td>Sorghum, sesame and watermelon</td></tr>
<tr><td>Small owner</td><td>2 to 10 maad</td><td>Canal Zone</td><td>Sorghum, sesame, watermelon, henna and vegetables</td></tr>
<tr><td>Share-farmer</td><td>5 to 20 maad</td><td>Wadi zone</td><td>Sorghum, sesame and watermelon. Some cotton</td><td rowspan="3">Same system with few less animals</td></tr>
<tr><td>Share-farmer</td><td>2 to 10 maad</td><td>Canal zone</td><td>Sorghum, sesame, watermelon, henna, jasmine and vegetables. Some cotton</td></tr>
<tr><td>Rain-fed land owner</td><td>10 to 250 maad</td><td rowspan="2">Rain fed zone</td><td rowspan="2">Sandy soil</td><td rowspan="2">Rain</td><td rowspan="2">Millet and sorghum, cowpeas, math beans, sesame</td></tr>
<tr><td>Share-farmer</td><td>10 to 50 maad</td></tr>
<tr><td>Big herd owner</td><td rowspan="2">No land</td><td rowspan="2">Anywhere in wadi and rainy zone</td><td rowspan="2">No land</td><td rowspan="2">No land</td><td rowspan="2">No land</td><td>50 to 300 goats and sheep, 5 to 20 cows</td></tr>
<tr><td>Share breeder</td><td>Same livestock but sharing from rich people</td></tr>
</table>

Figure 18: Farming activities before 1962

The crops' surplus are given by the share farmers to the sheikhs, who have then the monopole of market access for crops such as the cotton. But the goats, not linked to any land ownership, allow all the farmers including share farmers to insure their monetary needs and little by little to capitalize.

3.1.2 The revolution of the 1960's and the restructuring of land ownership make way for the development of family farm owners

In Wadi Mawr, the sheikh Hadi Heyg dies in 1954 and bequeaths his property to his 36 children. The lands are divided between each child, but the agricultural situation does not change a lot, until the revolution occurs.

The national Revolution and the instauration of the Republic:

From the end of the 1930's, some opposition to the Imam Yahaya appears in North Yemen. There are a lot of opponents including military, merchants, students, etc. This situation increases and the Imam is killed in 1948. His son, Ahmed, become the new Imam. He represses many revolts and tries to keep the power until his death, in 1962.

The opponents to the Imam regime, helped by the Egyptian Nasser, profit by the change of power to make a coup d'état. However, the new Imam, Al Badr, escapes and goes to the north with people supporting him.

During 8 years, a civil war occurs in North Yemen, with republican in Sana'a, Taez, Hodeydah and the Tihama and the royalist in the northern and eastern mountains.

In March 1970 the war stops and in July, the Yemen Arab Republic (YAR) is acknowledged with Al Rryani as council president.

In the same time slavery is abolished, and the Abid population recovers its freedom (Microsoft Encarta, 2006).

In 1962, after the coup d'état, the Heyg family has to leave Wadi Mawr and escapes with all royalists in the mountains, where the area in controlled by the army of the Imam, and in Saudi Arabia. Every share-farmer takes this opportunity to appropriate the lands and during few years, they get the whole production of their work.

In the same time, the republicans put new sheikhs in YAR and Al Shami family substitute for Al Heyg family in terms of power on Wadi Mawr.

After 1970, when the civil war stops, the children of Said Hadi Heyg can come back in Wadi Mawr and they take back their lands. But the family is not as rich as before the revolution. The new government gives to some heirs important jobs in the administrative sector in the Tihama or in Sana'a, and they start to sell their lands and leave. The new sheikh of Wadi Mawr buys a lot of lands. But some are also appropriated by rich people investing in agriculture, or by farmers using savings from agricultural activities and/or selling their herd to appropriate the land they used to work on.

Al Heyg family owned a very big part of the lands in Wadi Mawr and most of the farmers were sharing lands from them. The numerous children of the sheikh Hadi and the consequences of the revolution on his family have led to the redistribution of the lands: family farm owners become more numerous.

After these events, the heirs of the sheikh Hadi have smaller surfaces and the number of land owners increases. However the new sheikh Shami, the heirs of the Al Heyg family and even the rich people investing in agriculture keep on entertaining a capitalistic farming model based on share farming. The share farmers remain the biggest social category.

It has to be noticed that there are no technic changes at this time: the cropping systems still follow the same rotation according to the water access

3.2 FROM 1970 TO 1990, EMIGRATION AND AGRICULTURAL POLICIES: INCREASE OF FARM INCOMES AND SORGHUM FEEDER ORIENTATION, BUT UNEQUAL WATER ACCESS IN THE EAST AND THE WEST

In the post-revolutionary years of late 1960's and early 1970's, the president Al Rryani, and above all his successor Al Hamdi, aspire to take the North Yemen out of its enclave and start development policies throughout YAR. In the countryside hospitals and schools are built. In a lot of area in the country, the government builds electricity network in cities and roads between the important economic centers. Under Ali Abdulah Saleh, after 1978, the rural development will widen.

All those development policies are helped and partially financed by all the others Arabic countries, especially Saudi-Arabia and the Kuwait Fund for Arab Economic Development (KFAED) but also by the International Development Association (IDA), the UNDP and the EEC.

3.2.1 Early 1970's: Public infrastructure to enhance rural development

3.2.1.1 Health improvement: fast demographic growth and higher land pressure

The improvement of the health services leads to the quick diminution of mortality rate in rural areas (JOUBARI, 1999). While the birth rate stays high, average from 5 to 8 children by families, the population grows very fast.

Because of this fast demographic growth, more and more land is needed to feed the population. Progressively, most of the land, used as pasture before, becomes cultivated. In the East of the studied area, the new owners of the lands along the wadi, which was kept for animals to graze, decide to cultivate them. Those farmers or share farmers extend the crops there. In the big spate irrigated area, the cultivated lands increase as well.

With this evolution, the farming systems change progressively. The animals depend more and more on forage, while the spontaneous vegetation available is decreasing and become overgrazed: consequently, animal husbandry costs increase for the share farmers and the family farm owners, and the sorghum feeder and the residues take more importance. Small farmers start as much as they can to improve their land productivity by sowing twice a year.

Moreover, in this very cultivated area the grazing animals require more work than before: children are more requisitioned for this task.

Sheep become more numerous thanks the little supervising they need compared to goats.

3.2.1.2 Education allows economic activities to diversify

Concerning the education, the first primary school in Wadi Mawr is built by the government in the beginning 1970's in the main city of Al Zuhra. After this one, others are built the following years in Al Luhaya and in some big villages all across Wadi Mawr. Later, some secondary schools are built. Thanks to this expansion of primary and secondary education, the richest farmers like big owners and some family farm owners are even able to send their children to university in Hodeidah or even Sana'a. This is unrealizable for the share farmers as the costs are too high to be borne.

While before the revolution, the few schools were only teaching religion, after it more and more children start learning reading, writing and counting. There are several consequences upon Wadi Mawr activities.

The first impact of children education on these farming families is the decreasing availability of farm labor. Indeed, the children, essentially the boys but also the girls if no boys area available, are in charge of looking after animals in the fields during the day. They become more required because of the cultivated lands, and the families have either to change there farming systems, like grazing outside only one part of the day and giving more forage. But all the families are not able to manage this difficulty, and the schooling rate is low especially for the girls.

The second impact of the population instruction is the diversification of the activities. While everybody is farming or working on farms before the revolution, more and more people start to do non-agricultural jobs, especially after the building of the Hodeidah–Jizan road when exchanges increase.

3.2.2 Increasing and diversifying farm incomes from extra jobs and emigration to Saudi Arabia

During the 1970's and the 1980's, the diversification of the activities in Wadi Mawr does not supply enough employment to the fast growing population. Therefore, some young people leave the area to find some job in cities. During this period, the country is building up and the city of Hodeidah needs a lot of workers in houses and road building. Those jobs allow their families staying in Wadi Mawr to get salaries and increase their incomes.

During the same time, job opportunities with higher remuneration exist in Saudi-Arabia where it is possible for Yemenis to enter legally without visa. A lot of Yemeni people go there to work daily, particularly from Wadi Mawr because it is only few hours away

Thanks to the better salaries and the many job opportunities in this neighbor country, a part of the population from Wadi Mawr goes also to live in Saudi-Arabia and works in farms, restaurants, shops, industries… Many other people, mainly farmers, living in Wadi Mawr just go there few months every year to get additional money: when there is few work on the farm, like when the sorghum is growing. They mainly work in the building-trade, but some work in farms during harvesting periods or do any job.

Whatever they chose between emigrating or going seasonally to Saudi Arabia, the most common is that farmers keep their farms and the share farmers keep their lands, and members of their family stay working on them: sometimes only the men are traveling, while the women stay to take care of the house and the children, but also of the animals' management.

3.2.2.1 Development of exchanges and markets thanks to the Jizan – Hodeydah highway

With this moving population, in 1982 the trunk highway linking Hodeidah and Jizan, Saudi-Arabia, is completed. This road crosses Wadi Mawr at the east of the project area.

The first effect of this important axe of communication is that it provides to people easier access to markets and suppliers in Hodeidah. Indeed, Wadi Mawr becomes little more than 1 hour to Hodeidah while it was nearly 4 hour before.

Moreover, the high traffic along this road and consequently through Wadi Mawr make some activities to develop. Indeed, the two big markets along the road, Al Marras and Al Khamees, grow up quickly and the activities in those cities diversify. A lot of restaurants open, the number of all kind of traders increase and many workshops of cars, tractors and trucks are available.

3.2.2.2 From subsistence to market orientation for all the population

In the same period, people going to Saudi Arabia have the opportunity to eat there other kind of food, such as rice, sugar, wheat flour, which are imported from abroad. Little by little, they bring new alimentary habits in Wadi Mawr: when the area is opening, thanks to the new road and the development of marketing.

These imported products are more and more found on the markets at low price, are more interesting for small farmers to be bought rather than to consume sorghum with high production costs, and take the place of the old habits. The sorghum grain produced as well as the vegetables, watermelon or sesame, are now dedicated to the

market. For example, the sorghum grain is especially sold to the mountain people, who did not change their habits because of fewer contacts with Saudi Arabia. In Wadi Mawr, agriculture is slowly changing from farm consumption to market orientation.

At this time, the majority of the farmers of Wadi Mawr are still share farmers and small owners. They are the first to profit by those cheap food products, to develop crops market while continuing to breed animals for exportation. In the same time forage market develops also, due to the higher dependence on forage. Like bigger owners who travel as well, they have now savings to invest in their farms.

3.2.3 New investments fo water access and supports to the agricultural sector allow to increase the land productivity

3.2.3.1 Extension of irrigated agriculture with individual motor-pumps, especially in South West

After the Second World War, the governments of rich countries in Western Europe and Northern America help the improvement of their agriculture. In those countries, new plant varieties appear, irrigation systems enlarge, the use of chemicals and mineral fertilizers increases and moto-mécanisation develops. This agricultural development in the industrialized countries has a big impact in YAR from the 1970's and new agricultural machines are imported.

The most important change in Wadi Mawr is the apparition of big motor-pumps, which totally change the agricultural landscape. Migrants of the low water access areas such as the end of the spate irrigation of the South West, or of the North West, invest in wells and pumps. Indeed, they allow growing crops all the year around and any place where the groundwater is available in sufficient quantity.

However in the Western area of Wadi Mawr, because of its high salinity (ground water, part 2.2.2.2), the use of the groundwater for agriculture is impossible. Furthermore, this new equipment needs big investments from farmers and it is only profitable where the use of petrol is limited. Consequently, only the areas where the soil storage capacity is high and the fresh water available are using wells and motor-pumps.

- The big motor-pumps mainly develop in the area where the groundwater salinity is low, in the South-West and North-West areas of the project along the wadi bed.
- But it also develops in the area where the water available from the wadi is sufficient, in the Eastern part: indeed, some small motor-pumps are used as insurance when the wadi does not come sufficiently, to allow to grow vegetables, which need a lot of water.

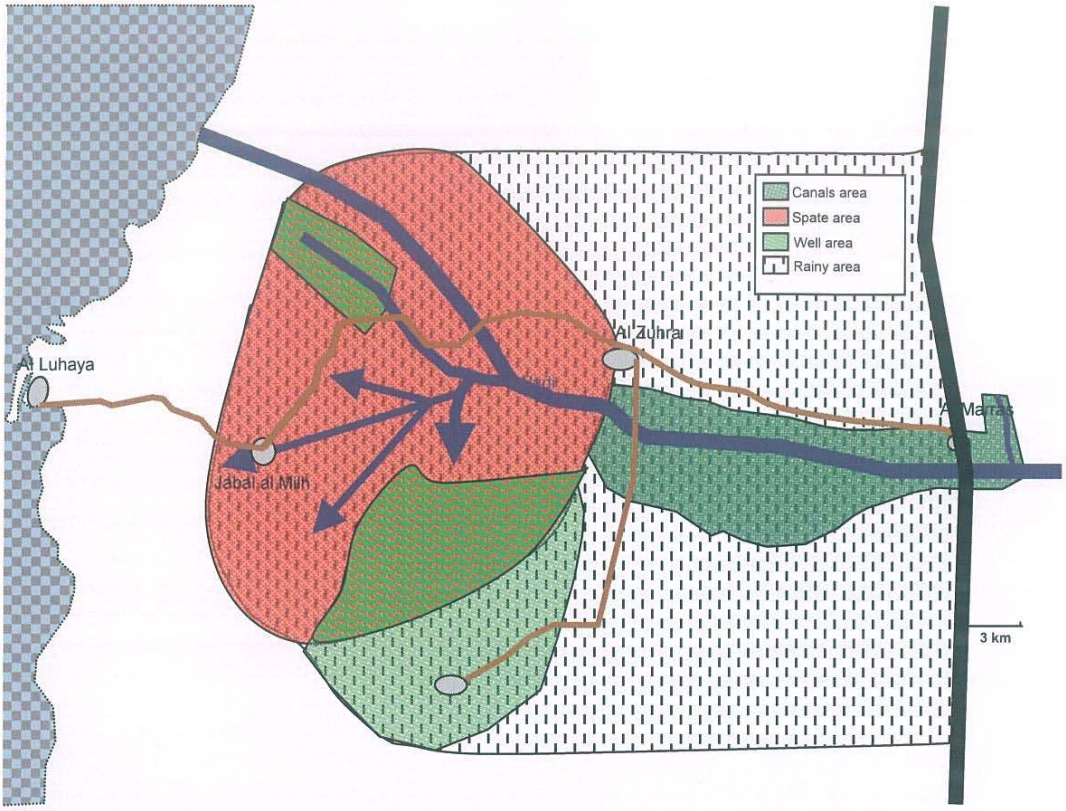


Figure 19: the use of groundwater is appearing in Wadi Mawr

Thanks to Saudi Arabia and to their savings, but also thanks to the sale of lands or animals, big, middle but also small owners have managed to invest in a motor-pump in the West area.

As there is no authorization to ask to build a well, a lot of farmers of the spate irrigation area invest in lands, in motor-pumps and build a well on their land. Some of the biggest owners are then able to take share farmers to cultivate part of their lands irrigated by well, and they mix family and capitalistic farming incomes.

A motor pump purchase

An old farmer of the South West area is owner of 40 maad, cultivating with his brother sesame and sorghum with a weak spate irrigation, and is breeding 80 small ruminants in the 1970's. He takes the advantage of an opportunity to go to Saudi Arabia and leave his lands to his brothers several years for a small job. In 1975 he comes back and invests in a well and a motor pump thanks to this money, and sells 40 animals to complete the purchase. He is now irrigating for him 20 maad and gives the other 20 maad land to 3 share farmers.

With well and irrigation, the farmers still follow the two *Seif* and *Kharif* cropping seasons, but also develop the sowing in *Shubat* or *Mossemi* to provide the market in grain and forage with interesting returns. But it also has an impact on the farming systems management, as the irrigation takes now a very important part of the work calendar and of the production costs of those farmers.

3.2.3.2 The arrival of equipment improves labor productivity

Others agricultural equipments also appear in the beginning of the 1970's: new tools are used making easier the farm works: shovel, pickaxe, wheel-barrow, can… But the most important are tractors and threshing-machines, now used at the expense of bulls and manual threshing.

As the studied area is irrigated from wadi, the need of plowing and sowing a lot of land in a limited time when the water comes, makes the use of tractor very useful for farmers: one maad plowed by tractor takes now 2 hours, whereas it takes 12 hours by bulls. A lot of farmers adopt renting to richer farmers investing in tractor purchase.

But it depends also on the amount of lands to work on. Concerning the smallest surfaces, as the bulls are used only for plowing and sowing and fed with cultivated forage rather than natural plants, the expenses in food during all the year make the rent of tractors cheaper. Moreover, the value of bulls is very high and a lot of farmers, when they have shortage of money, prefer to sell them rather than to take the risk of their death it if they cannot buy sufficient forage.

As a result, bulls progressively decrease.

The advantage of tractor renting for a small farmer cultivating sorghum twice a year (current prices):

A small farmer, cultivating 5 maad of sorghum twice a year in the spate irrigation area, owns 2 bulls that he feed with 3 packs of sorghum feeder per bull everyday of the year. His costs of forage are high, 124080 RY/year.

He knows that now the renting of a tractor to work on one maad costs 16500 RY/year (Annex 3). With the money he invests in his bulls, he realizes he could work until 7,5 maad with a rented tractor.

Moreover, the short time available between the harvest and the new sowing makes difficult the use of bulls: in 15 days, he can only work 7 maad, while the tractor would allow him to work 6 times more surface.

However bigger or smaller than 7 maad his farm is, the renting of a tractor becomes more profitable than his bulls.

So he decides to sell his bulls, and to invest the additional money he can save in other activities.

The bulls are still bred by few big share farmers and middle owners, who have the money to feed them. In addition to this, most of those farmers cultivate once a year because of their bigger surface, so their bulls are still profitable as a large time is available to implement the crops.

The owners of the bulls become now the only source of reproduction males for the cattle that they start to lend for free to the other farmers. They also furnish the area in provision of services by renting their bulls to farmers with small lands, or when all the tractors available are busy because the area is very cultivated and in the same period of time.

3.2.3.3 New agricultural public subsidies for research, training and services to farmers

Studies and funding for the development of the agriculture in YAR start after the revolution. Because of the very little knowledge available upon agriculture, the first emphasis is to improve the sectors' institutions, by acquiring basic data, training manpower, and establishing Ministry of Agriculture and needed organizations in order to conduct surveys and start few projects. As a result, important organizations are created: the Central Planning Organization (CPO), the Agricultural Credit Fund (ACF) and the Agricultural Credit Bank (ACB), which will merge into a single organization the Cooperative and Agricultural Credit Bank (CACBank).

Moreover, in order to improve farming and develop agriculture potentialities, agricultural schools are established to train technicians, engineers and veterinaries. Firstly, agricultural and veterinarian secondary schools are created across YAR. Then, the University of Agriculture of Sana'a is established. YAR trains people in rural development, animal and vegetal production, able to improve farming and to increase farms productivity in the country.

In 1973, the period when agricultural development policies start, the Tihama Development Authority (TDA) is created as the semi-autonomous organization responsible for land and water resources development in the Tihama coastal plain. It carries out several studies and development projects in the Tihama from this year and supports agriculture and breeding by financial help to farmers, but allows also larger local development by providing infrastructures to the population. Since 1985, TDA has been responsible for agricultural extension. It has a well established extension service with 51 supervisors and 172 agents working at field level, of which 41 are women under the RWDU (Rural Women Development Unit).

3.2.3.3.1 Support to the production and organization of the agricultural sector

Under Tihama Development Project I from 1973 to 1979, TDA consultants carry out the feasibility study of Wadi Mawr's agricultural development, which also forms the basis for other projects in other wadis in the South: Wadi Surdud and Wadi Rima. Then, a five year plan is initiated in 1977, which puts broad objectives like developing irrigation, livestock production, fisheries, forestry and extending crop research and training. After this, two projects are financed by IDA and KFAEC, the first one for grain storage and processing and the second one for livestock and processing credit.

The farmers of Wadi Mawr, whenever owner or share farmers they are, receive at this time numerous advices and supplies on vegetal production.

- For example a new millet variety giving more grain and more adapted to sandy soils, but which has to be cultivated alone, is adopted by a lot of farmers and share farmers: as the millet forage is less eaten by the animals, harvesting more grain allows its sale and then the purchase of sorghum feeder. The association of millet with sorghum, cowpeas and math beans decreases in the rain fed area.
- Vegetables grown in the canal area, supply the local market. Pesticides and chemical fertilizers are sold to increase productivity.
- In this development policy the cotton is supported in the spate irrigation area and become to be cultivated on wells by owners and share farmers: it is bought to the farmers by a national Yemeni company implanted in Wadi Mawr, who provides them with seeds and chemicals.

3.2.3.3.2 Development of the infrastructures and extension policy

Under Tihama Development Project II, a fifth project in Wadi Rima is executed to complete the first one. Then, two important UNDP-financed projects, Institutional Support to the Ministry of Agriculture and Central Agricultural Research and Training Organization, help the government to overcome the lack of infrastructure and the shortage of skilled agricultural manpower (MIAN and al, 1979). Those programs have indirect impact on Wadi Mawr, through improvement of agricultural global knowledge.

Extension policy develops with skilled engineers and technicians, to insure the continuation of the Tihama Development Project I in terms of agriculture and breeding improvement and of marketing organization.

The animal production starts to be supported. Veterinarian services are proposed to all the farmers, owners and share farmers, and vaccination and prophylaxis campaign are led through Wadi Mawr at very low prices for farmers.

3.2.4 The Wadi Mawr project to secure water: farming systems differentiation due to unequal water access in the East and West of the project area

In 1979, the *Tihama Development Project III (Wadi Mawr)* starts.

The quick access to the more and more organized markets is focused: the building of the road between Al Marras and Al Luhaya starts, while other roads and pathways relying the different villages are improved especially to avoid destructions when the wadi overflows the area, and to allow the ways to vehicles.

Water supply is the important part of the project: studies are led on groundwater and a lot of villages are provided with water installations for free domestic use. But the central step of this new public support is the improvement of surface water access: the Wadi Mawr Project in 1985.

3.2.4.1 Upstream: safety of water access

To achieve the objectives assigned in Wadi Mawr, the main project is the construction of a diversion weir and the distribution of water flows into the traditional canals to increase agricultural production: by increasing the total surface of the canal area, and securing and controlling water supply.

Indeed, the wadi diversion allow to take off more water when the wadi is coming, to extend the irrigated land from 15 000 to 18 000 ha to the North and the South, and to increase the irrigated land productivity.

Moreover the farmers of the canals area are able now to sow twice a year.

The new diversion and distribution system assure the optimum utilization of the available water for irrigation. For the durability of the system, the farmers themselves are charged of choosing a manager for each secondary canal; all the taxes paid (10% of the harvest) are used to the maintenance of the canals that is realized by the farmers together.

Moreover, the existing customs of water allocation gives priority to the upper riparian for the use of wadi flows. To achieve the whole benefits from the project, assurance, from the upper irrigators, was obtained during negotiations that the government controls the water deliveries to ensure an equitable distribution of the wadi annual flows.

Unfortunately this control will not be applied and the upper irrigators will take most of the benefits of the project, while the people in the West and in the extreme North and South of the canal area have only few water supply.

- In Daraniah area, high value crops such as fruit production develop for local and national market. The farming system producing mangoes or bananas begin on the sheikh lands, inspired by other wadis of the Tihama, and are encouraged by TDA. Then family farm owners follow the example. Those capitalistic farms profit by water access all the year, and employing seasonal manpower.
- In the East of the canals area where water is also widely available, fruits develop more and more. Where the water has decreased, sorghum spreads little by little. The vegetables have now to be secured by small pumps, and as a consequence of this investment they start to be abandoned by a lot of share farmers.

3.2.4.2 Downstream: lack of surface water and extension of motor pump irrigation

During the same period, upstream, the population grows also in the mountain, developing agriculture, extending the cultivated lands and increasing the water use. The total water supply for the Wadi Mawr area is affected.

In the Western part of the project area, the lands are traditionally irrigated by wadi diversion and spate irrigation, using the surplus of water coming for the Eastern area. Four main ways of the wadi are carrying water to the North (two ways), to the South, and then to the West until the sea.

The impact of Wadi Mawr project upon this area is the decrease of available water for irrigation. The increasing water use, in both Wadi Mawr Project area and the mountains, has big impact upon the last irrigated areas in the South and in the West. Indeed, from this period, no water will reach these areas. The consequences differ according to the area and to the activities of the population.

- In the beginning of the spate irrigation area, the farmers keep on receiving the wadi flow like before, and a satisfying water access. They are still able to cultivate cotton, watermelon and sesame when the water is largely available.
- In the South-West and North-East parts, the underground water quality allows well irrigation, which some farmers are already using to increase irrigation and better the yields. After the dam construction, every farmer who has enough money invests in wells. These area becomes the most important area irrigated by wells in all Wadi Mawr. Cotton and sesame production, which needs a lot of water, keeps on developing for owners and share farmers, as well as the sorghum.
- In the West, the transition does not success because of the high underground salinity. In this area, people keep rain fed cultivation when the sparse rainfalls occur, but most of them start non-agricultural activities, such as fishing or working in salt quarry.
- Furthermore, some remaining nomads, big livestock owner, were grazing the non-cultivated lands in this Western area of Wadi Mawr, around Jabal Al Milh. But when the Wadi stops coming, and because of the very few

rains in this area, the natural plants availability decreases and they start feeding their livestock with forage bought from the well or the canal area. As a result, they move to settle in the South-East with their herds, according not only to the rainfall but also to the sorghum location, where they are insured to find forage at better price.

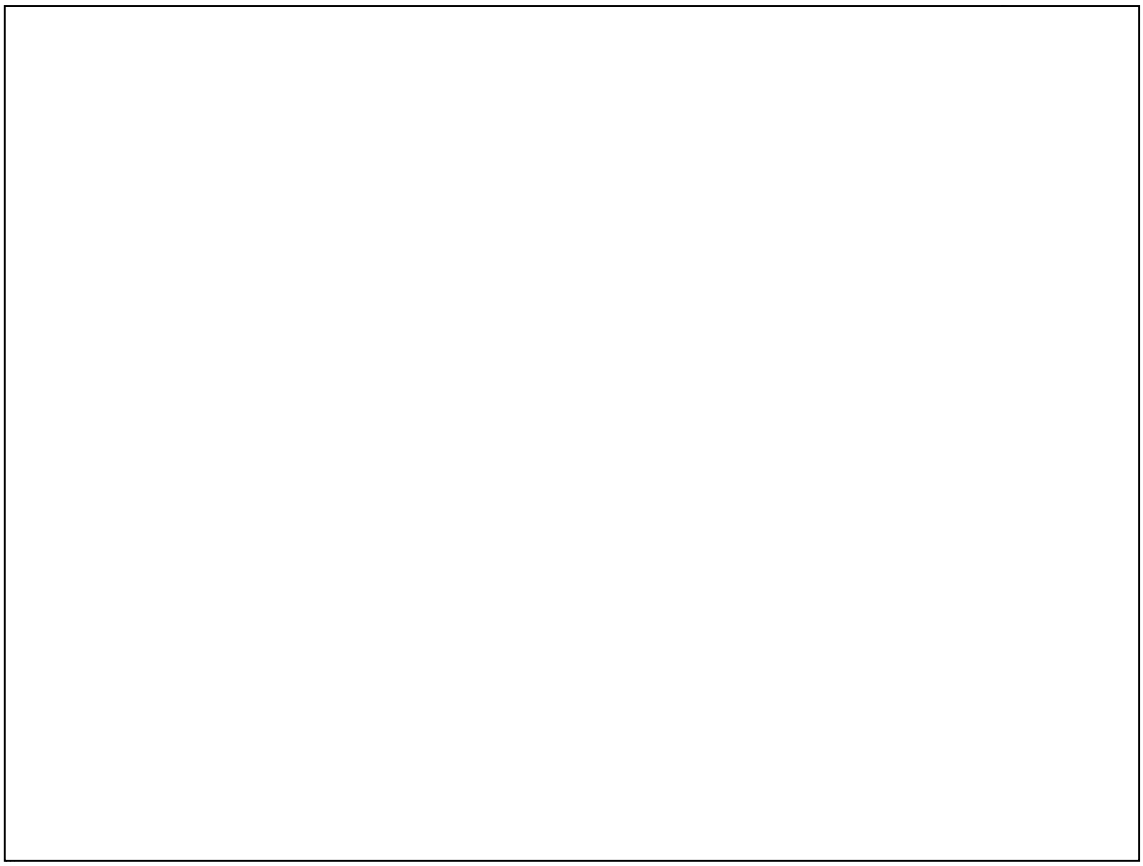


Figure 20: the new water access preventing the West from surface water and more relying on groundwater

3.2.4.3 Development of fattening

At the end of the 1980's, fattening advices are given by skilled technicians, and concentrates such as wheat and barley are first given then sold at good price to feed the young animals. While the veterinarian campaign is already spread, in all the area but intensively in the East where are concentrated the rich owners able to buy drugs and concentrates, fattening appears in the breeding systems.

A new share-breeding system develops in Daraniah area, based on fattening realized by small farmers or share farmers: rich owners provide concentrates and drugs, whereas the share breeder is in charge of the grazing and the forage, and then the production is equally shared.

3.3 FROM 1990 TO 2003, THE WADI MAWR ECONOMIC EVOLUTION MAKES THE FARM INCOMES DECLINE

Important political events affect Yemen but also the Arabic countries around at the beginning of the 90's. The reunification of the North and South of the country occurs in 1990 and lasts until 1994, but also the Gulf crisis of 1991, bring new changes in the politico-economic situation of the country, and in its agriculture.

3.3.1 Golf crisis, 1991: massive immigration leading to higher pressure on natural resources

The Gulf crisis:

When the Gulf crisis happens, the Yemen's position in the UN about the conflict is opposed to most of the other Middle East countries': Yemen supports indeed Saddam Hussein, and disagrees with any American intervention in Arabic countries. The neighboring Arabic countries, especially Saudi Arabia and Kuwait, which are moreover against the Yemeni reunification, decide to stop helping Yemen with economic aids for development.

In the same time the Yemenite people living in Saudi Arabia are thrown away. Starting form this period, a visa becomes necessary to enter in the country, what prevent a lot of people to go back there to work unless they do it illegally (GIROUD, 1997).

In Wadi Mawr the emigrants come back in the same time, and the population increases suddenly. The people who settle again come back with some money that they could save in Saudi Arabia, and can invest it in agricultural activities for themselves or their family.

- In the well area, some non agricultural population is starting agricultural activities, buying lands to other farmers who have sold land for well investments and/or buying motor-pump. Some ancient share farmers or small owners, who have let their families on the farm, invest and are able to become small or middle owners with motor-pump.
- In the canal area, the land availability is very low: the best lands are in great demand, and the land price is very high. People coming back have the opportunity to become quite only share farmer, unless they are owner and can develop for example vegetables with new small pumps.
- The rainy area is the most invested, because of the space available. Some new farmers buy some lands with lower price, or become share farmer. Some people only build their house there, but are share farmers in the canal area.

In addition to the cultivated lands, the number of animals increases a lot in Wadi Mawr, what contributes again to the decrease of the spontaneous vegetation available for the grazing. In addition to this, the wood cutting increases to build new houses in the villages. The pastures and feeder trees are less dense and become overgrazed, and paddocks appear to keep the animals in the rainy area during the dry period or in the well area when everything is cultivated.

Moreover, the groundwater is more and more consumed by the building of additional wells, and threatened to decrease severely what would affect the systems based on well irrigation.

3.3.2 The difficulties to establish the Yemen Republic and the high inflation

The North and South Yemen reunification, 22nd of may, 1990:

The first years of the new Yemen Republic are difficult. The country is weakened by the precedent war, by the amount of refugees coming back from Saudi Arabia, and impoverished by the interruption of the Arabic and international aid. Moreover some

people in South, against unification, maintain armed conflicts all the first half of the 1990's.

In 1994, countries like Saudi Arabia or Kuwait support the idea of a southern secession and Yemen goes again through a violent period between southern and northern units. Aden is quickly defeated, and Yemen finally stays unified.

A new constitution is applied in 1994, and in the same time the money of the South, the dinar, disappears little by little. The money of the North, the Ryal Yemeni (RY), becomes the official money of the Yemen Republic.

During these years, the bad economic situation of the country and the fact that Dinar value was upper than the Yemeni Ryal, are responsible for an important inflation (GIROUD, 1997) (Annex 4).

The life cost becomes very high, in Wadi Mawr like in all the regions of Yemen.

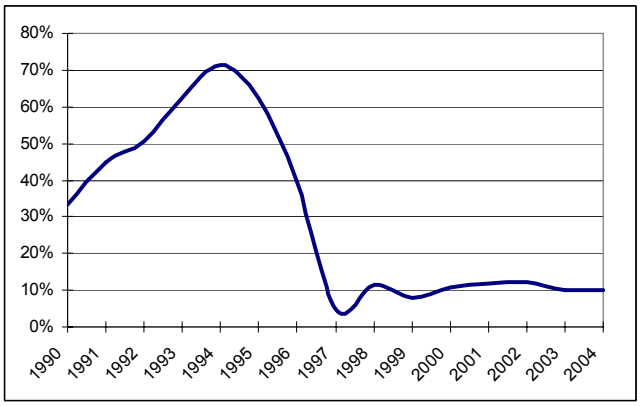


Figure 21: Inflation in Yemen from 1990 to 2004

In the well area, the production of sesame starts to decrease in Wadi Mawr at this time, and is substituted by sorghum. The sesame oil becomes indeed a lot cheaper on the exterior market and Yemen, with big ports like Aden and Al Hodeidah, develops the import of such products, and sells them in the cities.

In all the area the production costs for crops and for the animals are higher. The farmers often have to sell some animals to be able to live until the harvest, which money allows them only to cover the next production costs.

The sorghum to insure forage

An owner of well has stopped cultivating sorghum for two years. "I was cultivating sesame, but now I grow sorghum. With sorghum I have at least forage that I give to my animals or that I can sell. With sesame I get money but it is not like before. The sesame is not profitable anymore. The irrigation is too difficult to face, and the money is spent the same day on the market, for my family and the next irrigation."

However, the population stays agricultural and the rural depopulation to Yemeni cities is at this period restricted, as the Yemen does not offer a lot of job opportunities to absorb the labor.

3.3.3 Slowing down of TDA activities and impact on animal production

Since the middle of the 1990's, the TDA knows financial difficulties and staff restructuring, that have slowed down the supports to farmers. The increase of diesel and the lack of vehicles leads to the end of vaccination and fattening campaigns, and the farms do not have the intern capacity to pay drugs and concentrates at high cost.

The fattening, which had already started to decrease because of the inflation, is more affected, except in the Daraniah area where rich owners keep on giving their young animals to be fattened by share breeders.

3.3.4 Regular decrease of rainfalls and impact on land productivity

According to some old farmers, the total annual rainfalls have decreased since the 1970's. Moreover the first rains, and the first time the wadi comes in *Seif,* occur 20 to 30 days later than before.

The consequence for the cropping systems is that the grain maturity occurs nearly 1 month later. At this period some birds, the Rueppell's weavers (*Ploceus galbula*) are finishing their reproductive cycle with big flights of many young and adults individuals, and eating the sorghum grain. The Islam preventing from taking measures against birds, harvesting grain in *Seif* is today impossible.

This shortage of water reduces also by 1 month the cropping season, makes shorter the time for farmers between a harvest and the next sowing, and complicates consequently the use of bulls. Finally the fewer rainfalls along the growing year contribute to diminish the land productivity in all the area.

The well area is able to get round the birds reproduction's difficulty. Thanks to the pumps they are not dependant on the wadi flow, what allow them to bring the cropping season forward. The sowings happen one month before, and the Seif grain harvest is possible.

3.3.5 Decrease of cotton replaced by sorghum

The cotton is quite only bought to the farmers by the national Yemeni company, but those years the company does not pay the farmers how it is supposed to do. Some producers try to sign contracts with private merchants but their price is not profitable, and they do not provide any inputs.

The majority of the farmers and share farmers producing cotton in the well and the spate irrigation area stop this activity in Wadi Mawr: once again, the sorghum production extends.

3.3.6 Farming systems resulting from this evolution: a greater importance for sold crops and sorghum feeder

As a result of those thirteen years of agricultural evolution, the farming systems of Wadi Mawr can still be divided between big capitalistic farms, family farm owners spread in the whole area profiting by land security, share farmers and other farmers cultivating any land. However the activities are not anymore for family subsistence.

At the beginning of the 2000's, the agriculture and breeding activities are mainly dedicated to a market orientation: all the crops and animals supply numerous markets, that allow the farmers to buy their family needs. The restructuration of water access and

the lack of pasture, added to the politic and economic events, have led to an area dominated by the sorghum, which is cultivated with the first aim to provide the herds in forage. A market of sorghum feeder has developed to provide the local but also mountain farmers.

The good enhancement period of the 1970's has progressively turned to a decline of farm incomes. The production costs are too difficult to face, and small farmers are threatened by animals destocking.

Destocking:

A sixty years old farmer living on the road between the canal and the rainy area explains that when his first children were born, his herd was numerous. He managed to buy 2 maad in the canal thanks to the sale of some of his animals and to travels to Saudi Arabia. But he constats that his herd has been constantly decreasing since twenty years. "Before we were selling animals to buy lands. Now, we sell animals to buy food".

3.3.6.1 Big chieffery farms

Big capitalistic farms are still located where the best land quality and water access are, in Daraniah area and in the Eastern canal area. Those farms are the biggest of wadi Mawr, dedicated to fruit production using seasonal manpower, and/or to the fattening of small ruminants thanks to share-breeders. Those rich owners do not depend only on agriculture but invest also their money in other sectors.

In all Wadi Mawr, other big capitalistic farms are dedicated to other crops such as sorghum production, like for example the family Heig, or other big rich families.

3.3.6.2 Family farm owners beneficiating of land safety

In all Wadi Mawr, family farm owners have become very numerous, resulting from the dissociation of the ancient family Heyg ownership and the investment opportunities given by the emigration to Saudi Arabia, but also from the land heritance within the families. Those farms profit by the land security, and have animals that they feed first by supply of forage, and spontaneous pastures if it is still possible.

Middle and large farms growing crops with big motor pumps have developed in the new well areas thanks to money saved in Saudi Arabia. Sesame and watermelon are still cultivated but where the main production is sorghum to feed their herd and also supplying the markets all the year in grain and forage. Those farmers often let share farmers cultivate some lands and to use the well if they pay the irrigation costs.

Small farms growing crops like vegetables with small motor pumps are located in the canal area, and have bought pumps thanks to lower investments. They take advantage of a soil renewed by regular wadi access, and have water safety in case of shortage or to cultivate before the wadi coming. They include those vegetables in a rotation with sorghum to feed their animals, but also to be sold if there is surplus.

New fruits farms using a lot of water also develop, convinced by the high incomes fruits may allow. Those family farm owners are located in Daraniah area, but also in the canals area, growing it with big motor pumps.

Small and middle farms irrigated by wadi are present all along the wadi bed, in the spate irrigation area and in the canals area, dedicated mostly to sorghum but also to watermelon if the market price is regular. They generally sow twice a year according to the two wadi seasons, in order to maximize the land productivity. However, the shortage

of manpower forces the biggest farms to sow once a year, alternating one *Seif* cycle and one *Kharif* cycle.

Big farms in rainy area are more numerous, based on *Kharif* rain fed crops such as association of sorghum, cowpea and math bean, or such as millet. The low forage yields are not sufficient to feed the animals, and those farms are dependent on the canal and well areas for sorghum purchase.

3.3.6.3 Share-farmers with low incomes

The share farmers are less than before the Revolution, but still represent the largest and the poorest population of Wadi Mawr, without any land safety especially in canal and spate irrigation areas where all the lands are cultivated and in great demand. They rely on sorghum production sowed twice a year to improve their land productivity and feed their animals, and they face the high owner tax by searching external activities.

A lot of share farmers have very low incomes, what is not sufficient to make their families live correctly, and force them to look for another activity. In the well area the irrigation costs are very high especially in *Seif* when the rains are very little, and the share farmers have to give up some of their cultivated lands. In the rainy area where the yields are not sufficient the farmers feed their animals with difficulty and are dependant on external incomes.

3.3.6.4 Herders without land

The big nomad breeders are now joined by more new breeders coming from the Western area, leading their animals to graze and searching sorghum at the better price.

Finally, some persons are owning and/or sharing small herds, and improving their incomes by working seasonally in the fields, or looking for external jobs.

	Size of the farm	Location	soil	Main water resources	Cropping activities	Herding activities
Very big land owner	More than 100 maad	Wadi and canal zone	Clay loamy soils	Wadi and underground water	Not farmer	No herd
Rich middle land owner	5 to 30 maad	Canal zone			Fruit trees	
Big and middle land owner with well	30 to 300 maad	Wadi zone			Sorghum, sesame and watermelon	Breeding 2 to 30 sheep and goats and 1 to 5 cows. Using 1 to 3 donkeys and sometimes 1 dromedary for transportation Very few have 2 bulls to work
Big land owner using only well	15 to 100 maad	Rain fed zone		Underground water		
Middle land owner	10 to 30 maad	Canal or wadi zone		Wadi	Sorghum and watermelon	
Small owner with small well	2 to 10 maad	Canal Zone		Wadi and underground water	Sorghum, vegetables, jasmine, henna	
Small owner		Canal or wadi zone		Wadi	Sorghum	
Share-farmer using well		Wadi		Wadi and underground water	Sorghum and watermelon	
Share-farmer using only well		Rain fed zone		Underground water		
Share-farmer		Canal or wadi zone		Wadi	Sorghum	
Share-farmer fattening small sheep		Canal zone				Fattening 5 to 20 small sheep from rich owners
Rain-fed land owner	10 to 250 maad	Rain-fed zone	Sandy	Rain only	Millet and sorghum, cowpeas, math beans	Same as above (sheep, goats, cows, …)
Big herd owner	No land	Between wadi and rain-fed zone	No land	No land	Nothing	Breeding 15 to 200 sheep and goats and 1 to 10 cows Using donkeys and dromedaries for transportation
Share-breeder	No land	Between wadi and rain-fed zone	No land	No land	Nothing	Sharing 2 to 5 cows and 5 to 15 sheep and goats

Figure 22: farm categories in 2003

3.4 FROM 2003: NEW DIFFICULTIES MET BY SMALL FARMERS FACING DESTOCKING AND DEPENDING ON EXTERNAL INCOMES

Starting from 2003, new difficulties appear for farmers in Wadi Mawr what affect their incomes, especially in the Eastern canal area and in the wells area. The farmers have more difficulties to cover their production costs but also to make their family live, and are led to continue on destocking animals, and to search external jobs.

3.4.1 In the East: arrival of external investors in fruit farms threatening share-farmers without land safety

Some extern investors, coming from Hadramout, or Wadi Zabid, have been investing in agriculture for 2 years in the canal area because of the good land quality and the availability of water, particularly after the shortage of water in wadi Zabid. They especially develop specialized mangoes and bananas plantations with big motor pump. They buy or rent some lands to the big owners essentially, and have sometimes external share farmers from Zabid that were used to the fruit production there, or hire local seasonal workers for the harvest. Like the vegetables, the system is using chemicals and the high production is dedicated to the Yemeni market.

Some share farmers without any land safety are threatened to be thrown out of their lands to give the way to this new activity. The new fruit plantations are rarely letting the ancient share farmers keep on growing sorghum under the fruits. The share farmers consequently have to turn to sharing in the rain fed area, where the yields are a

lot lower, and/or even to other jobs, like agricultural workers or illegal emigration to Saudi Arabia.

3.4.2 In the West: increase of diesel price limiting motor-pumps use for small farmers

In July 2005, the Yemeni government decides to increase the diesel price, which goes suddenly from 17 to 35 RY. All the farmers who use tractors or motor-pumps find difficulties to hold on in this situation.

The price to rent a tractor to plow or sow the lands has reached to 1500 or sometimes to 2000 YR/hour, while it was 800 YR/hour the year before. Some farmers who were both using their bulls and renting tractors, have come back to use only their bulls.

But the biggest problem is for the farmers using wells. The rich owners or investors of the canal area are able to face the costs, but for share farmers the situation becomes very critical. The irrigation costs become so high, especially in *Seif* when there is few rain and it is very hot, that the share farmers of the area have to decrease their activity and cultivate 50% less land than the year before: they start to cultivate only in *Kharif*.

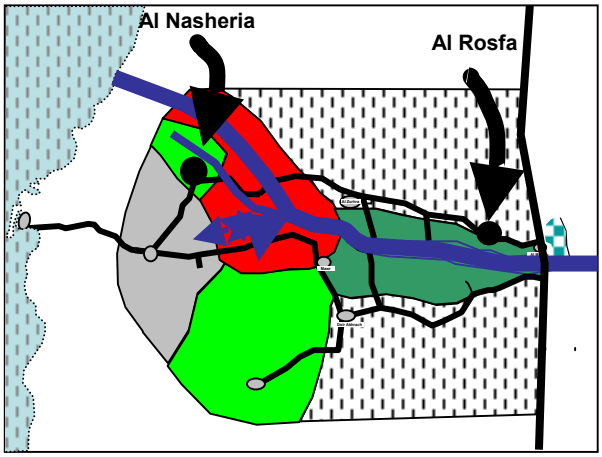
They grow quite only sorghum, less water consumer and so less diesel consumer for motor-pump. The sesame which had already decreased is once more very affected in the area and nearly no cultivated this year.

The sorghum price is threatened to increase again, what will affect all the area as the wells are is a very big source for sorghum feeder in Wadi Mawr.

3.4.3 Al Nasheria and Al Rosfa: two villages showing problems poor farmers are facing

The technico economic aspect of the study is focused on two villages representing the diversity of the area and exposing the main current issues the area is facing, and especially small farmers and share farmers: Al Rosfa, situated on the road between rainy and canal area, and Al Nasheria, in the well area and in relationship with the rainy area systems.

The spate irrigation area has been turned down of the study, as the farmers know better conditions for land security and for irrigation costs.



Al Rosfa is located on the Al Marras-Al Luhaya road, in the East of Wadi Mawr. The farming activities are both in rainy and canal area.

Al Nasheria is representing the North-West well area, but it can represent also the South-West area. This village is not provided by spate irrigation anymore, and is depending only on wells, producing a lot of sorghum.

Figure 23: localization of the two studies villages

The farming systems are defined according to the main factors of technico-economic differentiation. First of all the land access dissociate owners from share farmers and exclusive breeders, whose activities are situated inside and/or outside of the oasis. The social laws such as inheritance and/or the external incomes condition the size of the farm. Capital or savings from external incomes allow some farmers to secure their water access, while the others use what their location provides.

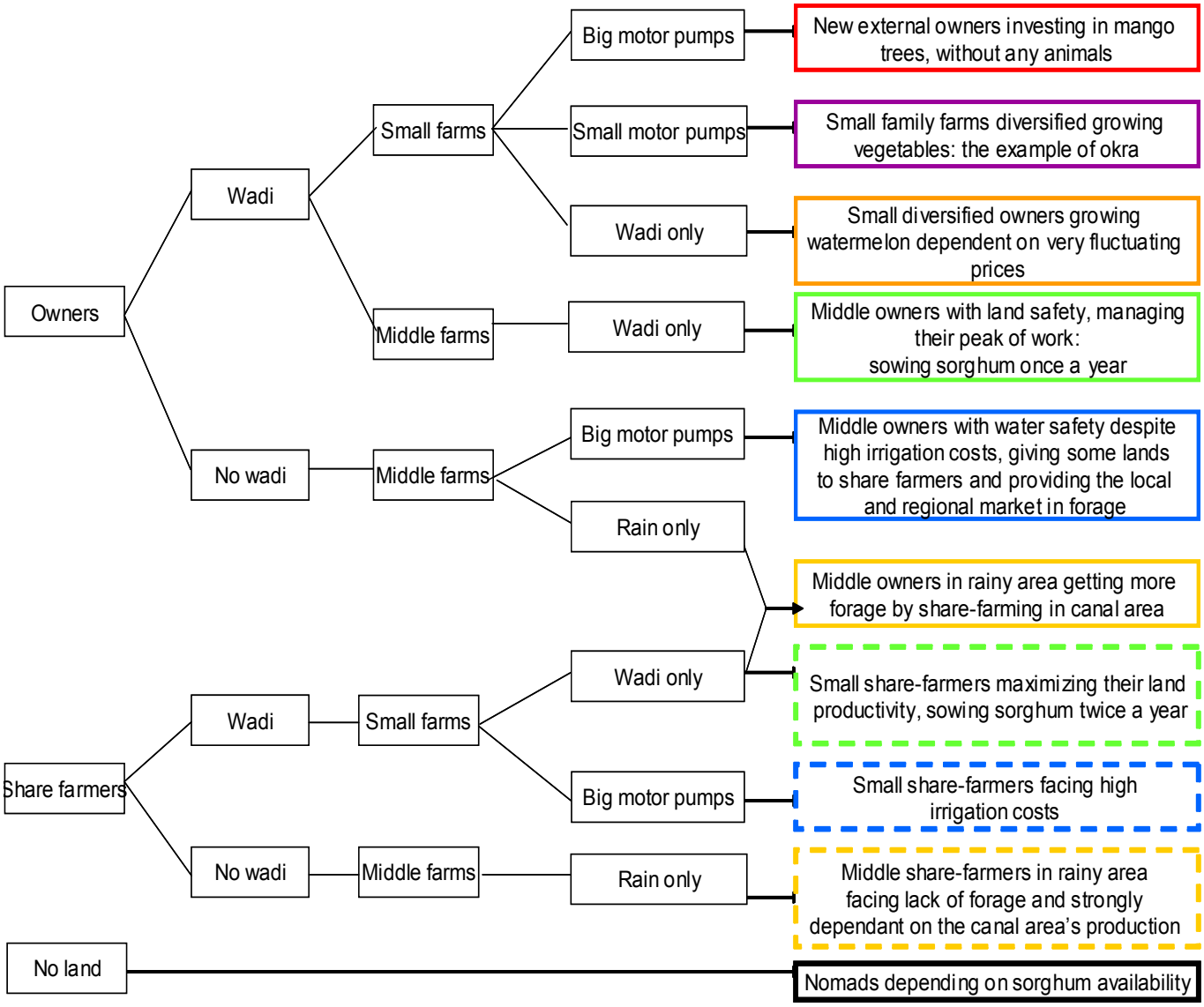


Figure 24: farming systems typology in the two studied villages Al Rosfa and Al Nasheria

4 CROPPING SYSTEMS: SORGHUM PRODUCTION MENACED BY THE DIFFICULT WATER ACCESS

Within the agrarian system, several cropping systems are exploited by farmers across the area. All of them are useful to be studied, but those irrigated by the wadi in canals area and spate area are very similar. Only the irrigation system has some differences and the technical performances are quite the same. Consequently, the mono-culture of sorghum (*Sorghum vulgare*) and the rotation with watermelon have only been studied in the canals area.

In order to understand easily each systems and their combination within the farming systems, we choose some code explaining the crop rotation (capital letter), the growing season and the irrigation if needed (both in small letter).

Code	*Ss*	*Skh*	*O*	*W*	*C*	*M*	*w*	*p*	*/*	*//*	*+*
Meaning	Sorghum grown in seif	Sorghum grown in kharif	Okra	Water melon	Cow peas	Millet	Irrigated by wadi	Irrigated by pump	Rotation within the year	Biennale rotation	Crops association

Figure 25: Explanation of code for cropping systems

It is fitting to inform that all the detailed technical and economic data for cropping systems, animal husbandry systems and farming systems are available in the annex 5,6,7.

4.1 SORGHUM FOR GRAIN AND FORAGE: OPTIMIZING LAND AND WATER RESOURCES AND MANAGING PICK OF WORK

4.1.1 *(Ss/Skh)w*: Sorghum irrigated by wadi: two cycles per year, one in each rainy season

(Ss/Skh)w stands for a mono-culture of sorghum irrigated by wadi with two cycles per year, one in *seif* and one in *kharif*. From the first cycle, the farmer can have one harvest of forage and makes animals graze few weeks later. From the second cycle, the farmer can have 3 harvests, 2 times for forage and grains and the last one only for forage.

This cropping system is performed by small farmers in the canals area. Thanks to the high water availability, they can grow in both rainy seasons and have high forage production on small land.

4.1.1.1 Technical sequence

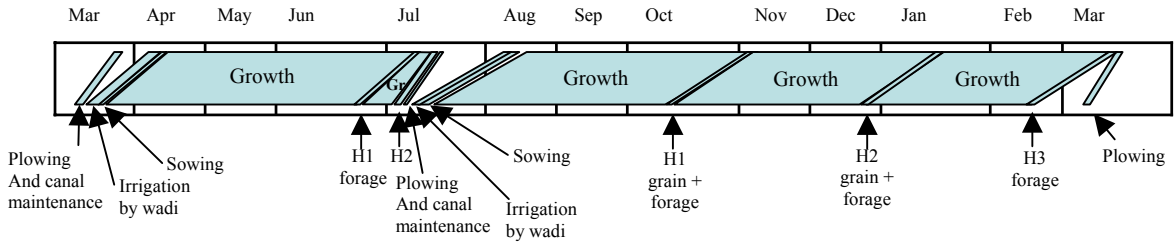


Figure 26: Technical sequence of (Ss/Skh)w

The first step of the cultivation is plowing, to bury the remains after the last harvest and to increase the water storage capacity of the soil before the irrigation.

The difficulty for farmers to grow two cycles of sorghum per year is the short time between the harvest and the sowing time. Indeed, sorghum feeder in *seif*, is harvested (H1) at the beginning of July, then the remains can be grazed (H2) two weeks later and the land must be plowed for *kharif* cultivation before July, 20th when the wadi is usually coming. The same problem is happening in March between H3 of kharif (March, 15th) and the irrigation time (usually end of March). In order to reduce this problem, farmers are plowing by tractor (2 h/maad) they rent rather than bulls (12 h/maad), what is also a profitable solution. During the plowing time, farmers have also to maintain canals with tractor.

In very few cases, farmers keep plowing by bulls. Indeed, when they have little land, bulls can be useful when no tractor is available. But, since two bulls can plow a maximum of 1,5 maad per day, and the number of bulls in Wadi Mawr is very low, very few lands are plowed with animals draught.

When the wadi comes, the field is overflowed and the water stored in the soil is sufficient for the whole cycle, complemented for the *kharif* cycle with few rains in August and September.

The farmer sows one week after the irrigation, when the water is well drained. He pays a tractor with driver and three member of the family sit on the back sowing with a 5 lines seed drill. The farmers try to keep seeds from the previous year, but the poor farmers usually cannot and have to buy new ones.

Photo 27: Sowing of sorghum (own source)

The harvest is 2,5 months after the sowing for forage (*seif*). 5 to 10 workers, supervised by the farmer, cut the sorghum with a sickle and put it on the soil. It dries three days and other workers make packs of about 15 kg of sorghum, which can be carried from the field to the farm, by dromedary, to be stored.

Sorghum needs 3 months to produces grains, what is done in *kharif* (2,5 months between H1 and H2). When the sorghum is on the soil, already cut by workers, the wife of the farmer supervises women who cut the panicles. These ones are stored few days until the owner of a threshing machine comes in the village. Then, the sticks, like in *seif*, are made in packs and stored on the farm for the animals.

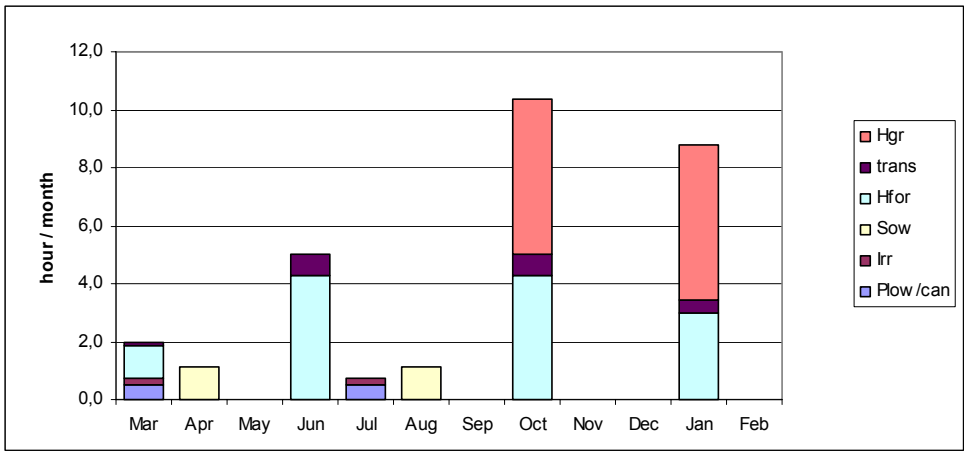


Figure 28: Working calendar of *(Ss/Skh)w*

The time for each task is calculated in human day (h.d), which means the number of day worked on the farm. During the field work, the time for each task (detailed in annex) has been collected in hour. For this representation, 1 h.d = 7 hours of work.

Even if some grains are kept for the home consumption, most of the harvest is sold. As for the forage, the packs are stored in the farm to feed the animals. However, the packs cannot be stored more than 3 months because of the termites, which start eating the stick.

4.1.1.2 Technical performances

Grains production is possible in H1 and H2 in *kharif*, but H3 is usually too dry to produce grains and in *seif* it is not possible because of some birds (*Ploceus galbula*), which are very numerous from mid-June to the end of September.

For a normal year, the yields are:

	H1 seif	Grazing seif	H1 kharif	H2 kharif	H3 kharif	**Total**
Forage (packs/maad)	370	eq. 30 packs	370	250	100	**1090**
Grain (kg/maad)			550	550		**1100**

Figure 29: Yield of (Ss/Skh)w

In bad year, the lack of water makes the third harvest of *kharif* impossible and decrease a lot the grains production especially for the second harvest.

In good year, farmers can harvest some grains the third harvest of *kharif* and the production of forage can be a lot more all the year, especially in *seif*.

However, the workers are paid in kind, proportionally to their work. Usually, the workers cutting and packing forage and the women cutting panicles take 10% each of

the work done. The threshing machine takes 10% also and the forage transportation by dromedary from the field to the farm takes 20%.

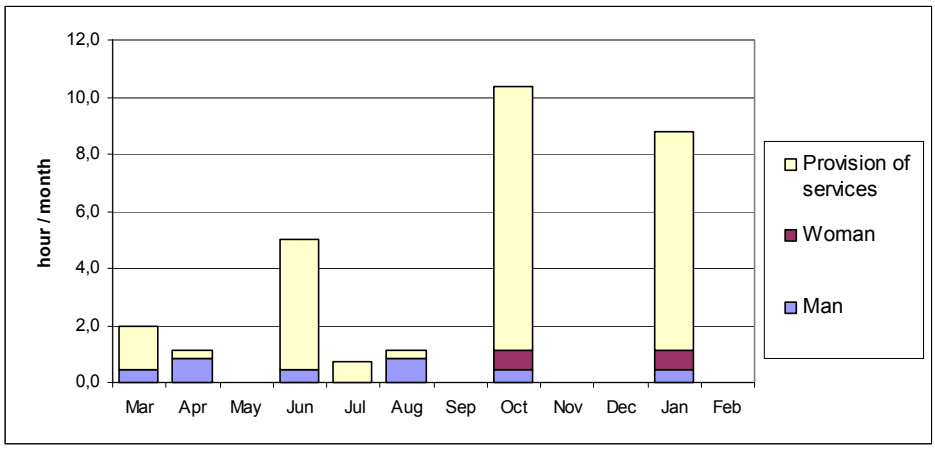


Figure 30: Work repartition between the workers within the family and the provision of services for (Ss/Skh)w

For example, concerning forage, a worker cut the equivalent of 100 packs. From these 100 packs, he takes 10% (10 packs). The following worker comes on the field to make the 90 packs remaining. From these, he takes 10% (9 packs). Then, anther man brings the 81 packs remaining from the field to the farm and takes 20% (16 packs).

After each of these steps, the farmer has on his farm 65 packs from the 100 on the field.

4.1.2 *(Ss//Skh)w*: Sorghum irrigated by wadi: one cycle per year, alternating one year in *seif* and one year in *kharif*

(Ss//Skh)w stands for a mono-culture of sorghum irrigated by wadi with on the same land one cycle of sorghum in *seif* one year and one cycle in *kharif* the following one.

Farmers combine this cropping system brought forward 1 year on two lands. One is starting in *seif* and one is starting in *kharif*.

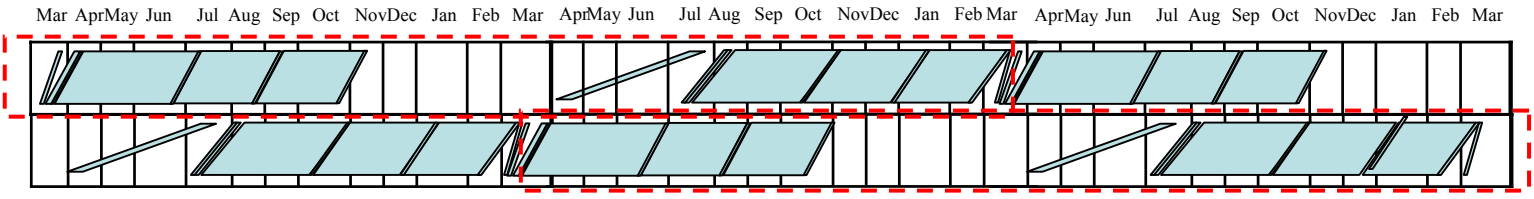


Figure 31: Combination of (Ss//Skh)w on 2 fields

This cropping system allows to let the sorghum grow in *seif* and having 3 harvests of forage. In *kharif*, the production is the same than the previous cropping system, 2 harvests of grains and forage and 1 of forage only.

4.1.2.1 Technical sequence

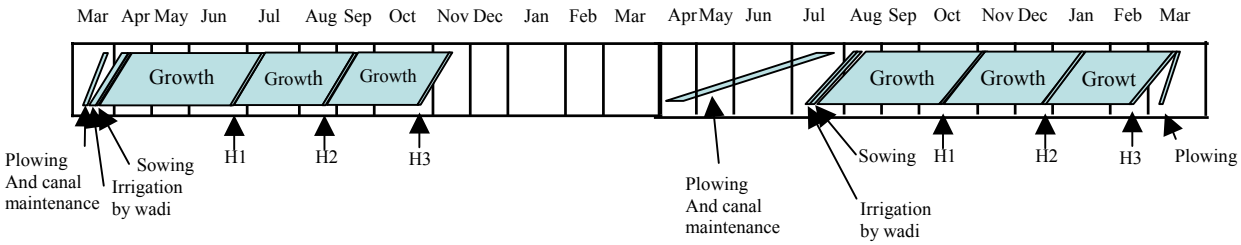


Figure 32: Technical sequence of (Ss//Skh)w

Farmers doing this system do not have any constrain of time between *seif* and *kharif* cultivation, since they have six months between the last harvest and the plowing. As the last harvest of kharif is not very big, it can be done earlier, from the end of February, what let some time to plow for *seif* cultivation.

All the others phases of the technical sequence, concerning irrigation, sowing and harvesting works, are similar with *(Ss/Skh)w*.

The advantage of this system is its flexibility and the possibility to manage the water availability between the two rainy seasons. Indeed, if during one year the conditions are good in *seif* and dry in *kharif*, half of the land is grown under favorable conditions, the roots of sorghum are well developed and the production is insured, while farmers doing *(Ss/Skh)w* have plowed their land and sowed sorghum under dry conditions. On the contrary, if *seif* is very dry, the farmers do not wait until the next year to grow sorghum but they plow, like (Ss/Skh)w, all their land and sow it in *kharif*.

4.1.2.2 Technical performances

This cropping system allows producing sorghum feeder all the year. For normal conditions, the yields on two years are:

	H1 seif	H2 seif	H3 seif	H1 kh	H2 kh	H3 kh	**Total**	**Mean per year**
Forage (packs/maad)	370	250	200	370	250	100	**1540**	**770**
Grain (kg/maad)				550	550		**1100**	**550**

Figure 33: Yield of (Ss//Skh)w

In bad year, the production of *seif* does usually not decrease, even for the third harvest, thanks to the rains in august. Only the production of *kharif* is affected.

In good year, the forage production increases and the third harvests in *seif* and *kharif* produce grains.

4.1.3 *(Ss//Skh)p*: Sorghum irrigated by motor-pump: one cycle per year, alternating one year in *seif* and one year in *kharif*

(Ss//Skh)p stands for a mono-culture of sorghum irrigated by motor-pump with on the same land one cycle of sorghum in *seif* one year and one cycle in *kharif* the following one.

In the western part of the project area, without access to the wadi, the irrigation with well is the only way to farm in such arid condition.

On the contrary to the other irrigated systems, the limiting factor in wells area is not the land, but the power of the motor-pump. Then, in order to manage as good as possible this point, farmers grows half of their land in *seif* and half in *kharif*. In this way, the pump is running nearly all the year.

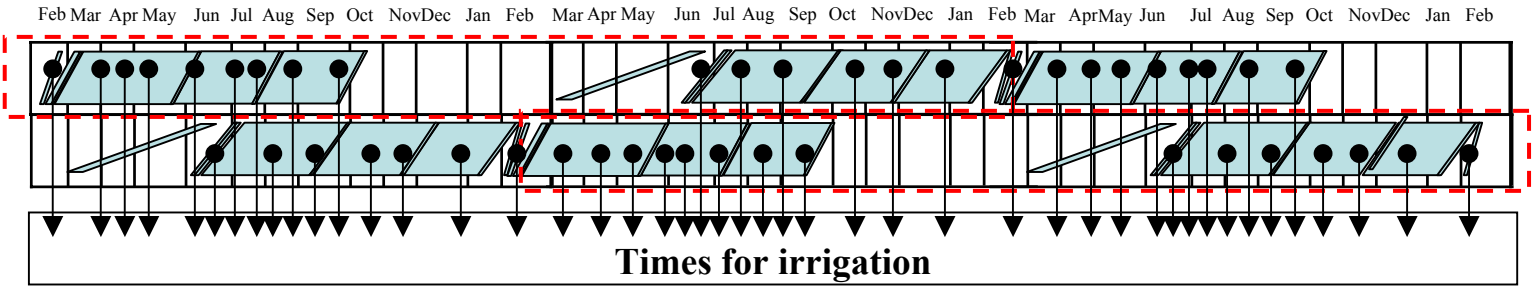


Figure 34: Combination of (Ss//Skh)p on 2 fields

The organization of this system is the same than previously, combining *seif* and *kharif* cultivation on two lands. However, the irrigation by motor-pump deletes constrain due the arrival of the wadi and allows starting *seif* cultivation one month earlier, which permit to harvest grains before the birds come.

The production is higher, but the costs increase a lot.

Moreover, a lot of workers are available to work on the farm since the harvest did not start in the canals and spate irrigated areas. The availability of tractors is also better.

4.1.3.1 Technical sequence

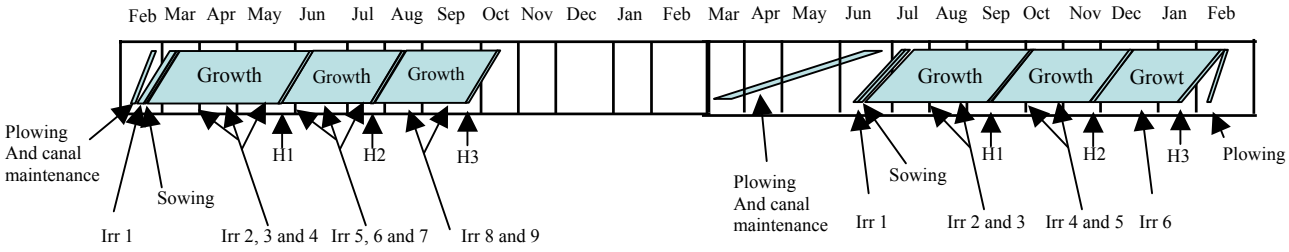


Figure 35: Technical sequence of (Ss//Skh)p

From the technical sequence describes above, only the irrigation changes. The farmer divides his land in small fields, 300 to 400m², to improve the irrigation because the motor-pump is not powerful enough. This division allows improving the water use, by decreasing the loss by percolation if the field is not flat enough.

The first irrigation in *seif* occurs in the beginning of March followed by 8 others irrigations until the last harvest. As for *kharif* cultivation, thanks to the lower temperatures, sorghum needs less irrigation, only 6. This work is the most important in the all technical sequence: more than half of the total annual work.

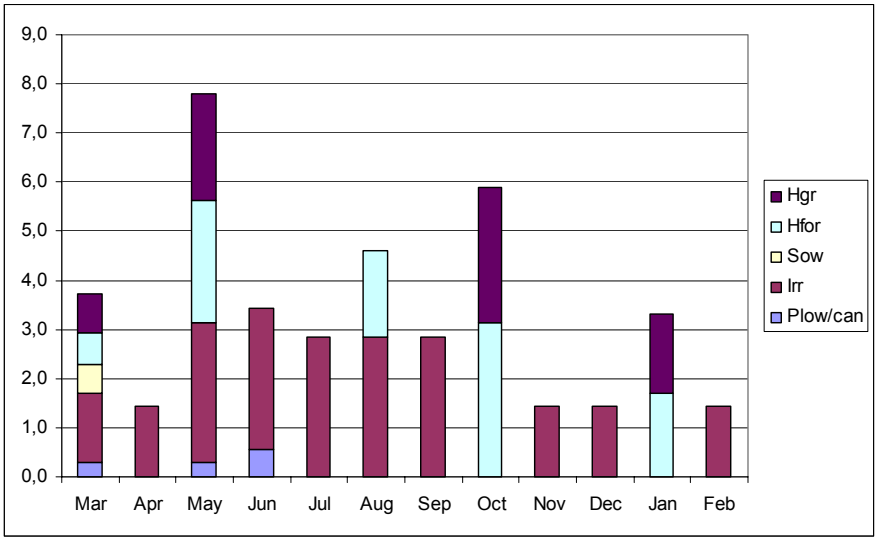


Figure 36: Working calendar of (Ss//Skh)p

Not only the need in work is important, but also the need in investment is very high to have sorghum production. In addition to the investment due to the well, to the motor-pump and to the high costs of maintenance, each irrigation needs 80L of diesel and the oil has to be changed every 10 days.

The total costs of production for (Ss//Skh)w are 18 485 RY/maad while for (Ss//Skh)p, they are 38 369 RY/maad including 23 394 RY for irrigation.

4.1.3.2 Technical performances

This cropping system allows producing sorghum feeder all the year. For normal conditions, the yields on two years are:

	H1 seif	H2 seif	H3 seif	H1 kh	H2 kh	H3 kh	**Total**	**Mean per year**
Forage (packs/maad)	370	250	150	370	250	100	**1490**	**745**
Grain (kg/maad)	440		110	440	330	170	**1490**	**745**

Figure 37: Yield of (Ss//Skh)p

Thanks to the high costs of production and more work, the farmer can produce more grain, by controlling the irrigation according to the plant needs. Consequently, the additional production furnishes extra money to pay the costs of irrigation. With a lot of work, the farmer can increase the land productivity in an area which would have rain-fed cultivation.

Compared to (Ss//Skh)w, the additional incomes from grain produced in *seif* and in the third harvest in *kharif* are 42 778 RY/maad; what is nearly the annual cost of irrigation: 46 787 RY/maad.

4.2 HIGH LAND PRODUCTIVITY CROPS WHERE WATER IS WIDELY AVAILABLE IN CANAL AREA

The following systems, thanks to the access to water, are more profitable than the previous ones and they are less dependent on animal production. Consequently, in this part, the economic approach, detailed in annexes, is more important than the technical one.

4.2.1 *W/Skh*: Increasing land productivity by growing sorghum in rotation with watermelon, without additional irrigation

Watermelon (*Citrullus lanatus*) production does not need specific investment like mango and okra. Therefore, this crop is widely grown by farmer across Wadi Mawr, where the water from the wadi is sufficient. However, even if this crop is globally profitable, the very fluctuating prices make the net return not insured from one year to the other and some farmers do not want to take risks.

4.2.1.1 Technical sequence

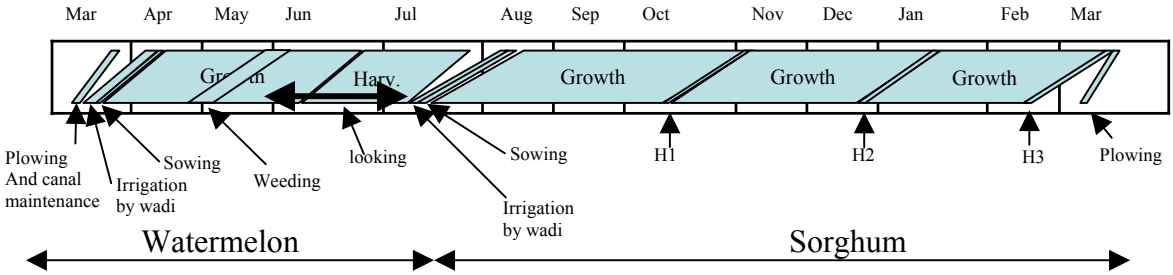


Figure 38: Technical sequence of (W/Skh)

Like sorghum, watermelon needs only one irrigation before sowing. Then, the field needs to be weeded one time. Then, when the fruits start to grow up, one person needs to stay night and day on the field to look after the production. It starts one or two week before the first harvest until the last one. This job, usually done by a worker, takes a lot of time but the man can look after about 5 maad of watermelon.

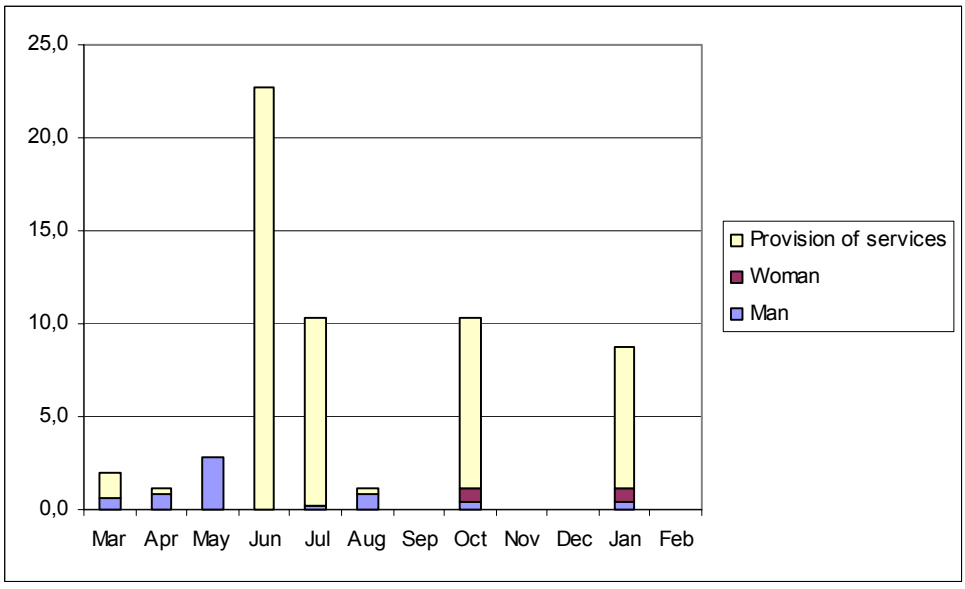


Figure 39: Work repartition (W/Skh)

This one, which spread on 1 month, is sold to trader coming on the field with worker and paying directly the production to the farmers. The total production depends on the number of cars the trader can fill up.

4.2.1.2 Technical performances

In a normal year, the price of watermelon is 20 000 RY/car and the system produces:

	Watermelon	H1 sorghum	H2 sorghum
Watermelon (cars)	3		
Grains of sorghum (kg)		550	550
Sorghum feeder (packs)		370	250

Figure 40: Yield of (W/Skh)

The very fluctuating price leads to bad years and the price can decrease a lot to 5 000 RY/car, which makes watermelon unprofitable, and farmers loose a lot of money. However, the good years are very profitable, the price can reach 30 000 RY/car.

These oscillating prices lead farmers to take risks and a lot of poor farmers cannot.

4.2.2 *O/Skh*: Increasing land productivity by growing sorghum in rotation with okra irrigated by a small motor-pump

O/Skh stands for a rotation within the year of okra (*Hibiscus esculentus*) following by sorghum grown in *kharif*.

The production of okra is a way to increase the land productivity. However, this system requires fewer investments, a small motor-pump is sufficient but it needs a lot of work, especially during the harvest.

This crop is harvested before mid-July to allow sorghum cultivation in *khalif*.

4.2.2.1 Technical sequence

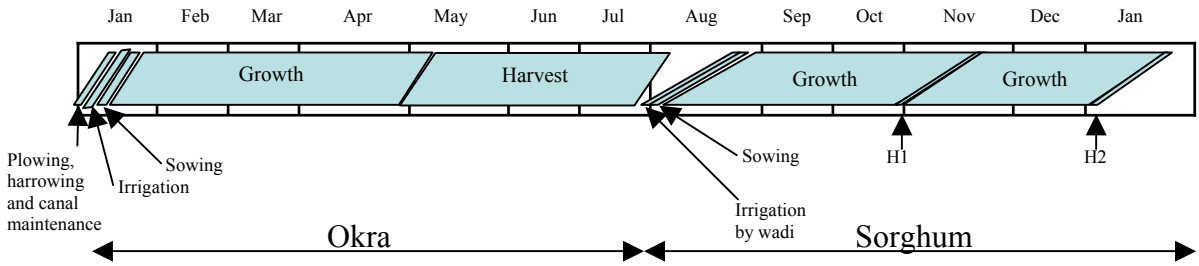


Figure 41: Technical sequence of (O/Skh)

From the sowing to the last harvesting, okra grows during 6,5 months. Consequently, okra must be sowed mid-January to allow sorghum cultivation in *kharif*.

Moreover, the price of okra decreases progressively from May to October, which makes okra harvesting very profitable in May and June in spite of the costs of production.

In addition to the plowing, okra needs harrowing and land division for irrigation (the land is divided in small 5x5 m square) before sowing by hand. Then, okra cultivation requires fertilizer and insecticide, against white fly, aphid, jaside.

The harvest spreads during 2,5 months, with 1 harvest every 3 days. The farmer harvest okra during 7h in the day, helped by 3 workers. The following day, he goes to a market, usually Al Marras, to sell his production, what needs 6 hours to go to Al Marras, to sell the production and to come back.

Then, the farmer grows sorghum in *kharif*. Like in the other systems, sorghum produces grains and forage for H1 and H2. However, in order to grow okra the following year, the field is plowed after H2 and there is not the third harvest.

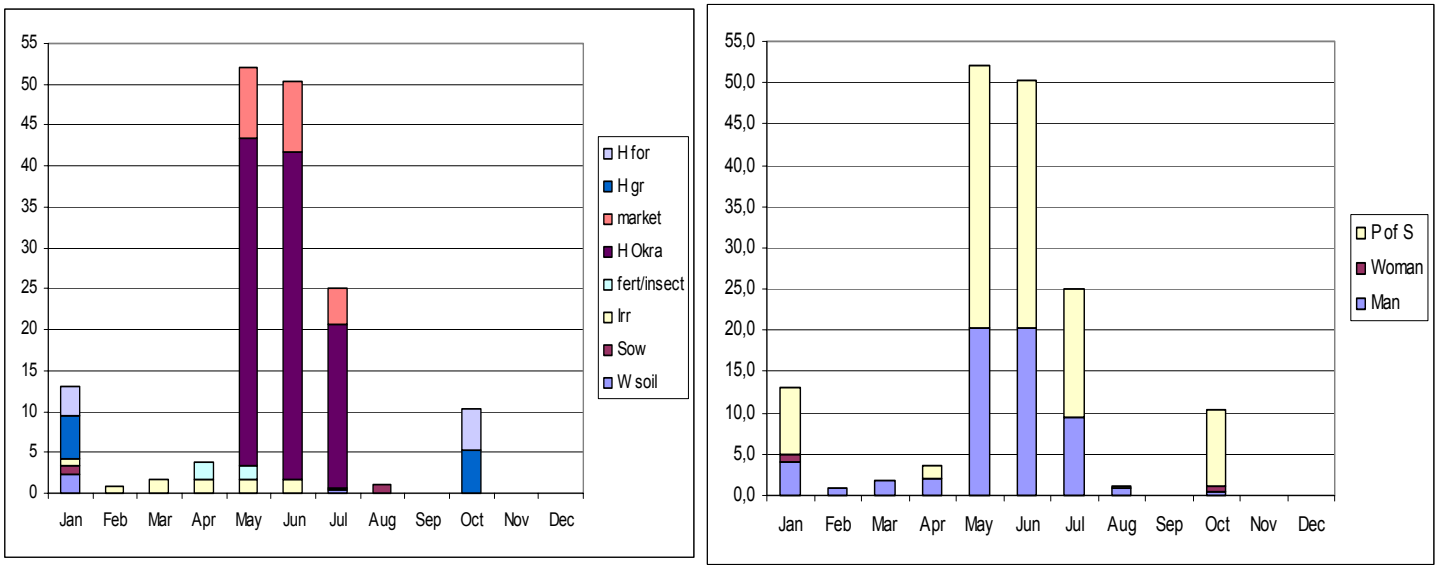


Figure 42: Working calendar and tasks distribution between workers

4.2.2.2 Technical performances

	Okra	H1 sorghum	H2 sorghum
Okra (unit)	45000		
Grains of sorghum (kg)		550	550
Sorghum feeder (packs)		370	250

Figure 43: Yield of (O/Skh)

4.2.3 *Mango*: Trees irrigated by motor-pump, no more place for sorghum

Mango tree (*Mangifera indica*) production is a way to increase land productivity. Widely grown in the Daraniah area thanks to the permanent water supply, the production is more difficult in the canals area. Indeed, it needs motor-pump to insure irrigation when the wadi does not come.

4.2.3.1 Technical sequence

During the first 5 years after the plantation, farmers grow sorghum under the trees, spaced 10*10m or 36 trees/maad, until the canopy does not let enough light reach the soil. During these years, the farmer lets the trees grow and only works on the sorghum on the remaining land between the trees, about 2/3 of the field. When the production of sorghum stops, the farmer keeps plowing the soil once a year to improve the structure.

When the trees start producing, they need to be treated against fungus once a year, during the blossom, in the beginning of March. The other works the few months preceding the harvest are weeding and cleaning under the trees and attaching the branches.

The most important work along the year is irrigation. Indeed, the trees need not less than 9 irrigations per year. The first one is beginning of February, then another one is beginning of March, then every 2 weeks during the harvest, in April, May and June, and then a last one end of July, one month after the harvest. However, two or three irrigation in April are done by wadi, what reduce the costs.

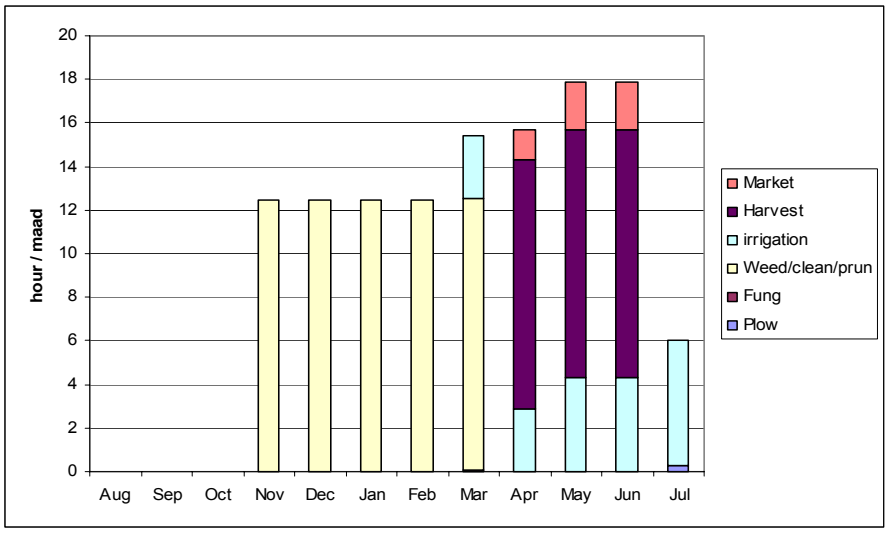


Figure 44: Working calendar of Mango

The first days of the harvest, some fruits are not ripe enough to be sold. To resolve this problem, the farmer treats the first few boxes of fruits with carbon. The other parts of the production do not need it and can be sold on the market in Al Marras.

4.2.3.2 Technical performances

Until the 4th year the trees do not produce any fruit and sorghum is the only product. Then, the trees increase progressively their yield until the 8th year, when the production is maximal.

	1st year	2nd	3rd	4th	5th	6th	7th	8th to 30th
Sorghum grain (kg)	1100	1100	1100	1100	1100			
Sorghum feeder (packs)	1090	1090	1090	1090	1090			
Mango (kg)				720	1440	2880	7200	10260

Figure 45: Yield of the cropping system Mango

4.3 RAIN-FED CULTIVATION WITH UNCERTAIN RAINFALL, ASSOCIATING SORGHUM AND LEGUMINOUS FOR FORAGE OR GROWING MILLET FOR GRAIN

The following systems are done by farmers in the rainy areas. Because of the lack of rainfall the crops can only grow in *kharif*.

4.3.1 *Skh+C+M*: Rain-fed sorghum associated with cowpeas and math-beans grown in *kharif*, to supply forage to animals

Skh+C+M stands for the association of sorghum, which is the crop producing the most, with cowpeas (*Vigna sinensis*) and math beans (*Vigna aconitifolia*). All of these crops are grown for grains, home consumption, and forage, animal consumption.

Sorghum is not adapted to such arid conditions and produces very few or even nothing if there is not enough rainfall. Consequently, in order to improve the environment for the crops, farmers grow it depression, where the soil is a little lower to try to little increase the water availability due to the runoff.

4.3.1.1 Technical sequence

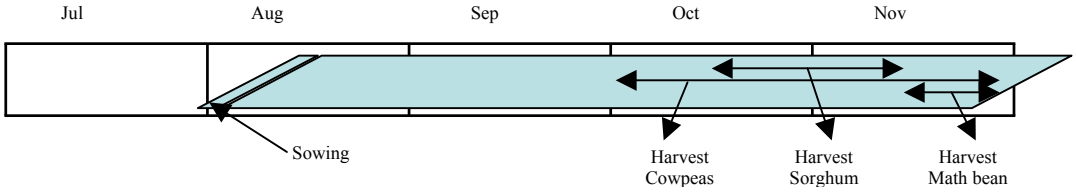


Figure 46: Technical sequence of Skh+C+M

Thanks to the very sandy soil, plowing is not necessary and farmers sow directly by tractor. Since the rainfalls in the Tihama occur few days after the mountains, the sowing is usually mid-August. One month after it, farmers weed the field, few hours every day. Some of the spontaneous plants removed are given to the animals, but others are toxic or even poison.

Then, if the rainfalls have been sufficient for the crops, the harvest occurs 2,5 months after sowing. In this area, because of the lower yields, the harvests are done by the family. The crops are harvested progressively every day and the forage is directly given to the animals. The harvest of cowpea is the first one to start, harvesting every 3 or 4 days grain and forage. Then the harvest of sorghum spread on 20 to 30 days, harvesting little by little every days. When this harvest is finished, farmers can harvest math bean and finish harvesting cowpeas.

Then, the land is not cultivated until the following year.

4.3.1.2 Technical performances

In a normal year, the system produces:

	Sorghum	Cowpeas	Math bean
Grains (kg)	50	40	6
Forage (packs)	65	15	15

Figure 47: Yield of (*Skh*+*C*+*M*)

In this very arid climate the yield are very low in normal year. But in bad year, with less than 50 mm, there is not any production of grains and the farmer harvests forage only few months after sowing to not let it dry.

The good years are very sparse and the rainfalls unusually exceed 300 mm.

4.3.2 *Millet*: Rain-fed millet grown in *kharif*, a cash crop through grain

Millet (*Pennisetum glaucum*)is a crop better adapted than sorghum to dry conditions and farmers grow it on the hills, where sorghum cannot grow.

Moreover, it produces usually more grains, but the sticks are very strong and all the animals do not like it.

4.3.2.1 Technical sequence

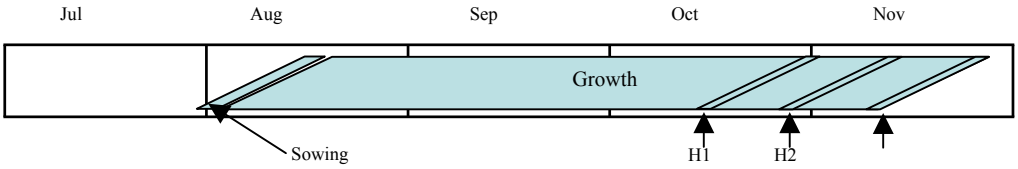


Figure 48: Technical sequence of Millet

Millet is also grown in rainy area, where the sandy soil allows direct sowing.

In the association between sorghum, cowpea and math bean, the crops are growing on the soil and stop weeds. As for millet, which is grown alone, it needs weeding. Like for sorghum, women starts by cutting the panicles. The millet grows back and a second harvest of grains is possible two weeks later. Then, a third and last one is possible. At this time, the sticks are also harvested by men to feed the animals.

Then, the land is resting until the following year.

4.3.2.2 Technical performances

In a normal year, the system produces 150 kg/maad and 50 packs.

The price of a pack of millet is 30RY/pack, a little lower than pack of sorghum at this time, which is 40RY/pack.

Like for the previous cropping system, rainfalls is very determinant for the production and in bad years the production can be none.

4.4 COMPARISON OF THE CROPPING SYSTEMS: SORGHUM IS EVERYWHERE

From all the cropping systems, it appears that sorghum is grown nearly everywhere, in all the systems, what indicates that it is an important crops for farmers. The grain is always the biggest part of the gross return, but forage seems a strategic product for animal production, which is very important through Wadi Mawr.

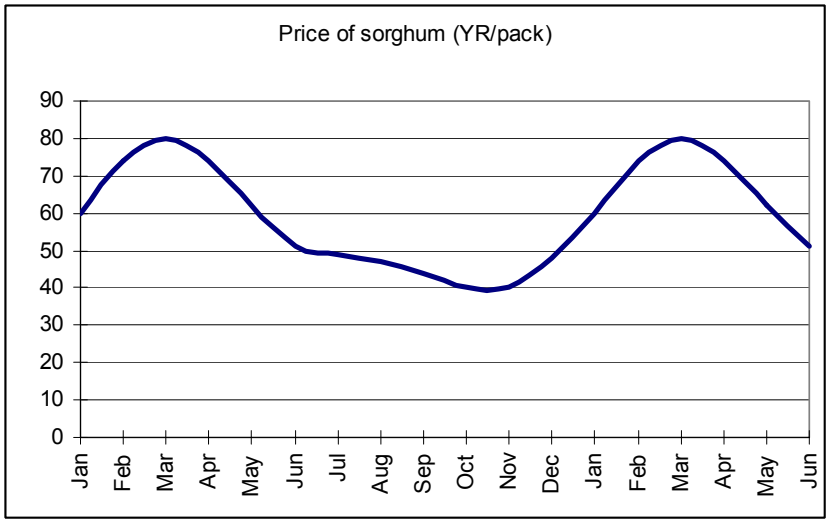


Figure 49: Evolution of sorghum price during the year

The price of sorghum is changing along the year according to the spontaneous plants and forage availability across the area. In rainy season and when sorghum sticks is available in big quantity, the price is very low, while it is a lot higher at the end of the dry season. The availability of forage decreases a lot at the end of the dry season, in February, March and April. Farmers depend a lot on sorghum feeder and consequently on its price. However, its importance depends on the cropping system implemented.

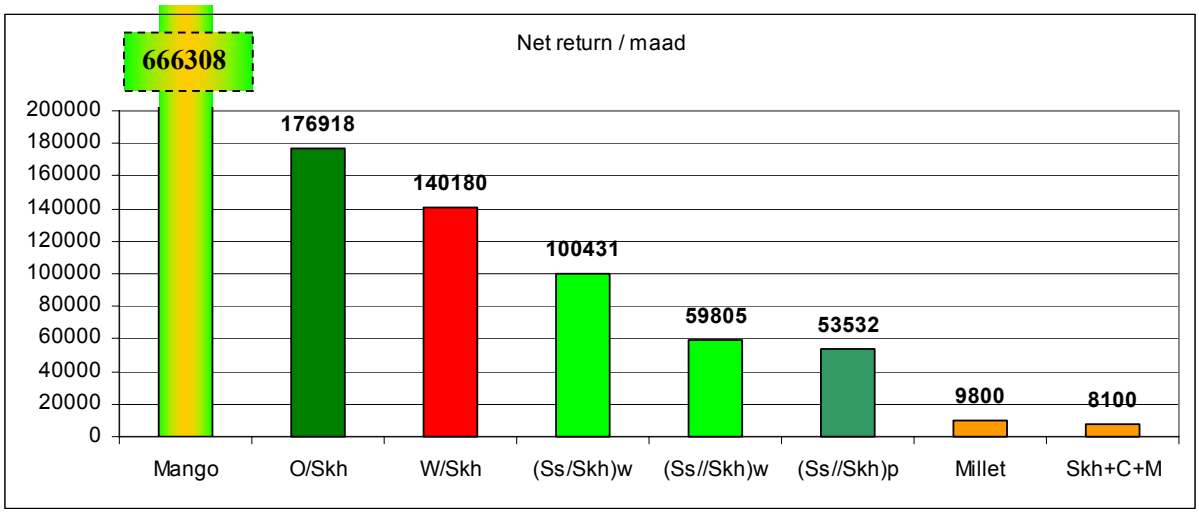


Figure 50: Land productivity

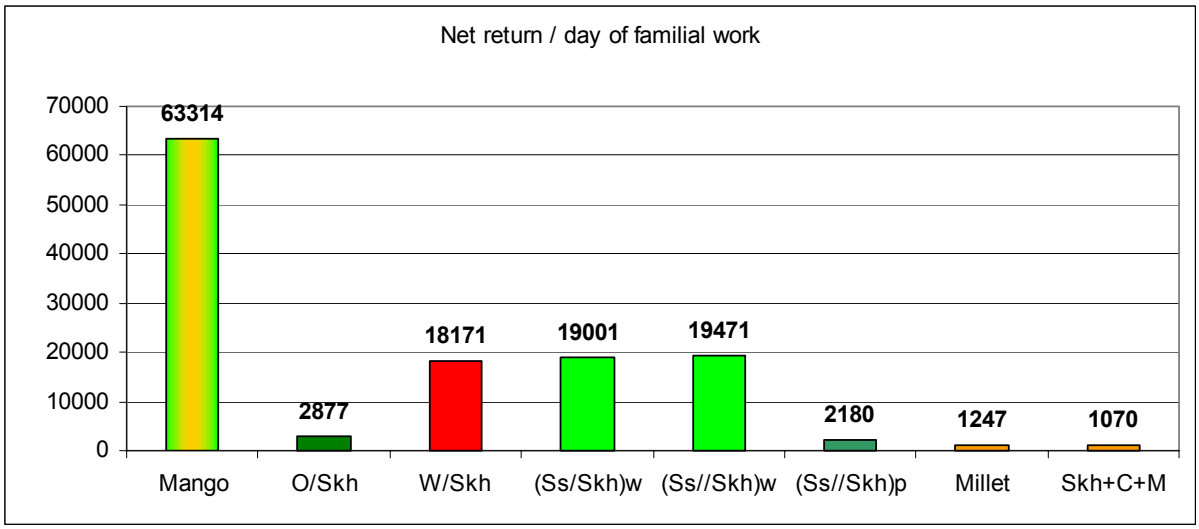


Figure 51: Familial labor productivity

On these graphs, it appears clearly that mango production, thanks to big investment, has a lot higher land productivity than the other crops, with little labour. Consequently, this one and maybe the others fruits crops, banana, paw-paw, etc, will probably develop in the canals area in the coming years, even if the price of fruits decreases. The consequences of this extension will be the reduction of the total sorghum production in the area and therefore of the total forage availability for animals.

The system associating okra and sorghum has also high land productivity. However, this one has few economic but high familial labor investments. In this system, the high investment in familial labor makes low the familial labor productivity, but elevated income to the farm, since a large part of the work is done by familial members, on the contrary to all other systems except (Ss//Skh)p.

The economic results of watermelon production explain why, in spite of the risks due to the very changing price, it is such widely grown across Wadi Mawr. Indeed, this system has high land and labor productivity, and thanks to the sorghum grown in kharif, supply forage to animals.

Concerning the systems of sorghum irrigated by wadi, the land productivity makes understandable, due to the higher land productivity, that some farmers, especially the smaller ones, grow 2 cycles of sorghum per year. The difference of labor productivity between these 2 systems is not sufficient to understand why large farmers grow only one cycle per year. However, by looking the working calendar, it appears that farmers growing 2 cycles per year have a lot of work in a short period of time at the end of July. This peak of work, combined with the flexibility facing water access developed above, explains why large farmers grow only one cycle per year.

By wells, even if the production, especially of grains, is better, the costs for irrigation make the land and labor productivities the lowest of the irrigated systems; but the land productivity stays a lot higher than rain-fed cultivation systems. This system, thanks to the expensive investment in a big motor-pump and a lot of work, insures sorghum production and especially big quantity of forage compared to the rain-fed lands.

Then, in the rainy area, the land productivity is a lot lower than anywhere else and the labor productivity is the lowest. It is interesting to notify that, thanks to the grains production, the system *Millet*, better adapted to arid conditions, is more land and labor productive than the association of sorghum, cowpea and math bean. The importance of

the sorghum grown in rainy area, illustrates the need in forage for those farmers. Indeed, they prefer to produce less but insure forage production for their animals.

Thus, the compared land productivity shows that the increasing access to sufficient quantity of water, either by well, wadi or rain, allows farming activities to be more and more profitable. Concerning the agricultural production, farmers who cannot diversify their production nor intensify their familial labor depend mainly or even only on sorghum production.

5 ANIMAL HUSBANDRY SYSTEMS MANAGED MOSTLY BY WOMEN AND CHILDREN, DEPENDING ON FODDER ACCESS

Among the animals bred in Wadi Mawr, the animals which role is to constitute savings and insure food security for the farmers have to be distinguished from those which are used for transportation.

The purchase of animals is an important way for farmers to save their money that is not consumed nor used for farm production costs. Those animals allow the families to get milk every time of the year, or meat for any important occasion (Aid Al Kebir, wedding…), and represent a source of money in case of any need. The first animals sold are rather the small ruminants before the cows, and as the farmers try to keep the females for the reproduction, they give the sale of young males priority.

Every family has at least one donkey for the transportation, but sometimes also dromedaries, especially in case of some land owners or of nomad breeders.

One particular point is that in the area is that the animal dejections are never valorized in dung. Only farmers coming from the mountains take them for their *qat* production, and generally for free.

But whatever animal husbandry system the farmer can manage in any area, the lack of pasture is an important obstacle in Wadi Mawr, and the main current characteristic to be noticed is the increasing dependence on forage for the alimentation.

5.1 SMALL RUMINANTS TO SUPPLY MONETARY INCOMES

In Wadi Mawr, the most important breeding activity concerns the small ruminants, sheep and goats, which are observed in big quantity in all the areas. The goats belong to the local breed of Wadi Mawr, but they are more and more crossed with males coming form Wadi Surdud, another irrigated area of the Tihama, Southern than Wadi Mawr. Those reproductive males are imported for their aptitudes in arid areas. The breed of sheep is spread in the Tihama. The herds are mixed with sheep and goats, managed together in a similar way, even if their economic valorization differs. The number of animals in the herds varies a lot according to the number of maad the farmers can cultivate.

5.1.1 *SRc*: Sheep and goats grazing in canal area where there are a lot of pastures and feeder trees

In the canal area where it is very cultivated, it is easier for farmers to lead sheep to graze. Indeed, the activity and the high mobility of the goats require more work to be looked after between the cultivated fields. Consequently the mixed herds are here dominated by sheep. The farmers can own from 2 to 30 animals according to the various situations that exist, with two thirds of sheep.

5.1.1.1 Reproduction and herd management

The farmers all use natural reproduction. As only few of them own a male, they usually borrow one in the neighbourhood to richer owners, that they bring to the females several times a year. The male is kept few days to cover one or several females

in the yard, supervised by the woman, or in the herd while grazing, supervised by the breeder (generally not with children).

The reproductive females are kept generally until they die, around average 10 years, unless the farmer urgently needs some money; invests for the farm or the wedding of a son can led them to sell reproductive mothers. The first covering is at 10 months, and the females stay regularly productive until the age of 7 years. In Wadi Mawr, the sheep are more prolific and give more young animals in one year than the goats, but in consequence they face more abortion problems.

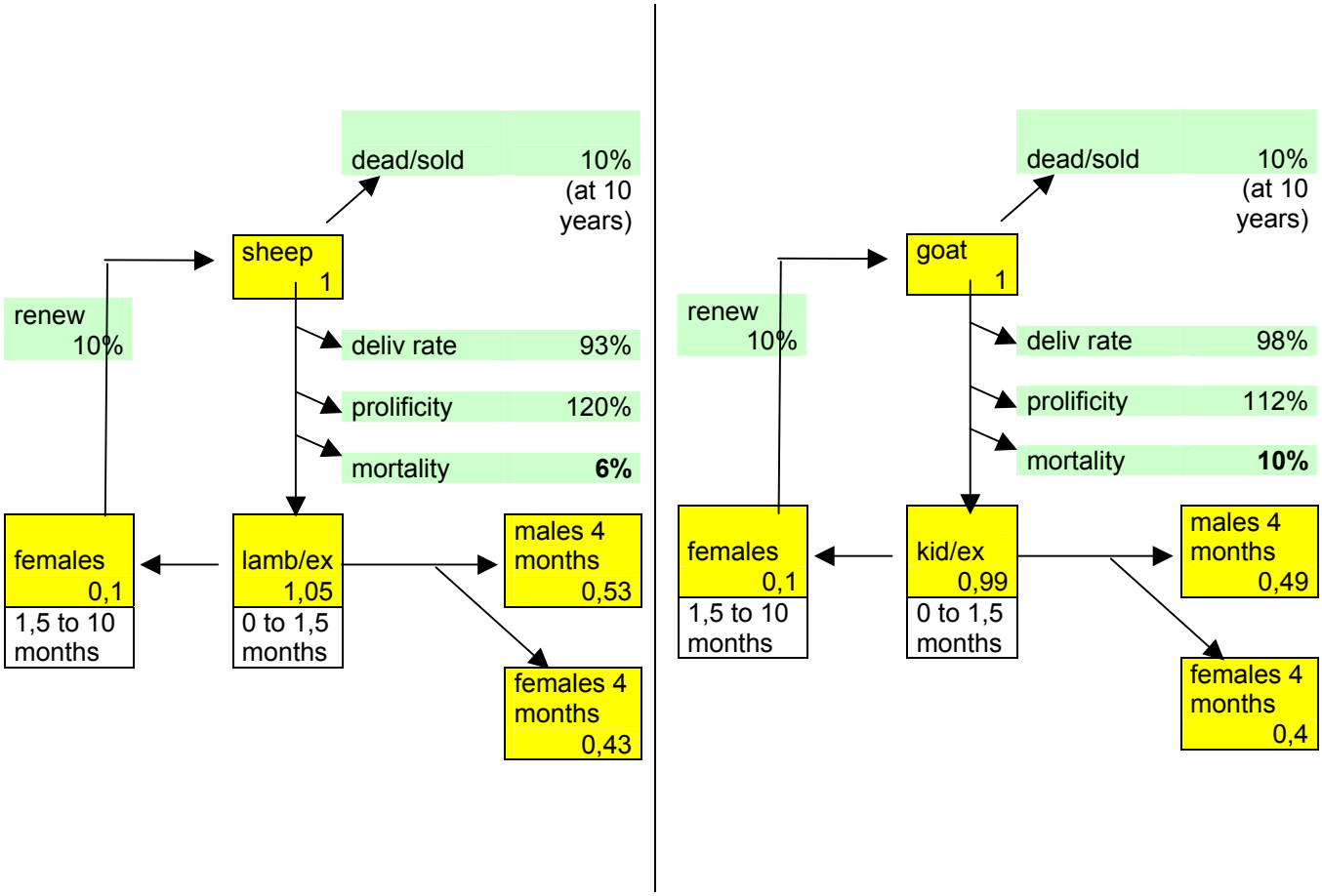


Figure 52: Scheme of renewing of herds for sheep and goats in canal area

The inseminations are rarely grouped, as the farmers need to sell young animals all year long. However it is more satisfying to get deliverances at the beginning of *Kharif*, because there is more natural grass for the milking period. The mortality for young affects more goats, which are more sensitive to diseases according to the farmers. However in the irrigated area, the farmers manage to use some drugs for the animals, especially vaccination against PPR (Small Ruminant Plague) dedicated to young animals. But the colds, diarrhoeas that the farmers observe sometimes in the herd are rarely cured. The animals going grazing are often washed in the canals for the external parasites, but no medicine is given for this purpose.

The farmers regularly need money for their farm (sowing costs, purchase of forage…) or for family needs (food, hospital costs…), so they rarely manage to save some young females for their herd, and most of the time all the production is sold. They try to keep or to buy new females when they have to renew the herd. The farmers would like to sell first the young males and keep the females for the herd if it is possible. But

they rarely manage to keep females according to their need of money: finally all the young are led to the market at the age of 2 to 6 months. To earn more money, they try to keep the young males longer to be little fattened and sold with better price. If they are kept after 6 months, they can be a little used for reproduction before being sold.

The young are weaned at the age of 1,5 months. The families use the milk of goats from one week after delivering, that women keep on taking every morning during 4 months: average 0,75L a day. The milking is effectuated twice a day, every morning and every evening, as a consequence the young animals are separated from the mother during the afternoon and the night. The milk is never sold on the market.

5.1.1.2 Alimentation of the herd

The reproductive and the young already weaned animals (more than 3 months) depend on pasture and sorghum feeder everyday and all along the year.

To go grazing, the herds are individually managed, and sometimes grouped between different members of the family or of the village. They are led by children (generally boys) too young to work in the fields, or by breeders earning a salary if no children are available. One person can lead alone until around 50 animals (photo), as it is a big work to supervise the herd between the cultivated fields.

Figure 53: picture of a child leading small ruminants in the morning

In *Seif* and *Kharif*, the animals go grazing in the morning from 7 am to 12 am, come back at midday to the farm to drink water brought back by the girls and have rest especially when it is very hot. They return to the pastures in the afternoon from 4 pm to 6 pm. However some farmers let their animals grazing all day long, and provide the breeder with a lunch to take away.

They eat natural grasslands and feeder trees (*Ziziphus spina christi*, *Acacia tortilis*, *Acacia ehrenbergiana,* poaceaes, cyperaceaes….) on the pathways and along the wadi and the main canals, but also along the small irrigation canals where they eat grasses (cf. spontaneous plants 2.2.4) and drink water (Figure).

The resting lands are an important part of the route, as some lands are only cultivated once a year, and the crops remains are punctually valorised. Those remains are available after the first harvest of *Seif* concerning the farmers who cultivate two

cycles in the year, or after the last harvest of *Seif* concerning the farmers who cultivate one cycle (cf. Cropping system *(Ss//Sk)w*, part 4.1.2): the breeders have generally free access, unless the residues are high and sold by the farmers (from 2000 to 15000 RY/maad according to the height).

In *Mossemi*, even if some *Seif* resting lands are available, the pastures decrease with the drought, and the time spent outside is reduced.

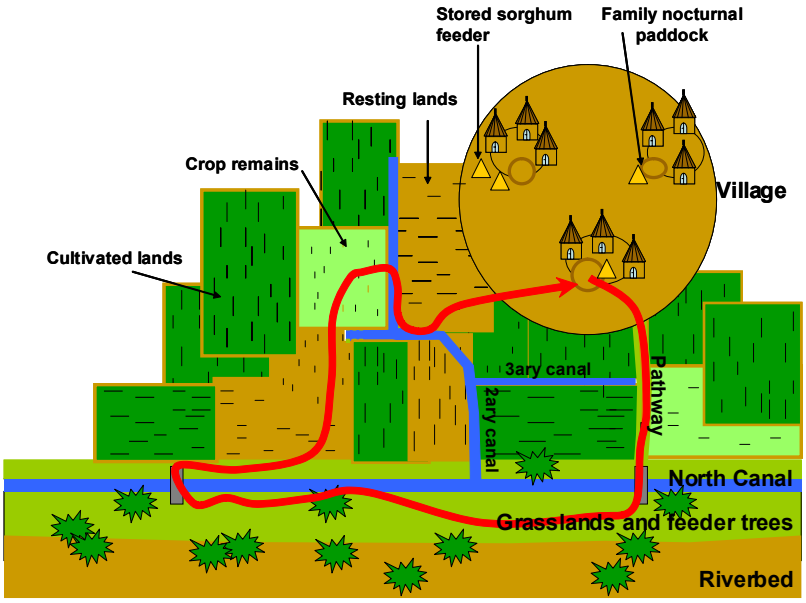


Figure 54: scheme of the daily route made by small ruminants herds

At home the alimentation is part of the women work. The animals are fed with sorghum feeder, to fill in the lack of pasture. The women go to the sorghum storing place, with their donkey if it is too far, and bring back packs to give them in the morning and in the evening, in the family yard or in their nocturnal paddock. During the harvest periods, the animals are nourished with green sorghum, better valorised by the animals. The rest of the year, they are given stored dry sorghum, which quality is worse, the sticks being usually not eaten by the animals and staying without valorisation on the yards' ground.

The small ruminants get a bigger quantity of forage from the first harvest of *Seif* to the second harvest of *Kharif*: 1 pack per 4 small ruminants. After that, the *Mossemi* dry season makes the sorghum rarer, the price increases and the quantity of forage given is 1 pack per 5 animals. During this difficult period, as well as at the end of *Seif,* when it is very hot and dry, the women go twice a day in the fields to cut and bring back big bags of spontaneous herbs: they cut the herbs between the cultivated crops for free or on the canal banks, that complement the animal food.

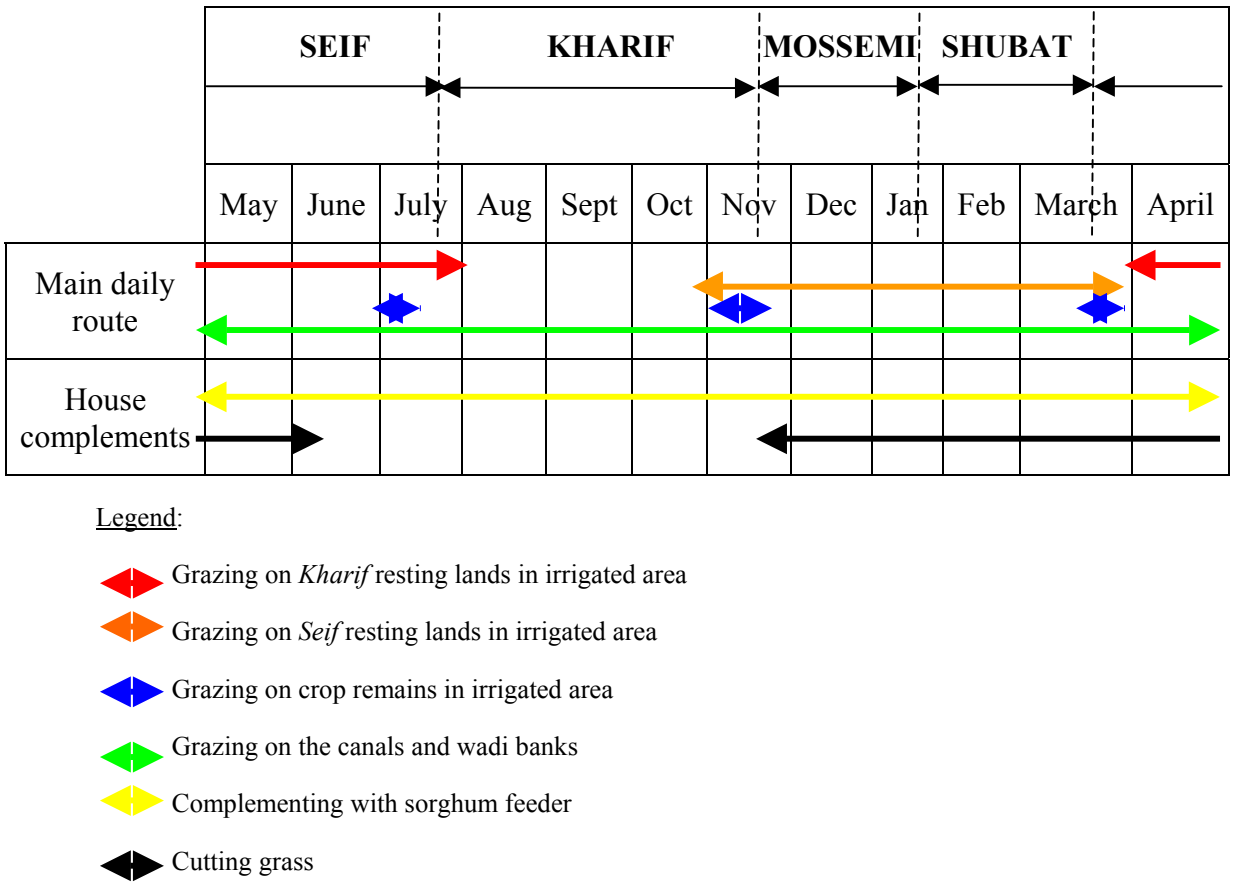


Figure 55: Alimentation calendar of small ruminants going grazing

The younger animals stay all day long in the yard. From the age of 1 month, before the weaning, until the sale, in some farms the women give them increasing quantity of concentrates like sorghum grains or wheat bran. When the animals going out are given sorghum in the yard, they are joined by the younger weaned babies (from 1,5 to 3 months) who eat the sorghum leaves and the spontaneous herbs.

5.1.1.3 Working calendar

Most of the work realized on this animal husbandry system concerns the alimentation of the animals, and women and children are in charge of it. Making the animals graze represents the biggest time, and in a lot of families it prevents some children from been schooled.

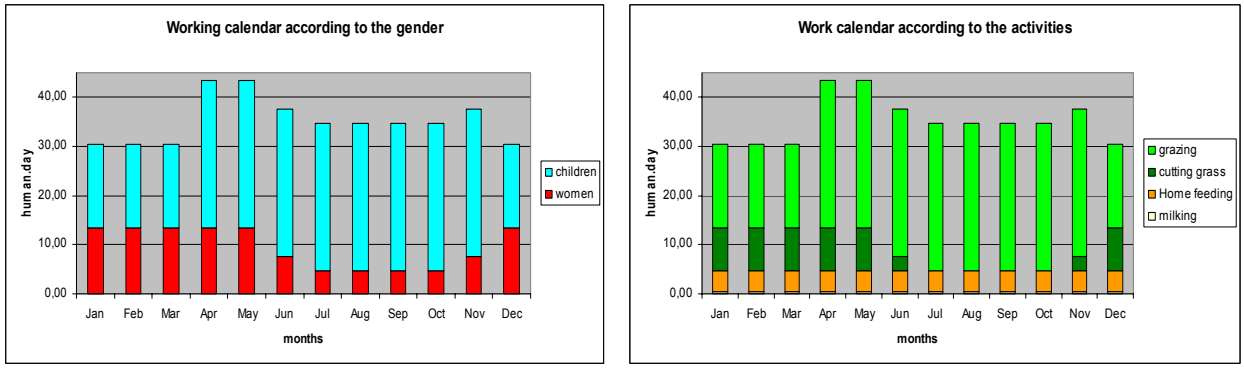


Figure 56: for a herd of 15 small ruminants, working calendar shared between women and children, mostly dedicated to alimentation

5.1.1.4 Economic performances

The young animals are sold on the local market. In Wadi Mawr the goats are more expensive than the sheep: for example a lamb of 4 months costs 5000 RY while a kid of the same age costs 8000 RY, so the farmers need more money to invest in reproductive goats. But the two options are interesting for farmers: the sheep are more productive in a year so the farmers are able to sell more lambs, but the goats allow interesting benefits with their expensive kids and especially for food security thanks to milk production.

Another point is the impact of fattening. The young animals can be given wheat flour and wheat bran, and sometimes sorghum grain after the harvests, from the age of 1 month until their sale. The quantity is increasing little by little, and is average 10 kg of mixed concentrates per month and per young animal. With 1054 RY of concentrates per small ruminant added to the alimentation costs in a year, the net return doubles from 3230 to 6793 RY. But this is not realisable by all the farms, as they rarely have this additional money to invest.

5.1.2 *SRr*: Goats and sheep grazing with difficulty in the rainy area and kept around the houses

The rainy area is a lot less cultivated, and the cropping period is limited to *Kharif*. Moreover it has been described in 2.2.4.2) that the area is very poor in low vegetation, and is dominated by thorny shrubs. The herds are there less numerous than in the irrigated area, mixed between sheep and goats also, but largely dominated by goats that are better adapted the natural ecosystem: around two thirds of the animals are indeed goats. The size of the herds can be very various, from 2 to 30 animals, but also big herds counting until 200 animals. But the importance of breeding activity has led to overgrazing: this issue is increased by the climate that is getting arider, and the animals are very dependant on forage supply.

5.1.2.1 Reproduction management

In the rainy area, the reproductive females face more abortion problems, because of the dry conditions, because of their important moving to search pasture, but also because of some toxic spontaneous vegetation they may graze.

The mortality of young animals is also higher than in the irrigated area, as the lack of pasture and the difficult climatic conditions affect the quality of the milk production and their health.

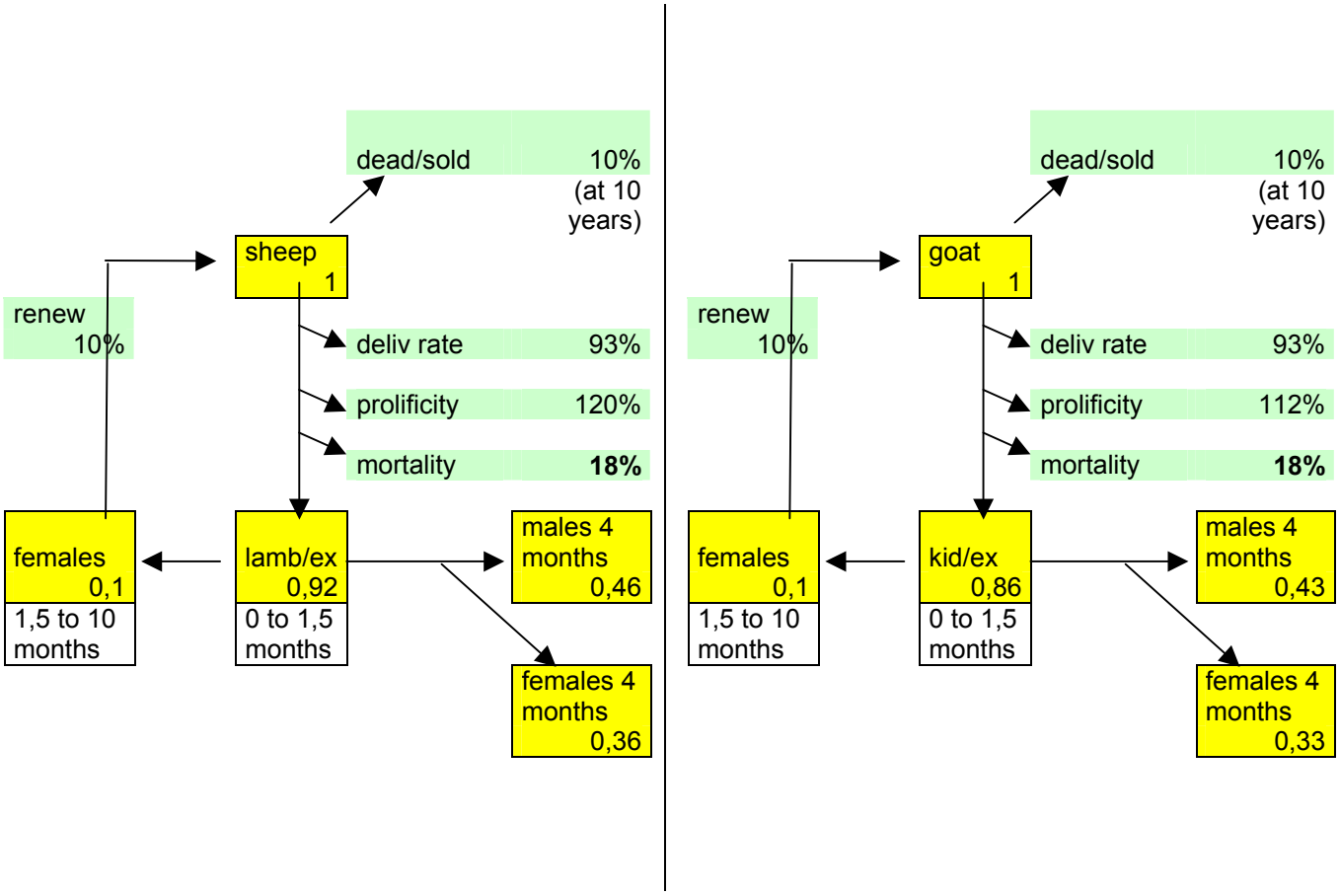


Figure 57: Scheme of renewing of herds for sheep and goats in rainy area

5.1.2.2 Alimentation of the herd

There is not enough pasture for the animals to go out all the year. So the herds stay in the farm yards or in paddocks, and go out only in *Kharif*, when the rain comes. They also graze on crop remains after the harvest. The water for the animals is daily taken from wells by the girls, in the same time as the household needs.

This breeding system depends consequently mostly on forage supply, local sorghum and millet after the rainy area harvest, and then sorghum produced in the canal or the wells area that men go and buy daily. The animals receive also grain and forage of cowpeas and math beans during a short period in October. The quantity given to animals decrease in *Mossemi*, but it is difficult to complement it with spontaneous herbs.

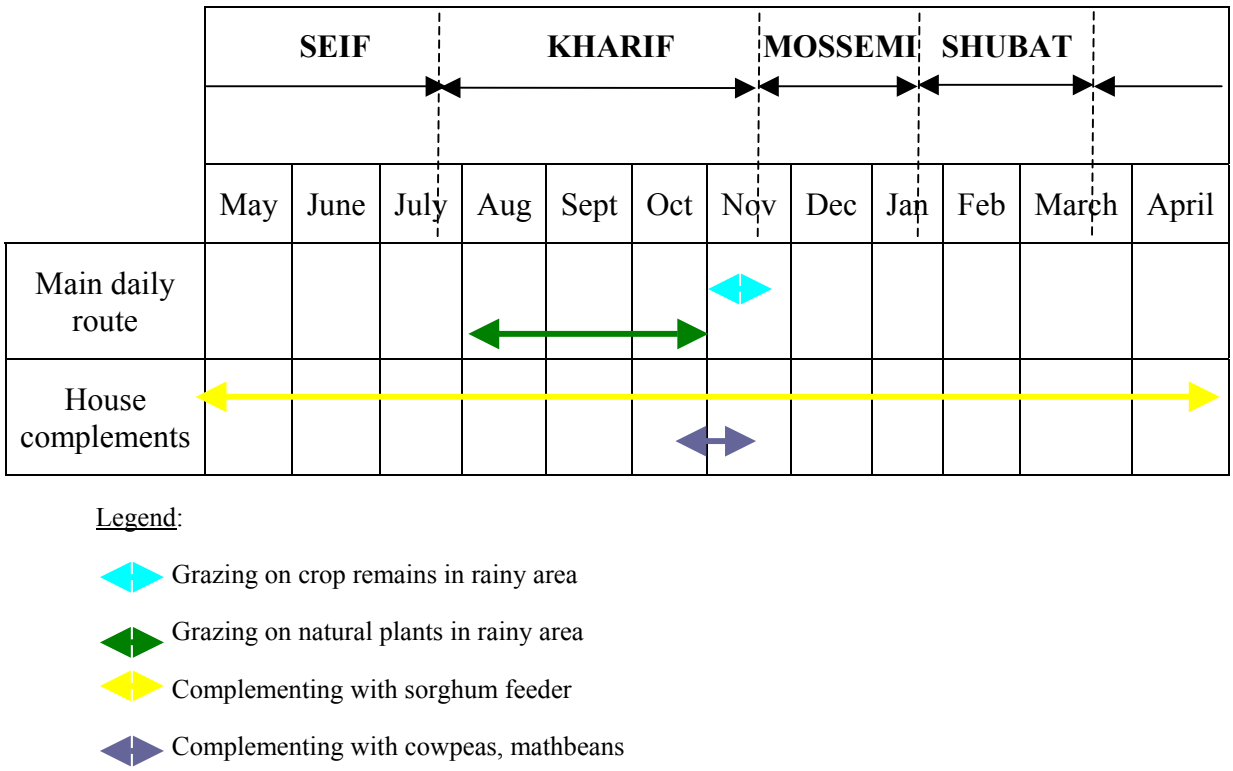


Figure 58: Alimentation calendar of small ruminants going grazing

5.1.2.3 Working calendar

The time dedicated to the grazing in only in Kharif. In this system the men have to go everyday to buy sorghum, as only the men can go on the market, that women or men will then give to the herd.

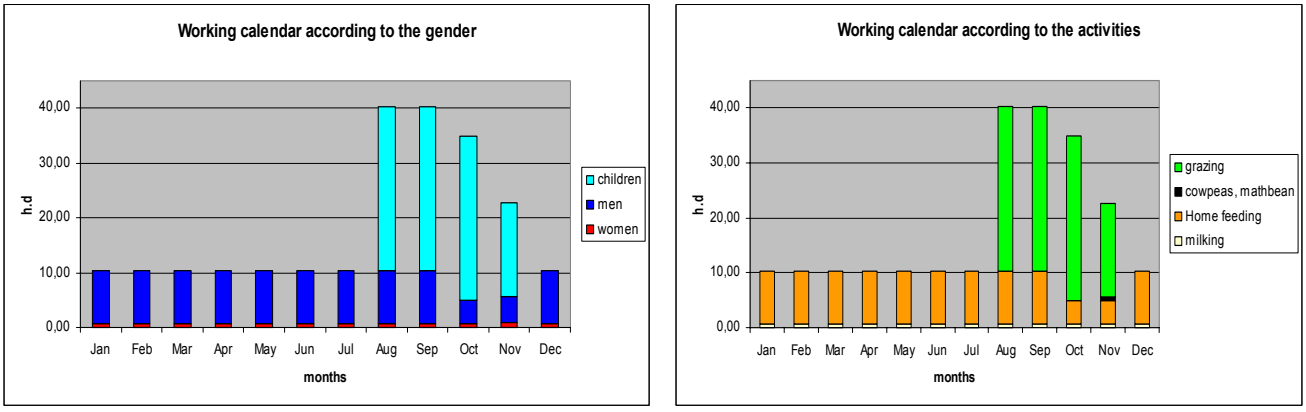


Figure 59: for 15 small ruminants, working calendar shared mostly ensured by men, dedicated to the purchase of sorghum feeder

5.1.2.4 Economic performances

In this area, the farmers using drugs and veterinary services are rare, as the costs for alimentation depending on forage are high for the breeders. The abortion and mortality rate affects the economics results of the system. Moreover the animals are often sold weak and thin, so the price can be lower (4000 RY for sheep and 7000 RY for goats at the age of 4 months), and the milk production for goats is less important. Few farmers can use concentrates for the young animals, which are sold very young. The net return obtained is here 2077 RY per animal, while the fattening can improve it to 4290 RY.

5.1.3 *SRrc*: Goats and sheep herds on the limit between rainy and irrigated areas take the advantage of pastures availability

In some places, especially along the road from Al Marras to Al Luhaya, the families have farming activities in both sides, in the irrigated and in the rainy area. The herds are also dominated by goats, which are adapted to the rainy area. But the system is profiting by the proximity of the irrigated area and consequently of pasture and spontaneous herbs in the dry season, resting lands and crops remains. The animals are indeed led to graze in the irrigated area all the year, and in *Kharif* they are both led in irrigated area and in rainy area where spontaneous vegetation has grown with the rains.

In the yard, they are supplied by the two areas, grass cut in the irrigated area during the dry season, but also cowpeas and math beans of the rainy area at the end of *Kharif* .

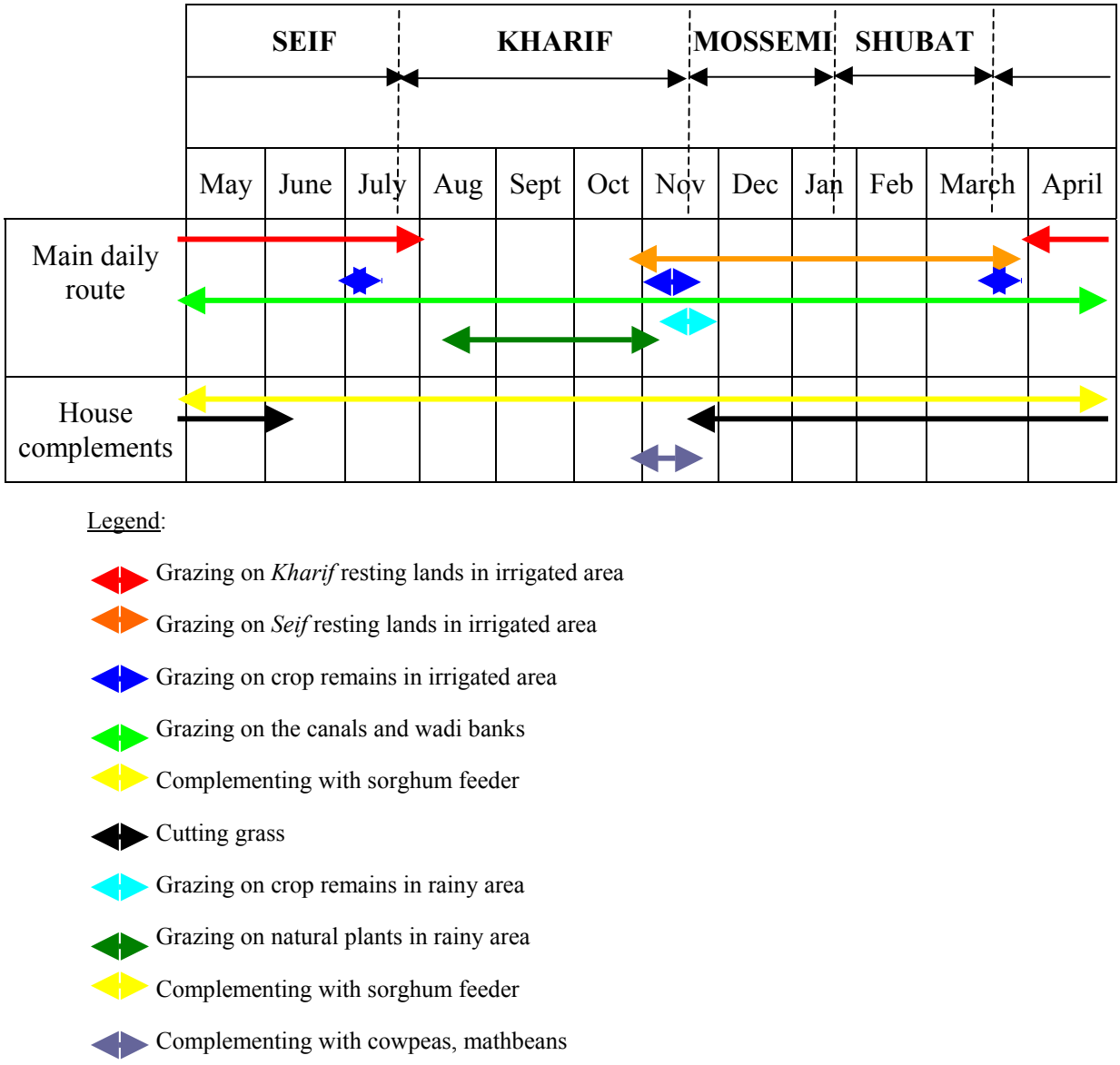


Figure 60: Alimentation calendar of small ruminants between rainy and irrigated area

The animals are better fed than in the exclusive rainy area. They consequently allow health, reproduction results and economic returns close to the *SRc* presented in 5.1.1): the net return is 2894 RY without fattening, and 5408 RY with it. However, the

breeders have to pay more attention in the supervision of the goats in the irrigated cultivated.

5.2 COWS PROVIDING FOOD SECURITY THANKS TO THE MILK

In Wadi Mawr, a lot of farmers have at least one cow of the zebu breed. This breeding activity implies the biggest investment for the farmers. But it is very important for the food security of the families with milk production, and it constitutes a potential immediate big source of money thanks to high prices of calves and cows on the market. In Wadi Mawr, the cows staying attached in the yard is the major system identified, but they can be led to graze in some farms of the irrigated area.

5.2.1 *Cac*: Cows always staying attached in canal area for the farmers able to provide sorghum all the year

In the irrigated area when they are not numerous (1 to 3 reproductive females), the cows are always kept attached to a picket in the farm yard, generally with other cows of relatives or neighbors.

5.2.1.1 Reproduction management

Like for the small ruminants the farmers use natural reproduction, thanks to bulls of the neighbourhood. The bulls are not numerous in the area and owned by the richest farmers of the villages, but lent them for free to the others. The bull is kept few days also in the yard with the cow when the farmers, women or men, detect the oestrus.

The cows live until 15 years in average, unless they are sold or they accidentally die. The first covering is realized at around the age of 12 months. The interval between two calving is around 15 months, and the coverings are not realised at a particular period, as people want to get milk all the year. The apparent abortion rate is low but problems may happen at the deliverance and the farmers may ask veterinarian services for that. Otherwise they rarely use drugs for cows.

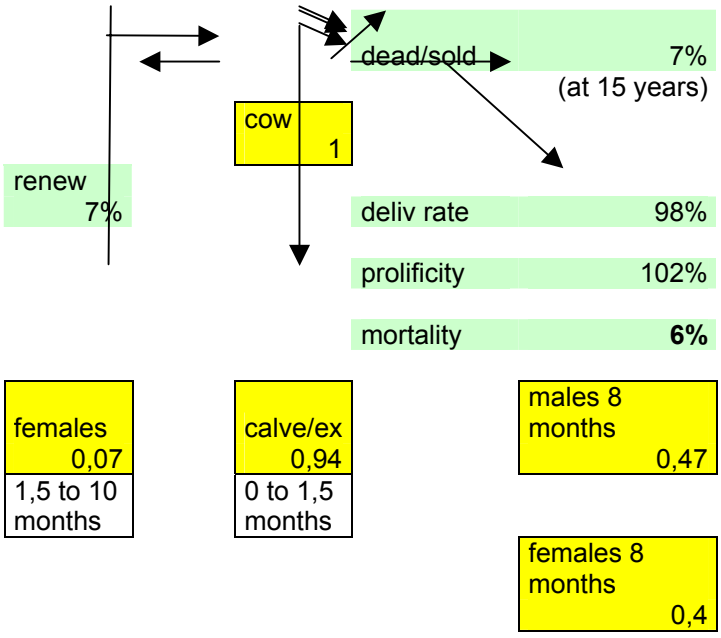


Figure 61: Scheme of renewing of herds for cows attached in irrigated area

The farmers try to keep the young females but they rarely manage. However the calves are sold after the lambs and the kids. The young calves go on the market at the age of 8 months, fattened if it is possible. The young are weaned at the age of 5 months.

The milking is realized by women twice a day, in the morning and in the evening, and the calves are separated from the mothers in the night and during the afternoon for them not to drink the milk. The milking is insured by women, lasts 7 months and gives average 4,6L/day. It is never sold on the market.

5.2.1.2 Alimentation

The cows always stay attached, and consequently are totally provided in forage. They get sorghum feeder twice a day all the year together with the small ruminants, in the morning and in the evening: 2 packs a day per cow what is the optimal quantity to be given according to farmers.

They are only fed with sorghum, except during the dry season when they profit by the cutting of spontaneous plants.

The calves stay all day long attached in the yard or in the paddock with the young small ruminants. Starting from 2 to 3 months, in some farms they begin to eat concentrates (constant increasing quantity, but average 18 kg per month during 6 months), natural grass and sorghum leaves with the other animals. From 5 months, they eat sorghum like the mothers.

The water is also brought to the cows in the yards by little girls.

5.2.1.3 Working calendar

The work dedicated to this animal husbandry system is very low, as the cows do not graze, and is realized by women.

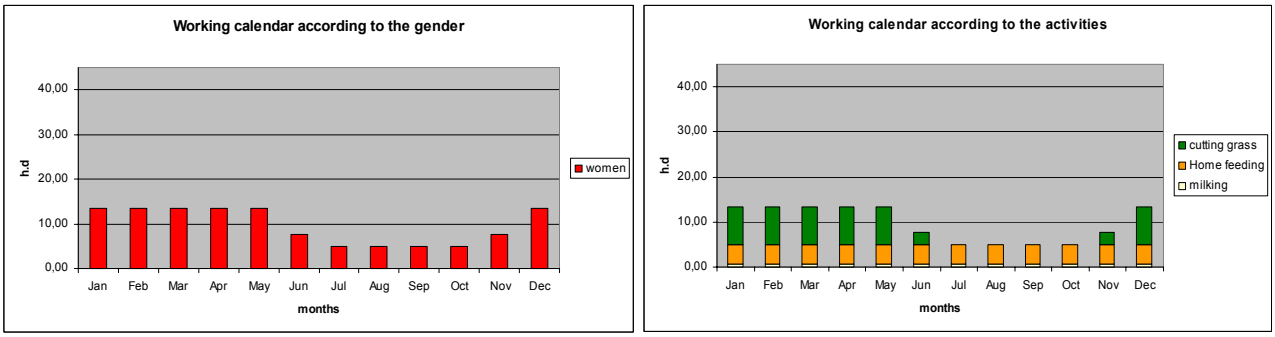


Figure 62: for one cow, a system requiring few work for women

5.2.1.4 Economic performances

The milk is the priority of this breeding system that is the most productive. The farmers sell the young animals as late as possible to be more expensive, but the alimentation costs are high and the net return is finally 31619 RY per cow including the milk (61% of the net return), what can be increased to 39028 RY if the calves are fattened.

5.2.2 *Car*: Cows always staying attached in rainy area with lower performances

This system is concerning the farmers living in the rainy area, and depending only of it. Since the lack of pasture, the cows are also kept attached. They are totally fed with

forage as the precedent system *Cac*: they depend on local sorghum and millet of the *Kharif* harvest, and then sorghum produced in the canal or the wells area: 1,5 packs per cow. The animals receive also grain and forage of cowpeas and math beans after the *Kharif* harvest.

The cows are less fed than those staying attached in the irrigated area: 1,5 packs a day per cow. Consequently the milk production is affected: 3L during only 5 months, and the mortality of calves is a little higher than in the irrigated area. Moreover, the high alimentation costs prevent the farmers from spending money neither in health services nor in drugs, and rarely in concentrates for the calves.

The net return for this system is lower, 13370 RY including the milk (42%), and 19950 RY if there is fattening.

Figure 63: In a yard of the rainy area, calves and cows attached together after the milking, in the morning

Most of the few work in this animal husbandry system represents the purchase of sorghum, what is realized by men.

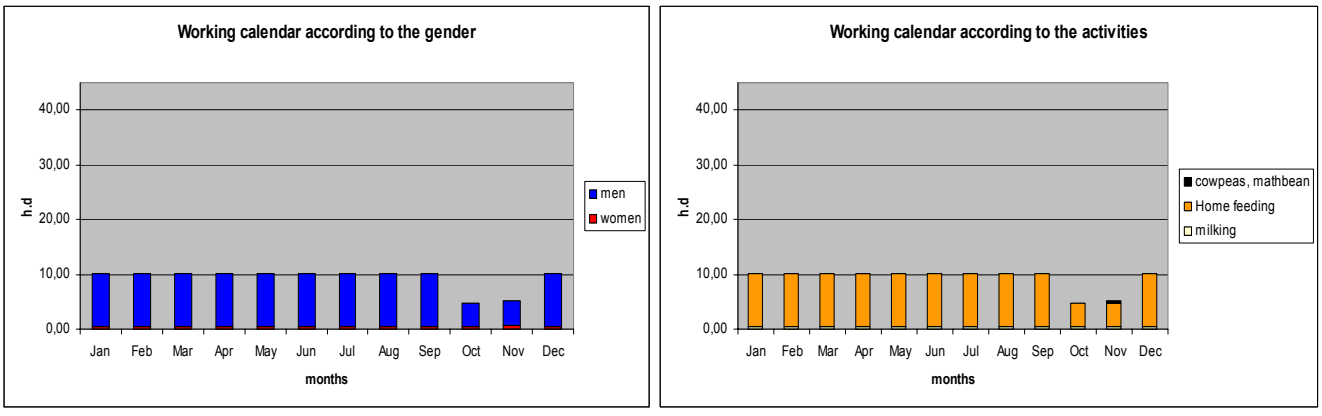


Figure 64: for one cow, a system with little work, requiring regular moving for men

5.2.3 *Cgc*: Cows going grazing in canal area for small farmers to avoid high costs of sorghum

When the cows are more numerous especially in the irrigated area or on its boarders, from 3 to 5, some farmers make them go grazing on the same kind of route as the small ruminants in the morning and in the afternoon (cf. 5.1.1.2). They are generally led separated from the small ruminants, thanks to other children, or thanks to a breeder who is paid to make different herd graze in the same time.

Figure 65: picture of children leading several small herds of cows to graze in irrigated area

Since those cows graze every day, they face more abortion problems. The milk production is also affected: the grazing cows give 4,6L of milk during only 5 months, and the quality is sometimes lower (taste).

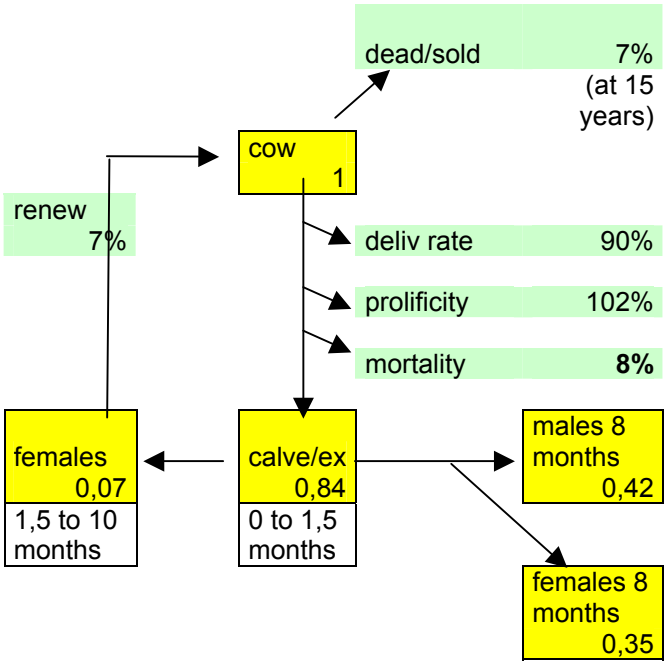


Figure 66: Scheme of renewing of herds for cows grazing in irrigated area

However the alimentation costs are lower, the farmers are relying on pastures and are able to decrease the sorghum supply: 1,5 pack a day per animal. In the yard, the cows will receive the same food as the small ruminants.

The young animals join the herd to go grazing at the age of one year, in the case of young females are kept to renew the system.

Although this system allows making economies on forage supply, the net return is less than the attached cow, 16680 RY including the milk (47%), or 23260 RY if the cows are fattened.

5.3 ANIMALS FOR TRANSPORTATION NECESSARY IN ALL THE FARMS

The lack of running water, or the distance to any field or market, force every family to possess animals for transport. They are used for example by women and children to go and search water in the wells, spontaneous grasses, or to bring back the sorghum from the storing locations, but they are not used as traction energy for the fields. The most common animals are donkeys, but some richer families able to invest in a dromedary profit by the higher strength. Those dromedaries are used for paid services as sorghum feeder or wood carrying.

5.3.1 *Donkeys owned by every families for quotidian work*

As the donkeys are not used for the fields, the females are more profitable for farmers because they may give young animals to be sold.

The donkeys are very resistant to the dry conditions, and are kept until they die, around the age of 15 years. They never get any health service, and are hard working. The reproduction is not supervised as precisely as it is for the small ruminants or the cows. Male and female stay together in the yard or in the village, attached or in divagation. But in general the females are covered for the first time at the age of 1 year, and after that will average give young donkeys every 18 months that are sold to other farmers on the market.

The donkeys are fed totally by sorghum feeder: 1 pack a day per animal, that decreases in *Mossemi* to 0,5 packs. They can also graze along the route while transporting people, and drink in the wells. Usually they eat in the same time as the other animals in the yard and are given grass or cow peas to compensate for the *Mossemi* dry conditions.

This system is a transport service, producing a negative net return constituted by important alimentation costs. It is higher for females thanks to the young animals sold with interesting price. For the production system the average net return for male and female is: -11820 RY.

5.3.2 *Dromedaries to carry heavy products*

The dromedaries are used for their high capacity to carry farm products, for the high value of young animals, but also for the milk especially in nomad systems.

The dromedaries are managed like the donkeys. The dromedaries live until the age of 20 years; the females are giving young animals every 2 years starting from 12 months. They are able to provide milk to the farm during 1 year after delivering.

They are also fed according in the same way as the donkeys, except the quantity of sorghum: 2 packs in *Seif* and *Kharif*, and 1 in *Mossemi*.

Females provide a value for the farm thanks to the milk and the young dromedaries. The average net return for males and females is still negative, -10276 RY.

Moreover, the owners making provision services with their dromedary are ensured to feed it thanks to the packs it carries, and above it to make big additional profit.

The advantage of dromedary's strength for provision services:

The dromedaries are commonly used for sorghum transportation during the Wadi Mawr harvests.

An owner of a dromedary takes 20% of the harvest of the farmer he is working with, what represents for example 149 packs for one maad cultivated (Ss//Skh)w giving average 745 packs a year.

His animal needs to be fed with 560 packs of sorghum a year. So a dromedary-driver transporting at least 3,8 maad gains the sorghum he needs annually.

As he is usually working for a lot of farmers on a lot of maad during the harvest seasons, his dromedary is very profitable.

5.4 ANIMAL PRODUCTION'S MARKETTING INSURED BY MEN

The men are the only members to go on the markets. While they regularly have to buy food, they are also in charge of the sale of the animals, on the big local markets like Al Marras, Al Zaher, Al Rafi and Al Khamis.

They bring one or several animals that are negotiated according to the aspect and the weight. In the same time, they can buy concentrates and sorghum for their farm.

	Price of concentrates (in RY/kg)
Wheat flour	36
Wheat bran	25,7

Figure 67: price of concentrates for young animals

The fattening increases the value of the young animals.

		Price of the young animals (in RY)	
		Non fattened	**Fattened**
Lambs	4 months	5000	9000
	6 months	7000	10000
Kids	4 months	8000	10500
	6 months	10000	12000
Calves	8 months	45000	60000
	12 months	50000	70000

Figure 68: prices of young animals sold on the Wadi Mawr markets showing the advantage of fattening *(average estimation between females and males)*

The milk is never sold, except in some big goats' herds of the rainy area. However the milk price can be estimated thanks to farmers and to Yemeni market prices.

	Estimated price of local milks (in RY/L)
Goats	25
Cows	67
Dromedaries	60

Figure 69: price of milk in Wadi Mawr

5.5 COMPARISON OF THE DIFFERENT BREEDING SYSTEMS ACCORDING TO THEIR PRODUCTIVITIES

5.5.1 Livestock productivity according to the alimentation costs

According to the high dependence on forage which concerns all the areas, the animal husbandry systems' productivities can be firstly compared according to the sorghum feeder they consume. The production of one animal is divided by the annual cost of sorghum the breeder has to invest.

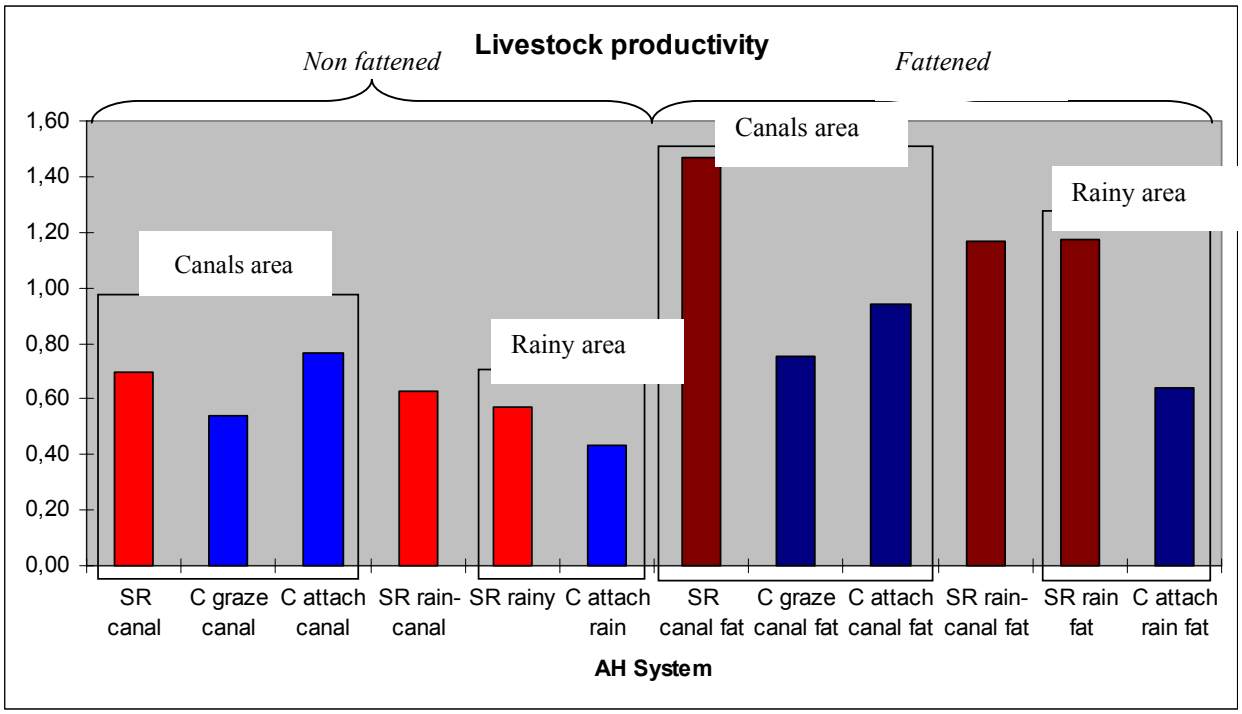


Figure 70: livestock productivity of the different animal husbandry systems

Even if their net return is inferior, the small ruminants generally are more productive than the cows and need less invest in forage. The advantage of having a cow remains the high quantity of milk it provides, before the calves, especially for the cows kept attached in the canals area where they are the most intensively bred.

Whatever animals the farmers have, the net return is always better in the canal area, where there is a better alimentation supply which allows better productivity. That is why farmers located at the limit of rainy and irrigated area and breeding small ruminants have better results than those only in the rainy area. It is also more profitable to have cows in the canal area; however making them graze affects a little the net return even if it decreases the alimentation costs.

All the returns are improved a lot thanks to the concentrates for young animals, what all the farmers know and try to develop according to their financial possibilities. They are not always used, or if they are used the farmers are sometimes not able to give them regularly, or stop rapidly.

5.5.2 Labor productivity

The productivity can be also evaluated according to the work the families invest in their animal husbandry systems.

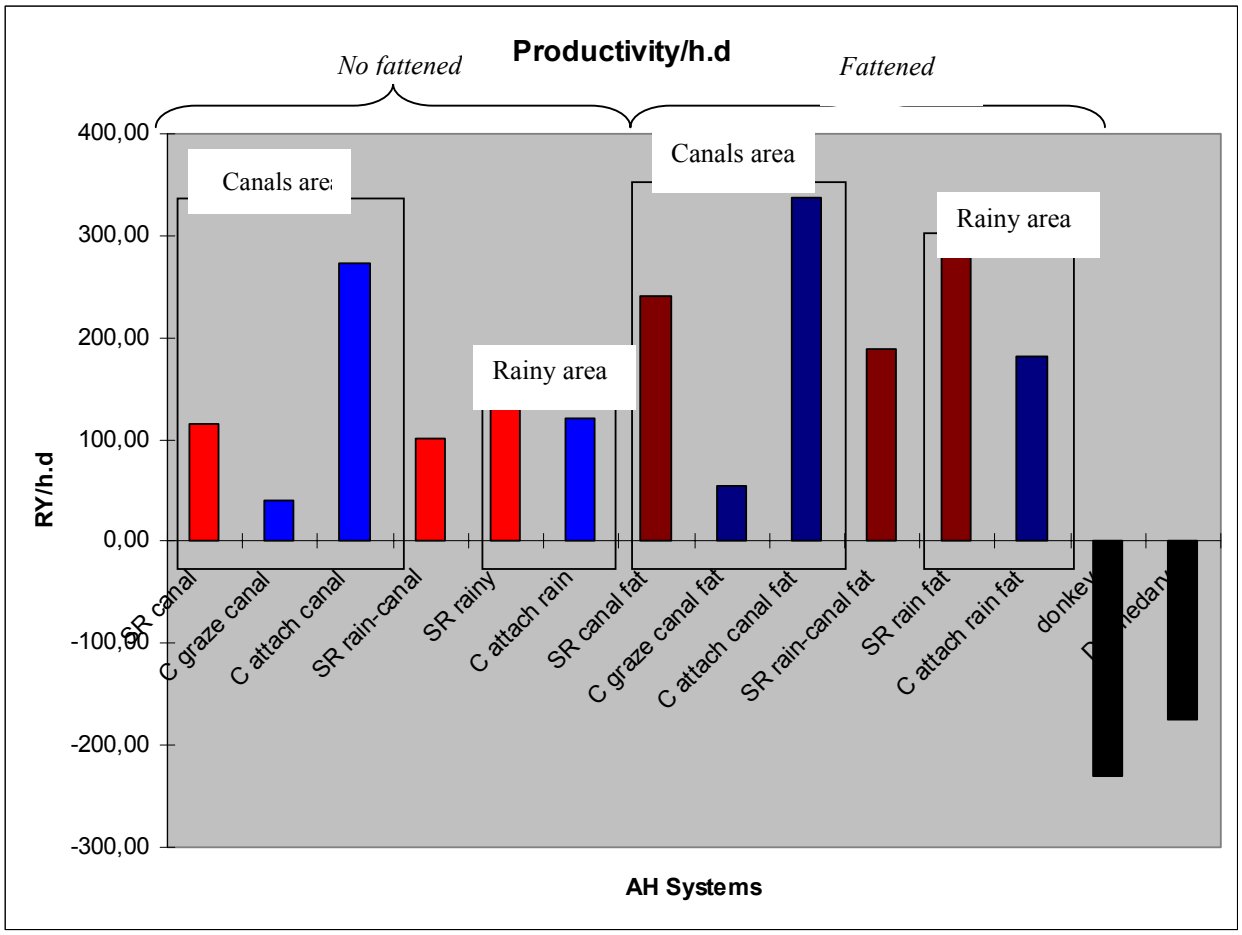


Figure 71: labor productivity of the different animal husbandry systems

The systems making their animals graze imply a lower labor productivity, whereas the attached cows are very extensive in labor. It is then easy for breeders to combine grazing and attached systems, according to the family manpower they have, especially children. The best results are obtained with animals staying inside, as it gives high returns for less work, but it is difficult for farmers to do it. They are not able to buy enough sorghum feeder and must make their animals graze, taking the risk of toxic plants, or of decreasing milk production.

6 FARMING SYSTEMS COMBINING AGRICULTURE AND BREEDING

Across Wadi Mawr, nearly all farmers are combining agriculture and breeding. Only two of them do not: the rich farmers growing mangoes, who do not have animal and the nomads breeding livestock, who do not have land. Among the others systems, the importance of livestock within the farm income depends on the access to both land and water, which are respectively the result of the history of the farm and the location in Wadi Mawr.

Each farming system in the area has cows, sheep, goats and donkey. Only the poorest families do not have cow and depend on the neighborhood for milk.

In the following farming systems, the proportion of each cropping and animal husbandry systems within the farm has been chosen according to the reality we have met on the field, through numerous meeting we had with farmers. We have chosen typical proportion, which are explained through the objective of the farmers and, for livestock, through the availability in forage and/or the ability to buy it.

6.1 COMPARISON OF CROPPING AND ANIMAL HUSBANDRY SYSTEMS TO UNDERSTAND FARMING STRATEGY

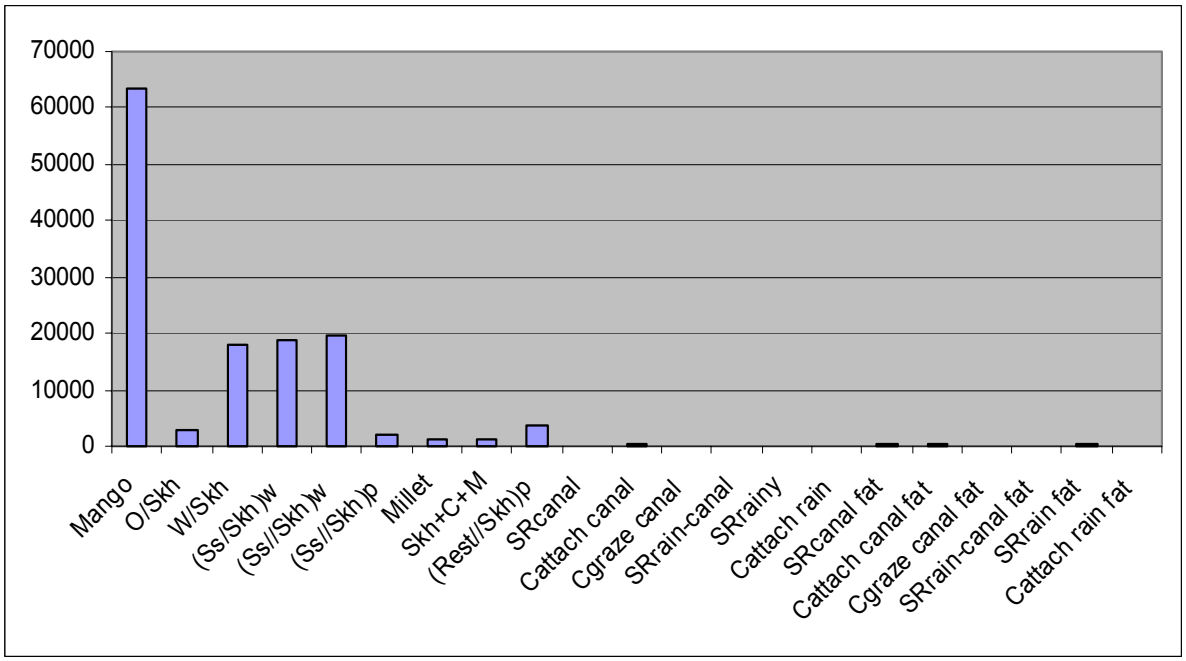


Figure 72: Familial labor productivity for cropping and animal husbandry systems

This graph show the differentiate labor productivities between crops and livestock production. It shows the net returns per day of familial work, the average money that can produce a person of a family by working during one day.

The cropping systems are much more labor productive than animal husbandry systems. Indeed, even the lowest labor productivity for cropping system, Skh+C+M, is three times higher than the highest labor productivity for animal husbandry system, an intensive cow production with fattening.

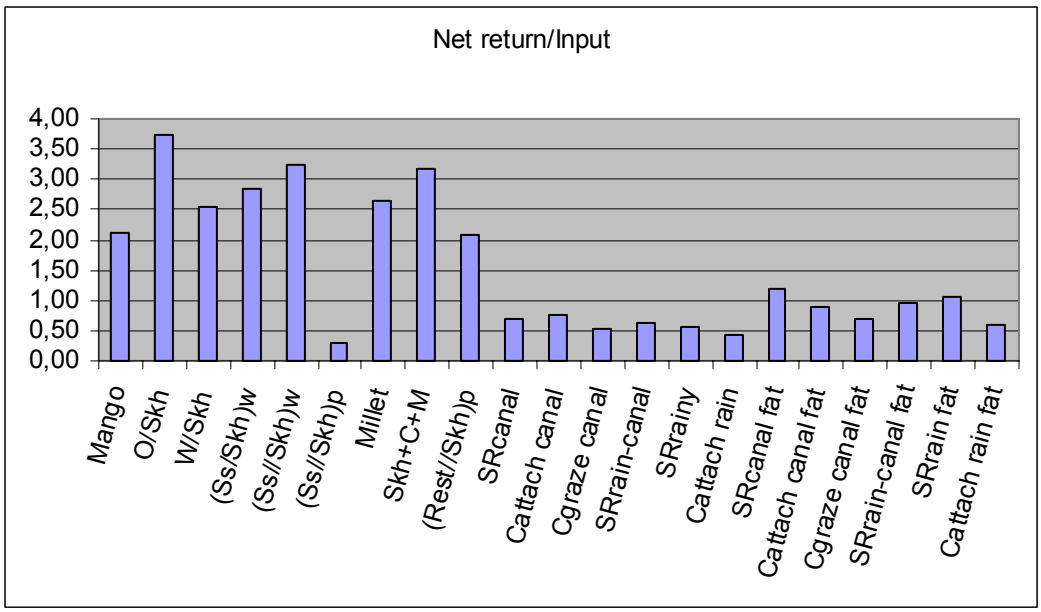


Figure 73: Net return upon the investment for cropping and animal husbandry systems

Moreover, the return of the money invested for the crops is better than for the animals. A farmer investing money in plowing, sowing, sometimes diesel, etc has more benefit from the harvest than investing the same amount in forage, concentrate and drugs. Only farmers having invested in well have low return on investment.

As a result, farmers have more interests in growing crops than in breeding animals. Consequently, the agricultural part is the priority for a lot of farmers and the animal production is a complementary income. However, for many small farmers who do not have sufficient income from crops, especially share farmer, animal production remains the only solution to increase the farm income.

Nevertheless, as animal production is not highly productive, a lot of farmers do not get the income to cover the family needs.

Survival threshold:

It has been calculated from the basic needs of the family to live, according to the food availability and the local prices. It takes in account mainly food, but also the drugs and clothes.

In average in Wadi Mawr, a person needs for one year:

- 30 300 RY for the basic food (Wheat flour 19 %, rice 21 %, sorghum 9 %, milk 13 %, potatoes 7 %, tea 9 % and others 22 %)

- 1 000 RY for clothes

- 500 RY for drugs

In the population, for a typical family, for each person working, 1 other (child, sick or old person) is dependent. Consequently, the survival threshold for a worker is 63 600 RY/year.

6.2 AL ROSFA, BETWEEN CANAL AND RAINY AREA

The village of Al Rosfa is situated between the canals area and the rainy area. Therefore, the diversity of farmers is elevated with some cultivating the irrigated lands and others the rain-fed ones, in addition to the differentiate access to land ownership and mean of investment.

6.2.1 Farmers growing sorghum for human and animal consumption, thanks to the insured water from the North canal

6.2.1.1 Small share farmers maximizing their land productivity

The historical analysis of the area pointed up that most of the farmers in the canals area are still small share farmers. They have very limited access to land, with most of them cultivating between 2 and 8 maad, or sometimes until a maximum of 20 maad for farmers having relationships with the owner. The land access is in those farms, with 4 familial workers in average, the most limiting factor to increase farm income. Thus, the maximal land availability per familial worker is 5 maad.

Thanks to the water security, due to the weir and the canals, they choose to apply the cropping system (Ss/Skh)w in order to maximize the land productivity and to limit the risks. For those farmers, the limited access to land makes them poor with very low farm income. Therefore, it is not possible for them to take risks to grow crops with uncertain return, like watermelon.

The cropping system (Ss/Skh)w supplies them sufficient forage for their animals even if they give half of their production to the land-owner. Indeed, growing sorghum twice a year allows the share farmer to increase his forage availability of 64% in comparison with growing it only once. In this farming system, it appears consequently that all the sorghum produced on the farm is consumed by the animals on the farm. This system allows farmers to adapt the food of animal to the forage supply according to the production of the year. However, if the year is very productive he goes on the market and sells forage or buys some if it is very dry.

In the case of a share farmer with 10 maad, 10 sheep, 5goats, 3cows and 2 donkeys, the production of forage is equal with the consumption by the animals.

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Forage available		1200	300				1200		810		320		
Small ruminants	**15**	3,75	3,75	3,75	3,75	3,75	3,75	3,75	3	3	3	3	3
Cows	**3**	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5
Donkeys	**2**	2	2	2	2	2	2	2	2	2	1	1	1
Monthly consumption		307,5	307,5	307,5	307,5	307,5	307,5	307,5	285	285	255	255	255
Stock		893	885	578	270	-38	855	548	1073	788	853	598	343

Figure 74: Forage calendar for a share farmer with 10 maad, 15 small ruminants, 3 cows and 2 donkeys

Concerning animals, small share farmer combine the breeding of cows, sheep, goats and donkey for several purposes. As explain in the previous part about animal husbandry systems, each animal is use for a specific objective. The small ruminants are sold for the meat on the market to supply monetary income to the family. The cows, one or two animals, produce in priority milk for home consumption but also calves to be

sold on the market. Finally, the donkey(s) are use for human, water and forage transportation.

Since, most of the needs for the family are bought on the market, they need high monetary income. This one comes from the grain of sorghum sold, but concerning the animals it mainly comes from the small ruminants. For that reason, they try to have as much small ruminants as possible. For a farm between 2 and 10 maad, the number of small ruminants varies from 3 to 15 animals. As for the cows, the number changes from 1 to 3 in order to try to have milk all the year if it is possible. To reduce the costs of feeding that small share farmer cannot face up, the cows do not stay inside only fed with sorghum, but they go grazing.

The work within the farm is allocated to different members of the family.

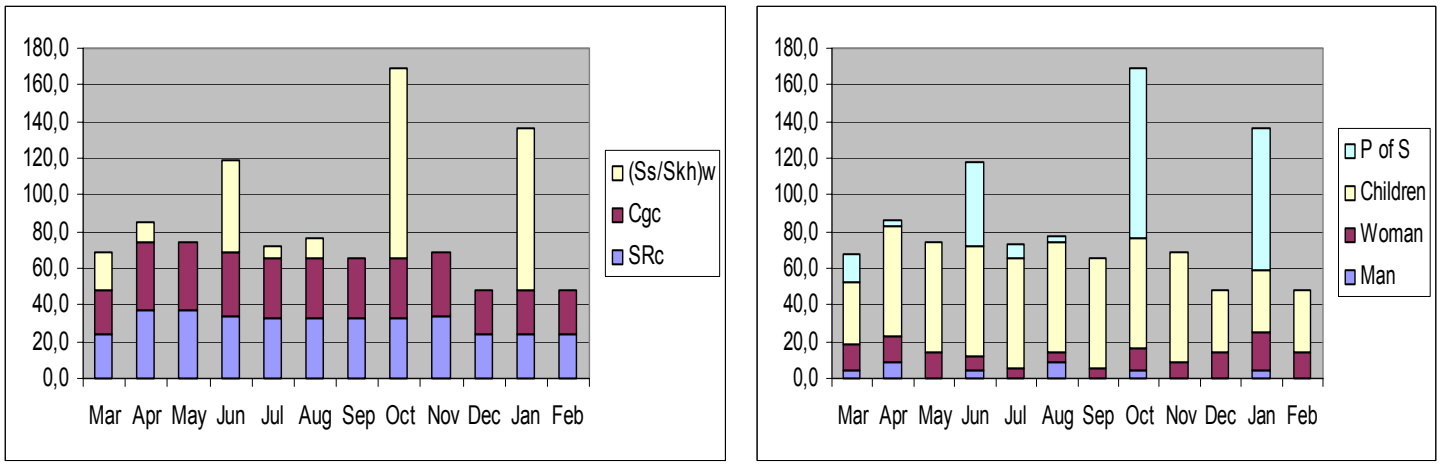


Figure 75: Working calendar and distribution of tasks of share farmer in canal, with 3 familial workers, 10 maad, 15 small ruminants, 3 cows and 2 donkeys

In addition to those work, the man of the family profit by going to the market to buy food or any needs for the family, to sell grains of sorghum or animals.

In this farming system, 4 persons are necessary. The man works on the sorghum, especially for the harvest of forage and goes on market to sell any farm product. The woman is in charge of the feeding and the milking of the animals; she is also responsible for the harvest of sorghum grain. Finally, one child is needed to take the small ruminants to graze and one other for the cows.

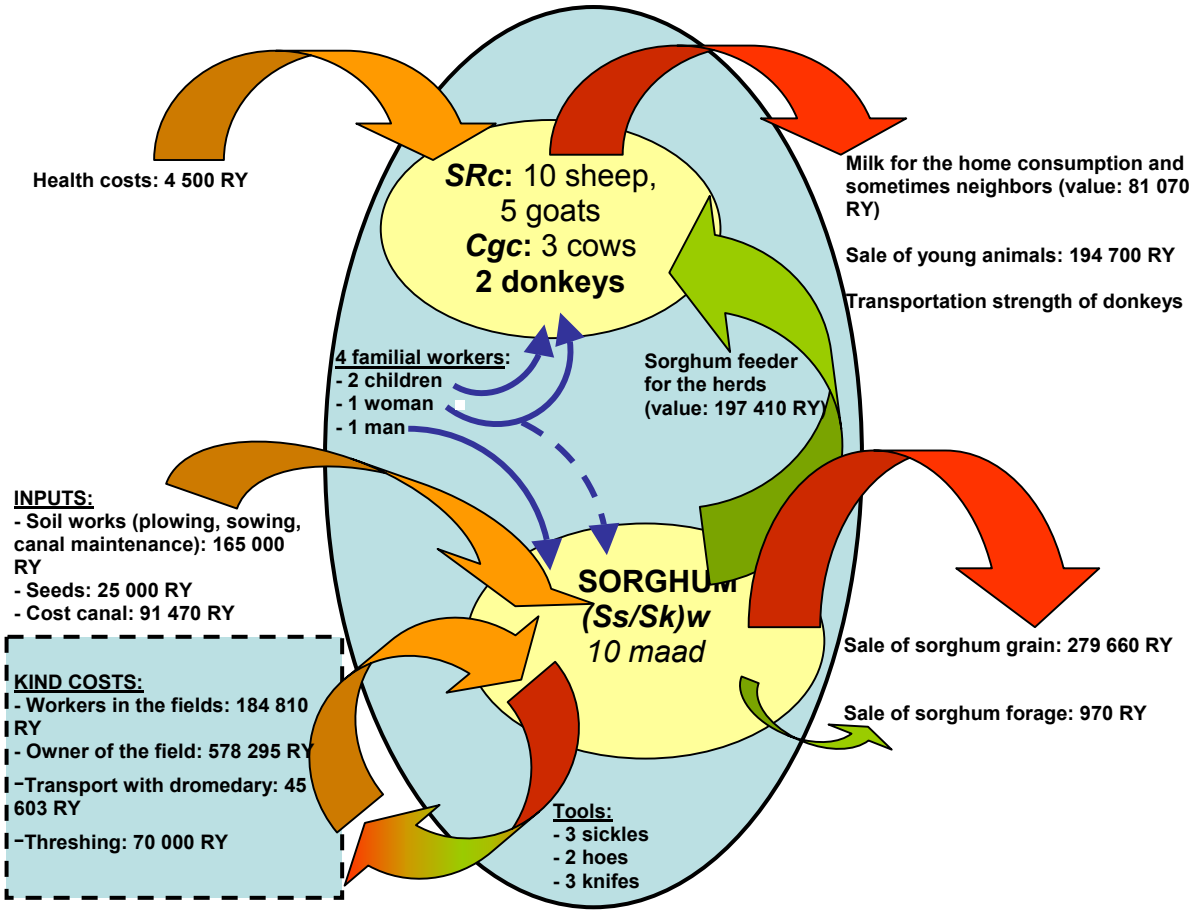


Figure 76: Functioning scheme

In the above example, the farm income is composed in 195 606 RY from the crops and 74 849 RY from the animal, what supply to the family 270 455 RY/year.

In this family with 4 workers, 3 children and 1 old person are not working and depending on the farm income. The survival threshold is consequently 254 400 RY/year.

This family hardly covers its needs and is vulnerable to bad years.

This system is economically very difficult. As the survival threshold is 63 600 RY/year/person, or 254 400 RY/year for 4 workers, and the income per maad from this system is 27 045 RY/year, a farm with less than 9,4 maad, 2,35 maad/worker, cannot survive from the farm income.

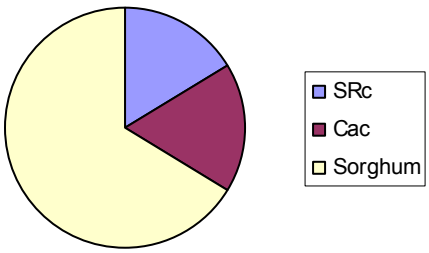


Figure 77: Farm income composition for small share farmer in canals area

For these farmers, most of the people do not have access to enough land to reach the survival threshold. As a result, they must find external job to face this lack of money. If they do not find any job or if they need exceptional expenditures, for any disease for example, they have to sell animals, which leads to destocking and then to the decrease of the farm income.

6.2.1.2 Middle owners taking advantage of their land safety to manage the peaks of work

Those farmers have bigger farms, most of the time inherited for their parents. Thanks to the land as well as water access and security, they can perform the cropping system (Ss//Skh)w. As they have high cultivable area, they grow less labor intense system but can have better income than the previous farmers. Moreover, these ones are owner of their land and profit by all the production.

Like for the previous system, the most limiting factor is the land access, but those one are owners and they usually have more land. While most of the previous ones have between 2 and 8 maad, these systems have between 10 and 20 maad.

As they are larger, these farms depend less on animal production, but like everybody they have donkey and they breed sheep and goats, from 10 to 20. Thanks to the high sorghum production, they can keep cows inside, what increase the net return, and even sell some forage. On the contrary to almost all small farmers, those ones have a dromedary for sorghum transportation.

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Forage available		1888		1276			2863		1418		510		
Small ruminants	**15**	3,75	3,75	3,75	3,75	3,75	3,75	3,75	3	3	3	3	3
Cows	**4**	6	6	6	6	6	6	6	6	6	6	6	6
Donkeys	**3**	3	3	3	3	3	3	3	3	3	1,5	1,5	1,5
Dromedary	**1**	2	2	2	2	2	2	2	2	2	1	1	1
Monthly consumption		382,5	382,5	382,5	382,5	382,5	382,5	382,5	360	360	315	315	315
Stock		1506	123	1017	384	2	2482	100	1158	438	633	318	3
Sold on the market		1000		250			2000		360				

Figure 78: Forage calendar for a middle owner in the canals area with 14 maad, 10 sheep, 5goats, 4cows, 3 donkeys and 1 dromedary and 3 familial workers

In these large farms, the income from animals is mostly coming from the cows which stay inside, which can be well fed and even sometimes fattened.

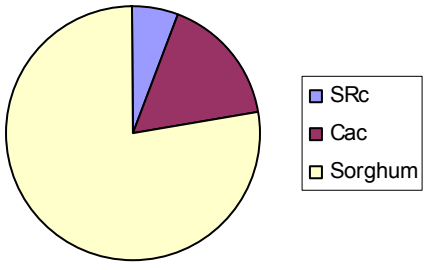


Figure 79: Farm income composition for middle owner in the canals area

For those farmers, the herd is not managed like for the small farmers. Indeed, while it is absolutely necessary for small farmers, for these ones it is complementary

income, the crops already supplying high returns. Consequently, they can sell a big part of it, for weddings or fête, with few consequences upon the farm profitability.

A farmer is growing 14 maad, 7 in seif and 7 in kharif. From this production, in addition to the costs of production describe in the cropping systems, he pays workers in kind, what is the equivalent of the value of the sorghum. Then, he pays zeka, 10 % of the production.

After these costs, the remaining forage and grain really available for the farmer and the farm income from the crops is less than the net return, which not include external worker and taxes.

Net return / 14 maad	837263

		Salaries			Zeka		
	Production	Kind	Costs	Threshing	Kind	Costs	Available
H1 seif	2590	492	24605		210	10490	1888
H2 seif	1750	333	16625		142	7088	1276
H3 seif	1050	200	7980		85	3402	765
H1 kharif gr	3892	389	27244	350	350	24520	2802
H1 kharif for	2590	492	19684			0	2098
H2 kharif gr	3892	389	27244	350	350	24520	2802
H2 kharif for	1750	333	19950			0	1418
H3 kharif	700	133	10640		57	4536	510
Total costs			153972			74554,2	

Farm income from the crops: 608737

Figure 80: Farm income from the crops for a farm growing 14 maad of sorghum

With the man working on the crops, the woman for the grain harvest and for milking and feeding the animals and a child taking the small ruminants to graze, this system needs only 3 persons.

For most of those farmers, they will not face any big problem, since they have land security, water access and they benefits entirely from their production, contrary to share farmers.

6.2.2 Farmers growing crops with higher land productivity and depending less on animal production

6.2.2.1 Small owners diversified growing okra thanks to investment in small motor-pump

Small farmers has been able to invest in a small motor-pump (20 000 RY amortized during 5 years), to grow vegetables.

Because the pump does not allow to grow a lot of land and because okra cultivation is very labor intensive, farmers grow only a small part of their farm in okra, usually around 20%, growing the other 80% in Sorghum, (Ss/Skh)w. Moreover, the high familial labor investment does not allow to grow large area.

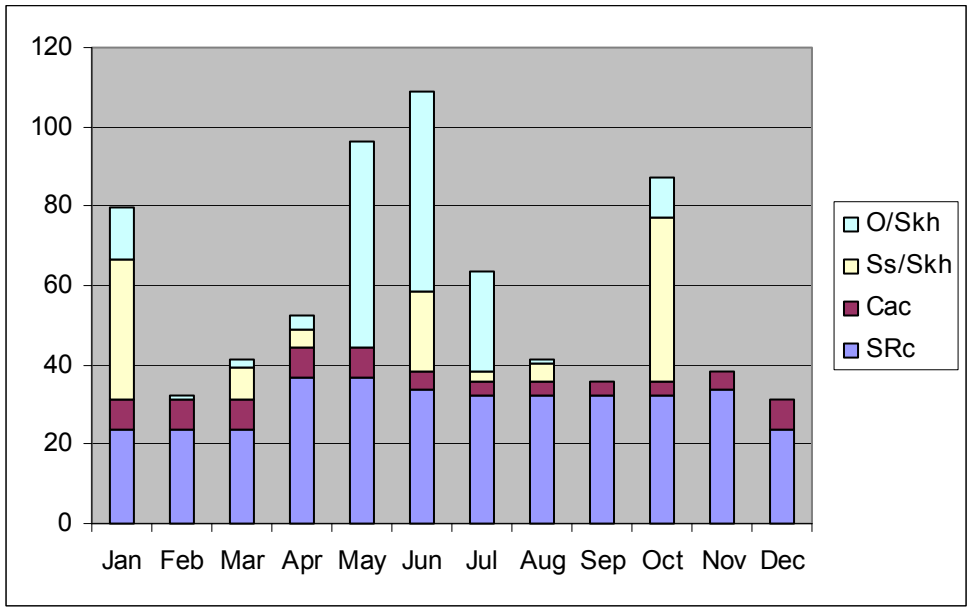


Figure 81: Working calendar of small farm diversified growing okra, with 3 familial workers growing 1 maad of O/Skh and 4 maad of (Ss/Skh)w with 5 sheep, 3goats, 2 cows and 1 donkey

In this system, the man is nearly only working on crops. The peak of work for him, in June, is about 4,4 days/maad. During this time, the man work 30 days per month. Consequently, a family with 3 familial workers but with only one man, can work on a farm of a maximum of 6,8 maad, which is 2,3 maad/familial worker.

For those farmers, livestock is minor in the farm income, it represents only 16 %. However, these families are used to have animals and keep breeding some small ruminants and cows.

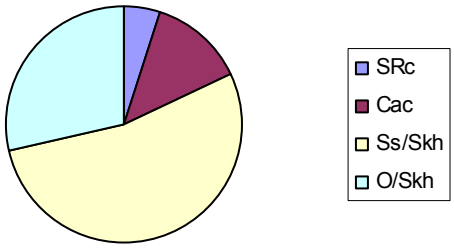


Figure 82: Farm income composition for small owner diversified with a small motor pump

The animals are consuming ¾ of the sorghum feeder produced on the farm (657 packs/maad), selling the remains on the market. Consequently, if, as described in the part 5, food is the biggest cost of production for animal husbandry systems, it does not need any investment in the case of those farmers. The only investment is in work, through the children who takes the small ruminants to graze and through the women, milking the cows and the goats, and cutting spontaneous plants during the dry season to complement the alimentation.

With only 3 familial workers and a very small area, this system allows to supply easily the family in basic needs.

Even if those farmers are very small, they usually have sufficient income to live. Thanks to okra production, they have high monetary income, which allows both to supply needs to the family and to buy forage for the animals, especially during the dry season. Indeed, 2 maad (0,67 maad/worker) are sufficient to reach the survival threshold

for the family with 3 familial workers, with stable income insured from the irrigated okra.

6.2.2.2 *Small owners diversified growing watermelon dependent on very fluctuating prices*

Other farmers grow watermelon, which is very well adapted to the natural environment and grown for many years in Wadi Mawr. However, the very fluctuating prices lead farmers to grow about two third of their farm in sorghum, (Ss/Skh)w.

This system, like most of the other in the canal area or not limited by any technical production factor, but by the access to land. These farmers cultivate usually less than 20 maad on a farm with 4 familial workers.

Even if for them, the income from agriculture is not insured like for farmers growing vegetables, thanks to the high incomes from the watermelon, farmers with small farm have sufficient money to live and they depend lowly on animal production. But they keep few sheep, goats and cows as insurance for bad years.

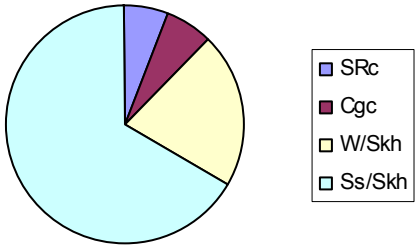


Figure 83: Farm income composition for small owner in the canals area cultivating watermelon

Like in the previous system, livestock does not require any investment for food since it is entirely produced on the farm. However, it is not as high as the above system and farmers may have some difficulties to feed sufficiently cows. As a result, a child takes them to graze.

With 4 familial workers, this system performed in the canals area have growing watermelon supply high income to the family which depend less on animal production. Indeed, with more than 2,9 maad, the family is over the survival threshold.

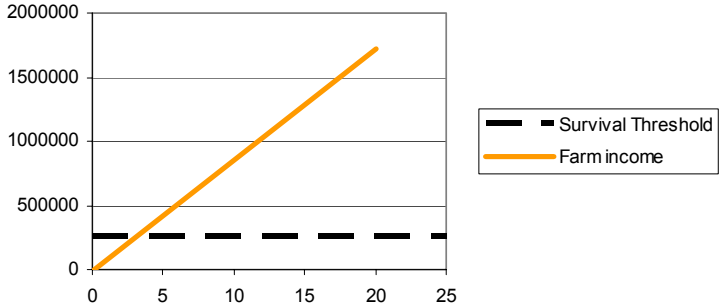


Figure 84: Farm income according to the farm area

6.2.3 New external owners investing in mango trees in eastern canals area, a threaten for small share farmers

Farmers growing mango trees in canals area do not cultivate any other crop neither breeding any animal. The only system performs is *Mango*.

Compared with all the others cropping and animal husbandry systems, it has the highest labor productivity. Furthermore, thanks to the very high land productivity, farmers who are able to invest, even on a very small farm, do not need other incomes. Moreover, it is not possible to find a lot of land in the canals area and land access is the first limiting factor, with farm hardly larger than 5 maad.

The greatest cost is the initial investment in the well, to dig it and to buy the pump, the engine, and the pipes. This investment is rising 3 000 000 RY (15 152 US$), amortized during 30 years, in an area where farmers do not have access to credit. Moreover, the average cost for maintenance is rising 40 000RY/year.

The particularity of this system is that is done by external investor who work only few hours on the farm and workers are doing most of the labor.

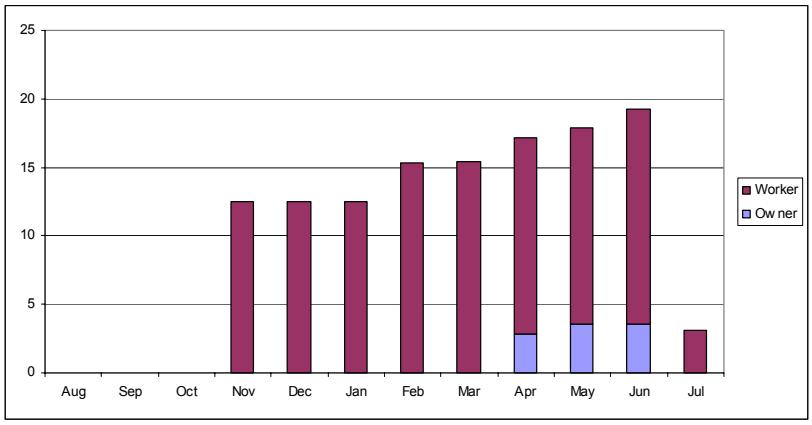


Figure 85: Distribution of work between farmer and workers

The cropping system *Mango*, as explain in the part 4.2.1, requires a lot of work. The investor pays workers, 500RY/day, to achieve the tasks and he only supervises the work.

Even if the farmer pays workers, for nearly all the works on the farm, a small farm allow him to make high output. With a farm with only 2 maad of mango, his income is 831 010 RY/year.

This very profitable system without labor investment, is likely to extend in the canals area, since, contrary to the other wadi in the South of the Tihama, there is still underground water.

6.2.4 Farmers having limited or even no access to irrigated land and depending more on livestock production

6.2.4.1 Middle share farmers in rainy area facing lack of forage

These farmers are either people who came back from Saudi Arabia without money to buy land, or who did not find land, or share farmers who were cultivating in the canals area and who have been thrown out when fruit farms arrived.

Today they are doing rain-fed cultivation, with uncertain production according to the rainfalls and they need more than 3 times more land than in the canal to have the same income. It combines millet, which has higher monetary return thanks to the grain, with sorghum associated with leguminous, which supplies forage for animals.

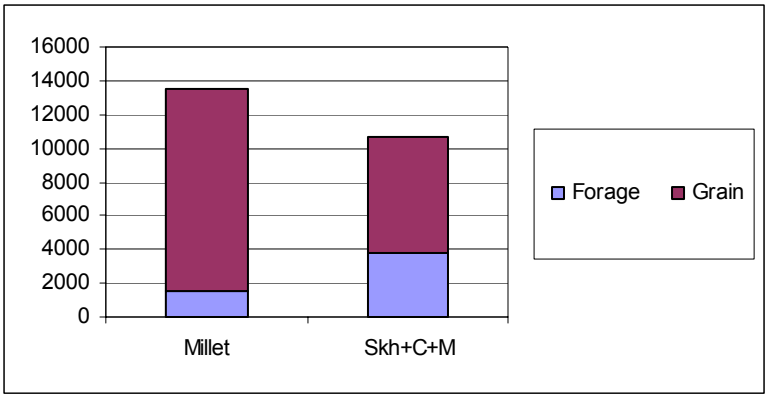


Figure 86: Comparison of the production for 1 maad of millet and 1 maad of sorghum associated with cowpea and math bean

Moreover, the combination of those systems is managed according to the micro-relief. Indeed, the millet is more drought resistant than the other crops and can be cultivated up on the hills, while the sorghum is grown in hollow.

This system needs also a lot more work than the systems in the wadi. The peak of work is in November, during the harvest, with 3,4 h.d/maad. A person working alone on the farm can consequently grow a maximum of 8,9 maad.

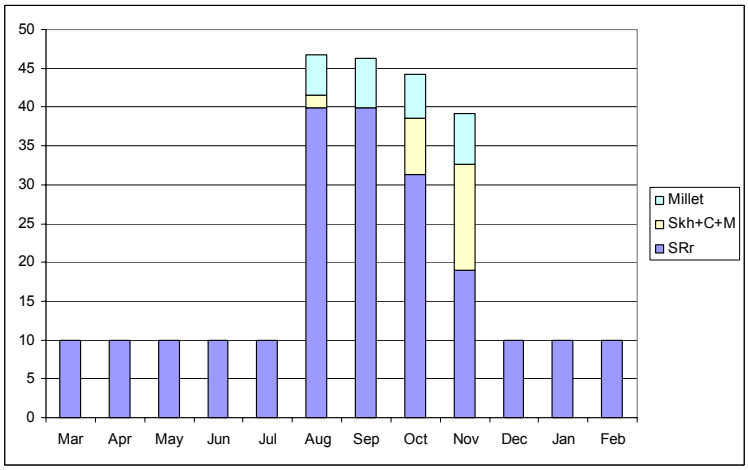


Figure 87: Working calendar and labor repartition of share farmer in the rainy area, 3 familial workers, with 3 maad of Millet, 3 maad of sorghum associated with cowpea and math bean, and with 4 goats, 2 sheep and 1 donkey

As for animals, they depend nearly only on forage, since the spontaneous vegetation is very low in the rainy area. Moreover, the forage production is very low on the farm and farmers need to buy high quantity of forage, which represent big monetary investment for those poor people, but it is also a big investment in time as the men needs to go every 1 or 2 days to the market to buy sorghum. As a result, they have fewer animals and are among the poorest farmers of the area.

For those systems, animal production is very important and represents 43 % of the low farm income, which is always under the survival threshold.

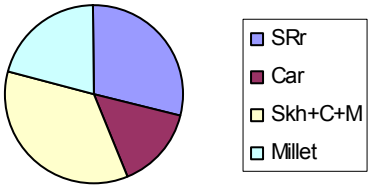


Figure 88: Farm income composition for share farmer in the rainy area

For those systems, it is nearly impossible to make sufficient income from the farm to live. The family needs to find other job, what can be difficult. If they do not earn enough money, it often happens that they can buy food for the family but not for the animals. In this case, they must sell one animal to buy forage in order to feed the others. This problem of destocking is concerning almost all share farmers is the rainy area.

6.2.4.2 Middle owners in rainy area getting more forage by share-farming in canal area

Some farmers living in Al Rosfa and owner in the rainy area take benefit of the proximity to the canals area to share few maad. This combination of rainy and canals area allows them to manage big herds with buying few forage.

The land availability is very limited in the canals area and the area represents in those farms only a small proportion of the total cultivated area, only 15 %. Then, the canal area supplying forage for the livestock, most of the rainy area can be grown in millet, for what the land productivity is higher. However, those farms have a lot of work, especially at the harvest time in October. The peak of work makes the maximal area per familial worker at 12,8 maad.

For this system, livestock is very important and especially goats and sheep, which represents 28 % of the farm income. It takes also a long time and the herd of small ruminants, which can be over 100 animals, needs sometimes 2 or 3 workers.

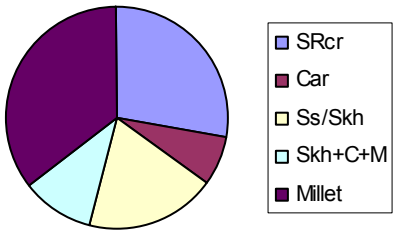


Figure 89: Farm income composition for owner in the rainy area sharing land in the canals area

6.3 AL NASHERIA, A WELL AREA

Al Nasheria is located in the West of the project area, where the wadi does not reach nowadays. All farmers are irrigated sorghum by well and the bigger ones are supplying nomads.

6.3.1 Farmers using groundwater to produce sorghum intend for both animal and human consumption

In the North West of the studied, like in the South West, the only resource of water is the underground water. In this area, some people have been able to invest in well. They give to others the possibility to benefit from the water supply.

6.3.1.1 Middle owners with water security despite high irrigation costs and giving some lands to share farmers

Farmers, who have been able to invest in a well and a big motor-pump, have insured access to water even if they need high investment for the inputs, especially since the increase of diesel price in July 2005.

These farmers are doing the cropping system (Ss//Skh)p, which needs high financial and labor investment. However, thanks to the water, the production is insure, particularly for grains, and allows to pay back all the costs of irrigation. Those farmers live nearly all the time near the motor pump to be ready if any problem occurs and the other members of the family, like the previous systems, are working with the animals.

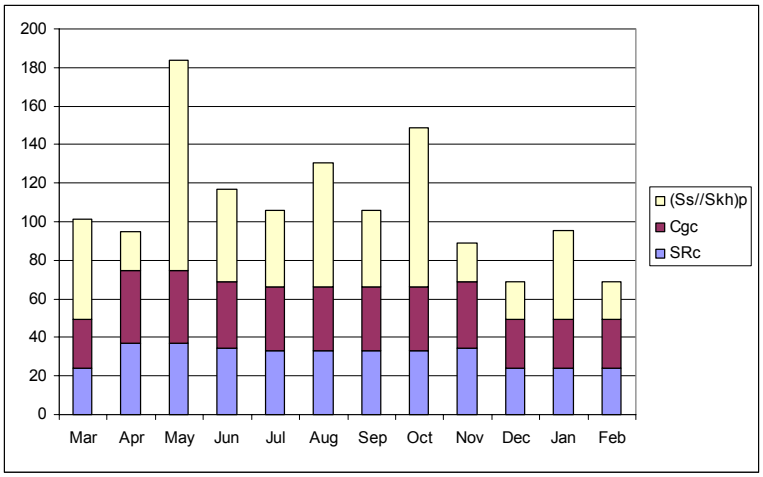


Figure 90: Working calendar for a middle owner of big motor pump, 3 familial workers, growing 7 maad in seif, 7 maad in kharif with 14 sheep, 7 goats, 4 cows and 3 donkeys

Thanks to the good land productivity, compared to the rainy area, and thanks to the land access, those farmers have high income from the cropping system and the animal production represents only 17 % of the farm income.

Like for all large land owners, animal production is a way of savings in case of emergency or problem.

Moreover, this system is widely spread in the South and North West of Wadi Mawr and it produce a lot of sorghum feeder which is sold on the market or directly to traders. Indeed, those large and numerous farms producing sorghum, sell in average 34 % of their production, pay workers with 21 % and consume the remains on the farm. This represents in average 260 packs/maad of sorghum which is sold. Upon the hundreds of maad cultivated in sorghum, it is a very big market.

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Total production		2590		1750			3640		1750		1050		
Workers + Zeka		492		474,25			691,6		332,5		284,55		
Forage available		2098		1276			2948		1418		765		
Small ruminants	**21**	5,25	5,25	5,25	5,25	5,25	5,25	5,25	4,2	4,2	4,2	4,2	4,2
Cows	**4**	6	6	6	6	6	6	6	6	6	6	6	6
Donkeys	**3**	3	3	3	3	3	3	3	3	3	1,5	1,5	1,5
Monthly consumption		427,5	427,5	427,5	427,5	427,5	427,5	427,5	396	396	351	351	351
Stock		1670	43	891	464	36	2557	1130	2151	795	1210	359	8
Sold to the mountain		1200					1000		960		500		

Figure 91: Forage calendar for a middle owner with 14 maad, 21 small ruminants, 4 cows and 3 donkeys

However, not all the land is cultivated by those people. A big part of it is given to share farmers to produce sorghum for themselves. The share farmer, as explained before, gives half of the production, 346 packs/maad, to the land owner. As a result, since he has enough forage from his own production, all the forage from the share farmer is directly sold.

For those farmer, the economic situation seems satisfying, with high income from the farm, completed by the payment from the share farmers. However, as we have seen earlier, the diesel price has increased a lot last year, and is likely to increase again in the coming years. Moreover, on the contrary to the canals and spate irrigated areas, the water is coming from the underground and do not carry any nutrient in the soils. Consequently, the yield is expected to decrease. Even if the sorghum price, with the increasing costs of production, will probably increase, the farm income for those farmers is threatened.

6.3.1.2 Small share farmers facing high irrigation costs

Those farmers were doing the same cropping system that above farmers do until 2005, alternating *seif* and *kharif* cultivation. However, with the increase of the diesel price, it has become a lot more difficult to cultivate sorghum and even not profitable for share farmer to grow it in *seif*, due to the part of the production given to worker, land owner and then for transportation. Because of a well cannot irrigate more land in the same growing season, they alternate, on the same field, one year sorghum in seif and the following one without growing anything.

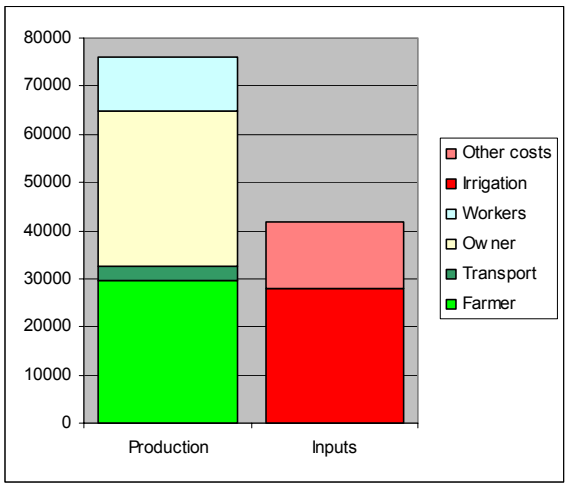


Figure 92: Net return for share farmer growing sorghum in seif

As a result, the farm income decreases a lot as well as the forage production. For those very small farms, cultivating only 2 to a maximum of 15 maad allocated by the land owner, which means 1 to 5 maad grown per year, this situation becomes very critical.

Like for most of the other systems, this one needs 3 familial workers, including the man, the woman and a child.

Since they are share farmer and they give half of their production to the owner, animal production was very important for the farm income, before the increase of diesel price. Today, while they depend even more on cows and small ruminants, 48 %, they meet difficulties to buy sufficient forage. Fortunately, they can graze along the water ways, small canals, irrigating the fields.

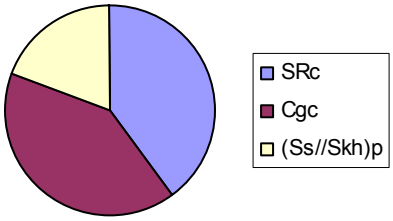


Figure 93: Farm income composition for share farmer irrigated with a big motor pump

Those farmers, because of the high costs of inputs, need a least 12 maad to reach the survival threshold, while 7,5 maad were enough until last year. As almost all of them are cultivating between 5 and 10 maad; it was just sufficient for them to face their needs and it become this year very critical. Most of the farmers met on the field have already sold a big part of their reproduction females, either small ruminants or cows, to buy diesel for the pump, forage for the other animals or to feed the family. Moreover, this very fast destocking have already led some farmers to stop farming and they go and try to find moonlighting in Saudi Arabia.

6.3.2 Nomads depending on sorghum availability to feed animals

In the rainy area close to the wells area, some nomads have installed their houses or tents on lands of big land owners.

Those big families are living on exclusive breeding activities and own big herds of small ruminants, from 50 to 200 animals dominated by goats, but also several cows, donkeys and even dromedaries.

As they live in very dry areas, the nomads depend essentially on sorghum, and settle according to the places where the sorghum is widely available. The men buy regularly few maad to harvest it by themselves, what cost from 20000 RY without grain (*Seif*), to 60000 RY if there is grain. They also buy crop residues to put their herds on, which represent 6000 RY per maad. The men take then the packs to the houses where they are stored and quickly consumed according to the big size of the herd.

During the year in the s*eif* and *kharif* seasons, men take for short periods the small ruminants to graze close to the irrigated area or the mountains, while the women and the children stay at home with the attached cows.

Once a year, they have to go to the biggest city they depend on to pay the government tax on big herds.

The women stay in the yards and are in charge of the milking and the processing the butter, what feed their families. They also ensure the quotidian alimentation of the animals with their husbands, giving sorghum to the herd and concentrates to the young animals.

The men often go on the markets to sell their young animals, and sometimes additional milk. In the same time they buy all the family needs, concentrates and even some sorghum feeder if they need. When the harvest seasons begin, they may propose transportation services, to earn sorghum packs thanks to their dromedaries.

The children are rarely schooled, and the boys help their father to supervise the animals while going grazing. The girls stay at home, and are regularly sent to the closest well to take water thanks to the donkeys.

The nomads always search places where the sorghum is the cheapest. They can stop moving several years, until they find another strategic location to settle further.

Even if they have very big livestock compared to other farmers in Wadi Mawr, the nomads do not have any land and they depend totally on the sorghum market. Even if they sell a lot of animals, sheep goats, cows, dromedaries, the costs of alimentation are very high.

For example, a family with 70 goats, 10 sheep, 1 cow, 2 dromedaries and 3 donkeys has a gross product around 1 430 000 RY. However, the costs for forage, concentrate and drugs get to 1 390 000 RY. In this case the farm income is only 40 000 RY, which is completed by other jobs, harvesting sorghum to get additional forage, transportation by dromedaries or even by going to Saudi Arabia if needed.

Since the sorghum price is increasing, the costs of inputs for nomads would augment rapidly and the farm income would decrease if the price of the animals does not change. Consequently, on the contrary to the general opinion in the area, nomads, even if they have very large herds, face the problem of an uncertain sorghum price, which would have treacherous consequences for those families if it increases just few ryials.

7 AN AGRARIAN SYSTEM ECONOMICALLY DYNAMIC BUT UNBALANCED

7.1 RELATIONSHIPS BETWEEN FARMING SYSTEMS BASED ON SORGHUM EXCHANGES

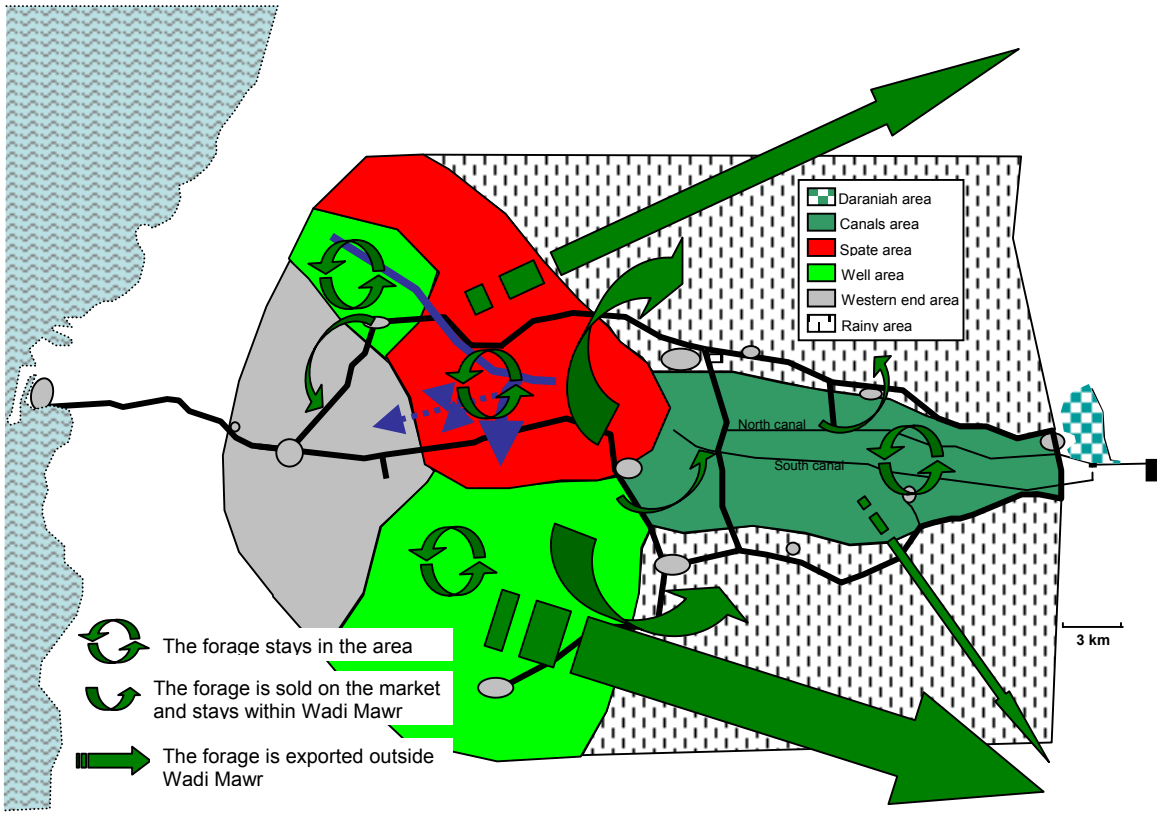


Figure 95: Exchange of sorghum feeder in Wadi Mawr

This figure shows the functioning of the exchange of sorghum feeder produced in Wadi Mawr. According to the TDA technicians working in Wadi Mawr, about 70 % of the production is consumed within Wadi Mawr.

One part stays with one area and is directly consumed on the farm, sold to the neighborhood or paid in kind. Another part is sold to another area deficient in sorghum, for example the owner of well sells sorghum to nomads living in the rainy area or to farmers living in the western part of the canals area, where there is no water for irrigation. Finally, the over production, 30 %, is exported outside Wadi Mawr, through merchant or to farmers coming from the mountains.

As for the share farming, the payment is also done in kind, what means that the share farmer is giving sorghum feeder and grain to the owner. In the relationship between owner and the share farmer the sorghum remains the most important means of payment.

7.2 FARMING SYSTEMS COMPARISON

From the study of the farming systems, it seems that two main factor are limiting the farm potential. The first one is the access to land for all share farmers across Wadi

Mawr, but this point concerns also the small owner in the canals area. And the second point is the access to water, which after the land access, is the most important point.

Those limiting factors, make farms have more and more difficulties to face their needs. When the incomes from the crops are insufficient for the family, they breed sheep, goats and cows in order to increase it. As a result, it appears that the farmers with the fewest incomes depend the most on animal production. However, those poor people do not have monetary means and have difficulties to buy forage, concentrate and drugs.

To sum up, the farmers who most need animal production have usually the worse technical results and the worse livestock productivity.

7.2.1 According to land access

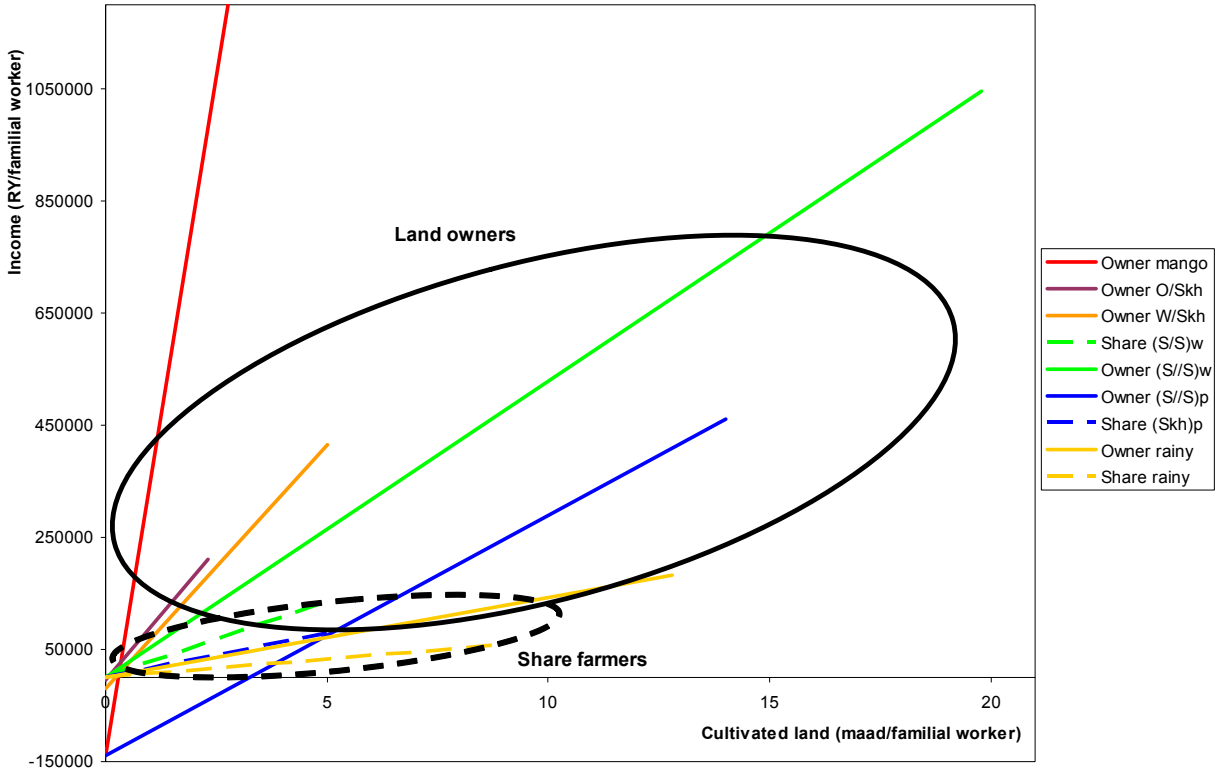


Figure 96: Farm income according to land access

It is clearly observable on this graph that the land tenure is largely responsible for the incomes differentiation between farming systems. The share farmers have to give half of the production to the land owner, what decrease a lot the income generated from the crops. As the crops are in all the farming system, except for nomads, the main resources of income, the wealth of share farmer is directly affected.

Since the income generated for the cropping systems is reduced, in proportion, the importance of animal production increases. As a result, those farmers become more dependent on animal production and dedicate their small cropping production to animals, by growing mainly sorghum.

Indeed, for the share farmer, the income generated from livestock in the total farm income goes from 28 % for share farmers in the canals area, 31 % in the rainy area, to 48 % in the well area; while it goes from 0 to 18 % for land owner.

7.2.2 According to water access

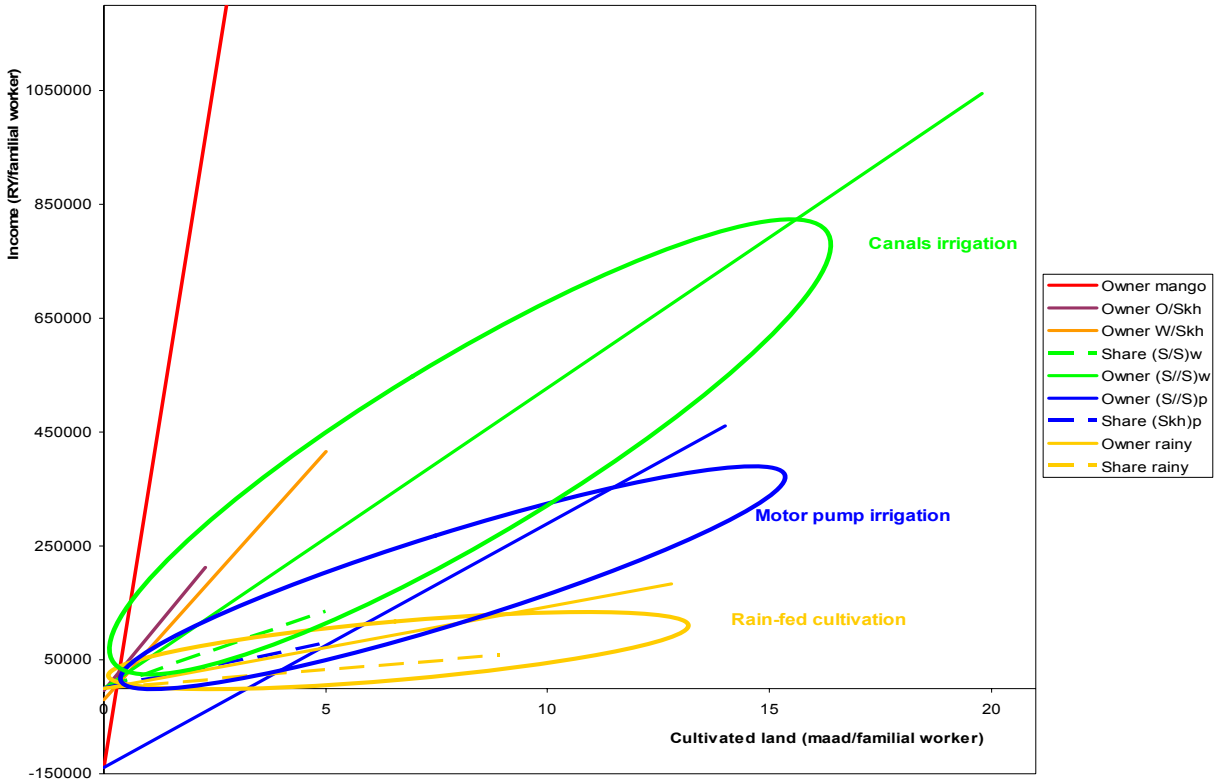


Figure 97: Farm income according to water access

From this graph, it appears clearly, that the higher water access, taking in account the costs of this access, increases the total farm income. As above, the diminution of the water access leads directly the incomes from the crops to decline. As a result, the farmers with less access to water depend proportionally more on animal production than others people having big quantity and secure water.

Indeed, for farmers in the rainy area, the income generated from livestock in the total farm income goes from 30 % for land owners to 100 % for nomads, while it goes from 0 % to 28 % in the canals area.

The support to animal production, would directly lead to the enhancement of poor farmers incomes. From the above results, the focus would have to be on share farmers and on people living in the rainy and in the well area and but also in the western part of the canals area, where farmers do not access water due to canals management.

7.3 EXTERNAL ACTIVITIES ESSENTIAL FOR FARMERS UNDER SURVIVAL THRESHOLD

Sociability threshold:

The sociability threshold, in addition to the survival threshold explained above, is taking in account not only the basic needs to survive, but also the basic incomes to live in the local society. The most important expenditures in Wadi Mawr, like everywhere in Yemen, are for an average family of 8 persons (4 familial workers):

- The qat, consumed daily by people, with a minimum of 300 RY/family/day. The annual cost for qat is consequently 109 500 RY/family.

- The others expenditures concerns the religion events and eventual weddings. Those costs have been evaluated to be annually 75 000 RY/family.

The sociability threshold is consequently higher than the survival threshold and is in Wadi Mawr estimated at 109 725 RY/familial worker.

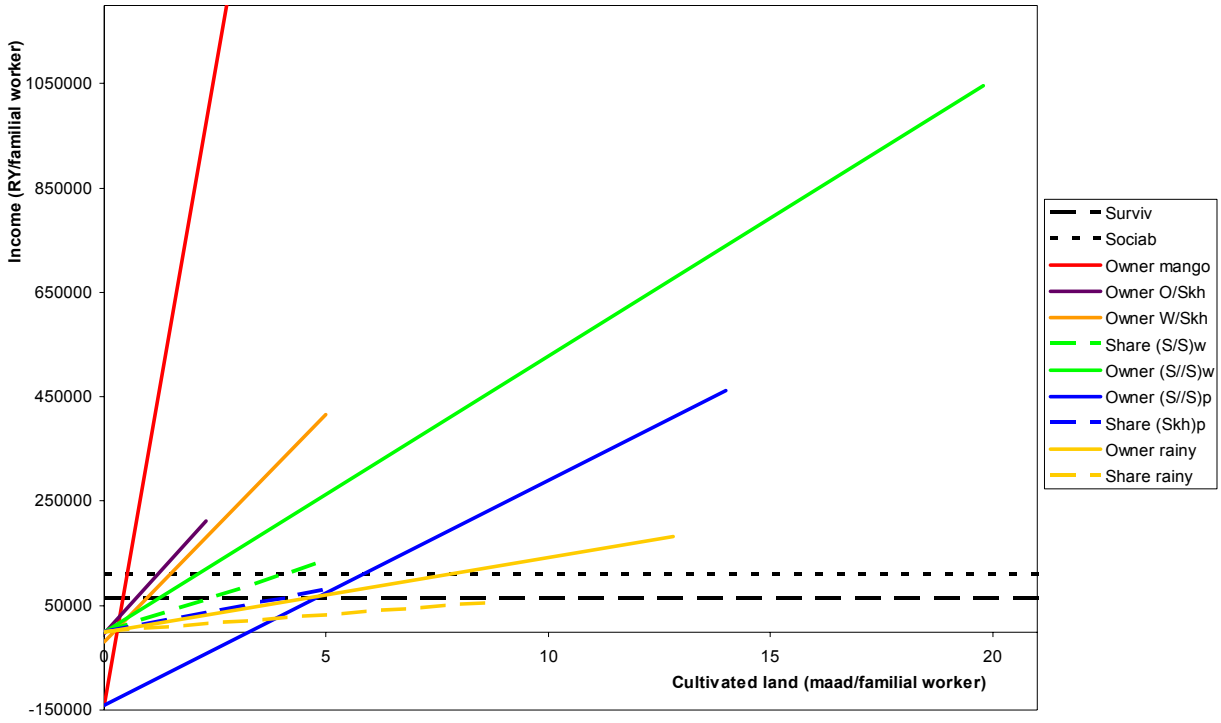


Figure 98: Farm incomes compared to survival and sociability thresholds

Farmers with limited access to land and/or water have low income, and a lot of them are situated under the survival threshold. For those people, the crop and the animal productions are not sufficient and doing external activities is absolutely necessary.

Those ones can be very different according to the needs of the family. It can be sufficient to go and cut some sorghum on other farms during the harvesting period. This additional sorghum can either be sold are used to breed more animals. The farmer or one of his sons can also go and work seasonally or permanently in Saudi Arabia; this is what happens nearly every times.

The incomes of each farming system have been compared with the survival threshold to understand the absolute necessity for farmers to find external jobs. However, it appears that most of the time, the people try to find external incomes until they earn more than the sociability threshold. Indeed, the survival threshold is the strict minimum to only buy food and does not allow any problem in the family and the sociability threshold is considered by most of the population as the minimum level of life.

Consequently, a large part of the Wadi Mawr population is benefiting from the proximity to Saudi Arabia and going periodically there, even if the jobs are today not very well paid, especially for a Yemeni. However, the jobs opportunity in Yemen is very low and almost all poor people from Wadi Mawr are trying to work illegally in the rich neighboring country to make his family live.

8 SOME RECOMANDATIONS TO HELP FARMERS IN DIFFICULTIES

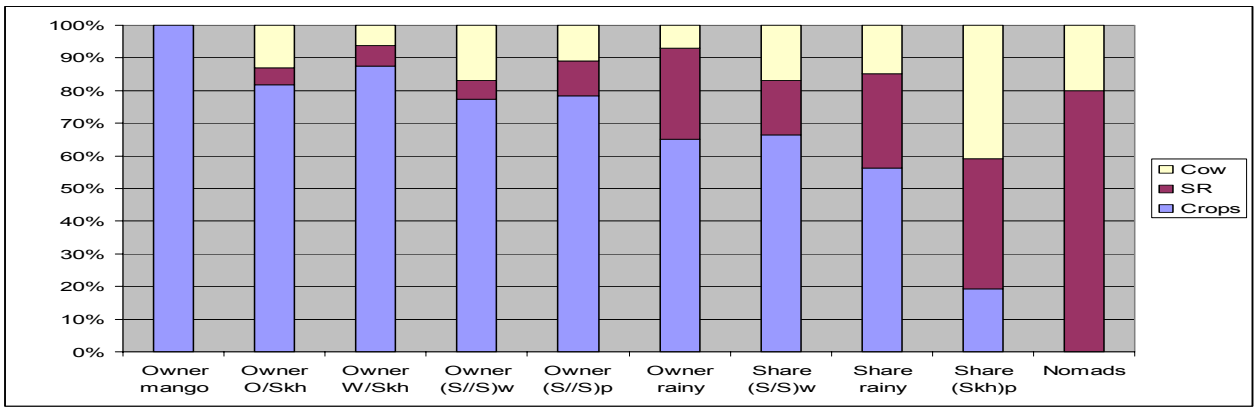
Through this systemic and multidisciplinary approach, the objective of the agrarian diagnosis in Wadi Mawr was double.

The study had to confirm the importance of animal production in Wadi Mawr especially for small farmers, thanks to complete technico economic assessments on the main farming systems.

But it had also to put a stress on main suggestions, for the PADZEY project to implement actions that lead to its first objective: increase the technico-economical results of small farmers through the reduction of the constraints and obstacles limiting the development of their livestock activities.

8.1 IMPORTANCE OF BREEDING FOR POOR FARMERS

It appears according to the current technico economic results (part 6) that the animal production is essential for small farmers. The farmers' incomes are invested in animals that they would sell for any need. In the economic analysis realized in the small farming systems, the animals represent an important part of the farmers' income: by selling regularly young animals in the year, they get the money to buy food, and the milk provided by cows and goats contributes to the food security for the families. The recent economic situation, the high production costs, and for share farmers the few land security, force the small farmers to sell more animals to insure their survival and costs of forage, and are threatened by severe destocking.



Importance of animal production in farm income

It is consequently essential for the project to try to improve the global economic results of small farmers, by aiming especially animal production. The main point to focus on is above the animal alimentation, according to the high dependence on sorghum and the difficulties of its purchase for poor farmers. But health and complementation management are also essential ways to improve the animal performances.

8.2 FORAGE AS THE MAIN CONSTRAIN

8.2.1 Improvement of animal alimentation thanks to new cropping systems

The technico economic assessments shows that the whole area is concerned with an increasing lack of spontaneous pasture and feeder trees, what leads the farmers to a very high dependence on forage that they produce and/or buy.

But for poor farmers, it is very difficult to buy forage as they do not have the money to do it. They often have to restrict their animals, feeding them with insufficient forage quantity, or to sell animals to have money to feed the others.

The *Mossemi* season is particularly difficult for the farmers especially in the rainy area, as there is nothing to graze, as they have low yields of forage, and as the drought added to little alimentation weaken the animals and decrease their performances. Farmers have to find solutions at this period to feed their animals, like going to the irrigated areas and cutting grasses between the crops, or finding external jobs.

The recent increase of diesel price in the well area threatens with destocking more and more small share farmers cultivating on well, and the farmers express their difficulties to face high alimentation costs. They are more and more numerous to give up their cropping activities, and the only solution may be emigrating again to Saudi Arabia.

The spate irrigated and eastern canals areas are little less concerned by forage difficulties, as the water availability and security provide better yields, and some remaining pastures.

8.2.1.1 Other sources of alimentation for the herds

The farmers would agree to the test of any other crop rather than sorghum feeder, that should provide more forage for the animals at low cost. The TDA have already experienced crops such as elephant grass, but it requires a lot of water and must be irrigated. It consequently not adapted. Other crops adapted to loamy sandy soils and resistant to drought should be tested in Wadi Mawr on willing farmers' lands.

Another proposition should be inspired by the traditional crop associations effectuated in the rainy area. The integration of *fabaceae* among the cereals is an interesting way to increase the soils' fertility while allowing another forage supply for the animals, with high protein content. Associations could be reintegrated regularly in the sorghum or millet rotations, especially in the dry areas with low yields, as complementation for the herds.

8.2.1.2 Improvement of the yields particularly for the sorghum

The soils fertility is also an important point. Even if the wadi renews a lot of soils on cultivated lands, the wells area and the rainy area are threatened with a decrease of the soils potentials, especially with the intensive well cropping system. Moreover the yields could be higher than they are for an irrigated sorghum.

In Wadi Mawr, the numerous animal dejections are never used by the farmers, and the non eaten sorghum sticks are always lost and thrown on the villages' ground, eaten by termites. It would be interesting to think about tests of organic fertilization to make on loamy or even sandy lands (ex: dung to valorise the lot of lost sorghum sticks and the dejections, made by watering in enclosed location, and subventions of carts).

Moreover reasoned use of chemicals could be tried on sorghum to increase the forage production available for the whole animals of Wadi Mawr (ex: subventions of basic fertilizers, with contracts on the respect of a reasoned use).

8.2.2 Maximize the daily ration of sorghum feeder

Every day in the yards, the sorghum is given on the floor to all the animals in the same time. Consequently the animals deject on the forage, not everything is consumed. Moreover as the sorghum gives several harvests, the canes given as forage are too big for the animals, which do not eat the sticks.

Solutions to improve the ration and to avoid the waste of the sticks could be proposed, such as tests on upper mangers, or with hashed forage to allow the animals to ingest better the sticks.

8.2.3 A pastoral area to be restored

The non cultivated lands are also divided in ownership, which traditional management has been exposed in the part 2.4.2.The animals have already the right to graze for free wherever it is not cultivated, including most of the crops residues.

But the high number of herds in addition to productive agriculture, wood cutting and dryer climate, have lead to a critical lack of vegetation and to the overgrazing of the remaining pasture lands. The feeder trees such as acacias have decreased, and the area is colonized by the invasive *Prosopis juliflora* that threatens the ecosystem.

In the canals' area, the animals still graze on the canal banks or on the numerous resting lands. They are mostly small ruminants, but also cows when the farmers cannot provide enough forage. But in the spate irrigation or well areas where all is cultivated or in desert resting lands, or in the deserted rainy area, the animals often stay in paddocks. Consequently the goats, traditionally eating trees and less adapted to those cultivated lands, are not fed as well as before.

Due to the drought of the *Mossemi* and *Shubat,* but even *Seif* when the rains are very rare especially in the West, the resting lands of the dry areas are not usable and in the canals area they are very few. It seems impossible to sow herbs to make the animals graze on the resting lands.

New implantation of endemic trees such as acacias or *Ziziphus spina christi*, but also other trees resistant to drought and adapted to sandy soils and deep groundwater would be a way to give back pastoral areas at least to the goats. The trees could be planted in the area, for example one or two per maad cultivated, what would not disturb the cropping activities, to be then grazed during the resting land periods.

Measures to slow down the invasion of *Prosopis juliflora* in the area can be developed especially in the wadi area where it sucks dangerously the ground water.

8.3 HEALTH AND COMPLEMENTATION TO IMPROVE PERFORMANCES

8.3.1 Necessity of a better health management which implies trainings to farmers

Farmers regularly complain that their animals face diseases, such as fever, diarrhoeas or colds.

The arid conditions influence the health: they limit the parasitism compared to very humid areas, but increase the risks of mortality with the heat. The canal and spate irrigation areas are concerned by more diarrhoea problems than the rainy area, especially during the wadi seasons. But the rainy area faces high mortality rate during *Mossemi*: the drought affects indeed the milk production and implies more dead young animals, and sometimes the death of adult animals which are already weakened by the lack of forage. Moreover some poisonous plants may cause problems of abortion and death to the grazing animals. Finally, the cows which always stay attached face logically less parasitism than the grazing ones.

Some recurrent graver diseases occur also, like PPR, and other infection. The farmers are aware of those main problems and vaccine their animals.

But the study points out that they rarely use medicine for current diseases for their animals' health: they usually cannot identify the diseases, or do not have saved money to face this cost anytime a disease happens. Moreover, the veterinarian centre is located in Al Zuhra what is too far for most farmers in case of emergency, due to the long distance.

The TDA during the first ten years of its work in Wadi Mawr has lead big campaigns of vaccination, especially in the canal area, for PPR and for external and internal parasitism. Veterinarians and skilled technicians were wandering in all the area to administrate drugs to the farmers: the drugs were previously offered, than sold at interesting price by the TDA (lower than the market price) in numerous centres spread in all the area.

The meetings with farmers show that they are all aware of the importance to cure their animals. But they explain that during this campaign period, they were not taught about the identification of the diseases, and few about the drugs to take and the way to cure their animals. Now that the TDA's campaigns have almost disappeared, some of the farmers are indeed still not able to recognize the diseases, and the prices of the market are impossible for them to face. In addition to this, most of the veterinarian and drugs centres are not efficient anymore.

8.3.1.1 Farmers' trainings

Consequently, it would be important to make laboratory tests on herds to identify the main diseases and parasites that affect the herds, in all the area including the canal area despite the TDA's previous actions.

The farmers, asked in both Al Rosfa and Al Nasheria, are expressing their need of trainings to identify health problems and on health management like how to administrate drugs, and wash animals for parasitism. The farmers agree with the idea to receive advices and to diffuse them to other neighbours or family farmers.

The women and the children have to be focused with priority in these trainings, as they are responsible for the quotidian feeding and milking of the animals, and are the first aware of any problem in the health of their herd as they confirmed during the meetings.

8.3.1.2 Low prices for drugs

This first step should be followed by accessible prices for the basic drugs concerning the most common diseases of Wadi Mawr. The drugs have to be sold whatever the farmers need, as to say very small doses available.

8.3.1.3 Rapid supply thanks to numerous centres

The TDA technical centres in the area should work in cooperation with the project and provide easy and quick access to the farmers to be able to cure quickly their animals.

The nomads should be integrated in this health program, has they have very big moving herds that can contract disease at larger scale and propagate them to the other herds in the common pastures. Moreover as big breeders, they often have a developed animal management that could be interesting to be studied.

8.3.2 A genetic selection to improve the reproduction management

The breeds available in Wadi Mawr are well adapted to the dry area and resistant to diseases. The sheep of the area are known for their high ability to have twins, and the goats of Wadi Mawr have good meat performances. The zebu breed is also giving sufficient milk to the families while being fed with few forage.

However the farmers never do any selection for the reproduction of their herds. The males are not chosen for their performances but only for their easy availability, most of the time animals of the neighbourhood. The imported Wadi Surdud breed is more and more mixing with the local goat genes, what would lead to the lost of the local characteristics. It would be interesting to do investigation about the potential of this local breed to know if it needs to be protected or not.

A selection project for local breeds could be interesting, to provide the area with males with typical genetic characteristics, especially for the small ruminant and their meat performances (ex: pool of males could be bred by the project and lend to groups of organised farmers)

8.3.3 The complementation, very important for the herds

Crop residues in the fields are an interesting way to valorise the last harvests. The farmers already know it, as they lead their animals on the residues mostly for free.

Another important point is the use of concentrates. In the same time as the drugs, TDA has spread a campaign for their use, with good prices. Now thanks to this campaign, all the farmers are aware of the benefits they can make by fattening the young animals, but unfortunately they cannot buy regularly concentrates. This activity is consequently spread in all the area, but rarely well realized in small farmers' herds. Indeed, the farmers cannot provide themselves with concentrates as they never have the investing capacity. During the meetings, the farmers agreed with the benefits to group themselves and of the realisation of credits for the purchase of concentrates, even if the Charia does not encourage those initiatives.

As for the alimentation, all the recommendations concerning home alimentation should particularly be made to the wives of the farmers that manage the alimentation of their herds. This can be effectuated with the cooperation of the *murchidat* who knows the fields and a lot of women of the area.

8.4 OTHER SUGGESTIONS FOR THE ECONOMIC DEVELOPMENT OF SMALL FARMS

The small farmers do not manage to produce or buy all the sorghum they need in the year, especially in the rainy area where the animals are constantly depending on sorghum feeder and consequently under nourished.

However, even if a lot of sorghum is produced in the area, it is sold in other regions, as the lack of sorghum for the local small farmers comes only from their lack of incomes. So it is not the first aim to help the constitution of bigger herds, if the farmers cannot feed them.

Propositions to increase farmers' incomes could go beyond the animal production and support the general economic activities of the farming population. The livestock is admittedly essential for the farmers' budget management and for the production costs, but the main family incomes are made by the cropping activities.

Technical support on livestock is essential, but not sufficient to help the poor farmers who need also to insure their crop yields. In parallel, giving the farmers means to increase their incomes would allow them to buy enough sorghum for their animals.

Indeed the systems analysis allowed us to understand that the animal production performances depend mainly on the total farm income which mainly comes from the crops. As a result, the support to animal production has to work not only directly on the animals, but also on the global farm income.

Non agricultural support can also be implemented, like support women-made crafts, such as basketwork, pottery, to give more income sources to the families.

CONCLUSION

According to its ecosystem as well as the people using and managing its resources, Wadi Mawr is a contrasted area which has been invested for centuries for its agricultural and breeding possibilities. Mainly turned to subsistence production, the area was dominated by big capitalistic farms and cultivated by very numerous share farmers.

In the beginning of the 1970's, the Revolution has restructured the land ownership. All the lands likely to be cultivated have been little by little invested to nourish the fast growing population, supported by the government which improves the production and makes it turn to a wide market orientation. The pastures have become rare and overgrazed, distinguishing few breeding activities still using little pastures from the wide majority now relying only on forage. The sorghum has increased to be the most important production, dedicated to all the numerous herds of the area, or to other regions of Yemen.

Nowadays, the land is still completely divided, in ownerships of various sizes that insure land security to some persons. The poorest farmers still have to share their production to be able to cultivate, and more breeders without any cropping activity manage their big herds by going over the whole landscape.

This wide oasis of an arid plain, where the public policies have redistributed the wadi flow, provides the farmers with different water accesses, and various cropping possibilities. The water security, thanks to the groundwater use, is allowed only for the farmers who have been able to invest high capitals from Saudi Arabia or external activities, in the purchase of a motor pump.

But whoever they are, the majority of the farmers of Wadi Mawr have always been investing their incomes in their herd, to make profits on their savings but also to insure daily food security to their families. Now they all depend on sorghum, and dedicate all their cropping production to buy forage and cover the needs of their animals. For the smallest farmers, the current high production costs, or the lack of access to land, limit their incomes and make them very vulnerable: they often are prevented to feed their whole herd, and have to destock or search profitable extra jobs.

Due to the importance of livestock for familial budget management, allowing better animal production to the small farmers would surely imply sales at higher price, and higher possibilities for personal or farming investment. Consequently providing technical support based on trainings of women and men, such as improvement of forage availability, health services, fattening of young animals, are important. But to feed and cure their animals, the farmers need money. In terms of income sources, the economic results of the farming systems show that the crops are the most important. The project should also be widened to largest objectives: for example a study of crops channels and possibilities to increase the land productivity in the most critical situations, or extra ways of insuring money to farmers to buy sorghum and face the other production costs.

However, we are conscious that the unequal land ownership and water access prevent a lot of initiatives to develop in Wadi Mawr. The better solution would be a land redistribution that would allow everybody to have lands or to increase his surface. Moreover, the water security permitted by groundwater is possible as long as the wells are not too numerous.

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Annex 1: Methodology

USING AN AGRARIAN DIAGNOSIS SURVEY TO ANALYSE WADI MAWR AND TAIZ AGRICULTURE

Lionel **ROUX**
Michaël **SPADA**
Elvia **TEOTSKI**
Floriane **THOUILLOT**
ESAT1 STUDENTS, CNEARC

March 2006

1-CONTEXT AND OBJECTIVES OF OUR STUDY

The main objective of the PADZEY project is to contribute to the development of animal production in order to reduce poverty in two pilot rural areas of Yemen where herding is an important activity: Wadi Mawr in Tihama Province and Al Barh in Taiz Province.

The PADZEY project aims to increase in a sustainable way the incomes of the small farmers in the two pilot areas of the project by:

- Improving the traditional techniques of animal husbandry and processing of Taiz cheese to increase production and improve the quality (hygiene, public health issues);
- Diversifying agricultural production and increasing the value of the products by improving processing and marketing;
- Promoting sustainable management of natural resources (soil, water, fodder crops, genetic resources, and land tenure).
-

To help the staff of PADZEY project implement and carry out activities, our objectives are to:

- provide basic knowledge on the different ecosystems, agricultural activities, different modes of exploitation, and on the main natural features of the two project areas since little information is currently available.
- help PADZEY staff elaborate appropriate project strategies by characterizing the farming systems in the two areas, their constraints, potential, and possible evolution.
- create a data base (technical and economic) on animal production systems to enable the project to provide technical and economic advice and to monitor changes in herd management.
- identify the main regulations that affect management of natural resources, the main constraints, and identify possible zones to create committees to implement micro projects to improve natural resources management. The study will focus on the natural resources used for the animal production (pastures or forage resources and water).

2- IMPLEMENTING AN AGRARIAN DIAGNOSIS SURVEY

To fulfil the above objectives, we need to identify and understand agricultural practices, and the decision-making process of the farmers who implement them. We need to identify the environmental biophysical potential, characteristics and constraints

of the different ecosystems as well as the socio-economic organisation and the dynamics of changes.

First we have to consider that the agricultural situation is not always easy to understand because of its *complexity* and its *diversity*. *Diversity* relates to the difference between farmers, even within a small region, where farmers have developed different practices depending on the farm's origin and history; their capacity to mobilize resources and combine means of production. In this way farmers cannot be considered as a homogeneous group. *Complexity* refers to the fact that the process of agricultural transformation is determined by a set of factors that interact at different levels of organization. Consequently, knowledge and information have to be integrated at different scales (the plots where the crops are grown, the herd, the farm, the region). How a particular element functions at a given level needs to be examined in its context (for example: a new regional road may influence farm production in terms of market access). This means that in order to understand a problem identified at a given level, it may be necessary to look at the situation at a different scale.

As the social, economic and technical context is always changing, and farmers have to adjust to these changes to achieve the objectives of our study, we need to analyse the complexity and the dynamics of all these changes to understand how and why rural communities exploit their ecosystem today and for what kind of result (standard of living).

Thus, we propose to implement an **Agrarian Systems Diagnosis.** This is a systemic and multidisciplinary approach that emphasizes interactions between the different systems components at different scales. It moves from the general (regional scale) to the specific (farm or plot scale) situations. It allows to answer in a relative short time (4 months) to the main questions:

Who are the farmers? What are they doing? Where and Why? For what results? Can they survive from their agricultural activities and sustain their farm? What the main trends of agricultural development including natural resources management and farmers differentiation?

Our basic hypothesis is that farmers have good reasons to do what they do. The agrarian systems diagnosis aims to identify, understand, explain the diversity of farming households, practices and their origins, reasons of being. It allows then to assess main future trends and the conditions of changes.

3 SYSTEMS DEFINITIONS

Doing a agrarian diagnostic survey suppose to work at different scales of organisation (regional scale, farm scale and plot or herd scale). To each of these scale a system concept is associated:

At the plot scale, for a set of plots cropped in the same way in a given agro-ecological environment, a **cropping system** refers to specific spatial combination and temporal succession of crops and their management.

At the herd scale, the **animal husbandry system** refers to a set of animals bred in the same way for one or several end-products.

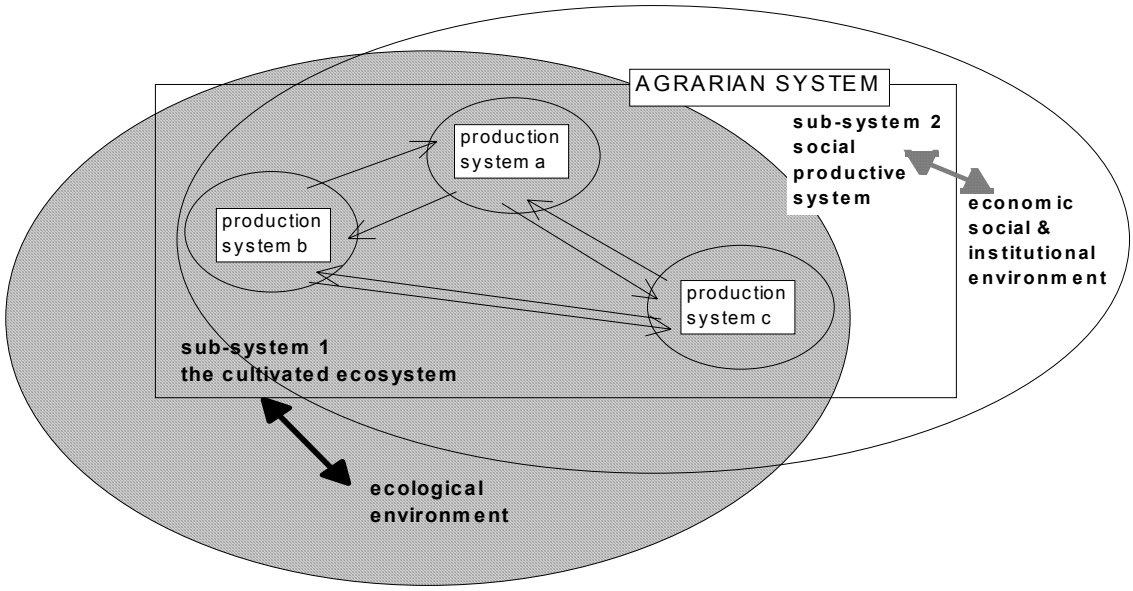
The **processing system** refers to activities led by the household to process farm end-products. For example, the milk processed into cheese in Taiz area by farmers.

At this stage, we are still working at the scale of the plot or the herd. The analysis has so far taken little account of the overall production unit. At the farm scale the concept associated is the **farming system**, which is " a mode of combination between land, labour and capital in order to produce crops and/or herds, identical to several farms. A farming system is characterized by the kind of products, labour (qualification), means of production used and by theirs proportions" Reboul (1976).

At the regional scale, several farming systems together and the interactions between them constitute an **agrarian system**. The agrarian system is the sum of relationships between the farming systems and the general social and economic organisation of the whole society. M. Mazoyer defines the agrarian system as: "**a mode of exploiting the environment historically created and sustainable, a system of production forces adapted to the bioclimatic conditions of a given space and responsive to the social conditions and needs of that moment**". In FAO, 2002. *Guidelines for agrarian systems diagnosis,FAO Land tenure service rural development division,69p,*

The internal coherence of the mode of exploitation of the environment raises questions about the overall technical, economic and social conditions of production. Mazoyer identifies the following essential variables which combine in an agrarian system in one form or another:

- the cultivated ecosystem: original environment and its historical transformations
- the production elements: tools, machines and biological materials (cultivated plants, domestic animals), and the social manpower (physical and intellectual) to manage them.
- the mode of transforming the environment resulting from reproduction and exploitation of the cultivated ecosystem.
- the social division of labour between agriculture, craft industry and industry which allow a) the reproduction of work tools, b) the production of agricultural surplus and c) the satisfaction of other social groups, beyond the needs of the farmers.
- the exchange relationships between these different but associated sectors of the economy, the relations of ownership and strength which determine the share of the production work, of the production and consumer goods.



The Agrarian System: a complex open system, made of two sub-systems (based on Mazoyer, in Land Reform 1992-93, FAO)

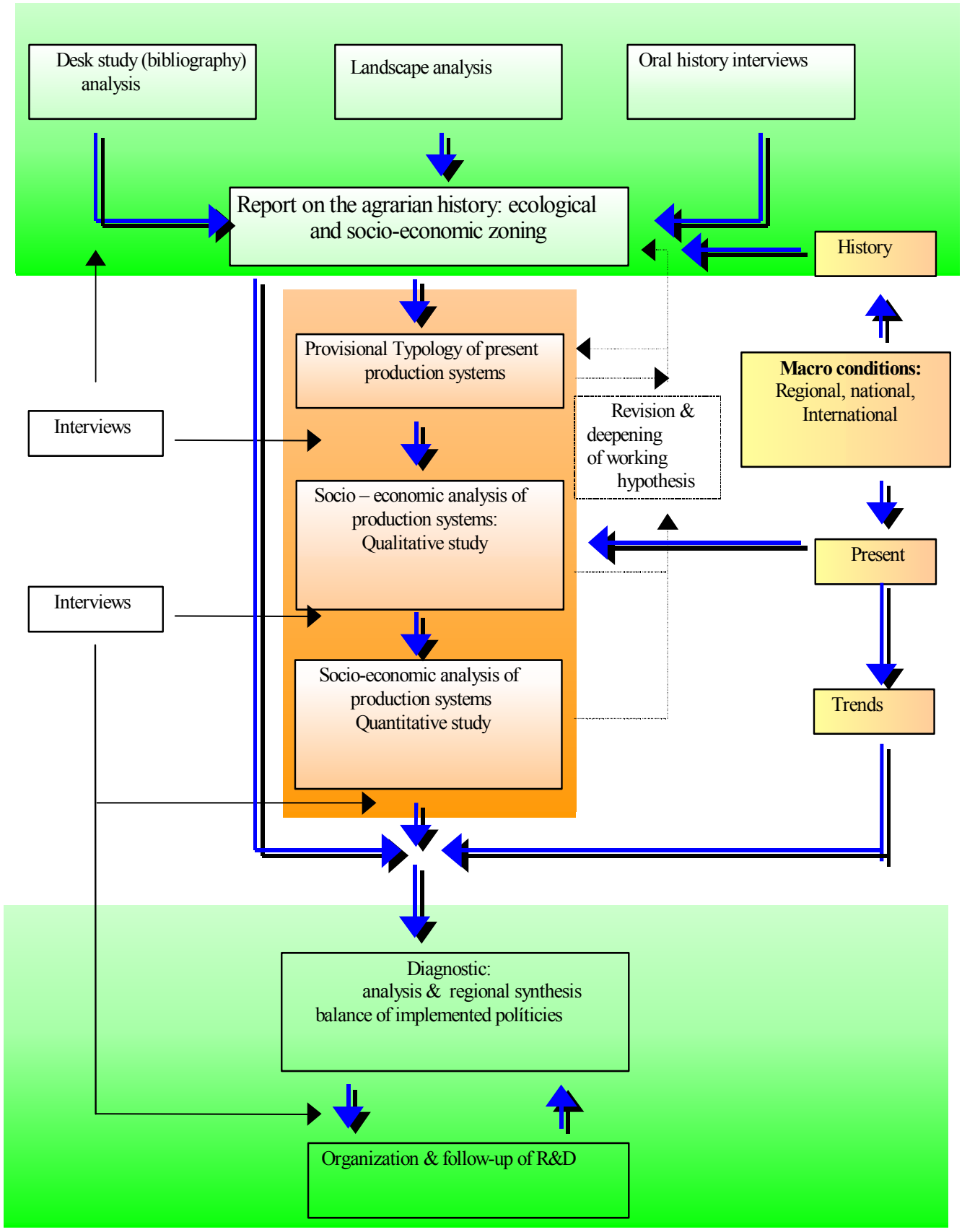
It is important to say that theses concepts are useful for giving a simplify but explicative representation of the complex reality.

4- THE GENERAL OUTLINE OF THE STUDY

In order to achieve the agrarian diagnosis survey our work will be divided into five steps:

- **step 1**: at regional scale: main bio-physical, human and socio-economic characteristics and main modes of ecosystems exploitations.
- **step 2**: at farm scale: historical assessment of agricultural transformations, identification of the diverse situations faced by farming households and drafting of a preliminary typology of the areas farming systems.
- **step 3:** at farm scale: technical and economic analysis of the different sub-systems (cropping systems, husbandry systems) and the agricultural product processing systems;
- **step 4:** at farm scale: technical and economic analysis of farming systems;
- **step 5:** comparison of the economic performances of different farming households in the area, analysis of the different exchanges between farming systems, synthesis on agricultural differentiations and changes, discussion about the importance of husbandry systems in the economy of the families and of the area; discussion of the outputs and proposals with the local population, proposition of actions (justification, conditions, expected impacts)

➢ The following graph presents the logical progression between the different steps in the agrarian systems diagnosis survey. For our work the last step will focus on the discussion of PADZEY project activities, priorities, constraints and conditions.



The different steps of the proposed method (FAO , 2002)

4.1 - STEP 1 - LANDSCAPE ANALYSIS

This step consists in identifying the different types of ecosystems in the study area and the agricultural practices, including the management of natural resources developed by the different farms.

The biophysical environment, the existing infrastructure, and the socio-economic and cultural characteristics of the region have to be examined. The most important features to analyse in this step are the historical and spatial aspects of land settlement, and agricultural practices.

This step relies heavily upon secondary data (topographic maps, statistical rainfall data, earlier surveys, etc), field observation and knowledge of local people, and is essentially an overlay of both kinds of knowledge. Fieldwork is necessary in order to observe the agricultural landscapes and discuss with the farmers to make hypothesis on the mains environmental factors affecting the different agricultural practices. In this kind of study, the landscape analysis is principally used to save time and to improve the accuracy of further in-depth rural appraisal. Local empirical knowledge, observations and secondary data complement one another. It is a real participatory work because it is based on a permanent dialogue between the local people and the investigators .

The **objectives** of the first step are to:

- describe the regional characteristics in terms of biophysical resources (water, vegetation, soil)
- identify the natural resources and man-made agricultural infrastructure, their use and access for different categories of people;
- pre-identify the main types of agricultural practices and farming systems and provide possible explanations for their diversity,
- pre-identify past and present agricultural and socio-economic changes,
- use these results to select zones for further study in step 2 (see below).

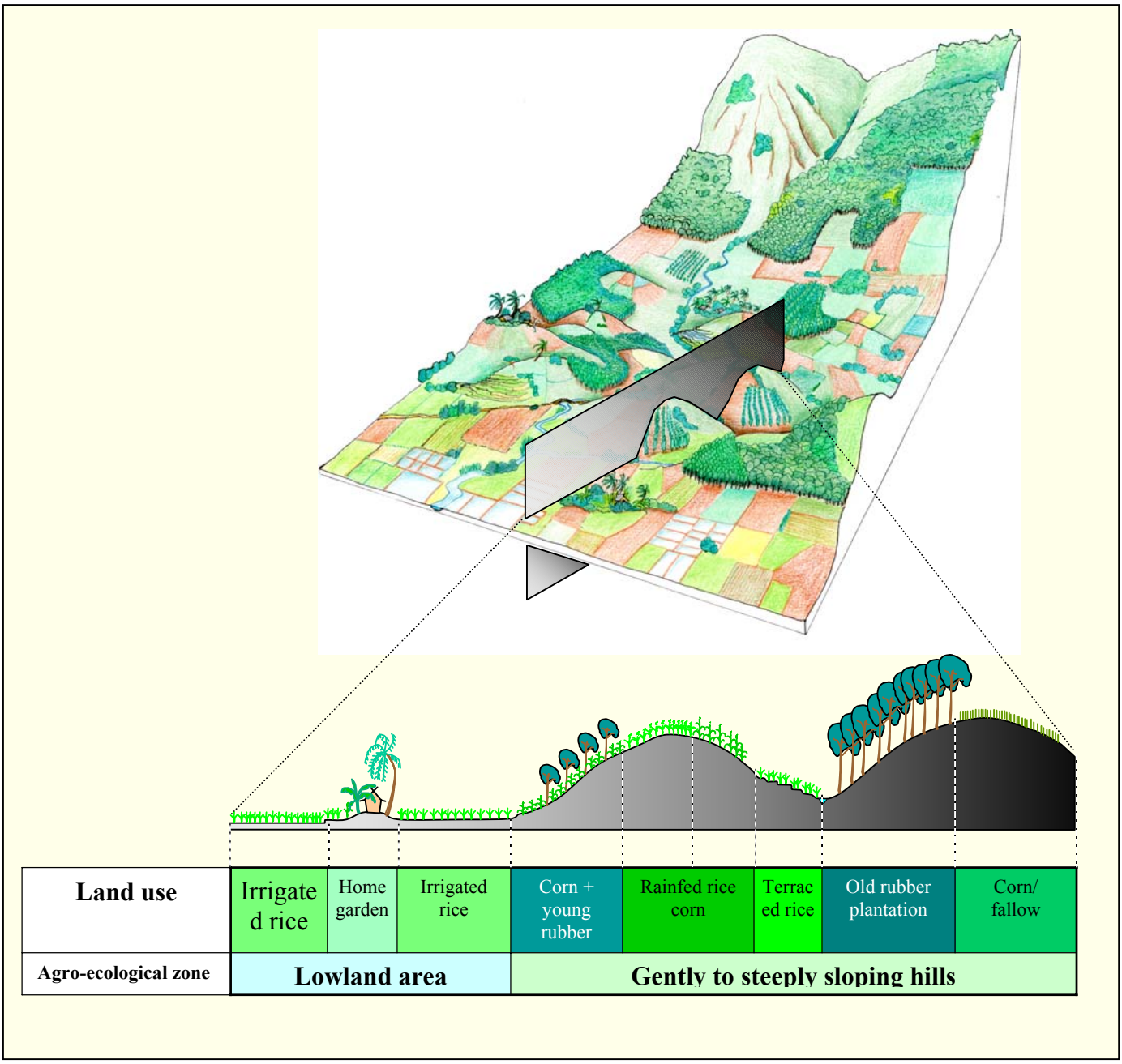
To achieve these objectives two investigative tools should be used:

- visual observations;
- interviews with key resource persons.
- bibliography

The main expected **outputs** for this step are:

- agro-ecological zoning of the area (maps, diagrams and transect models): zoning means the division of an area into smaller units, which have similar characteristics;

How to make a transect diagram:



provisional typology for agricultural holdings.

4.1.1 -Carrying out a landscape analysis

The landscape analysis provides the first objective impression and description of actual landscape. When conducing a landscape analysis, it is important to put aside any preconceptions to ensure that one's observations are as objective as possible. We should observe landscape, raise some initial questions and make assumptions, which make up the first set of data and hypotheses. This preliminary investigation provides the basis of subsequent work.

To describe the landscape, we have first to describe the more general features from an elevated point, but we also have to walk and look at the immediate surroundings. So we have to use an iterative process at different scales.

The landscape analysis can give rapid information on important ecological and socio-economic environment, agricultural practices and differentiation of farmers. We have to observe: - Soils, geomorphology, climate

- Rivers, lakes, hydraulic infrastructures (irrigation systems, wells, other specific watering systems for animals etc.) ;
- Cultivated species and natural, spontaneous vegetation, which are often good indicators of the substratum or climatic characteristics or of a former activity;
- Development stages of cultivated species and specific cultural practices (contour ploughing on sloping land, terraces, rotations, crop associations etc.);
- Types of fodder resources, kind of their management (pasture with fences, etc) ;
- Size and types of fencing around the fields;
- Animal species, herd practices ;
- State of roads and other infrastructures such as market, schools, etc.;
Etc..

4.1.2 - Interviewing key resource people

Development agents and agricultural officers are stakeholders in agricultural development. They have their own point of view about the actual agricultural situation and its evolution. They have their own explanation of interactions between different factors such as geographical features and choice of cropping systems.

Interviewing stakeholders (farmers, original settlers and any willing knowledgeable persons) who contribute to the region's agricultural development is an excellent way of obtaining complementary information and of analysing the different observations we have made in analysing landscapes. It is also a way of discovering the local terms used to describe the different types of biophysical resources. How local people classify things is often different with technical or official classifications. Local land classifications are especially important to discuss with farmers during the next steps.

These interviews enable us to propose and compare the hypotheses we have already formulated about the main different farming activities and their relationships with agro-ecological and socio-economic factors. These hypotheses will be validated and completed step by step along the whole survey.

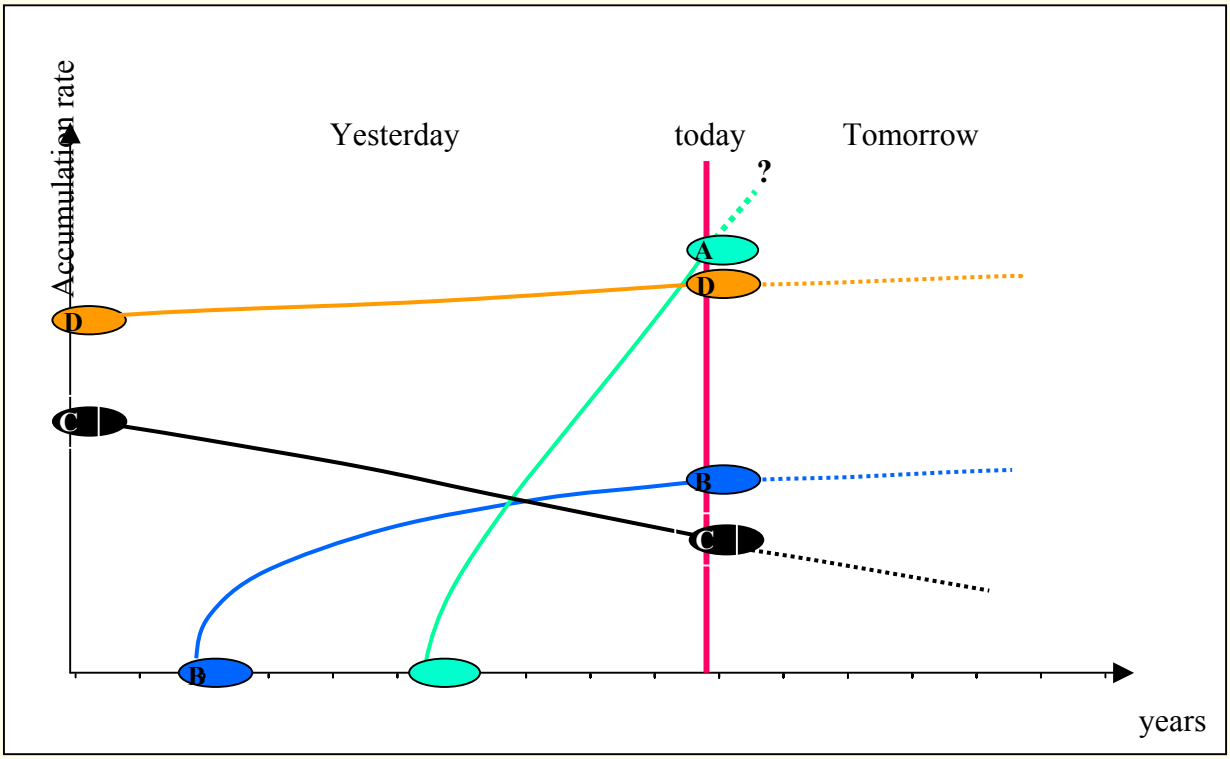
4.2 - STEP 2- HISTORICAL STUDY

At this point of the investigation it is important to consider the different evolutionary patterns and the actual situations faced by the farming households in the area.

The **objectives** of this step are to:

- look for the main evolutionary steps that the area has gone through and to focus on agricultural and socio-economic changes,
- identify the origin of the diversity of farming households and the foreseeable changes in agricultural systems.

The need for a dynamic approach.



Knowing the past helps understand the situation today and can contribute to forecasting tomorrow. *By taking into account the existing featurws of these four farms, we can identifiy the similarities (A and D were established recently, while B and C are inherited or holding farms), but when we examine their historical development, we see that four different pathways were used. Farm A is presently undergoing a rapid accumulation rate that we assume will continue if the current economic conditions prevail. Farm C is engaged in a process of decapitalization that will require analysis to understand the reason why and to find possible solutions.*

These objectives are achieved using interviews with key resources persons, mainly original settlers and old farmers but also village leaders, school teachers, agricultural shopkeepers, etc. The quality and openness of the questions are the key to a good historical interview. The historical survey should be sufficiently detailed to enable a rough comparison between the different situations in the area. We have to conduct a detailed analysis of the different phenomena that have occurred over time. Scientific and technical changes (such as the introduction of chemicals, new tools, new species) should be related to social changes (demographic evolution, changes in land tenure, etc.) and economic changes (opening of new markets, major changes in price ratios, etc.). Therefore, the data already obtained should be complemented, cross-checked, and questions to be asked so that it is possible to establish the correlation between the changes that have occurred.

In order to understand the past evolution of agriculture, the following data should be collected:

The village's demographic evolution;

The evolution of livestock population;

The natural changes of biophysical resources, essentially for water and fodder resources;

The changes in crops and livestock species, tools, etc.;

The evolution of infrastructure (roads, watering points, irrigation infrastructure, markets, etc.);

The changes in agricultural policies;

The evolution of resources access rules and agricultural practices;

Etc.

The expected **output are:**

- a list drawing up of when the changes occurred, their causes, and their impacts on the agricultural practices and on the differentiation of farming households;
- a pre-typology of the current farming systems of the area.

At this point, we should discuss about the importance of animal husbandry systems in the regional and households economy. The PADZEY Project has indeed required an agrarian diagnostic survey focused on husbandry systems. So it would be important to discuss with the project staff about the sampling of farming systems we will focus on for the next steps (only farms including livestock or not?).

To facilitate exchange of information and choices of farming systems sampling, we will write a synthesis of the main results (regional presentation of the different agro-ecosystems, the different farming systems and households, main trends and problematic of agricultural development) in majority still at the stage of hypothesis.

4.3 - STEP 3- SUBSYSTEMS ANALYSIS: CROPPING SYSTEMS, ANIMAL HUSBANDRY SYSTEMS AND AGROPROCESSING SYSTEMS

Thanks to the step 2, we have identified the main different farming systems of the area. At this point we are going to focus on zootechnical and agronomic aspects, and economic performances of each sub-systems that compose each farming system. This study is done at the farm scale.

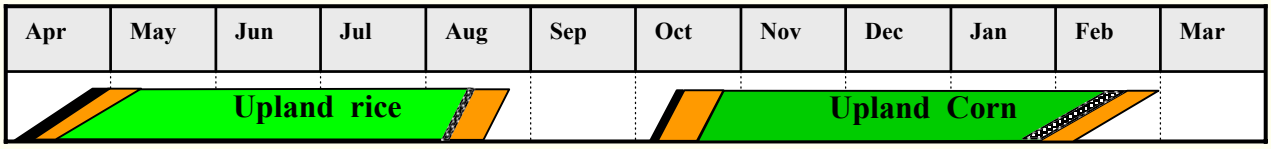
It is important to note that we will collect data of the current year, but as they may be not representative enough of the efficiency of the systems, we would have to find the ways to identify with farmers the yields variations, theirs explicative factors (such as climate) and frequency. We would have to characterise the quantitative performances of the systems (yields, etc) in a normal year (more frequent), a bad or good year.

4.3.1 - To study a cropping system we need to:

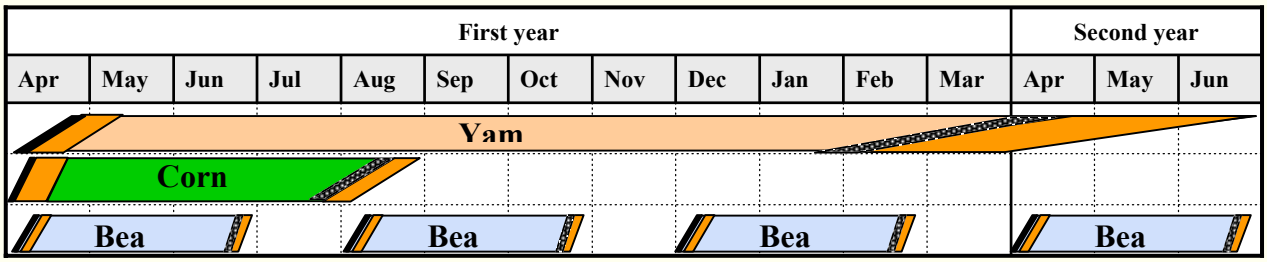
- identify the agro-ecological environment in which the plots are located for each cropping system. The area used for a specific system should be assessed in order to determine how land is allocated to each system.
- characterise the specific spatial combination and temporal succession of crops.

- describe and analyse the technical sequence (the logical and ordinate sequence of cropping operations) from tillage to harvesting for each crop.

The first example shows what the crop sequence on one plot could be:



The second example shows another possible crop association (corn, yams, and beans).



Length of the line = duration of the

- Planting
- Inter-annual variability of the start of the
- Harvesting

Caution:

- *in some cases the yearly cropping pattern extends over more that 12 months (e.g. five lowland rice crops over 2 years).*
- *in some cases the crop sequence can be tightened by first growing the rice in a nursery, then planting out in the field. In this way, rice producers save time and the rice fields are constantly in production.*

➢ *Diagrams to show the yearly cropping pattern*

We need to find about each operation the main following data:
When does it take place?
Who carries out the operation (family or external labour, number of workers)?
How? Which tools are used? What draught power (equipment, tools and animals which are owned, shared, or hired)?
Which inputs? How many? When? Origin and cost?
How much time does the operation take roughly (total days of man-work)?
Why? (It is important to remember that nothing is obvious and everything is open to question)
What are the main constraints facing the farmer in relation to the technical sequence? (pests, climatic problems, buying inputs, water access...)

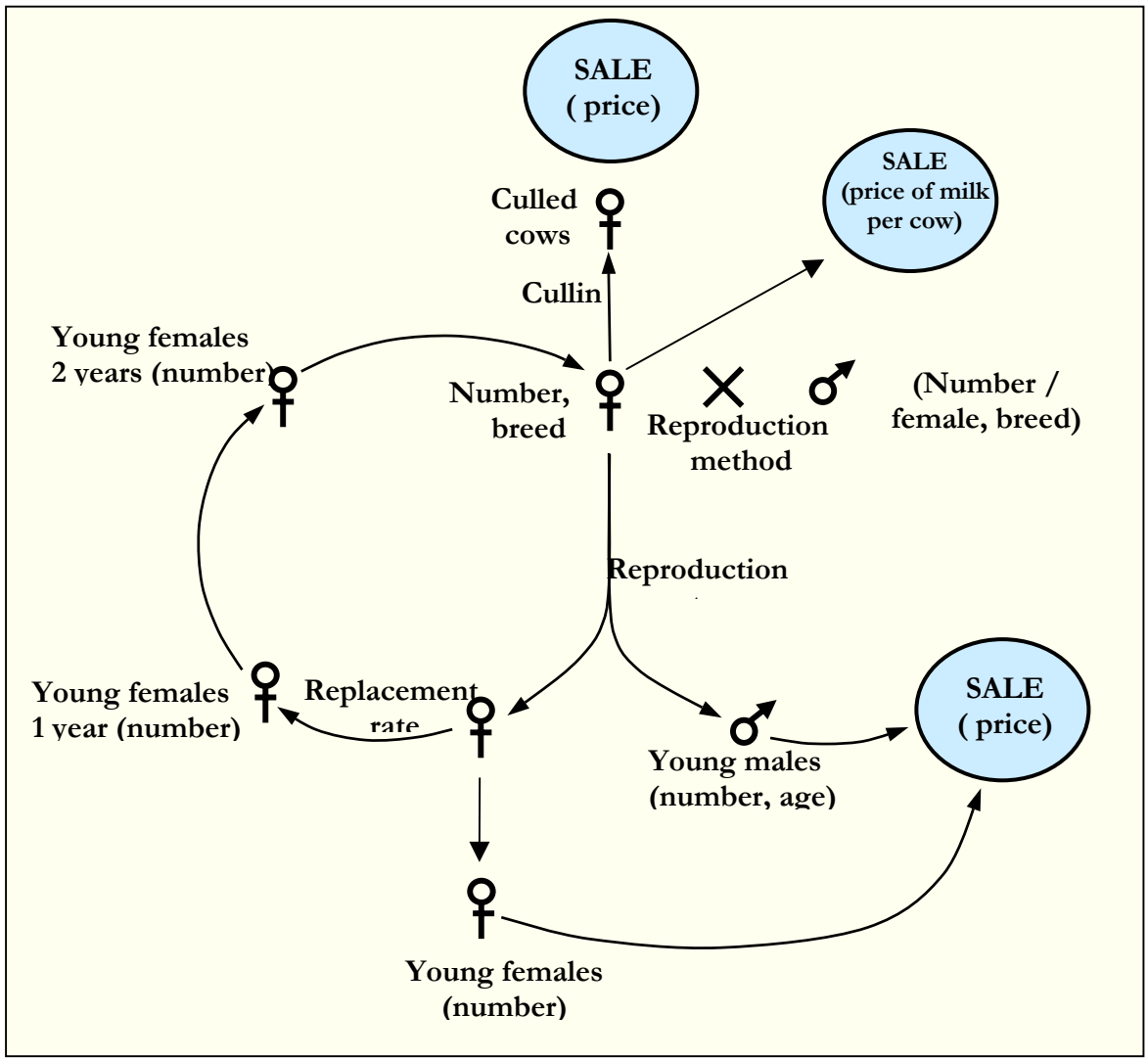
- estimate the efficiency of the technical sequences by asking the different yields and their variation (minimum, normal and maximum yields, frequency); evaluate the % of lost after harvest

- determine the use of agricultural products, market price of sale and buy (for auto-consumption) and their seasonal variation.
- Evaluate the different risks of bad results and how the farmers managed them?

4.3.2 - To study a husbandry system we need to:

- identify the functions of the animals (productions oriented, draught, hauling, fertility transfer, mid term savings, social customs, and so on).

Diagram to illustrate how a herd functions (example: dairy cattle).



- describe and analyse the different production practices.

We need to find the main following data:
Production and reproduction management
Number, type, sex and age of breeding stock.
Breeds, different reproduction rates, mortality rates.
Feeding: food resources along the year and how they are produced or purchased.
Crop by-products or domestic waste

Free grazing on private or common land
Forage: what kind of forage is used? Is it bought in or grown by the farmer? Where are the forage crops grown? What is the situation with land tenure? When and how much forage is produced? What kind of investment are required (labour, equipment, inputs)?
Other food sources (concentrates, root crops, leaves,...)

Health care and hygiene
What are the main hygiene problems?
How often do they occur?
How do farmers deal with them?
How much do farmers spend on animal health on average?

Labour requirement
Who carries out the operations (family or external labour, number of workers)?
How much time for each operation?

- know which products are auto-consumed or sold, when, where, why? The prices of sale or buy? The variations from one year to another, their causes. That helps to understand the main constraints facing farmers and the strategies they use for different husbandry systems.

4.3.4 - To study a agroprocessing system we need to:

- Identify the basic products which are processed (milk, animals, fruits, …) and its "relative *quality*" characteristic (age for animals, maturity for fruits, …)
- Know the multiple set of products processed (cheese, meat, …)
- Know if several processed products are made from the same basic product or not (butter and cheese for example)
- Understand if the agroprocessing system works the whole year or only a specific period
- Understand, analyse and describe each step of the agroprocessing system from the basic product to the finished product.

To characterise the process we need to find the following data:
How many steps there are in the process?
For each step:
How long does it take?
Who is working (family or external labour, number of workers)?
Kind, quantity, origin of the inputs?
How much does it cost (inputs, wages, …)
Is there a need of storage? (to dry meat or cheese,…)
How long does the whole process take?
How much does the whole process cost? Use of final product and prices of sale or buy

- Enumerate the final quantity, the variations of results (quantities, qualities), theirs causes of each processed product,
- Know the uses of the final product, when they are sold or consumed and the prices of sale and buy?

- This help to understand and assess the interests and constraints, risks associate to the agro-processing system.

4.3.5 - Outputs from the technical sub-systems analysis

- We will Identify and characterize of each cropping, animal husbandry and agro-processing systems. For each system we should be able to present a:
- yearly calendar of technical sequences for each cropping system herd management schemes (number of animals, reproduction and food calendar...) for each animal husbandry system
- Working calendar: it represents time spent for each operation in a sub-system. It is important to know the time needed for an operation and the period in which it can be made. That calendar leads to identify peak of works, bottle neck for the organisation of the farmer's work..
- Technical performances (yields, variations)

4.3.6 - Economic performances of the sub-systems

To assess the interests and constraints of each systems from the farmers or nation point of view, it is important to evaluate also their economic performances. Farmers produce in order to satisfy sustainably their family needs not in order to reach the best yields.

For each sub-system we need to assess :

Gross Return = Output x Unitary market price

The outputs are the products that actually go out for sale, home consumption, wages in kind, gifts, rent of land in kind, etc. In case of home consumption, gifts, the prices to take into account is the price of buy.

Net Return = Gross return – Inputs x Unitary market prices

The net return is used to assess the efficiency of the productive processes (wealth created). Then the wealth created can be compared with the other agricultural system or economic activities in the country.

The analysis can be taken further by calculating the following ratios for each sub-system:

Land productivity = net return / ha

"how much money can a farmer earn from 1 ha of land down to a given cropping system?"

Daily labour productivity = net return / man-day

"How much money can a farmer earn in one day when he works for a given sub-system?"

Herd productivity = net return / breeding mother

"How much money can a farmer earn from 1 breeding mothers and its offspring for a given sub-system?"

A man-day represents the work made by a worker (family or external labour) during a day. So, the total man-days represent the amount of work needed for a sub-system during one year.

To compare different herd productivities, it is necessary to use equivalence between animals. The comparison is made thanks to the need in food and pasture. For example, in many cases, a cow is equivalent to 6 ewes or 6 goats.

It is important to analyse several years (normal, particularly bad and good years) to identify the variations of the net return according to the evolution (evolution of the prices and the yields). Those variations and their frequency allow to understand the risks and the problems faced by the farmers.

The land and labour productivities and associated risks of the different agricultural systems can be compared. There are very interesting ratios to :

- better understand and explain the choices of production of farmers regarding their conditions of production,
- discuss what kind of agricultural systems are interesting for the regional development and for the nation regarding the priorities functions agriculture should fulfil.

4.4 - STEP 4- FARMING SYSTEMS ANALYSIS

At the farm scale we have to analyse the combination of sub-systems farmers managed, their reason of being and performances.The economic analysis allows to assess whether the farmers who manage a same type of farming system meets basic needs of his family and maintain his means of production. A farmer can only consider new investments and changes to his farming system when this objective is reached.

4.4.1 - Combination of sub-systems

The sub-systems can be either complementary or competitive, the combination depends on:

- Availability of means of production (land, labour, water,...) and means of acquisition
- Evolution of the social, economic and politic environment of the farm
- Compatibility between the different sub-systems (according to the needed resources (labour, tools, land, water, etc..) and their time repartition, etc..).

	area or size of herd	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
cultivated plot 1	1.5 Ha												
cultivated plot 2	0.5 Ha												
cultivated plot 3	2 Ha												
flock 1	5 buffaloes												
off-farm activities													
Amount													
Comments			Peak of work			Peak of work			Peak of work		Peak of work	Dry season, less work	

Working calendar

4.4.2 - Economic analysis

The objective of this analysis is to evaluate the viability of the farming system (Is the the net farm income enough to cover the basic needs of the family?) and to compare the different farming systems.

Farmers can use equipment and goods which last longer than one year (tools, plantation, irrigation equipment). This category of means of production is called "**fixed capital**". It is important to substract its yearly depreciation of the net return to consider the need of renewing them for the system to be reproductive.

Annual depreciation of equipment = current renewal value / life spent within the farm

The aggregated value represents the wealth created by the farmers combining the different activities (farming system).

Aggregated value = net returns(*) – depreciation of fixed capital

(*)*The net returns are the added net return of each sub-system that composes the farming system.*

The wealth created do not go entirely to the farmer. A part of it is redistribute as wages, rent, financial payments and taxes.

Farmers do not always own the resources that they use. Therefore, it is important to take into account their tenurial status (is land owned or not?) and if the labour is provided by family members or external labourers.

We also have to deduce financial payments and tax payments, which are considered as a redistribution of a part of the net return.

We can calculate the net income available for the farmer's family as follows:

Net farm income = aggregated value – (costs of external labourers + land rent + financial payments + taxes)

As well as for the step 3, it is important to assess the variations of the economic result to analyse the risks associated to each farming system.

The net farm income depends on:

- The technical efficiency of the different cropping, animal husbandry and agro-processing systems,
- The farmer's socio-economic status (tenant or owner-occupier, family labour or external labour, does he finance his activities with available cash or does he have borrow?, etc.)
- The stability of the market prices

To conclude this part, we can compare the economic results of each farming system, their viability and the problems they meet.

- Shedlight on farmers' decisions in terms of farming systems regarding their resource allocation, access to different services, others opportunities of work, etc….
- Compare the relevant economic criteria (land and labour productivity) for each sub-system and for farming systems (interests, constraints, reasons of specialisation or diversification).
- Assess the reproductive capacity of the farming systems.

Then, we are able to highlight and discuss the factors that differentiate the farming systems and determine potential evolution; anticipate the consequences of different possible agricultural changes in relation to trends in socio-economical, environmental and political context;

4.5 - STEP 5- SYNTHESIS AND RESTITUTION

The aim is to formulate the diagnosis of the agrarian systems; the importance of husbandry in the agrarian system, the relations between agriculture and animal productions.

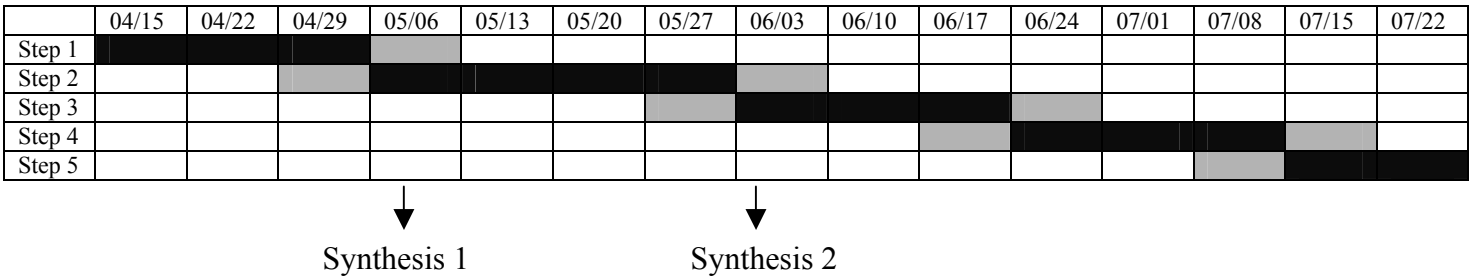
It is then needed first to put together all the processed and collected data, to analyse them at the regional level and eventually to conduct some rapid complementary enquiries (such as quantitative evaluation of the different farming systems, etc.).

We would then be able to discuss development priorities: what changes are possible, suitable or not?

A restitution will allow us to exchange with farmers, local actors, staff project, our analysis, in order to complete and correct it and to select activities which can help to better the economic and social situations of the family. What kind of individual and collective changes can be proposed, what are the conditions to allow them, what kind of activities, priorities micro-project for PADZEY intervention?

After the local restitution, rapid specific studies will probably be needed to correct, complete the diagnosis and the project proposals. But is probable that we will not have enough time to carry them out. Some of our propositions would then be complementary studies.

5 - TIMETABLE



Finally we can say that this present paper is just a general guide for the whole study. All through the diagnostic survey, by discovering the local context, new questions will certainly be raised. Thus we will adapt our method to that context and probably propose different added inquiries.

Annex 2: TDA, 2005. Climatic information

Information collected from department of climate and hydrology in TDA, Hodeidah. Climatic data about Wadi Mawr collected by TDA from 1980 to 2005

Minimum temperature in Al Zuhra

Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	avg
1980	19	18	21,2	20,2	23,5	25,8	27,2	24,6	21	20	20	18,2	**21,6**
1981	17,5	18,6	19,9	23,3	24	25	25	25	23	21,2	19	17,7	**21,6**
1982	16,4	18,9	18,7	24,4	21,9	19,9	18,9	20,2	20,8	18,4	19	19,8	**19,8**
1983	12,4	18	19,5	21,5	21	21,9	17	23,6	24	20,2	19,5	17,5	**19,7**
1984	17	17,8	17,8	21,4	20	25	25	22,5	20,4	19,7	18,9	17,6	**20,3**
1985	17,7	18	18,9	22	20,7	22	22,2	22,3	22	19,5	17,5	20,3	**20,3**
1986	16	19,2	19,6	20,8	21	17,8	22	25	23	20	19,8	17	**20,1**
1987	14	15	19	21	24,6	24	25	25,4			19	17,5	**20,5**
1988	19,7	19,4	20	22			20			20	18,2	16,2	**19,4**
1989	17	17	16,8	20	23,4	27,3	25	25,3	23,2	22,4	20	19	**21,4**
1990	18	18	17	17	22,8	24,5	20,4	25,5	21	21,2	18,5	18	**20,2**
1991	18	18,4	20,4	23	21,5	25	23,5	24	22,5	21	18,5	18,5	**21,2**
1992	15	19	19,5		24	23,5	25	21,5	24,5	22	18,8	19	**21,1**
1993	18	14,5	19	21	21	24	25	25	23	20	20	18	**20,7**
1994	16	19	20	22	23	26	23	23	23	22	21	18	**21,3**
1995	17	18,6	19	23	22,5	26	23	22	23	21	20	18	**21,1**
1996	18	19,3	20	22	23	24	26	25	24	21	18,5	18	**21,6**
1997	18	18	19	21	22	23	22,5	25	24	22,5	22	20	**21,4**
1998		17,5	21	23	24,5	26,5	25	23	22	22	19	18	**22,0**
1999	18	18	17,5	21	28	24	24	21,5	21	22	18	15,5	**20,7**
2000	18	17	18	22	24	23	25	21	23	21,5	19	18	**20,8**
2001	16	17	21	22	24,5	25	24	25	22	23	19	18	**21,4**
2002	18	19	21	24	25	25	25	24	22	22	20	19	**22,0**
2003	19,5	20	21	27	28,5	28,5	28	28	27	20	19,5	19	**23,8**
2004	27	28	29	28	29	30	28	29	28	30	28	26	**28,3**
2005	30	31	32,5	31,5	32,5	32,5	29,5	30	30,6	23,2	22,5	21,4	**28,9**
Mean	**18**	**18,9**	**20,2**	**22,6**	**23,8**	**24,8**	**24**	**24,3**	**23,3**	**21,4**	**19,7**	**18,6**	**21,6**

Mean temperature in Al Zuhra

Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	avg
1980	25,7	26,9	29	30,4	33	34	33,6	32,4	31,2	29,7	27,6	25,6	**29,9**
1981	25,6	26,1	28,4	30,1	31	33,5	32,4	32,5	31	29,3	27	25,3	**29,4**
1982	25,6	28,5	31,4	32,2	33,6	33,9	32,9	32,7	28,8	28,1	27	30,4	**30,4**
1983	25	26,8	28,6	28,8	31,1	33,7	34,5	33,4	33	30,5	28,1	26,1	**30,0**
1984	24	26,2	27,9	31	31,4	33,5	33,6	33,3	31,5	30,6	27,4	26,3	**29,7**
1985	25,8	26,3	29	30,7	31,7	33,3	33,3	32,4	30,7	28,2	24,2	29,6	**29,6**
1986	25,2	27,1	28,5	30,1	32,8	33,9	33,3	33,3	32,1	30	28,3	26,6	**30,1**
1987	25,3	26,6	28	29,1	31,7	33	33,8	34,1					**30,2**
1988	38,2												**38,2**
1989	25,6	26,4	27,8	30,6	32,7	33,4	34,7	34,7	30,5	32,5	29,6	27,6	**30,5**
1990	26,4	27	29,1	29,9	32	33,3	33,9	33,5	32,2	30,1	28,4	26,7	**30,2**
1991	26,3	27,1	28,9	31,2	32,9	33	33,1	33,3	32,1	30,9	27,9	26,6	**30,3**
1992	25,8	26,8	28,5	32,7	33,8	34,1	32,5	32,3	30,3	28,3	27	32,2	**30,4**
1993	26,1	25,7	28,1	30	32,7	33,7	33,9	33,5	33,2	30,9	28,8	26,8	**30,3**
1994													

1995													
1996	26,3	27,8	28,7	30,4	32,4	32,9	34,3	34	33,1	28,7	28	25,3	**30,2**
1997	24	28	28,2	32	33,7	35,3	34,6	33,4	33,7	31,2	29,7	28,6	**31,0**
1998		26,9	29,2	31,9	33	34,6	34,5	33,5	32,5	31,3	29,3	28,1	**31,3**
1999	22	22,6	25	31,2	33,5	33,8	32,5	33	31,6	30,6	29,1	21,5	**28,9**
2000	26	26	27,5	31,5	33	32,5	34	31,3	32	30	28	27,6	**30,0**
2001	28	25,5	30,1	32,2	33,8	34,2	34,2	33,7	33	32,6	29,8	27,4	**31,2**
2002													
2003	25	26,5	27	32,5	33,5	33,5	35	37	36	30,7	28,5	27,5	**31,1**
2004	27	28	29	28	29	30	28	29	28	30	28	26	**28,3**
2005	30	31	32,5	31,5	32,5	32,5	29,5	30	30,6	23,2	22,5	21,4	**28,9**
mean	**26,3**	**26,8**	**28,7**	**30,8**	**32,5**	**33,4**	**33,3**	**33**	**31,8**	**29,9**	**27,8**	**26,8**	**30,1**

Maximum temperature in Al Zuhra

year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	avg
1980	34,6	37,5	38,8	40	42	42,3	42	40,6	39,6	39	36	33	**38,8**
1981	34,6	36	36,8	37,2	40,5	41,8	40	39,8	39	37	36,5	33	**37,7**
1982	35,5	37,8	42,7	44,2	43,4	43,5	43,2	42,7	40,2	38,2	35,2	40,7	**40,6**
1983	35,5	36,1	38,4	41,4	45,5	44,4	44,2	42,2	46,8	43,3	38	36	**41,0**
1984	36,4	34,2	37,2	41	43	44,5	43,4	42	42	40,4	35,4	34	**39,5**
1985	33,5	34,5	39	41,7	42,2		42,4	42	43	42,2	33	33	**38,8**
1986	33,1	38,6	37,5	45,4	41	42,2	42,2	42	41,6	39	37,5	35	**39,6**
1987	33,6	34	38	41	40,5	41	44	44		38	34	38,8	**38,8**
1988	33	34	38										**35,0**
1989	32,5	35	37,8	40,4	44,2	41	43,4	43	41	40,9	36,2	34,2	**39,1**
1990	33,4	34	36,2	39,2	42,4	42	42	41,6	41,5	42	37,5	35,5	**38,9**
1991	32,7	34,5	37,7	40,5	41	43	41,6	38					**38,6**
1992							41,5	41	39,5	39,5	36,8	34,5	**38,8**
1993	35	38	36	39,5	40	42	42	41,5	41	39,5	36	34,5	**38,8**
1994	33	34	35,5	36	43	42	41,5	41	40	40	36	34,5	**38,0**
1995	32	35,5	37	40	41,7	42	41,5	41	41,7	41	37	35	**38,8**
1996	34	37,2	38	41	43	41	42,5	42	41,5	41,5	37,5	33,5	**39,4**
1997	33	34	34,5	39	41,9	43	43	42	42,3	39	37	35	**38,6**
1998		37	37,5	41,5	43	44	43	42,5	41,9	39,5	37,5	36	**40,3**
1999	35	35	38	43,5	44	43,5	42	42	41	39,5	40	35	**39,9**
2000	34	35	37	41	42	42	44,3	41,5	41	38	36	35,5	**38,9**
2001	31	33,5	38,5	40	42	41,5	42,5	41,5	41,5	40,7	38	35	**38,8**
2002	38	40	40,5	40,5	43	41,5	43,5	46	45	42	40	38	**41,5**
2003	34	36	38	39	40	41,5	41	43	42	36,4	32,5	32,5	**38,0**
2004	32	35	37	36	37	37,5	37	38	37	33,5	34	31,5	**35,5**
2005	32,7	35,5	36,2	36	37	37	34,6	38,8	37	36,5	35	32,5	**35,7**
mean	**33,8**	**35,7**	**37,8**	**40,6**	**42,2**	**42,4**	**42,4**	**41,9**	**41,6**	**39,8**	**36,5**	**35,1**	**39,0**

Daily evaporation in Al Zuhra

year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	avg
1980	5,4	5,9	7,8	8	9,4	9,1	9,8	8,7	6,5	6,2	6,3	5,2	**7,4**
1981	5,4	6,1	6,6	6,6	7,2	8,4	7,3	8	5,9	6,8	5,9	5,8	**6,7**
1982	4	7,3	6,7	7	6,4	6,9	7	5,9	5,2	4,2	3,8	5,9	**5,9**
1983	4,4	4,6	5,4	7,3	8,2	7,4	8,7	8,5	7,4	6,9	6,2	5,1	**6,7**
1984	5,5	5,2	6,3	7,8	6,7	6,6	7,1	7,1	7,1	7,3	4,5	3,5	**6,2**
1985	3,7	4,6	6	5,2	5,7	6	7,2	6,4	6,3	5,4	4,5	5,5	**5,5**

1986	4,4	4,7	5,5	6,4	6,5	7,6	8,1	7,3	5,7	5,2	5,3	4,6	**5,9**
1987	4,3	6,2	4,4	11,5	11,2	12,5	7,9	4,9	7,9				
1988	10	6,7	9	12,5	10,8	7,1	6,2	8,9					
1989	5,4	6,6	8,3	10,2	12	1,5	5,5	7,1					
1990	11	3,9	6,6	7,6	6,6	7,1							
1991	6	6,6	8,8	10	9,4	9,4	10,6	11	8,2	8	7	5,9	**8,4**
1992	5,4	7,1	7,3	12,9	11,1	14,1	12	11,6	10,6	8,6	7,7		**9,9**
1993	6,1	6,6	8,3	8,9	8	8,3	9,9	8,1	7,4	7,7	5,9	6,2	**7,6**
1994	7,1	7	7,5	9,1	8,7	8,5	8,8	9,2	8,3	8,2	6,8	5,6	**7,9**
1995	6,7	7,2	7,2										
1996	5,4	7,9	6,3	7,3	7,1	8,5	9,8	8,4	7,8	6,5	6,2	6	**7,3**
1997	6,5	6,9	7,2	8,6	9,2	8	7,8	8,5	7,6	4,7	6,2		**7,4**
1998									6,6	6,1	5,2	5,2	
1999	4,9	7,1	7,3	8,1	8,8	9,1	6,3	8,3	5,9	7,6	5,9	7,3	**7,2**
2000				9,1	9,7	9,3	7,6	8,2	6,7	8,2	5,4	5,9	**7,8**
2001	3,9	5	7			8,1	7,4	7,5	6,6	6,9	5	5,1	**6,3**
2002				11	10	8	8,7						
2003													
2004	9,8	11,6	11,2	6,8	8,8	9	7,1	9,4	8	5,3	4,8	4	**8,0**
2005	15,4	14,2	9,6	8,8	6,9	5,8	9,2	7,6	10,1	4,5	4	3,2	**8,3**
mean	**6,4**	**6,8**	**7,3**	**8,7**	**8,6**	**8,1**	**8,2**	**8,1**	**7,3**	**6,5**	**5,6**	**5,3**	**7,2**

Monthly evaporation in Al Zuhra

year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	avg
1980	168	170,5	240,6	232,4	291,6	273,3	303,8	252,8	168	161,3	187,8	171,2	**2621,3**
1981	167,5	170,1	184,7	171,4	201,1	252,1	211,8	216,1	146,9	188,9	175,6	179,1	**2265,3**
1982	115		224,9	202,2	216	193,1	212,8	216,6	176,9	612,5	125	114,6	**2409,6**
1983	135	127,3	167,4	219,2	255,7	222,7	269,1	260,8	222,8	214,3	148,8	154,2	**2397,3**
1984	170	150	187,8	178,7	207,3	198,9	219,4	220,3	213,2	225	134,6	107,6	**2212,8**
1985	113,2	127,8	185,5	156,2	171		186,4	200,6	192,4	189,7	162,6	140,5	**1825,9**
1986	136,8	131,7	167,4	151,1	189,8	229,3	242,8	226,9	170	161,7	157,9	137,5	**2102,9**
1987	134,7	159,8	173,6		353,5	345,9	346,2	385,9			213,2	152,7	**2265,5**
1988	300,7	192,9	179,8		260,3	334,6	256,7	276,5			190,2	193,4	**2185,1**
1989	167,1	167,1	167,1	167,1	167,1	167,1	167,1	167,1	167,1	167,1	167,1	167,1	**2005,2**
1990	298,6	108	219,1	199,3	224,9	224,5	248,6	254,7	206,8	207,6	220,8	191,2	**2604,1**
1991	187,6	184,2	271,1	300,7	282,8	281,9	330,1	342,2	246,4	248	209,3	170,6	**3054,9**
1992	168,2	199,6	182,6	284,1	385,5	333,1	437	287,8	347	329,2	258,3	238,6	**3451,0**
1993	183,7	172	257,9	267,5	247,5	249,9	307,5	251,5	222,9	216	176,3	192	**2744,7**
1994	220,1	194,9	232,5	271,8	259,8	255,9	271,3	286,1	257,3	271,3	286,1	257,3	**3064,4**
1995	207,1	201	221,8	225	244,9	290,4	243	195,6	234,3	238,2	206,4	193,8	**2701,5**
1996	167,6	227,6	194,7	219,3	215,9	254,5	302,7	260,2	234,4	202,6	187,1	184,8	**2651,4**
1997	202,8	193,3	223	259,2	283,9	239,2	243,1	262,7	226,5	144,9	184,4		**2463,0**
1998	197,1	196,9	224,5	250,8	274,1	260,7	216,7	259,9	197,9	188,3	170,6	160,2	**2597,7**
1999	191,3	200,4	225,9	242,3	264,2	282,2	190,3	257,1	177,8	236,5	167,9	226,4	**2662,3**
2000					282,6	290,2	287,8	234	243,5	208,4	164,4	181,6	**1892,5**
2001	120,1	139,2	216			242,6	228,4	233,6	197,3	212,5	151,2	159,5	**1900,4**
2002	245	280	320	345	310	248	271	0	0	0	0	0	**2019,0**
2003													**0,0**
2004	300	326	346	204,2	272,1	280	221,2	221,2	263,1	282,8	142,6	227	**3086,2**
2005	477,4	379,6	297,6	264,6	208	172,5	284	284	240,2	138,3	118,8	90,5	**2955,5**
mean	**198,9**	**191,3**	**221,3**	**229,1**	**252,9**	**255,1**	**259,9**	**244,1**	**206,6**	**219,3**	**172,3**	**166,3**	**2617,1**

Rainfall in Al Zuhra

year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	avg
1979	0	0	4	7,8	0	0	0	35	98,5	20	0	7	**172,3**
1980		0	0		0						2,9	7,3	
1981	0	0	0,3	22,3	6	0	0	9,3	35,4	12,5	0	0	**85,8**
1982	34,4	0	4	0	16	0	9	4	35,9	96,5	6,9	3,5	**210,2**
1983	17,8	19	6	8,5	97	1	6,2	1,4	1	35	5,5	124,2	**322,6**
1984	2,5	0	0	0	82,5	0	0	0	57	0	0		**142,0**
1985	0	1,5	0	66	47	0	1,5	11,8	11	10,6	0	0	**149,4**
1986	0	0,5	5,5	34,9	0,2	0	9,5	27,7	44,6	30,8	0	6,5	**160,2**
1987	0	0	1,5	11,8	2,7	0	1,2	16,3	13				**46,5**
1988	9	0	0	0	0	0	9	58	45,1	0	0	0	**121,1**
1989	0	0	4,5	8,9	0	0	0,8	0	0	0	0	12	**26,2**
1990	0	0	0	90,2	0	0	0	0	17	5,5	0	0	**112,7**
1991	0	7,1	0	7,1	0	0	0	0	0	0	0	0	**14,2**
1992	8,3	0	9	0	0	0	8	84	22,9	84,4	8,6	48,4	**273,6**
1993	0	13,8	0	9,4	44	2,5	0,4	4,6	0	78,5	0	0	**153,2**
1994	0	0	19	0	0	0	44,8	1	15,1	4,5	28	0	**112,4**
1995	0	0,8	22,2	0	0	0	22,9	37,2	0	28,9	0	0	**112,0**
1996	0	0	0	12,6	53,3	16,6	0	30	5,6	26,2	12	0	**156,3**
1997	0	0	2,2	0	0	7,3	16,5	0	10,2	170,6	4,2	0	**211,0**
1998	0	0	7,7	0	0	0	12	238,4	82	14	0	0	**354,1**
1999	0	0	0	0	0	0	44,3	24	51,8	95,8	0	0	**215,9**
2000	0	0	0	0	0	0	10	51,5	45,2	48	0	0	**154,7**
2001	10	0	0	0	0	0	23	12,6	49	43	0	0	**137,6**
2002	0	0	0	27,6	0	0	0	22	46	0	0	0	**95,6**
2003	0	0	0	0	0	0	10	20	3	0	0	0	**33,0**
2004	0	0	0	80,7	0	0	2,5	32,5	46	0	0	0	**161,7**
2005	**0**	**0**	**13**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**14,0**
mean	**3,2**	**1,6**	**3,7**	**14,9**	**12,9**	**1,1**	**8,9**	**27,8**	**28,3**	**32,2**	**2,6**	**8,4**	**145,6**

Rainfall in three stations in Wadi Mawr

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kudmat Marraryh	1,6	0,5	7,3	10	32	10,3	24,3	66,4	65,7	37	5,2	2,8
Al Zuhra	3,2	1,6	3,7	15	12,9	1,1	8,9	27,8	28,3	32,2	2,6	8,4
Jabal Al Milh	6,7	4,2	1,8	8,7	6,5	0,4	3,6	12	7,5	7,5	7,9	6,5

Total wadi flow measured at Shat al Erg Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1990	1,18	7,85	11,63	28,27	4,73	10,50	11,80	12,81	5,93	2,10	1,11	0,90	**98,81**
1991	0,89	5,08	6,78	25,02	12,90	1,00	13,90	15,04	8,02	2,44	1,93	4,00	**97,00**
1992	0,64	0,64	0,42	1,62	4,72	2,88	24,47	130,70	55,82	10,16	8,41	23,29	**263,77**
1993	4,81	3,45	11,04	123,20	97,43	27,59	37,77	30,36	4,51	7,65	2,92	2,91	**353,64**
1994	2,84	1,10	1,43	1,80	1,98	1,92	3,01	15,54	8,27	3,92	5,13	1,76	**48,70**
1995	2,46	2,59	37,30	7,57	13,16	3,28	10,06	42,00	10,06	6,00	5,24	6,27	**145,99**
1996	5,66	6,14	54,94	21,43	6,82	58,63	9,40	11,23	9,13	5,31	4,34	5,26	**198,29**
1997	2,48	2,28	22,69	17,48	25,87	57,60	64,09	41,84	12,22	47,25	25,44	10,27	**329,51**
1998	3,19	2,82	43,89	4,55	15,23	2,91	11,74	68,99	44,72	0,00	0,00	0,00	**198,04**
1999	0,77	0,79	17,11	0,83	0,85	0,87	35,19	35,33	14,49	4,57	0,81	0,74	**112,35**
2000													

2001	1,30	2,90	39,62	27,84	23,25	15,00	52,32	29,57	14,00	14,00	12,00	8,00	**239,80**
2002	7,67	2,10	4,48	26,79	3,10	3,60	23,18	44,84	28,47	5,20	4,20	4,80	**158,43**
2003	9,73	11,82	12,94	126,38	11,74	17,89	13,85	86,50	21,36	11,63	12,43	10,07	**346,34**
2004	17,12	10,44	13,21	95,33	9,43	18,00	67,40	38,10	12,15	10,62	9,72	9,42	**310,94**
2005	8,95	10,13	16,24	89,05	26,12	8,10	8,00	43,76	19,67	8,00	7,75	7,50	**253,27**
Mean	**4,65**	**4,68**	**19,58**	**39,81**	**17,16**	**15,32**	**25,75**	**43,11**	**17,92**	**9,26**	**6,76**	**6,35**	**210,33**

Base flow used for Daraniah canal irrigation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1990	1,18	3,48	3,63	3,13	4,73	3,20	2,21	6,21	5,07	2,10	0,93	0,90	**36,77**
1991	0,89	0,93	2,52	4,23	2,32	1,00	1,08	1,71	1,70	1,25	0,67	1,23	**19,53**
1992	0,73	0,64	0,42	1,62	4,72	2,88	6,14	14,76	8,62	4,24	3,69	7,65	**56,11**
1993	3,34	3,45	3,36	7,33	8,61	12,80	12,44	8,73	4,51	5,34	2,92	2,91	**75,74**
1994	3,39	3,29	0,54	0,00	0,00	0,00	3,21	14,75	1,59	7,18	2,05	3,41	**39,41**
1995	2,46	2,59	5,36	3,33	3,53	2,46	4,40	14,45	7,29	5,41	5,24	5,88	**62,40**
1996	5,66	6,14	5,96	7,58	6,68	8,58	8,18	8,51	8,84	5,31	4,34	5,26	**81,04**
1997	2,48	2,28	3,14	4,75	7,91	1,56	11,77	14,67	10,66	11,60	11,10	10,27	**92,19**
1998	3,91	2,82	4,79	2,64	3,39	2,59	7,87	15,80	19,12	0,00	0,00	0,00	**62,93**
1999	0,77	0,79	0,91	0,83	0,85	0,87	1,02	0,87	1,40	0,91	0,81	0,74	**10,77**
2000													**0,00**
2001	1,30	2,90	7,90	14,30	15,00	15,00	16,00	15,00	14,00	14,00	12,00	8,00	**135,40**
2002	2,17	2,10	4,48	2,70	3,10	3,60	10,40	14,00	12,90	5,20	4,20	4,80	**69,65**
2003	9,73	11,82	12,94	15,86	11,74	9,80	13,85	19,46	21,36	11,63	12,43	10,07	**160,69**
2004	12,64	10,44	13,21	15,84	9,43	8,64	9,23	13,79	12,15	10,62	9,72	9,42	**135,13**
2005	8,95	10,13	12,64	7,45	7,90	8,10	8,00	9,00	8,00	7,75	7,50	7,50	**102,92**
Mean	**3,97**	**4,25**	**5,45**	**6,11**	**5,99**	**5,41**	**7,72**	**11,45**	**9,15**	**6,17**	**5,17**	**5,20**	**76,05**

Flood available for irrigation other than Daraniah canal area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1990	0,00	4,37	8,00	25,14	0,00	7,30	9,59	6,60	0,86	0,00	0,18	0,00	**62,04**
1991	0,00	4,15	4,26	20,79	10,58	0,00	12,82	13,33	6,32	1,19	1,26	2,77	**77,47**
1992	-0,09	0,00	0,00	0,00	0,00	0,00	18,33	115,94	47,20	5,92	4,72	15,64	**207,66**
1993	1,47	0,00	7,68	115,87	88,82	14,79	25,33	21,63	0,00	2,31	0,00	0,00	**277,90**
1994	-0,55	-2,19	0,89	1,80	1,98	1,92	-0,20	0,79	6,68	-3,26	3,08	-1,65	**9,29**
1995	0,00	0,00	31,94	4,24	9,63	0,82	5,66	27,55	2,77	0,59	0,00	0,39	**83,59**
1996	0,00	0,00	48,98	13,85	0,14	50,05	1,22	2,72	0,29	0,00	0,00	0,00	**117,25**
1997	0,00	0,00	19,55	12,73	17,96	56,04	52,32	27,17	1,56	35,65	14,34	0,00	**237,32**
1998	-0,72	0,00	39,10	1,91	11,84	0,32	3,87	53,19	25,60	0,00	0,00	0,00	**135,11**
1999	0,00	0,00	16,20	0,00	0,00	0,00	34,17	34,46	13,09	3,66	0,00	0,00	**101,58**
2000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
2001	0,00	0,00	31,72	13,54	8,25	0,00	36,32	14,57	0,00	0,00	0,00	0,00	**104,40**
2002	5,50	0,00	0,00	24,09	0,00	0,00	12,78	30,84	15,57	0,00	0,00	0,00	**88,78**
2003	0,00	0,00	0,00	110,52	0,00	8,09	0,00	67,04	0,00	0,00	0,00	0,00	**185,65**
2004	4,48	0,00	0,00	79,49	0,00	9,36	58,17	24,31	0,00	0,00	0,00	0,00	**175,81**
2005	0,00	0,00	3,60	81,60	18,22	0,00	0,00	34,76	11,67	0,25	0,25	0,00	**150,35**
Mean	**0,63**	**0,40**	**13,25**	**31,60**	**10,46**	**9,29**	**16,90**	**29,68**	**8,23**	**2,89**	**1,49**	**1,07**	**125,89**

Area irrigated by wadi

North supply canal			
Secondary canals		Area (ha)	Area (maad)
1	Madbaiah	200	556
2	Al Mawasiah	490	1361
3	Al Naseriah	240	667
4	Hazamiah	200	556
5	Fath Al Bary	280	778
6	Baraodah	250	694
7	Gulafiga	190	528
8	Taheriah	720	2000
9	Bakeriah	200	556
10	Adam	660	1833
11	Labadah	150	417
12	Hashediah	330	917
13	Bakhashiah	300	833
14	Juniah	500	1389
15	Markozah	110	306
16	Makkiah	100	278
17	Maslyah	300	833
total area		5220	14500

South supply canal			
Secondary canals		Area (ha)	Area (maad)
1	Baraaniah A	460	1278
2	Baraaniah B	430	1194
3	Baraaniah C	1290	3583
4	Basheeriah	270	750
5	Hamoiah	310	861
6	Asmara	800	2222
7	Sabakhiah	860	2389
8	Bakryyah	200	556
9	Mastorah/Traktoriah	880	2444
10	Gazilyah	890	2472
11	Darbah	550	1528
12	Wadiain	350	972
13	Kharifah	150	417
14	Haraji	290	806
15	Moriah/Berriah	780	2167
16	Jadidah	180	500
17	Gadyah	380	1056
18	Masaud	270	750
19	Jezam	470	1306
20	Kadaid	920	2556
total area		10730	29806

Daraniah Canal	
Area (ha)	Area (maad)
900	2500

	Area (ha)	Area (maad)
Total area	**16850**	46806

Canal area: **16 850 ha**

Total area irrigated by wadi: **40 000 ha**

Annex 3: Prices used for economic analysis

Costs of inputs and provision of services

	Price	Unit
Plowing and sowing by tractor	1500	YR/h
Threshing machine	10%	
Harvesting sorghum	10%	
Banding sorghum	10%	
Carrying sorghum from field to farm by camel (50 bandings)	20%	
Seeds in *Sef*	5000	YR/hakam
Seeds watermelon	4500	YR/450g
Seeds cattan / degra	4800	YR/1,25hakam
Taxes for secondary canals	10%	
Zeka	10%	
Wheat bran	25,7	YR/kg
Wheat grain	36	YR/kg
Diesel	35	YR/l
Bidon 220L (+300YR transport)	8000	
Petrol	60	YR/l

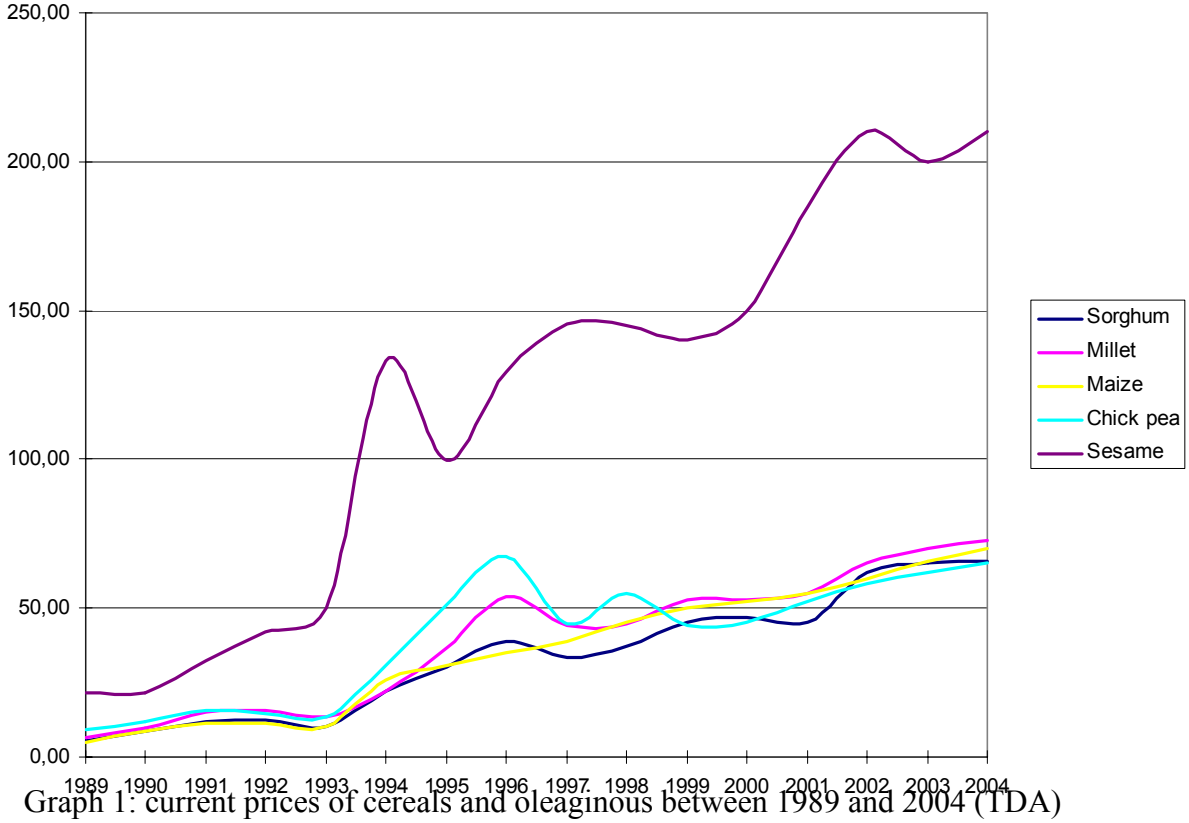
Price of products

Sorghum in harvesting time	7000	YR/big bag	
Millet	8000	YR/big bag	
Sorghum feeder in market	70	YR/20kg banding	
Sorghum Price pack Hsef	50	May to August	
Price pack H1	40	September to december	
Price pack H2	60	january to feb	
Price pack H3	80	March to april	
Millet	30		
Price watermelon bad	5000	YR/car	
Price watermelon normal	20000	YR/car	
Price watermelon good	30000	YR/car	

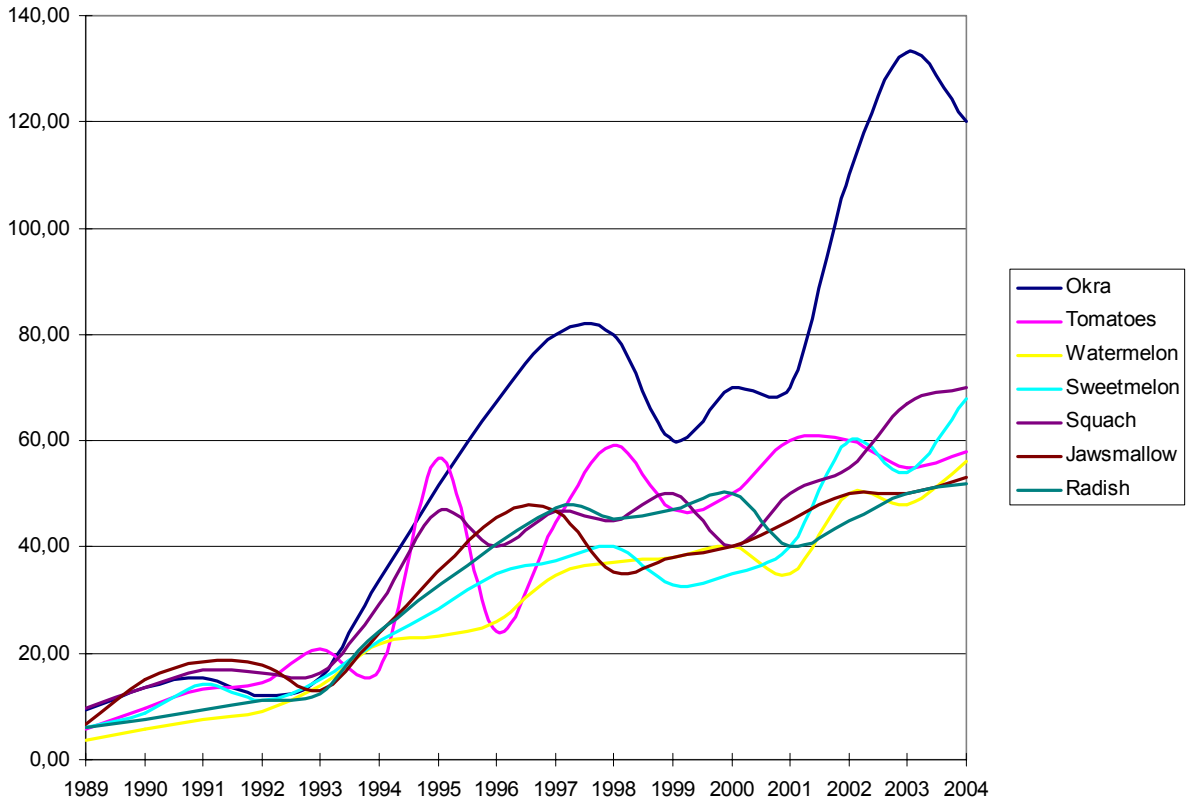
		CANAL	Rainy area
Non fattened	Sheep male/female4 months	5000	4000
	Goats male/female4 months	8000	7000
	Calf 8months	45000	
	Donkey	20000	
	Dromedary	60000	
fattened	Sheep male/female4 months	9000	
	Goats male/female4 months	10500	
	Calf 8months	60000	
	Milk of Goat	25	YR/l
	Milk of Cow	67	YR/l

Annex 4: Prices evolution

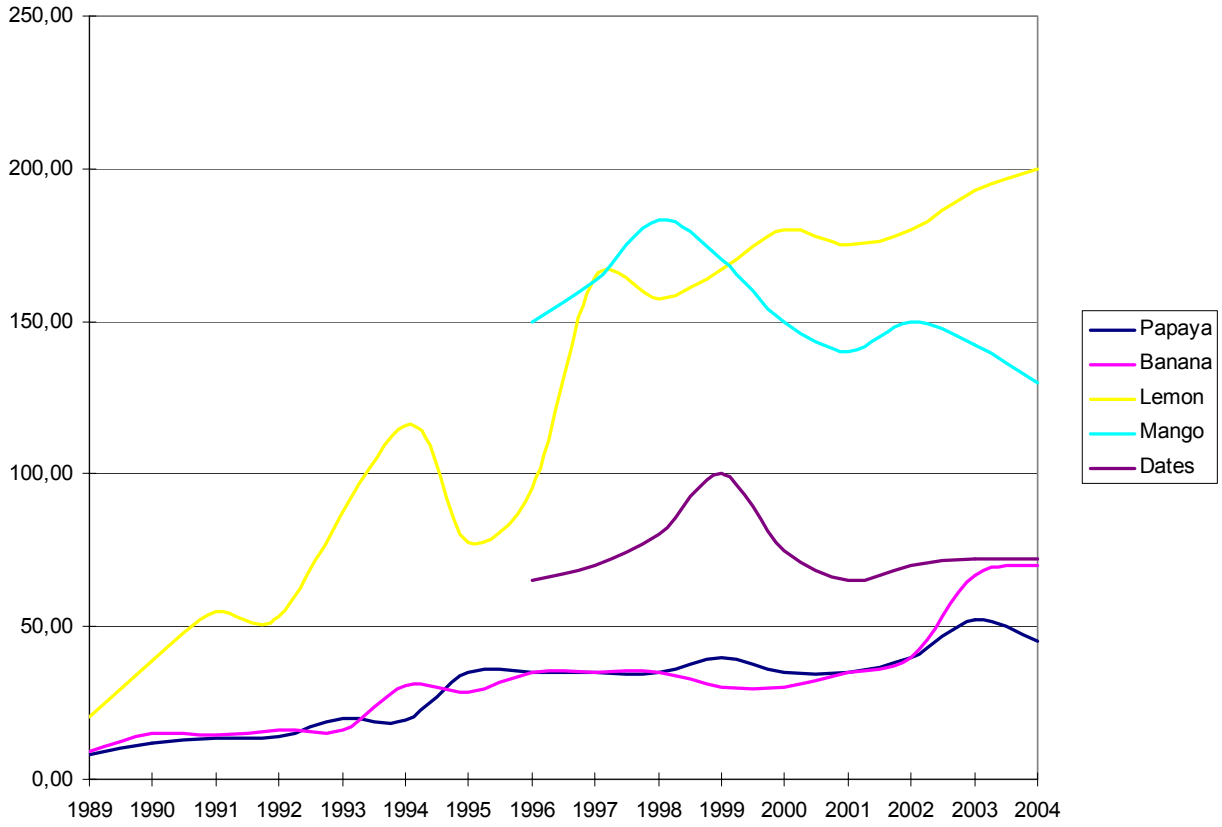
Agricultural and livestock prices (RY/kg) in Al Hodeidah governorate between 1989 and 2004



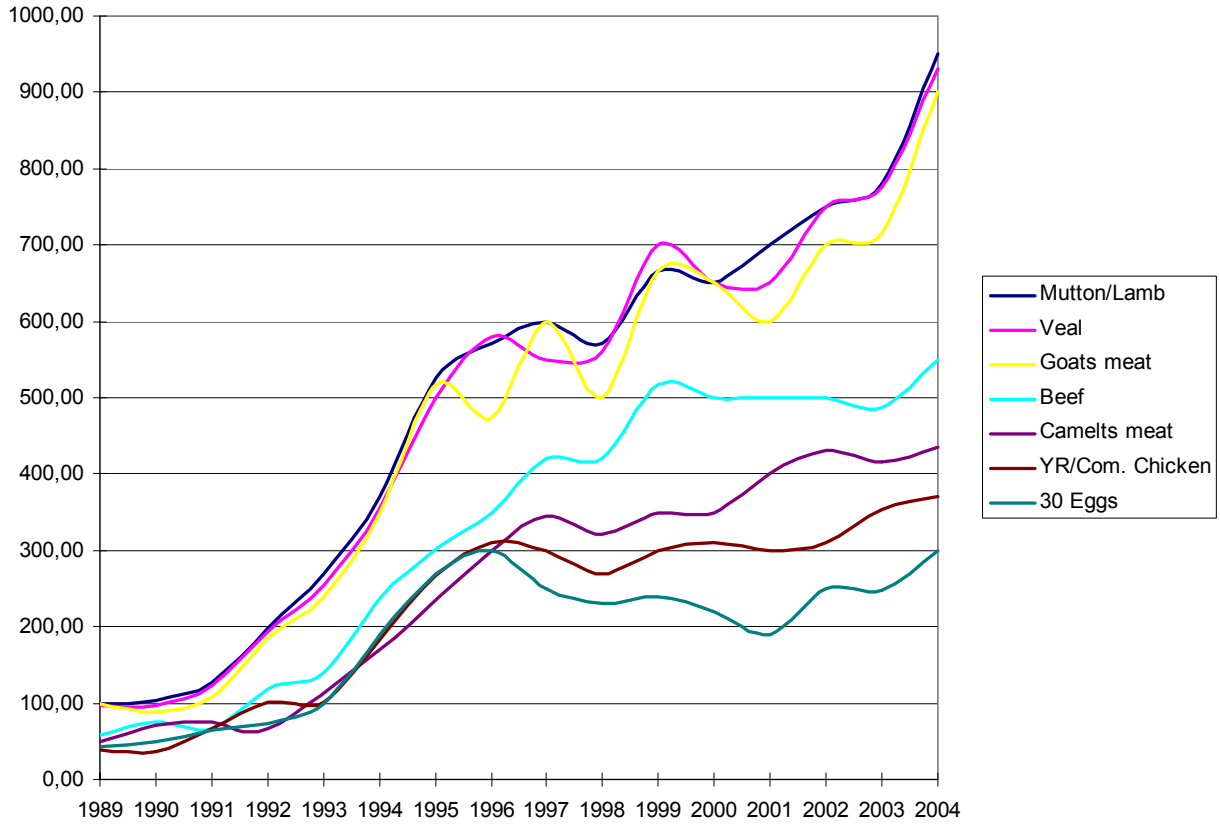
Graph 1: current prices of cereals and oleaginous between 1989 and 2004 (TDA)



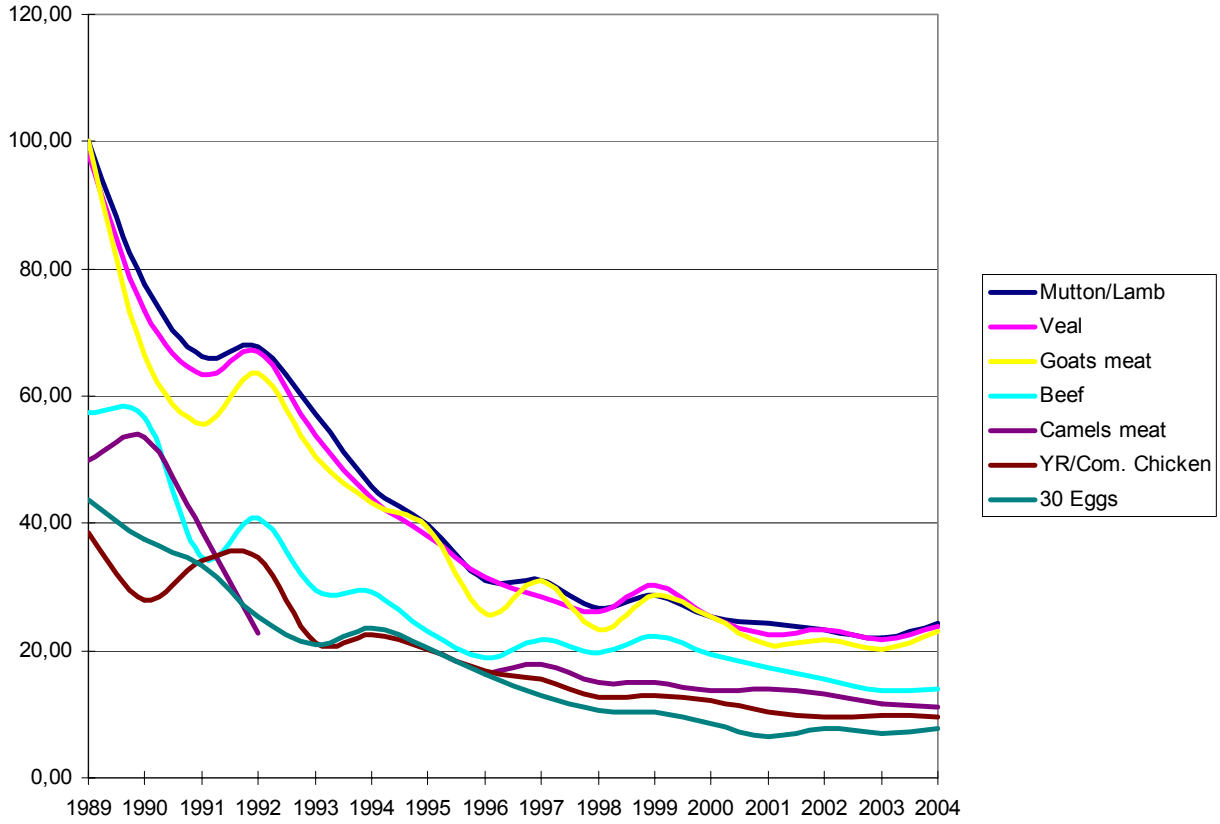
Graph 2: current prices of vegetables between 1989 and 2004 (TDA)



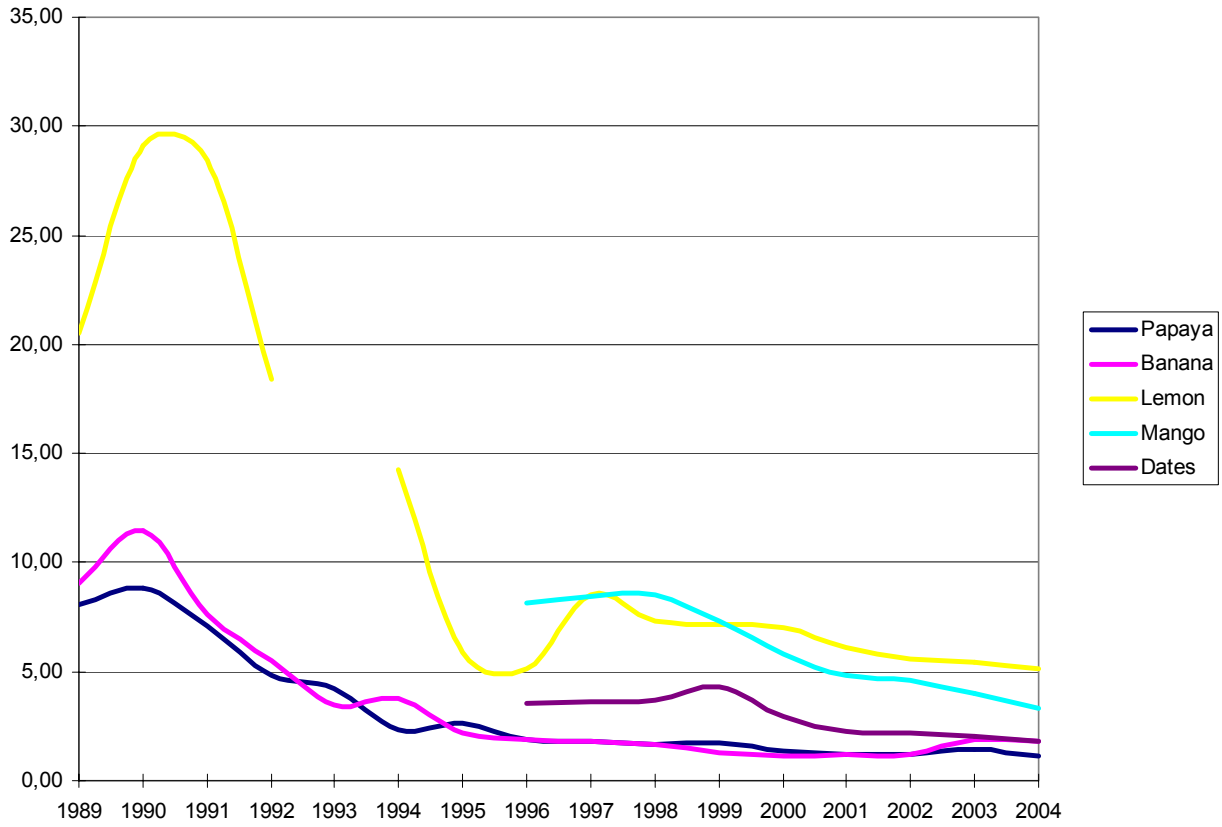
Graph 3: current prices of fruit between 1989 and 2004 (TDA)



Graph 4: current prices of animal production between 1989 and 2004 (TDA)



Graph 5: constant prices of animal production between 1989 and 2004 (TDA)



Graph 6: constant prices of fruit between 1989 and 2004 (TDA)

Annex 5: Cropping systems

Mango:

Period	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
Plantation	Planning the field		4	6000	
	Plantation (trees+work)		9	18000	
	Well + motor-pump			3000000	
	Leaves fertilizer (2nd year)		0,5	2500	
	Leaves fertilizer (3rd year)		0,5	2500	
	Leaves fertilizer (4th year)		0,5	2500	
Sorghum production	1st year	25	111	23431	90385
Cropping system	2nd year	25	111	23431	90385
(Ss/Skh)w	3rd year	25	111	23431	90385
2/3 of maad	4th year	25	111	23431	90385
	5th year	25	111	23431	90385
Mango 4th year	Fungicide		0,5	2500	
	Irrigation		180	24953	
	Harvest	15	105		72000
	Carbon			600	
	Taxe canal			3600	
	Market	20			
Mango 5th year	Fungicide		0,5	2500	
	Irrigation		180	24953	
	Harvest	20	160		144000
	Carbon			600	
	Taxe canal			7200	
	Market	30			
Mango 6th year	Plowing		2	3000	
	Fungicide		0,5	5000	
	Weeding		36		
	Cleaning / Prunning		200		
	Irrigation		180	24953	
	Harvest	30	210		288000
	Carbon			600	
	Taxe canal			14400	
	Market	50			
Mango 7th year	Plowing		2	3000	
	Fungicide		0,5	5000	
	Weeding		36		
	Cleaning / Prunning		300		
	Irrigation		180	24953	
	Harvest	30	210		720000
	Carbon			600	
	Taxe canal			36000	
	Market	50			
Mango 8th to30th	Plowing		2	3000	
	Fungicide		0,5	5000	
	Weeding		36		
	Cleaning / Prunning		400		
	Irrigation		180	24953	
	Harvest	30	210		1026000
	Carbon			600	
	Taxe canal			51300	
	Market	50			

Mean results for one year

Days of family work (7 hours/day)	11
Gross return	842464
Costs of inputs	176156,2
Net return / maad	**666308**
Net return / day of family work	**63314**

O/Skh:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Plowing + Harrowing		4	6000	
	Division (by hand)	12			
	Seeds			1400	
	Sowing (by hand)	8			
Seif	irrigation	10*6		7260	
	Fertilizer	2		3500	
	Insecticide		4*6h	1500	
	Harvest	25days*7h	3pers*25*7		112500
	Transport to market	25*6			
	Plowing		2	3000	
	Canal maintenance		1,5	2250	
	irrigation	1,5			
	Seeds			1250	
	Sowing	2*3pers	2	3000	
	H1 grains	5	30		38889
	Taxe canal			3500	
	Threshing		2	3500	
	H1 forage	2+1	18+9		14800
Kharif	Dromeary to farm		5		
	H2 grains	5	30		38889
	Taxe canal			3500	
	Threshing		2	3500	
	H2 forage	2+1	12+6		15000
	Dromeary to farm		3		

Days of family work (7 hours/day)	62
Gross return	220078
Costs of inputs	43160
Net return / maad	**176918**
Net return / day of family work	**2877**

W/Skh:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Plowing		2	3000	
	Canals maintenance		1,5	2250	
Seif	Irrigation	1,5			

	Seeds			4500	
	Sowing	2*3pers	2	3000	
	Weeding	20			
	Looking		200		
	Harvest		27		60000
	Harrowing		1	1500	
	Canals maintenance		1,5	2250	
	Irrigation	1,5			
	Seeds			1250	
	Sowing	2*3pers	2	3000	
	H1 grains	5	30		38889
	Threshing		2,5	3500	
	Taxe canal			3500	
Kharif	H1 forage	2+1	18+9		14800
	Dromeary to farm		5		
	H2 grains	5	30		38889
	Threshing		2,5	3500	
	Taxe canal			3500	
	H2 forage	2+1	12+6		15000
	Dromeary to farm		3		
	H3 forage	2+1	3+2		8000
	Taxe canal			648	
	Dromeary to farm		1		

Days of family work (7 hours/day)	7,7
Gross return	175578
Costs of inputs	35398
Net return / maad	**140180**
Net return / day of family work	**18171**

(Ss/Skh)w:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Plowing		2	3000	
	Canals maintenance		1,5	2250	
	Irrigation	1,5			
	Seeds			1250	
Seif	Sowing	2*3 persons	2	3000	
	Harvest	2 + 1	18 + 9		18500
	Taxe canal			1499	
	Dromeary to farm		5		
	Grazing				1500
	Plowing		2	3000	
	Canals maintenance		1,5	2250	
	Irrigation	1,5			
	Seeds			1250	
	Sowing	2*3 persons	2	3000	
	H1 grains(women)	5	30		38889
	Threshing		2,5	3500	
	Taxe canal			3500	
Kharif	H1 forage	2 + 1	18 + 9		14800
	Dromeary to farm		5		

	H2 grains(women)	5	30		38889
	Threshing		2,5	3500	
	Taxe canal			3500	
	H2 forage	2 + 1	12 + 6		15000
	Dromeary to farm		3		
	H3 forage	2 + 1	3 + 2		8000
	Taxe canal			648	
	Dromeary to farm		1		

Days of family work (7 hours/day)	5,3
Gross return	135577,885
Costs of inputs	35147
Net return / maad	**100431,385**
Net return / day of family work	**19001**

(Ss//Skh)w:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Plowing		2	3000	
	Canals maintenance		1,5	2250	
	Irrigation	1,5			
	Seeds			1250	
Seif	Sowing	2*3 persons	2	3000	
	H1	2 + 1	18 + 9		18500
	Taxe canal			1498,5	
81	Dromeary to farm		5		
	H2	2 + 1	12+6		12500
	Taxe canal			1012,5	
	Dromeary to farm		3		
	H3	2 + 1	3 + 2		10000
	Taxe canal			810	
	Dromeary to farm		1		
	Plowing		2	3000	
	Canals maintenance		1,5	2250	
	Irrigation	1,5			
	Seeds			1250	
	Sowing	2*3 persons	2	3000	
	H1 grains	5	30		38889
	Threshing		2,5	3500	
	Taxe canal			3500	
Kharif	H1 forage	2 + 1	18 + 9		14800
	Dromeary to farm		5		
	H2 grains	5	30		38889
	Threshing		2,5	3500	
	Taxe canal			3500	
	H2 forage	2 + 1	12+6		15000
	Dromeary to farm				
	H3 forage	2 + 1	3 + 2		8000
	Taxe canal			648	
	Dromeary to farm		1		

Results for one year

Days of family work (7 hours/day)	3,07
Gross return	78289
Costs of inputs	18484,5
Net return / maad	**59804,5**
Net return / day of family work	**19471**

(Ss//Skh)p:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Plowing		2	3000	
	Land division/canal		2	3000	
	Seeds			1250	
	Sowing	2*3 persons	2	3000	
Seif	irrigation	9*20		28072	
	H1 grains	4	24		31111
	Threshing		2	2800	
	H1 forage	2+1	18+9		18500
	Dromeary to farm		5		
	H2 forage	2+1	12+6		12500
	Dromeary to farm		3,5		
	H2 grains	1	7		7778
	Threshing		0,5	700	
	H3 forage	2+1	3+2		6000
	Dromeary to farm		1		
	Plowing		2	3000	
	Land division/canal		2	3000	
	Seeds			1250	
	Sowing	2*3 persons	2	3000	
	irrigation	6*20		18715	
	H1 grains	4	24		31111
	Threshing		2	2800	
	H1 forage	2+1	18+9		14800
Kharif	Dromeary to farm		5		
	H2 grains	3	18		23333
	Threshing		1,5	2100	
	H2 forage	2+1	12+6		15000
	Dromeary to farm		3		
	H3 grains	1,75	10,5		11667
	Threshing		0,75	1050	
	H3 forage	2+1	3+2		12000
	Dromeary to farm		1		

Results for one year

Days of family work (7 hours/day)	25
Gross return	91900
Costs of inputs	38368,5

Net return / maad	**53531,5**
Net return / day	**2180**

(Rest//Skh)p:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Plowing		2	3000	
	Land division/canal		2	3000	
	Seeds			1250	
	Sowing	2*3 persons	2	3000	
	irrigation	6*20		18715	
	H1 grains	4	24		31111
	Threshing		2	2800	
	H1 forage	2+1	18+9		14800
Kharif	Dromeary to farm		5		
	H2 grains	3	18		23333
	Threshing		1,5	2100	
	H2 forage	2+1	12+6		15000
	Dromeary to farm		3		
	H3 grains	1,75	10,5		11667
	Threshing		0,75	1050	
	H3 forage	2+1	3+2		12000
	Dromeary to farm		1		

Results for one year

Days of family work (7 hours/day)	10
Gross return	53955,5
Costs of inputs	17457,5
Net return / maad	**36498**
Net return / day of family work	**3555**

Millet:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Seeds			1000	
	Sowing	1*4 persons		1500	
	Weeding	30			
Kharif	Harvest grains	9			12000
	Threshing		1,5	1200	
	Harvest Forage	12			1500

Days of family work (7 hours/day)	7,9
Gross return	13500
Costs of inputs	3700
Net return / maad	**9800**

Net return / day of family work	1247

Skh+C+M:

Growing season	Step	Family work(h)	P of services(h)	Inputs(YR)	Products(YR)
	Seeds			745	
	Sowing	1*4 persons		1500	
Kharif	H Sorghum grains	4			3500
	Threshing		0,5	315	
	H Sorghum forage	10+5			2600
	H math beans grains	10			480
	H math beans forage	5			600
	Hcowpeas grains	10			2880
	Hcowpeas forage	5			600

Days of family work (7 hours/day)	7,6
Gross return	10660
Costs of inputs	2560
Net return / maad	**8100**
Net return / day of family work	**1070**

Annex 6: Animal husbandry systems

SRc

In the canal area:

Herd Composition	
Sheep	67%
Goat	33%

REPRODUCTION CHARACTERISTICS OF THE HERD:

REPRODUCTION	deliv	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/ex	Ex/Carrier	Prod/year	To sell
Sheep	93%	120%	6%	7,5	10	10	**105%**	14,7	**155%**	**145%**
Goat	98%	112%	10%	11	10	10	**99%**	10,1	**100%**	**90%**

REPRODUCTION TERMS:

Deliv: deliverance rate per reproduction exercise of a female
Prolif: prolificity rate (number of twins) per exercise
Mort young: mortality rate of young animals (from birth to sale) per exercise of a female
I deliv-deliv: interval between 2 deliverances
1st cover: age in months of first covering for young females
Dead/sold: age in years of death for reproductive females (rarely sold)
Prod/ex: productivity of young ruminants per reproductive female and per exercise
Ex/carrier: number of exercises in the live of a reproductive female
Prod/year: productivity of young ruminants per reproductive female and per year
To sell: percentage of young animals sold, per reproductive female and per year

PRODUCTION COSTS PER ANIMAL:

Costs of sorghum feeder according to the seasons:

ALIM	Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh 15/6 - 15/10	122	0,25	50	1525	4625
H1kh-H2kh 15/10 - 15/1	92	0,25	40	920	
H2kh-H3kh 15/1 - 15/3	59	0,20	60	708	
H3kh-H1sef 15/3 - 15/6	92	0,20	80	1472	

Health costs:

VETO	Sheep	Goat	Costs/animal
	100	100	100

Fattening costs:

CONCENTRATE	Qty(kg)/day/young	Time (days)	price (RY/kg)	Costs (RY)
wheat flour	0,15	90	36	1054
wheat bran	0,15	90	25,7	

GROSS RETURN PER ANIMAL:

Sale of young animals per female:

			price RY	% in the her	young to be sold	Return/animal
ALIVE ANIMALS (4 months)	Non fattened	Sheep male/female (67%	5000	67%	145%	7215
		Goats male/female (33%)	8000	33%	90%	
	Fattened	Sheep male/female (67%	9000	67%	145%	11832
		Goats male/female (33%)	10500	33%	90%	

Milk for auto consumption:

MILK	L/day	time (days)	price/L	Prod/year	% goats	Prod/an (RY)
Goat	0,75	120	25	100%	33%	740

NET RETURN PER ANIMAL:

		Inputs	**Products**
Alimentation	H1sef-H1kh	1525	
	H1kh-H2kh	920	
	H2kh-H3kh	708	
	H3kh-H1sef	1472	
Veterinarian services		100	
Fattening		*1054*	
Milk			740
Animals	non fattened		7215
	fattened		*11832*

Results for one year:

Gross return without fattening	7955
Gross return with fattening	12572
Costs of inputs	4725
Costs of fattening	1054
Net return / animal without fattening	**3230**
Net return / animal with fattening	**6793**

WORKING CALENDAR FOR A HERD OF 15 ANIMALS:

WORK TIME	number of SR: 15

Time dedicated to the milking of goats:

	time (h)/ 1 milking	time (days)/yea	Time average (h) /month	nb goats in the herd	pro/year	time (h)/goat/month	time(h)/herd/month
Milking goats	0,07	120	0,7	33%	100%	0,23	3,45

Time for feeding the animals:

		time (h)/day	time (h)/animal/month
Grazing	dec-march	4	120
	april-nov	7	210

	searching forage (h)/day	giving food (h)/day	time (h)/animal/month
Home feeding	0,75	0,25	30

		time (h)/day	time (day)/month	time (h)/animal/month
cutting grass	nov	2	10	20
	dec-may	2	30	60
	june	2	10	20

Human.day per month according to the activity:

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
milking	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Home feeding	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3
cutting grass	8,6	8,6	8,6	8,6	8,6	2,9					2,9	8,6
grazing	17,1	17,1	17,1	30,0	30,0	30,0	30,0	30,0	30,0	30,0	30,0	17,1

Human.day per month according to the gender:

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
women	13,4	13,4	13,4	13,4	13,4	7,6	4,8	4,8	4,8	4,8	7,6	13,4
children	17,1	17,1	17,1	30,0	30,0	30,0	30,0	30,0	30,0	30,0	30,0	17,1

Nb h.j/ animal	**423**

SRr

In the rainy area:

Herd Composition	
Sheep	33%
Goat	67%

REPRODUCTION CHARACTERISTICS OF THE HERD:

REPRODUCTION	deliv r	Prolif	Mort young	I deliv-del	1st cover	Dead/sold	Prod/exercise	Ex/Carrier	Prod/year	To sell
Sheep	93%	120%	18%	8	10	10	**92%**	13,8	**126%**	**116%**
Goat	93%	112%	18%	12	10	10	**86%**	9,2	**79%**	**69%**

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh	15/6 - 15/10	122	0,15	50	915	3647
H1kh-H2kh	15/10 - 15/1	92	0,25	40	920	
H2kh-H3kh	15/1 - 15/3	59	0,20	60	708	
H3kh-H1sef	15/3 - 15/6	92	0,15	80	1104	

VETO	Sheep	Goat	Costs/animal
	0	0	0

CONCENTRATE	Qty(kg)/day/young	Time (days)	price (RY/kg)	Costs (RY)
wheat flour	0,1	90	36	468
1/2 wheat bran	0,1	90	25,7	

GROSS RETURN PER ANIMAL:

			price RY	% in the herd	young to be sold	Return/animal
ALIVE ANIMALS	Non fattened	Sheep male/female (67%)	4000	33%	116%	4754
(4 months)		Goats male/female (33%)	7000	67%	69%	
	Fattened	Sheep male/female (67%)	8000	33%	116%	7435
		Goats male/female (33%)	9500	67%	69%	

MILK	L/day	time (days)	price/L	% goats	Prod/year	Prod/an (RY)
Goat	0,7	105	25	67%	79%	970

NET RETURN PER ANIMAL:

		Inputs	Products
Alimentation	H1sef-H1kh	915	
	H1kh-H2kh	920	
	H2kh-H3kh	708	
	H3kh-H1sef	1104	
Veterinarian services		0	
Fattening		*468*	
Milk			970
Animals	non fattened		4754
	fattened		*7435*

Results for one year

Gross return without fattening	5724
Gross return with fattening	8405
Costs of inputs	3647
Fattening	468
Net return / animal without fattening	**2077**
Net return / animal with fattening	**4290**

WORK TIME	number of SR: 15

	time (h)/ 1 milkin	time (days)/year	Time average (h) /month	nb goats in the her	pro/year	time (h)/goat/month	time(h)/herd/month
Milking goats	0,07	105	0,61	67%	79%	0,32	4,85

		time (h)/day	time (day)/month	time (h)/animal/month
Grazing	august-oct	7	30	210
	nov	4	10	120

		searching forage (h)/day	giving food (h)/day	time (h)/animal/month
Home feeding	dec to sept	2	0,25	67,5
	oct-nov	0,75	0,25	30

		time (h)/day	time (day)/month	time (h)/animal/month
cowpeas, mathbean	nov	0,25	15	3,75

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
milking	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7
Home feeding	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	4,3	4,3	9,6
cowpeas, math												
bean											0,5	
grazing								30,0	30,0	30,0	17,1	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
women	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	1,0	0,7
men	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	4,3	4,6	9,6
children	0,0	0,0	0,0	0,0	0,0	0,0	0,0	30,0	30,0	30,0	17,1	0,0

Nb h.j/ animal	**221**

SRrc

At the boarder of canal and rainy area:

Herd Composition	
Sheep	33%
Goat	67%

REPRODUCTION CHARACTERISTICS OF THE HERD:

REPRODUCTION	deliv r	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/exercis	Ex/Carrier	Prod/year	To sell
Sheep	93%	120%	6%	7,46	10	10	**105%**	14,7	**155%**	**145%**
Goat	98%	112%	10%	10,9	10	10	**99%**	10,1	**100%**	**90%**

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh	15/6 - 15/10	122	0,25	50	1525	4625
H1kh-H2kh	15/10 - 15/1	92	0,25	40	920	
H2kh-H3kh	15/1 - 15/3	59	0,20	60	708	
H3kh-H1sef	15/3 - 15/6	92	0,20	80	1472	

VETO	Sheep	Goat	Costs/animal
	100	100	100

CONCENTRATE	Qty(kg)/day/young	Time (days)	price (RY/kg)	Costs (RY)
wheat flour	0,15	90	36	898
wheat bran	0,15	90	25,7	

GROSS RETURN PER ANIMAL:

			price RY	% in the herd	young to be sold	Return/animal
ALIVE ANIMALS	Non fattened	Sheep male/female (67%)	4000	33%	145%	6116
(4 months)		Goats male/female (33%)	7000	67%	90%	
	Fattened	Sheep male/female (67%)	8000	33%	145%	9528
		Goats male/female (33%)	9500	67%	90%	

MILK	L/day	time (days)	price/L	% goats	Prod/year	Prod/an (RY)
Goat	0,75	120	25	67%	100%	1503

NET RETURN PER ANIMAL:

		Inputs	Products
Alimentation	H1sef-H1kh	1525	
	H1kh-H2kh	920	
	H2kh-H3kh	708	
	H3kh-H1sef	1472	
Veterinarian services		100	
Fattening		*898*	
Milk			1503
Animals	non fattened		6116
	fattened		*9528*

Results for one year

Gross return without fattening	7619
Gross return with fattening	11031
Costs of inputs	4725
Fattening	898
Net return / animal without fattening	**2894**
Net return / animal with fattening	**5408**

WORK TIME	number of SR: 15

	time (h)/ 1 milkin	time (days)/yea	Time average (h) /month	nb goats in the herd	pro/year	time (h)/goat/month	time(h)/herd/month
Milking goats	0,07	120	0,7	67%	100%	0,47	7,013210862

		time (h)/day	time (h)/animal/month
Grazing	dec-march	4	120
	april-nov	7	210

	searching forage (h)/day	giving forage (h)/day	time (h)/animal/month
Sorghum feeding	0,75	0,25	30

		time (h)/day	time (day)/month	time (h)/animal/month
cutting grass	nov	2	10	20
	dec-may	2	30	60

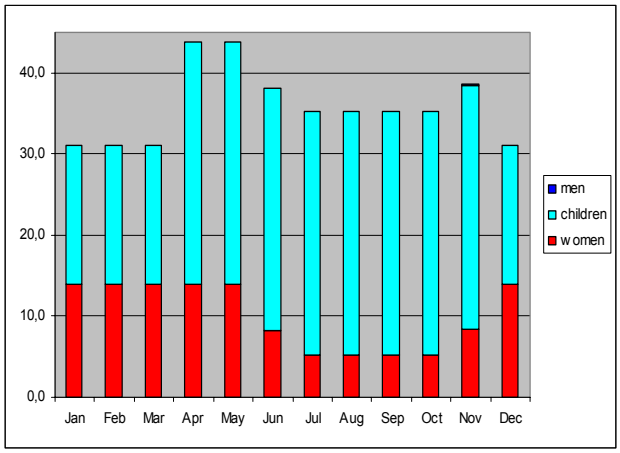
	june	2	10	20

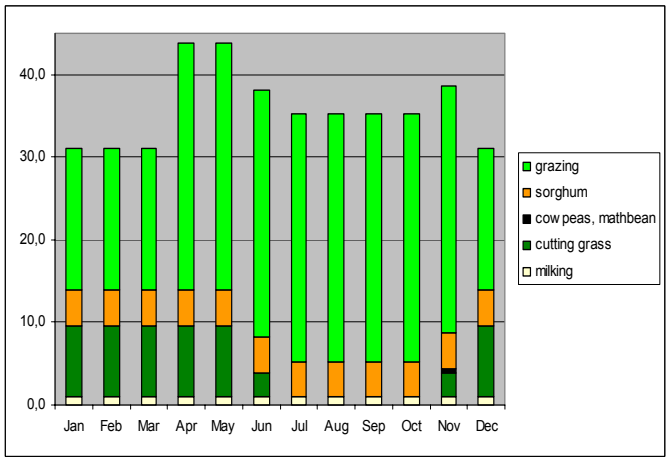
		time (h)/day	time (day)/month	time (h)/animal/month
cowpeas, math bean	nov	0,25	15	3,75

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
milking	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
cutting grass	8,6	8,6	8,6	8,6	8,6	2,9					2,9	8,6
cowpeas, math bean											0,5	
sorghum	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3
grazing	17,1	17,1	17,1	30,0	30,0	30,0	30,0	30,0	30,0	30,0	30,0	17,1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
women	13,9	13,9	13,9	13,9	13,9	8,1	5,3	5,3	5,3	5,3	8,4	13,9
children	17,1	17,1	17,1	30,0	30,0	30,0	30,0	30,0	30,0	30,0	30,0	17,1
men	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0

Nb hours/ animal **430**





Cac

REPRODUCTION CHARACTERISTICS OF THE COW:

REPRODUCTION	deliv	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/exercise	Ex/Carrier	Prod/year	To sell
Cow	98%	102%	6%	15	12	15	**94%**	11,2	**70%**	**63%**

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh	15/6 - 15/10	122	2,00	50	12200	41360
H1kh-H2kh	15/10 - 15/1	92	2,00	40	7360	
H2kh-H3kh	15/1 - 15/3	59	2,00	60	7080	
H3kh-H1sef	15/3 - 15/6	92	2,00	80	14720	

VETO	Costs/animal
	1000

CONCENTRATE	Qty(kg)/day/young	Time (days)	price (RY/kg)	To sell	Costs (RY)
Wheat flour	0,3	180	36	63%	2115
wheat bran	0,3	180	25,7	63%	

GROSS RETURN PER ANIMAL:

		price RY	To sell	Return (RY/cow)
ALIVE ANIMALS	Non fattened	45000	63%	28571
(8 months)	Fattened	60000	63%	38095

MILK	L/day	time (days)	price/L	Prod/year	Prod/an (RY)
cow	4,6	210	67	70%	45408

NET RETURN PER ANIMAL:

		Inputs	Products
Alimentation	H1sef-H1kh	12200	
	H1kh-H2kh	7360	
	H2kh-H3kh	7080	
	H3kh-H1sef	14720	
Veterinarian services		1000	
Fattening		*2115*	
Milk			45408
Animals	non fattened		28571
	fattened		*38095*

Results for one year

Gross return without fattening	73979
Gross return with fattening	83503
Costs of inputs	42360
Fattening	2115
Net return / animal without fattening	**31619**
Net return / animal with fattening	**39028**

WORK TIME 1 cow

	time (h)/ 1 milking	time (days)/year	Time average (h) /month	pro/year	time (h)/goat/month
Milking cow	0,33	210	5,775	70%	4,05

	searching forage (h)/day	giving food (h)/day	time (h)/animal/month
Home feeding	0,75	0,25	30

		time (h)/day	time (day)/month	time (h)/animal/month
cutting grass	nov	2	10	20
	dec-may	2	30	60
	june	2	10	20

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

milking	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Home feeding	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3
cutting grass	8,6	8,6	8,6	8,6	8,6	2,9					2,9	8,6

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
women	13,4	13,4	13,4	13,4	13,4	7,7	4,9	4,9	4,9	4,9	7,7	13,4

Nb hours/ animal	**116**

Car

REPRODUCTION CHARACTERISTICS OF THE COW:

REPRODUCTION	deliv	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/exercise	Ex/Carrier	Prod/year	To sell
Cow	90%	102%	8%	15	12	15	84%	11,2	63%	56%

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh	15/6 - 15/10	122	1,50	50	9150	31020
H1kh-H2kh	15/10 - 15/1	92	1,50	40	5520	
H2kh-H3kh	15/1 - 15/3	59	1,50	60	5310	
H3kh-H1sef	15/3 - 15/6	92	1,50	80	11040	

VETO	Costs/animal
	0

CONCENTRATE	Qty(kg)/day/young	Time (days)	price (RY/kg)	To sell	Costs (RY)
wheat	0,3	180	36	56%	1879
wheat bran	0,3	180	25,7	56%	

GROSS RETURN PER ANIMAL:

		price RY	To sell	Return (RY/cow)
ALIVE ANIMALS (8 months)	Non fattened	45000	56%	25377
	Fattened	60000	56%	33836

MILK	L/day	time (days)	price/L	Prod/year	Prod/an (RY)
cow	3	150	67	63%	19013

NET RETURN

PER ANIMAL:

		Inputs	Products
Alimentation	H1sef-H1kh	9150	
	H1kh-H2kh	5520	
	H2kh-H3kh	5310	
	H3kh-H1sef	11040	
Veternarian services		0	
Fattening		*1879*	
Milk			19013
Animals	non fattened		25377
	fattened		*33836*

Results for one year

Gross return without fattening	44390
Gross return with fattening	52849
Costs of inputs	31020
Fattening	1879
Net return / animal without fattening	**13370**
Net return / animal with fattening	**19950**

WORK TIME 1 cow

	time (h)/ 1 milking	time (days)/year	Time average (h) /month	pro/year	time (h)/goat/month
Milking cow	0,33	150	4,125	63%	2,60

		time searching forage (h)/day	time giving food (h)/day	time (h)/animal/month
Home feeding	dec to espt	2	0,25	67,5
	oct-nov	0,75	0,25	30

		time (h)/day	time (day)/month	time (h)/animal/month
cowpeas,	nov	0,25	15	3,75

math bean				

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
milking	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Home feeding	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	4,3	4,3	9,6
cowpeas, math bean											0,5	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
women	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,6	0,4
men	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	9,6	4,3	4,6	9,6

Nb hours/ animal	**110**

Cgc

REPRODUCTION CHARACTERISTICS OF THE COW:

REPRODUCTION	deliv	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/exercise	Ex/Carrier	Prod/year	To sell
Cow	90%	102%	8%	15	12	15	84%	11,2	63%	56%

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh	15/6 - 15/10	122	1,50	50	9150	31020
H1kh-H2kh	15/10 - 15/1	92	1,50	40	5520	
H2kh-H3kh	15/1 - 15/3	59	1,50	60	5310	
H3kh-H1sef	15/3 - 15/6	92	1,50	80	11040	

VETO	Costs/animal
	1000

CONCENTRATE	Qty(kg)/day/young	Time (days)	price (RY/kg)	To sell	Costs (RY)
wheat	0,3	180	36	56%	1879
wheat bran	0,3	180	25,7	56%	

GROSS RETURN PER ANIMAL:

		price RY	To sell	Return (RY/cow)
ALIVE ANIMALS	Non fattened	45000	56%	25377
(8 months)	Fattened	60000	56%	33836

MILK	L/day	time (days)	price/L	Prod/year	Prod/an (RY)
Cow	4,6	120	67	63%	23322

NET RETURN PER ANIMAL:

		Inputs	Products
Alimentation	H1sef-H1kh	9150	
	H1kh-H2kh	5520	
	H2kh-H3kh	5310	
	H3kh-H1sef	11040	
Veternarian services		1000	
Fattening		*1879*	
Milk			23322
Animals	non fattened		25377
	fattened		*33836*

Results for one year

Gross return without fattening	48700
Gross return with fattening	57159
Costs of inputs	32020
Fattening	1879
Net return / animal without fattening	**16680**
Net return / animal with fattening	**23260**

WORK TIME 1 cow

	time (h)/ 1 milking	time (days)/year	Time average (h) /month	pro/year	time (h)/goat/month
Milking cow	0,33	120	3,3	63%	2,08

		time (h)/day	time (h)/animal/month
Grazing	dec-march	4	120
	april-nov	7	210

	time searching forage (h)/day	time giving food (h)/day	time (h)/animal/month
Home feeding	0,75	0,25	30

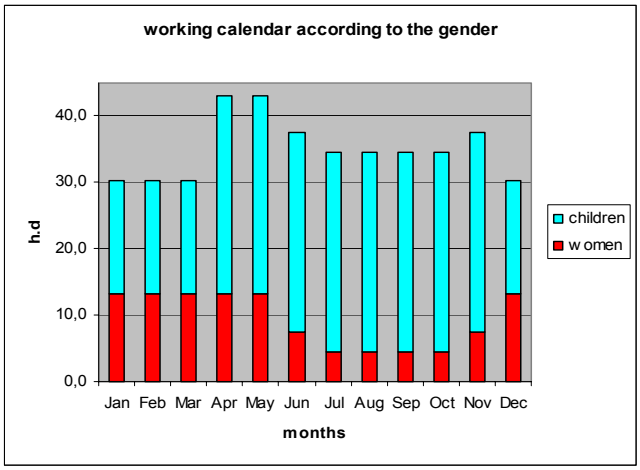
		time (h)/day	time (day)/month	time (h)/animal/month
cutting grass	nov	2	10	20
	dec-may	2	30	60

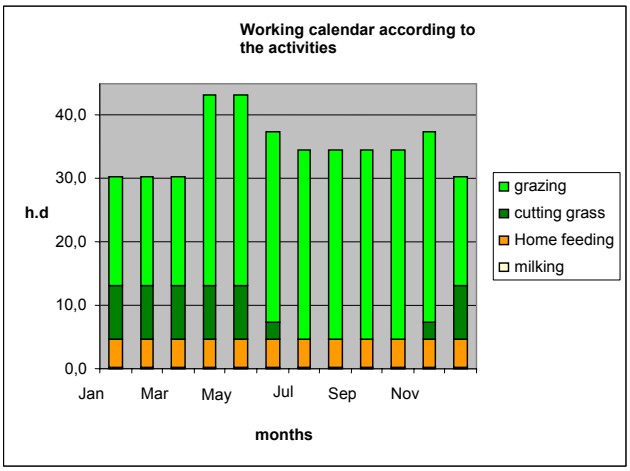
	june	2	10	20

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
milking	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Home feeding	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3
cutting grass	8,6	8,6	8,6	8,6	8,6	2,9					2,9	8,6
grazing	17,1	17,1	17,1	30,0	30,0	30,0	30,0	30,0	30,0	30,0	30,0	17,1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
women	13,2	13,2	13,2	13,2	13,2	7,4	4,6	4,6	4,6	4,6	7,4	13,2
children	17,1	17,1	17,1	30,0	30,0	30,0	30,0	30,0	30,0	30,0	30,0	17,1

Nb hours/ animal **421**





Donkey

REPRODUCTION CHARACTERISTICS:

REPRODUCTION	deliv /	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/exercise	Ex/Carrier	Prod/year	To sell
Donkey	98%	102%	6%	18	12	15	**94%**	9,3	**58%**	52%

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season	Total (RY)
H1sef-H1kh	15/6 - 15/10	122	1,00	50	6100	17000
H1kh-H2kh	15/10 - 15/1	92	1,00	40	3680	
H2kh-H3kh	15/1 - 15/3	59	1,00	60	3540	
H3kh-H1sef	15/3 - 15/6	92	0,50	80	3680	

GROSS RETURN PER ANIMAL:

	price RY	To sell	Return (RY/cow)
ALIVE ANIMALS	20000	52%	10360

NET RETURN PER ANIMAL:

		Inputs	**Products**
Alimentation	H1sef-H1kh	6100	
	H1kh-H2kh	3680	
	H2kh-H3kh	3540	
	H3kh-H1sef	3680	
Animals			10360

Results for one year

Gross return for females	10360
Costs of inputs	17000
Net return / male	**-17000**
Net return / female	**-6640**

Net return / donkey	-11820

WORK TIME 1 donkey

	time searching forage (h)/day	time giving food (h)/day	time (h)/animal/month
Home feeding	0,75	0,25	30

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Home feeding	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3

Nb hours/ animal	51

Dromedary

REPRODUCTION CHARACTERISTICS:

REPRODUCTION	deliv	Prolif	Mort young	I deliv-deliv	1st cover	Dead/sold	Prod/exercise	Ex/Carrier	Prod/year	To sell
Dromedary	98%	100%	6%	24	12	20	**92%**	9,5	**44%**	39%

PRODUCTION COSTS PER ANIMAL:

ALIM		Time (days)	packs/day/anl	price/pack	Price/season
H1sef-H1kh	15/6 - 15/10	122	2,00	50	12200
H1kh-H2kh	15/10 - 15/1	92	2,00	40	7360
H2kh-H3kh	15/1 - 15/3	59	2,00	60	7080
H3kh-H1sef	15/3 - 15/6	92	1,00	80	7360

GROSS RETURN PER ANIMAL:

	price RY	To sell	Return (RY/cow)
ALIVE ANIMALS	20000	39%	7751

MILK	L/day	time (days)	price/L	Prod/year	Prod/an (RY)
dromedary	4,2	360	60	44%	39696

NET RETURN PER ANIMAL:

		Inputs	**Products**
Alimentation	H1sef-H1kh	12200	
	H1kh-H2kh	7360	
	H2kh-H3kh	7080	
	H3kh-H1sef	7360	
Animals			7751
Milk			*39696*

Results for one year

Gross return for females	47448
Costs of inputs	34000
Net return / male	**-34000**
Net return / female	**13448**
Net return / dromedary	**-10276**

WORK TIME 1 dromedary

	time (h)/ 1 milking	time (days)/year	Time average (h) /month	pro/year	time (h)/goat/month
Milking cows	0,33	360	9,9	44%	4,33

	time searching forage (h)/day	time giving food (h)/day	time (h)/animal/month
Home feeding	0,75	0,25	30

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
milking	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Home feeding	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3	4,3

Nb hours/ animal **59**

Annex 7: Farming systems

		Al Rosfa							Al Nasheria		
	For 1 maad	*Small share-farmer growing 2 sorghum*	*Middle owner growing 1 sorghum*	*External investors*	*Small owner growing okra*	*Small owner growing watermelon*	*Middle share farmer in rainy area*	*Middle owner in rainy area, share-farmer in canals area*	*Middle owner irrigating by well*	*Small share-farmer irrigating by well*	*Nomads*
Number of maad of each cropping systems	*Mango*			1,00							
	O/Skh				0,20						
	W/Skh					0,33					
	(Ss/Skh)w	1,00			0,80	0,67					
	(Ss//Skh)w		1,00								
	(Ss//Skh)p								1,00		
	(Skh)p							0,15		1,00	
	Millet						0,50	0,64			
	Skh+C+M						0,50	0,21			
Number of animal of each animal husbandry systems	*SRc*	1,50	1,00		1,50	1,50			1,00	0,50	
	SRr						1,00				
	SRrc							1,50			
	Cac		0,30		0,40				0,30		
	Car						0,08	0,08		0,20	
	Cgc	0,30				0,30					
	Donkey	0,20	0,20		0,20	0,20	0,10	0,10	0,20	0,20	
	Dromedary		0,10						0,10		

Incomes from crops	19561	43481	485505	78696	79769	4425	10066	35457	8159	
Incomes from livestock	7485	9324	0	15129	7485	1965	4229	7485	7485	
Total farm income / maad	27046	52805	485505	93825	87254	6390	14294	42942	15643	
Non proportional costs	0	0	140000	4000	20000	0	0	140000	0	
Working person on the farm	4	3	1	3	4	3	3	3	3	

% of livestock in farm income	28%	18%	0%	16%	9%	31%	30%	17%	48%	100%

For the following farming systems, the net farm income is calculated by adding the net returns of each cropping and animal husbandry system, then by taking in account the salaries for worker, the part given to the land owner, the zeka and then the forage for transportation.

Each time, the costs are given both in kind and in monetary costs to take it in account in the calculation of the farm income.

In all systems, farmers do not use specific tools, and the value of the ones they are using can be neglected.

Small owner growing mango: 1 familial worker, a big motor pump

Net return/maad	666308

	Salaries		
	Time	Costs	Taxe market
4th year	280	28000	6840
5th year	535	53500	13680
6th year	1001	100100	27360
7th year	1106	110600	68400
8th to 30th year	1206	120600	97470
Total costs		102200	78603

Farm income from the crops:	485505
Total farm income / maad:	**485505**
Investment:	100000
Maintenance	40000
Non proportionnal costs	**140000**

Small owner growing okra: 3 familial workers, a small motor pump

(Ss/Skh)w	0,80
O/Skh	0,2

Taxe market okra
2250

Net return/maad	115729

		Salaries			Zeka			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
H1 seif	296	56	2812		24	1198,8	43	173
H2 seif graz	24							24
H1 kharif gr	556	56	3892	50	50	3502,8		400
H1 kharif for	370	70	2812			0	60	240
H2 kharif gr	556	56	3892	50	50	3502,8		400
H2 kharif for	250	48	2850			0	41	162
H3 kharif	100	19	1520		8	648	15	58
Total costs			17778			8852,4	8152	

Farm income from the crops:	78696

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available		173	24				240		162		58		
	Nb												
SRc	**1,5**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2
Cac	**0,4**	2	2	2	2	2	2	2	2	2	2	2	2
Donkey	**0,2**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5
Consum.		41,25	41,25	41,25	41,25	41,25	41,25	41,25	39	39	36	36	36
Stock		131	114	73	32	-10	189	148	271	232	254	218	182

Farm incom from animals:	SRc	4844,9
	Cac	12648
	Donkey	-2364
Total		15129
Total farm income / maad:		**93825**
Investment:		**4000**

Small owner growing watermelon: 4 familial workers

(Ss/Skh)w	0,67
W/Skh	0,33

Net return/maad	113548

		Salaries			Zeka			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
H1 seif	247,9	47	2355,05		20	1003,995	36	145
H2 seif graz	20,1							20
H1 kharif gr	556	56	3892	50	50	3502,8		400
H1 kharif for	370	70	2812			0	60	240
H2 kharif gr	556	56	3892	50	50	3502,8		400
H2 kharif for	250	48	2850			0	41	162
H3 kharif	100	19	1520		8	648	15	58
Total costs			17321,1			8657,595	7801	

Farm income from the crops:	79769

Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May

Available		145	20,1				240		162		58		
	Nb												
SRc	**1,5**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2
Cgc	**0,3**	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Donkey	**0,2**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5

Consum.		30,75	30,75	30,75	30,75	30,75	30,75	30,75	28,5	28,5	25,5	25,5	25,5
Stock		114	103	72	42	11	220	189	323	294	327	302	276

Farm incom from animals:	SRc	4845
	Cgc	5004
	Donkey	-2364
Total		7485
Total farm income / maad:		**87254**
Salaries for looking watermelon		20000
Investment:		0
Non proprtionnal costs:		**20000**

Share farmer growing sorghum in canals area: 4 familial workers

(Ss/Skh)w	1,00

Net return/maad	100431

		Salaries			Owner			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
H1 seif	370	70	3515		150	7492,5	30	120
H2 seif graz	30							30
H1 kharif gr	556	56	3892	50	250	17514		200
H1 kharif for	370	70	2812		150	5994	30	120
H2 kharif gr	556	56	3892	50	250	17514		200
H2 kharif for	250	48	2850		101	6075	20	81
H3 kharif	100	19	1520		41	3240	8	32
Total costs			18481			57829,5	4560,3	

Farm income from the crops: 19560,585

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available		120	30				120		81		32		
	Nb												
SRc	**1,5**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2

Cgc	**0,3**	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Donkey	**0,2**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5

Consum.		30,75	30,75	30,75	30,75	30,75	30,75	30,75	28,5	28,5	25,5	25,5	25,5
Stock		89	88	58	27	-4	85	55	107	79	85	60	34

Farm incom from animals:	SRc	4844,9
	Cgc	5004
	Donkey	-2364
Total		7484,9
Total farm income / maad:		**27046**
Investment:		**0**

Middle owner in canals area: 3 familial workers

(Ss//Skh)w	1,00

Net return/maad	59804,5

		Salaries			Zeka			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
H1 seif	185	35	1757,5		15	749,25		135
H2 seif	125	24	1187,5		10	506,25		91
H3 seif	75	14	570		6	243		55
H1 kharif gr	278	28	1946	25	25	1751,4		200
H1 kharif for	185	35	1406			0		150
H2 kharif gr	278	28	1946	25	25	1751,4		200
H2 kharif for	125	24	1425			0		101
H3 kharif	50	10	760		4	324		36
Total costs			10998			5325,3		

Farm income from the crops: 43481,2

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available		135		91			205		101		36		
	Nb												
SRc	**1**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2
Cac	**0,3**	2	2	2	2	2	2	2	2	2	2	2	2
Donkey	**0,2**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5
Drom.	**0,1**	2	2	2	2	2	2	2	2	2	1	1	1

Consum.		37,5	37,5	37,5	37,5	37,5	37,5	37,5	36	36	30	30	30

Stock	97	60	113	76	38	206	168	233	197	204	174	144

Farm incom from animals:	
SRc	3229,9
Cac	9485,7
Donkey	-2364
Drom.	-1028
Total	9324
Total farm income / maad:	**52805**
Investment:	**0**

Middle share farmer in the rainy area

Skh+C+M	0,50
Millet	0,50

Net return/maad	8950

		Salaries			Owner			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
Sorg gr	25			3	13	875		10
Sorg for	32,5				16	650		16
Cowp gr	20							20
Cowp for	7,5							8
Math gr	3							3
Math for	7,5							8
Millet gr	75			8	38	3000		30
Millet for	25				13	375		13
Total costs						4525		

Farm income from the crops: 4425

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available							44						
	Nb												
SRr	**1**	0,15	0,15	0,15	0,15	0,25	0,25	0,25	0,2	0,2	0,15	0,15	0,15
Car	**0,08**	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Donkey	**0,1**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5
Consum.		11,1	11,1	11,1	11,1	14,1	14,1	14,1	12,6	12,6	9,6	9,6	9,6
Stock		-11	-22	-33	-44	-59	-29	-43	-56	-68	-78	-87	-97

Farm incom from animals:	SRr	2077,1
	Car	1069,6
	Donkey	-1182
	Total	1964,7
Total farm income / maad:		**6390**
Investment:		**0**

Middle owner in the rainy area and share farmer in the canals area

(Ss/Skh)w	0,15
Millet	0,64
Skh+C+M	0,21

Net return/maad	23037,7

		Salaries			Owner		Zeka			
	Production	Kind	Costs	Threshing	Kind	Costs	Kind	Costs	Transport	Available
H1 seif	55,5	11	527,25		22	1123,88			4	18
H2 seif graz	4,5									5
H1 Sor gr canal	83,4	8	583,8	8	38	2627,1				30
H1 Sor for canal	55,5	11	421,8		22	899,1			4	18
H1 Sor gr rainy	10,5			1			1,05	73,5		9
H1 Sor for rainy	13,65									14
Cowp gr	8,4									8
Cowp for	3,15									3
Math gr	1,26									1
Math for	3,15									3
Millet gr	96			10			9,6	768		86
Millet for	32									32
H2 kharif gr	83,4	8	583,8	8	38	2627,1				30
H2 kharif for	37,5	7	427,5		15	911,25			3	12
H3 kharif	15	3	228		6	486			1	5
Total costs			2772			8674		842	684	

Farm income from the crops: 10066

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available		18	5				70		12		5		
	Nb												
SRcr	**1,5**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2
Car	**0,08**	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Donkey	**0,1**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5
Consum.		17,85	17,85	17,85	17,85	17,85	17,85	17,85	15,6	15,6	14,1	14,1	14,1

Stock	0	-13	-31	-49	-67	-15	-33	-36	-52	-61	-75	-89

Farm incom from animals:

SRcr	4341,2
Car	1069,6
Donkey	-1182

Total 4228,8

Total farm income / maad: **14294**

Investment: **0**

Middle owner irrigated by well

(Ss//Skh)p	1,00

Net return/maad	53531,5

		Salaries			Zeka			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
H1 seif gr	222	22	1554	20	20	1398,6		160
H1 seif for	185	35	1757,5					150
H2 seif	125	24	1187,5		10	506,25		91
H3 seif gr	55,5	6	388,5	5	5	349,65		40
H3 seif for	75	14	570					61
H1 kharif gr	222	22	1554	20	20	1398,6		160
H1 kharif for	185	35	1406					150
H2 kharif gr	222	22	1554	20	20	1398,6		160
H2 kharif for	125	24	1425					101
H3 kharif	75	14	1140		6	486		55
Total costs			12536,5			5537,7		

Farm income from the crops: 35457,3

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available		150		91			211		101		55		
	Nb												
SRc	**1,5**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2
Cgc	**0,3**	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Donkey	**0,2**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5
Consum.		30,75	30,75	30,75	30,75	30,75	30,75	30,75	28,5	28,5	25,5	25,5	25,5
Stock		119	88	149	118	87	267	236	309	281	310	284	259

Farm incom from animals:

SRc	4844,9

Cgc	5004
Donkey	-2364

Total	7484,9

Total farm income / maad:	**42942**

Investment:	100000
Pump maintenance	40000
Non proportional costs	**140000**

Share farmer irrigated sorghum by well

(Rest//Skh)p	1,00

Net return/maad	36498

		Salaries			Owner			
	Production	Kind	Costs	Threshing	Kind	Costs	Transport	Available
H1 kharif gr	222	22	1554	20	100	6993		80
H1 kharif for	185	35	1406		75	2997	15	60
H2 kharif gr	222	22	1554	20	100	6993		80
H2 kharif for	125	24	1425		51	3037,5	10	41
H3 kharif	50	10	760		20	1620	4	16

Total costs	6699	21640,5	
Farm income from the crops:			8158,5

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Available							60		41		16		
	Nb												
SRc	**1,5**	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,2	0,2	0,2	0,2	0,2
Cgc	**0,3**	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Donkey	**0,2**	1	1	1	1	1	1	1	1	1	0,5	0,5	0,5
Consum.		30,75	30,75	30,75	30,75	30,75	30,75	30,75	28,5	28,5	25,5	25,5	25,5
Stock		-31	-62	-92	-123	-154	-125	-155	-143	-172	-181	-207	-232

Farm incom from animals:	SRc	4844,9
	Cgc	5004
	Donkey	-2364
	Total	7484,9
Total farm income / maad:		**15643**
Investment:		**0**

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