Monetarization of Ecosystem Services of Oasean Biome (Case Study: Provisioning Services of Middle Draa Valley Oases, Morocco)

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Authors’ contributions

This work was carried out in collaboration between all authors. Author AK designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors II, MM and MYK managed the literature searches, reviewed the first draft and provided valuable assistance. All authors read and approved the final manuscript.

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ABSTRACT

Numerous studies have evaluated the monetarization of the ecosystem services throughout the world, but few have showed the oasean ecosystem services (Desert oasis). The purpose of this research is to identify and quantify ecosystem services as a tool to provide useful information for the management of arid lands. This study can serve as a reference to measure future changes in the oasean ecosystem mainly under the impact of extreme events. In this paper, we examine the economic value of the ecosystem services provided by the oases of Middle Draa Valley (MDV), which is part of Biosphere Reserve of southern Moroccan Oasis (UNESCO). The economic values are standardized to US$ per hectare per year (2008-2010 period prices). The total value is found to be 117639, 75Dhs /ha/year (14116,7US$/ha/year) in the arable area (for 26 000ha) and

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2039Dh/ha/year (244,7US$/ha/year) for the total area (1500 000ha). The study can be applied to other oases of the pre-Saharan part of Morocco because of the similarity of lifestyle, climate, and water requirements etc.

Keywords: Economic value; provisioning services; oasean ecosystem; Morocco; Africa.

1. INTRODUCTION

Ecosystem services (E.g.: clean water supply, pollination, seed dispersal, soil fertility…) are the material and nonmaterial benefits that humans derive from nature [1]. Analysis of ecosystem services is an increasing feature of such undertakings and has prompted a rapidly expanding literature regarding the implementation of such analyses [2-10]. Recently, the analysis of ecosystem services is oriented from a qualitative analysis to quantitative analysis [11]. Climate change poses new and significant challenges, not only for the adaptation of economic systems, but also within the scientific community of «ecological economy» [12], because it changes the quantity and location of services provided by natural systems. Adaptation to climate change involves the management of natural resources, based on quantitative analysis of ecosystem services. From here comes the idea to quantifying oasean provisioning ecosystem services. The purpose of this study is to quantify the provisioning services provided by the oasean ecosystem in Middle Draa Valley (MDV) that have a positive impact on local human well-being and food security. MDV is one of 67 biosphere reserves located in Africa and specifically is located in the Biosphere Reserve of Southern Moroccan Oasis (UNESCO). Which is an indicator of major climatic trends in the Mediterranean region, is currently, experiencing climatic degradation and rapid desertification (due to climatic and anthropogenic impacts) [13]. This situation threatens the oasean ecosystems already fragile. The need for such study is both for the environmental vulnerability [14] and for the importance of this ecosystem. Indeed, we can list seven major sites of interest: two RAMSAR sites [15], one national parks [16], three Moroccan Observatories of Sahara and Sahel (Issougui, Oued Mird and Fezouata Observatories) [17] and the solar complex of Ouarzazate [18].

In fact, Middle Draa Valley is located between the Moroccan High Atlas Mountains (north) and the Saharan desert in the south. As a result of its location, the region is characterized by [19]:

- High temperatures, especially between June and September (43 to 50°C);
- Strong thermal amplitudes (20°C in Tagounite near to Zagora city about 60km)
- Long hours of sunshine (between 3055 and 3078 hours/year)
- High rates of evapo-transpiration particularly during summer.

The oases of Draa get the water from the peaks of High Atlas. Agriculture and pastoralism dominates more than 70% of the local economy, these activities are unprofitable and does not always allow people meet their needs [20]. As agricultural production strongly depends on irrigation, water scarcity is a principal problem [21]. The environmental vulnerability is accelerated by social vulnerability, as shown in the Table 1, that makes the oasean communities of Middle Draa Valley often at the periphery of society, geographically, politically and economically.

Table 1. Middle Draa Valley [22]

|                        | Urban area | Rural area |
|------------------------|------------|------------|
| Human Development Indicators (HDI) |            |            |
| Illiteracy             | 34.75%     | 55%        |
| Rate of access to drinking water | 86%        | 63%        |
| Poverty rate           | 12.75%     | 37.64%     |

The degradation of the ecosystem in general and the oasis in particular due to climate change, combined today’s with human activities constitute a major obstacle to development in this region. The major issue identified in the area is: reduced number of palm trees especially because of Bayoud [23]. The Bayoud disease (Fusarium oxysporum F. sp. Albedinis) is a soil fungus that affects the palms. The disease was first known in Morocco (Middle Draa Valley) since more than a century ago [24]. In fact, the region suffers from the extension of Bayoud disease. This fungus attacks the best varieties of palm trees. Over the past decades, Moroccan production of dates decreased by 34% [25], partly due to the spread
of this fungus. The rate of expansion of Bayoud in an experimental zone in Nebch (MDV) is 4-15% [26]. In addition to this problem, there are other problems like soil and water salinization, youth migration, degradation of acacia forests, overgrazing and lack of drinking water and so on and so forth. All these factors contribute to widespread poverty in rural areas and the dependence of the poor on a sensitive climate for their livelihood. The rural community is among the poorest areas of the country and its environment undergoes several processes of disintegration, which makes such study very essential.

2. MATERIALS AND METHODS

2.1 Study Area

Fig. 2 shows the extrapolation of the most productive part of the study area represented by six oases (Mezguita, Tinzouline, Ternata and Fezouata, Tagounite and M'Hamid) aligned as a necklace. These oases are located along the Draa Wadi (temporary river) fed by Mansour Eddahbi Reservoir.

The Middle Draa Valley is characterized by a 200 km belt of six aligned oases with a width that varies from 100 m to 10 km. The total surface of the six Draa oases are nearly forty thousand hectare of which 26,118 hectare are arable land and irrigated [27]. Here, we will be analyzing the six oases of the MDV which are displayed in Figs. 2 and 3 in the focus area. Oasis Structure is schematically based on the interdependence of man, water and palm trees. Agriculture, livestock and tourism are the main economic activities [28].

Within each oasis, we distinguish between three types of farms, as described in Table 2.

Fig. 1. Middle Draa Valley (MDV) area (MDV map processed and modified from the digital IMPETUS atlas 2.1)
Fig. 2. Six aligned oases along draa wadi (Temporary River) (processed and modified from the digital IMPETUS atlas 2.1)

Fig. 3. Satellite images of the six aligned oases: Mezguita (A1) and Tinzouline (A2) oases; Ternata (B1) and Fezouata (B2); Tagounite (C1) and M’Hamid (C2)

Source: Processed from the USGS (www.landsatlook.usgs.gov); Sensors: TM, ETM+ and OLI.

01 November 2011

2.2 Methodology

Services provided by ecosystems contribute much to the well-being of individuals, of communities and of the economy. The monetarization of non-market natural assets is growing in popularity. Unfortunately, the research on the issue of ecosystem services (monetary characterization), at the national level is nonexistent. Monetary unrepresentative cause’s malfunctions in incentives associated with their use and contributes to the degradation of the natural heritage. In recent scientific literature there are a variety of methods for estimating the value of ecosystem services [29]. The selection of appropriate valuation methods is in part determined by the type of ecosystem service being valued [30].
We collected the data from a variety of sources, including bibliographic data (scientific data), government ministries, and environmental organizations (gray literature). Information was also gathered and classified in ecosystem services categories. Fig. 4 gathers some methods and approaches to valuing ecosystem services.

The Total Value ($V$) of Ecosystem Services $ES$ in $$/ha/year for ecosystem type $k$ is $V (ES_k) [31]$: 

$$V (SE_k) = \sum_{i=1}^{n} A(LUi) \times V(SE_{ki}) \quad EQ 1$$

Where:

- $A (LUi) = $ Area of $i$ (Land Use in hectares)
- $V (ES_{ki}) = $ Annual value of $k$ ES (Ecosystem Services) for each $i$ LU (in $$/ha/yr)

Table 2. Types of oasis farmers of middle draa valley, Morocco

| Farm type            | Description                                                                                                                                 |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Farms of government in Bni zouli (Ternata oasis: Fig. 3)  
N30°26'42.72" W5°54'40.32  
- 0.3% of the oasis area  
- High quality palm varieties  
- Surface water  
- Submersion irrigation  
- Large infestation of bayoud disease  
- Low production |
| Modern farms private  
Felja (Fezouata oasis : Fig. 3)  
N30°17'38.4" W5°55'19.2"  
- <1% of the oasis area  
- High quality palm varieties  
- Groundwater  
- Economic irrigation  
- No infestation of bayoud disease  
- High production |
| Traditional farms  
Bni zouli  
N30°26'16.8" W5°54'40.32"  
- 92% of the oasis area  
- Mixed varieties  
- Water surface and groundwater  
- Submersion irrigation  
- Low to moderate infestation of bayoud disease.  
- High production |
3. RESULTS

In this paper, the monetarization of provisioning services is made using the method of the market price. The results of the monetarization are divided into three levels; vegetal, animal and a third category that we'll call 'other products' including services such as water, soil and wood.

3.1 Vegetal Products

In the six oases of Middle Draa Valley; the vegetal products are classified in the following Table 3. The main vegetable products at the Middle Draa Valley play an important socio-economic role, with the added value they generate in rural areas. The major products (Table 3) are Common wheat and alfalfa for horticulture, and palm and almond for fruit trees.

We calculated the average unit price of cultivated products in Dh/kg ($1 Dh = 1 MAD (Moroccan Dirham) = 0.12 US $; www.oanda.com; Sept. 28, 2013) based on data from the years 2004 to 2008 (Table 4).

Economic values of vegetal services are summarized in Table 5, which brings together, ecosystem services, the size and quantity of each product and the unit price and the total value of these services.

The whole plant services produced a total economic value of the order of 1090330750Dhs/year (130839690$/year)

3.2 Animal Products

Livestock has always been an important activity besides trade. Pastures have been largely altered during the drought years. Despite this constraint, livestock plays a vital role in the daily life of the farming community. This activity is a central element of the agricultural sector. In terms of the importance of animal production (Table 6) sheep is in the lead, followed by goats, then cattle and camels. However, for local consumption, the most important agricultural product is bovine milk, followed by beef, chicken, and eggs. For small farmers, livestock is a ready source of cash for the purchase of inputs (seeds, fertilizers and pesticides) for agricultural production. Table 6 shows the number of livestock in the study area in the following 3 years (2008, 2009 & 2010), while Table 7 illustrate the milk production and Honey in this area.

The industrialized milk cooperative varies between 800 000 and 1 000 000 liters. The total production of red meat, is about 785 tonnes1. Talking about jobs, this sector, offers about 3547 jobs (Table 8).

1 Monographie agricole de Zagora (2009).
### Table 3. Average of last 5 years of areas and productions

| Horticulture      | Area in Ha. | Production in Qs | Fruit trees | Effective (trees) | Production in tonnes |
|-------------------|-------------|------------------|-------------|-------------------|----------------------|
| Durum wheat       | 50          | 1300             | Almond      | 32800             | 164                  |
| Common wheat      | 16850       | 589910           | Olive       | 6850              | 158                  |
| Barley            | 1400        | 29300            | Apple       | 31500             | 630                  |
| Maize             | 330         | 6675             | Palm        | 1421870           | 34125                |
| Alfalfa           | 3600        | 190000           | Apricot     | 40400             | 760                  |
| Vegetable gardening | 1445     | 260920           |             |                   |                      |

Qs: quintals, Source of data: Monographie agricole de Zagora, 2009

### Table 4. Average price of cultivated products (Dh/kg)

| Ecosystem | 2003/04 | 2004/05 | 2005/06 | 2006/07 | 2007/08 | Average |
|-----------|---------|---------|---------|---------|---------|---------|
| Durum wheat | 2.61    | 2.79    | 2.44    | 3.05    | 4.03    | 2.984   |
| Common wheat | 2.39    | 2.52    | 2.21    | 2.74    | 3.16    | 2.604   |
| Barley     | 1.61    | 1.95    | 1.61    | 2.36    | 2.99    | 2.104   |
| Maize      | 1.97    | 2.00    | 1.86    | 2.47    | 3.09    | 2.278   |
| Broad beans | 3.29    | 3.39    | 3.14    | 3.92    | 5.06    | 3.76    |
| Lentils    | 4.31    | 6.32    | 4.27    | 5.89    | 8.83    | 5.924   |
| Olives     | 3.22    | 4.26    | 4.95    | 4.72    | 5.06    | 4.442   |
| Shelled almonds | 46.17  | 53.5    | 57.77   | 52.3    | 48.02   | 51.552  |

Source of data: [22]

### Table 5. Summary of the economic value of vegetal services

| Ecosystem service | Area/Number | Quantity/Production | Unit price | Total in Dh | Total in $ |
|-------------------|-------------|--------------------|------------|-------------|------------|
| Durum wheat       | 50 Ha       | 1300 Qs            | 4DHs/Kg    | 0.52 Mln    | 62400      |
| Common wheat      | 16850 Ha    | 589910 Qs          | 4DHs/Kg    | 235 Mln     | 28 Mln     |
| Barley            | 1400 Ha     | 29300 Qs           | 4DHs/Kg    | 11.7 Mln    | 1.4 Mln    |
| Maize             | 330 Ha      | 6675 Qs            | 4DHs/Kg    | 2.6 Mln     | 0.32 Mln   |
| Alfalfa           | 3600 Ha     | 190000 Qs          | 2DHs/Kg    | 38 Mln      | 4.5 Mln    |
| Vegetable gardening | 1445 Ha  | 260920 Qs          | 4DHs/Kg    | 104 Mln     | 12.5 Mln   |
| Watermelon (2013) | 1130 Ha     | 671287 Qs          | 2.5DHs/Kg  | 167 Mln     | 20 Mln     |
| Almond tree       | 32800 Trees | 164 Ton.            | 60DHs/Kg   | 9.8 Mln     | 1.1 Mln    |
| Olive tree        | 6850 Trees  | 158 Ton.            | 4DHs/Kg    | 0.6 Mln     | 0.07 Mln   |
| Apple tree        | 31500 Trees | 630 Ton.            | 5DHs/Kg    | 3.1 Mln     | 0.37 Mln   |
| Palm tree         | 1421870 trees | 34125 Ton.     | 15DHs/Kg   | 511.8 Mln   | 61.4 Mln   |
| Apricot tree      | 40400 Trees | 760 Ton.            | 5DHs/Kg    | 3.8 Mln     | 0.45 Mln   |
| Total             |             |                    |            | 1090 Mln    | 130 Mln    |

Note: 1 US $ = 8.26 MAD; 1MAD = 0.12 US $; www.oanda.com; Sept. 28, 2013. Qs: quintals

### Table 6. Change of the number of livestock in the oasis ecosystem and its surrounding areas

| Livestock | 2008 | 2009 | 2011 | Average |
|-----------|------|------|------|---------|
| Cattle    | 4770 | 5538 | 5540 | 5282.7  |
| Sheep     | 70120| 82994| 83000| 78704.7 |
| Caprine   | 75130| 59721| 59720| 64857   |
| Camels    | 7950 | 9079 | 9080 | 8703    |
| Equine    | 7620 | 7796 | 7795 | 7737    |
| Beehives  | 886  | 1370 | 1370 | 1128    |

Source of data: Monographie agricole de Zagora, 2009
Table 7. Oasean animal products in the middle Draa Valley, Morocco. Monographie agricole de zagora, 2009

|               | 2008           | 2009           | Average       |
|---------------|----------------|----------------|---------------|
| Milk (L)      | 1442700.43     | 1773220        | 1607960.2     |
| Honey (Kg)    | 1580           | 1772           | 1676          |

Table 8. Agricultural cooperatives

| Type of cooperatives | Effectiveness | Number of adherents | Jobs offered |
|----------------------|---------------|---------------------|--------------|
| Procurement          | 8             | 969                 | 969          |
| Henna                | 4             | 554                 | 554          |
| Dates                | 4             | 1740                | 1740         |
| Dairy                | 2             | 112                 | 112          |
| Livestock            | 4             | 158                 | 158          |
| Use of agricultural equipment | 1 | 12 | 12 |
| Total                | 23            | 3547                | 3547         |

Source: Monographie agricole de zagora (2009)

To calculate the economic value offered by job creation, we multiply the minimum guaranteed wage or “SMIG=2300Dhs” with the number of jobs created: \((3547 \times 2300 \text{ Dhs} \text{ (2012)}\) =8158100\text{/month}) and 97897200\text{Dhs/year (11747664$/year).}

Industry is of secondary importance in economic activity in the Middle Draa Valley in the region. This is largely due to the remoteness and inaccessibility of the region. The only industrial unit is the Cooperative of milk processing (Table 9), which saves an added value of 524 000 Dh/year (62 880 $/year).

The economic value of the animals services are summarized in Table 10, which includes, ecosystem services derived from animal production, in terms of number of cattle, and the unit price and the total value of these services.

Ecosystem services of animal products therefore generate a value of 285411501Dhs/year (34249380, 12$/year).

3.3 Other Products

Such products, means products other than agricultural food products like firewood and construction wood...

3.3.1 Firewood

In 1993, the annual fuel consumption for one pottery in Tamgroute was 96.25 tonnes of which only 10% consisted of palms, and about 86 tonnes of bushes were used from the plains of Feija which corresponds to a destructive exploitation of 860 ha / year [32]. In rural areas, firewood represents about 90% of the energy consumed [33]. Indeed, it is intended to meet the needs of households and commercial purposes. Benchezkroune [34] reports that Igherem (Province of Ourarzazate in border with the study area) consumption of firewood in winter ranges from 65 to 120 kg per household per week. According to a study in Aït Zekri (Province of Ourarzazate) consumption of wood in the tribe is estimated at 1 kg/capita/day [35]. The study area houses 240 566 inhabitants (rural population), consuming 1kg/capita/day, which corresponds to a value of 384905,6/day and 138566016 Dh/year (16627921,92 $/year), see Table 11.

3.3.2 Construction wood

In the basin of the Draa, the habitat is usually "Moroccan house" or "rural category. The type of habitat is important because the resource requirements of the wood are very large. Indeed, the consumption of wood for a rural home is higher than the urban home. This type of accommodation occupies 66% of the type of habitat in the basin of Draa [36]. To build a house (rural construction 300 m\(^2\) average), we need 7 palms (trees) and 200 m\(^2\) reeds because part of the middle of the house about 100 m\(^2\) is not covered (Table 12).

The total households in Middle Draa Valley are 33000; 66% is rural type (22000 households). The construction of 22000 households required (22000×5000):110000000Dh (13200000$), provided by Oasis. To calculate the annual need of timber, we need to calculate the evolution of the number of houses/year in the study area, which is shown in Table 13.
### Table 9. Existing industrial units

| Company name          | Production  | Investment | Added value |
|-----------------------|-------------|------------|-------------|
| Halib Draa Cooperative | 3,538,000,00 | 483,000,00 | 524,000,00 |

*Source: Annual survey of processing industries 2009 edition*

### Table 10. Summary of the economic value of animal products

| Ecosystem service | Area /Number | Quantity/Production | Unit price | Total in Dh/year | Total in $/year |
|-------------------|--------------|---------------------|------------|------------------|-----------------|
| Cattle            | 5540         | n.d                 | 4000Dhs    | 21 Mln           | 2.5 Mln         |
| Ovine             | 83000        | n.d                 | 800Dhs     | 62.9 Mln         | 7.5 Mln         |
| Caprine           | 59720        | n.d                 | 6000Dhs    | 38.9 Mln         | 4.6 Mln         |
| Camels            | 9080         | n.d                 | 6000Dhs    | 52 Mln           | 6.2 Mln         |
| Equine            | 7795         | n.d                 | 500Dhs     | 3.8 Mln          | 0.46 Mln        |
| Beehives          | 1370         | n.d                 | 1000Dhs    | 1.12 Mln         | 0.13 Mln        |
| Milk              | -            | 1773220 Lit.        | 4Dhs       | 6.4 Mln          | 0.77 Mln        |
| Milk Transformation| -           | Added Value         | -          | 0.52 Mln         | 0.06 Mln        |
| Honey             | -            | 1772 Kg             | 200Dhs     | 0.33 Mln         | 0.04 Mln        |
| Agrifood Jobs     | 3547 Pers.   | SMIG                | 2300Dhs    | 97.8 Mln         | 11.7 Mln        |

*Note: 1 US $ = 8.26 MAD; 1MAD = 0.12 US $; [www.oanda.com](http://www.oanda.com); Sept. 28, Milion*

### Table 11. Economic value of the firewood in 1 year in middle draa valley

| Unit quantity | Unit price | Total In Dh | One day | Dh/year | $/year |
|---------------|------------|-------------|---------|---------|--------|
| Firewood      | 1 kg/Capita/Day | 1.6 dh/1 kg | 240 566 | 384905.6 | 140490544 | 16858865.28 |

*Note: 1 US $ = 8.26 MAD; 1MAD = 0.12 US $; [www.oanda.com](http://www.oanda.com); Sept. 28, 2013*

### Table 12. Economic value of the wood for 1 household

| Price unit | Number/Quantity | Total In Dh | Total In $ |
|------------|----------------|-------------|------------|
| Palm Tree  | 500 DH         | 7           | 3500       | 420       |
| Reeds      | 7.5DH          | 200m²       | 1500       | 180       |
| Total      | 5000           | 600         | 5000       | 600       |

*Note: 1 US $ = 8.26; 1MAD = 0.12 US $; [www.oanda.com](http://www.oanda.com); Sept. 28, 2013*

### Table 13. Evolution of households in MDV [31]

|            | 2004      | 2030      |
|------------|-----------|-----------|
| Population | 278398    | 338239    |
| Number of Households | 33143     | 47977     |

From the table, changing household at the rate of 570, 5/year which corresponds to 2, 6% of 22000. Therefore 570, 5/year × 5000 (price in Dh of Construction wood for a household) = 2852500 Dhs (342300$/year) wood of construction/year. This value is added to the value of the wood used for the renewal of homes per year. In fact, renewal of 80% of houses is done in 50 years (survey 2012-2013), which allows us to calculate the value offered by Oasis for timber. 80% of 22000: 17600/$50= 352 households /year; therefore 352 × 5000 = 1760000Dhs (211200$ /year). Table 14 summarizes the economic value of construction wood/year.

#### 3.3.3 Surface water and groundwater irrigation

In Middle Draa Valley, we have on one hand small water resources like the humidity present in the air and soil that some plants and animals benefit but on other hand we have large water resources such as:
Surface water (water from Draa River, Mansour Eddahbi and lakes reservoir) and
Groundwater (in the various aquifers throughout the valley)

It is important to note that we have based on an Average year of water resources (Table 15), knowing that the potential of water resources depends on the type of year (average year or a dry year) lower recess in a dry year.

3.3.4 Surface water

The Middle Draa Valley has about 200 km from Wadi (Draa River). Mansour Eddahbi Dam used to store water in Middle Draa Valley upstream. And other artificial lakes (Table 16) that allow groundwater recharge regulate the flow of Oued Draa and especially allow the irrigation of six palm groves in the Middle Draa Valley.

3.3.5 Groundwater resources

Each of these palm groves of the Draa Valley Middle has a shallow underlying aquifer [39]. Size of the aquifers and total groundwater reserves vary from one grove to another (Table 17).

The Joint Ministerial Decree of Agriculture, Finance and Equipment February 17, fixing the price of a cubic meter of water applied in irrigation were published in the Official Bulletin of March 16 (2000). It repeals and replaces the decree joint of 8 December 1998 on the same subject. So-called "balanced rate" prices are set to 0.18 DH/m³ for irrigation perimeters Draa (provinces of Ourarzazate and Zagora). The National average price of drinking water (production and distribution) is 1,26 dh/m³. The Table 18 shows of water resources in Middle Draa Valley.

People use water from traditional wells and water from the dam for domestic and agricultural uses. The wells are the main source of supply of most villages with drinking water. The total consumption of drinking water from the oasis and its surrounding area population is estimated at 1780731 M³ per year.

3.3.6 Water power

The Mansour Eddahbi Dam in upstream is 63 m high, 15 m wide at the base, and 285 m in length. The capacity of the reservoir is 536 million M³ and helps regulate some 250 million M³ per year. A hydro-electric plant with a production capacity of 10000 kW, installed at the foot of the dam [41]. Table 19 shows the economic value of this reservoir Mansour Eddahbi Dam produce 32385, 91 MW/year.

| Table 14. Summary of economic value of construction wood/year |
|-------------------------------------------------------------|
| Use | New building (construction wood) | Renewal (construction wood) |
| Unit | Total in Dh/year | Total in $/year | Total in Dh/year | Total in $/year |
| Total Price | 2852500 | 342300 | 1760000 | 211200 |

| Table 15. Water resource of the Middle Draa Valley, Morocco [37] |
|---------------------------------------------------------------|
| Use | Average year | Dry year |
| Potential resources | Mm³ | % | Mm³ | % |
| Surface water resources | 225 | 85 | 102 | 56 |
| Extracted groundwater resources | 40 | 15 | 80 | 44 |
| Total exploited resources | 265 | 100 | 230 | 100 |

| Table 16. Local dams diversions in the MDV [38] |
|------------------------------------------------|
| Local dams | User (palm groves) | Capacity in M³/S |
| Agdez | Mezguita | 3,14 |
| Tansikht | Tinzouline | 6,77 |
| Ifly | Ternata And Fezouata | 11 |
| Azghar | Ktaoua | 11 And 3,3 |
| Bounou | M’hamid | 4 |
Table 17. Area of aquifers and their reserves in the palm groves of the Middle Draa Valley [40]

| Palm groves | Total area of the aquifers Km² | Total natural reserves Mm³ |
|-------------|-------------------------------|---------------------------|
| Mezguita    | 45                            | 22.5                      |
| Tinzouline  | 69                            | 34.5                      |
| Ternata     | 178                           | 71.3                      |
| Fezouata    | 196                           | 127.1                     |
| Ktaoua      | 160                           | 86.4                      |
| M’hamid     | 70                            | 16.8                      |

Table 18. Economic value of water resource in Middle Draa Valley, Morocco (M=Million)

| Number/Quantity     | Unit price (Dh/M³) | Total in Dh | Total in $ |
|---------------------|-------------------|-------------|------------|
| Water Surface Irrigation | 0.18              | 40500000    | 4860000    |
| Groundwater Irrigation    | 0.75              | 30000000    | 3600000    |
| Drinking Water         | 1.26              | 2243721.06  | 269246.53  |

*Source of data: ONEE (2011). Direction regionale / SUD (rennements des semestres de 2011)*

Table 19. Economic value of water energy

| Number/Quantity     | Unit price (Dh/Kw) | Total in Dh/Year | Total in $ |
|---------------------|-------------------|------------------|------------|
| Water Energy | 1.27              | 41130105.7       | 4935612.7  |

* Source: [http://www.one.org.ma/](http://www.one.org.ma/)

3.3.7 Use of soil for construction

On the soil level, soil texture of the valley is generally sandy clay. In depth, clay content increase and porosity decreases [41].

The physical characteristics, construction techniques and environmental benefits of land (soil) make it an ancient building material on all continents. The land is recyclable, non-polluting, cheap, controlling moisture, absorbing heat. This saves energy and gain comfort.

3.3.8 Saving energy

How many kilowatt hours in 1 Celsius heat unit? The answer is 0.000527527916667 (www.convertunits.com). Rural housing saves at least 5°C temperature (The value of 5°C was estimated in the Bni Zouli village) compared to Moroccan cement habitat. So one house saves 0.000527527916667 (5 times), which gives a saving 0.00263764583335 KWh (1hour). In one year we will have a saving of 50687.75 Dhs (Table 20).

3.3.9 Soil of construction

From the Table 13, Evolution of the household at the rate of 570.5 household/year. To build a home of rural category using soil material, we need 100 small loading. The economic value of each load is estimated at 75dh thus requires a total of 75×100×570.5 = 4278750 Dh/year (513450$/year). Therefore the soil offers an economical value for the construction of house which adjoin 4866000dh/year (583920$/year) (Table 21).

3.3.10 Soil transformation: mining

The achievements of mining companies for Bleida Mine (the unique mining company) in Middle Draa Valley are in the following Table (22). Due to lack of data, we have estimated the value of the gold produced. In 2011, the 'Bleida' mine achieved a market production (golden) of 124.485 kg (Table 22). Multiplying this value by the price of one Kg of gold (332110.18 Dhs / Kg in Morocco [http://vente-achat-or.org/] Accessed 01-11-2014). The economic value obtained is about 41342735.8 Dhs.

The Table 23 illustrates the number of jobs created by mining sector.

3.3.11 Fishing

In Mansour Eddahbi Dam the Total fish caught (ton/year) is 500 tonnes (Estimated value per kg 5Dhs) so the value is 2500000 Dhs/year (300000$/year). We calculated just the value of the market price of fish caught. The economic values of recreational and cultural activities are not covered in this work.
Summary of economic value of other products (Table 24).

The latter category of services (other products) generates economic value of around 1682891295 Dhs/year (201946955 $/year). From the data compiled in the calculations of the economic value of plant procurement, animals and other products supplied by the Draa Valley, the total value became 3058633546 Dhs / year (367036026 $ / year) (Table 25).

The economic value of ecosystem services in the Middle Draa Valley, Morocco (relative to the total area of 1 500 000ha) is 2039 Dhs/ha/year (244,7 $/ha/year) and 117639,75 Dhs/ha/year (14116,7 $/ha/year) for the cultivated and irrigated area (26 000 ha).

### Table 20. Economic value of saving energy

| Seasons (2 Months) | Quantity | 1 hour | Season/Home | Economy in Dh | Economy in $ |
|-------------------|----------|--------|-------------|---------------|--------------|
| Winter 5°C        | 0.0005275| 0.7596402| -           |              |              |
| Summer 5°C        | 0.0005275| 2.6587407| -           |              |              |
| Total             | 3.4183809| 50687,75 | 6082,53     |              |              |

1MW=1000KW and 0.674Dh/kw

### Table 21. Economic value of the soil construction

| Number/Quantity | Unit Price | Total In Dh/year | Total In $ |
|-----------------|------------|------------------|-----------|
| Soil for construction | 7500    | 4278750          | 513450    |

### Table 22. Production and sales [42]

| Mined substance       | PTV (T) | PM (KG) |
|-----------------------|---------|---------|
| Gold                  | 57997   | 124,485 |

PTV: Production tout-venant and PM: Production marchande (production-run and market production)

### Table 23. Staff and sub-companies mining [42]

| Ingeners | Tamca | Ouvriers | Total |
|----------|-------|----------|-------|
| 5        | 8     | 6        | 19    |
| 72       |       |          | 91    |

### Table 24. Summary of the economic value of provisioning services (other products)

| Ecosystem service | Area/Number | Quantity/Production | Unit price | Total in Dh/year | Total in $ |
|-------------------|-------------|---------------------|------------|------------------|-----------|
| Firewood          | 240 566     | 1 kg/Capita/Day     | 1.6Dh/Kg  | 140.5 Mln        | 16.8 Mln  |
| Wood construction | 22000       | -                   | -          | 4.6 Mln          | 0.55 Mln  |
| Water surface irrigation | - | 225 Mln m³ (85%) | 0.18 Dh/m³ | 40.5 Mln | 4.8 Mln |
| Groundwater irrigation | - | 40 Mln m³ (15%) | 0.75Dh/m³ | 30 Mln  | 3.6 Mln |
| Drinking water    | -           | 17807313 m³         | 1.26Dh/m³ | 2.24 Mln | 0.27 Mln |
| Water energy      | -           | 32385,91 mw         | 1.27 Dh/Kw| 41 Mln   | 4.9 Mln |
| Soil of construction | 648.8 | -                   | 7500      | 4.28 Mln | 0.51 Mln |
| Soil energy       | -           | -                   | 0.67Dh/Kw | 50687,75 | 6082.53  |
| Soil transformation (Gold production) | - | 124.5 Kg | - | 41.3 Mln | 4.96 Mln |
| Mining sector jobs | -         | -                   | 2300     | 2.5 Mln | 0.30 Mln |
| Fishing           | 500 Ton.   | 100 Fishermen       | 5Dh       | 2.5 Mln  | 0.30 Mln |

Mln: Million
Table 25. Summary of the economic provisioning services

| Ecosystem service | Area/Number | Quantity/Production | Unit price | Total in Dh | Total in $ |
|-------------------|-------------|---------------------|------------|-------------|-----------|
| Durum wheat       | 50 Ha       | 1300 Qs             | 4 dh/Kg    | 520000      | 62400     |
| Common wheat      | 16850 Ha    | 589910 Qs           | 4 dh/Kg    | 235964000   | 28315680  |
| Barley            | 1400 Ha     | 29300 Qs            | 4 dh/Kg    | 11720000    | 1406400   |
| Maize             | 330 Ha      | 6675 Qs             | 4 dh/Kg    | 2670000     | 320400    |
| Alfalfa           | 3600 Ha     | 190000 Qs           | 2 dh/Kg    | 38000000    | 4560000   |
| Vegetable Gardening | 1445 Ha     | 260920 Qs           | 4 dh/Kg    | 104368000   | 12524160  |
| Watermelon (2013) | 1130 Ha     | 671287 Qs           | 2.5 dh/Kg  | 167821750   | 20138610  |
| Almond tree       | 32800 Trees | 164 Tonnes          | 60 dh/Kg   | 98400000    | 1180800   |
| Olive tree        | 6850 Trees  | 158 Tonnes          | 4 dh/Kg    | 6320000     | 75840     |
| Apple tree        | 31500 Trees | 630 Tonnes          | 5 dh/Kg    | 3150000     | 378000    |
| Palm tree         | 1421870     | 34125 Ton.          | 15 dh/Kg   | 511845000   | 61421400  |
| Apricot tree      | 40400 Trees | 760 Ton.            | 5 dh/Kg    | 38000000    | 4560000   |
| Total economic value of the vegetal services | | | | 1090330750 | 130839690 |

| Ecosystem service | Area/Number | Quantity/Production | Unit price | Total in Dh | Total in $ |
|-------------------|-------------|---------------------|------------|-------------|-----------|
| Bovins            | 5540 (Nb)   | -                   | 4000 dh    | 211308000   | 2535696   |
| Ovins             | 83000 (Nb)  | -                   | 800 dh     | 62963760    | 7555651,2 |
| Caprins           | 59720 (Nb)  | -                   | 600 dh     | 38914200    | 4669704   |
| Camelins          | 9080 (Nb)   | -                   | 6000 dh    | 52218000    | 6266160   |
| Equins            | 7795 (Nb)   | -                   | 500 dh     | 3868500     | 464220    |
| Ruches            | 1370        | -                   | 1000 dh    | 1128000     | 135360    |
| Milk              | -           | 1773220 Lit.        | 4 dh       | 6431840,87  | 771820,9  |
| Milk Processing   | -           | Added value         | 524.000    | 524000      | 62880     |
| Honey             | -           | 1772 Kg             | 200 dh     | 335200      | 40224     |
| Total economic value of animal services | | | | 285411501 | 34249380,1 |

| Ecosystem service | Area/Number | Quantity/Production | Unit price | Total in Dh | Total in $ |
|-------------------|-------------|---------------------|------------|-------------|-----------|
| Firewood          | 240 566    | -                   | 1.6Dhs/Kg  | 14049054    | 16858865,28 |
| Wood construction | 22000       | -                   | -          | 4612500     | 553500    |
| Water surface     | -           | 225 Mm³             | 0,18 Dh/M³ | 40500000    | 4860000   |
| Irrigation (85%)  | -           | 40 Mm³(15%)         | 0,75Dh/M3  | 30000000    | 3600000   |
| Drinking water    | -           | 9417363 m³         | 1,26Dh/M³  | 22437210,6  | 269246,53 |
| Water energy      | -           | 32385,91 mw         | 0,67Dh/Kw  | 4130105,7   | 4935612,7 |
| Soil of construction | 648.8      | -                   | 7500Dhs    | 4278750     | 513450    |
| Soil energy       | -           | -                   | 0,67Dh/Kw  | 50687,75    | 6082,53   |
| Soil transformation | 124,485 Kg | -                   | 41342735,8 | 4961128,3   |
| Fishing           | 500 Tonnes  | 100                 | 5dh        | 2500000     | 300000    |
| Mining jobs       | 91 Pers. SMIG | 2300             | -          | 2511600     | 301392    |
| Total economic value of other services | | | | 1682891295 | 201946955 |
| Total general of all provisioning services | | | | 3058633546 | 367036026 |

Note: 1 US $ = 8.26; 1MAD = 0.12 US $; www.oanda.com; Sept. 28, 2013. Qs: quintals

4. DISCUSSION

The oasean ecosystem provides a set of varied benefit for local populations, which include: provisioning (water, wood and food), regulating (water purification and regulating the flow), cultural (Tourism, biodiversity...) and supporting services (Soil, nutrients...). Their status and trend vary depending on the type and intensity of the pressures to which they are exposed. These pressures especially poverty, destructive exploitation in Feija plain (860 ha/year of bush), fire wood in rural and palm wood used to make homes lead to loss of ecosystem services, and
cause negative impacts on livelihoods. This degradation is induced by climatic factors, exacerbated by the socio-economic context marked (especially extreme poverty). Successive droughts in recent years have also limited the primary production in Middle Draa Valley. The Mansour Eddahbi Dam and other dams may have leveraged this drought. In fact, all reservoirs are vulnerable to siltation problems [43], with estimates that the Mansour Eddahbi and Hassa Addakhil reservoirs will be inoperative by about 2030 [44,45]. Moreover, the intensification of agriculture illustrates the pressures facing the oasis system. The provisioning services of oasean ecosystem include a wide range of food products derived from plants (E.g.,: firewood and palm wood for building households) and animals (E.g.,: bee honey, fishing). Forests are exploited for many reasons: timber for local construction, for the manufacture of charcoal local collecting of wood for heating and cooking. The main tree species existing in their natural state are 90194 ha of Acacia radiana and 20985 ha of Tamarix aphyla [42]. The contribution of forests to the local economy of the area is very important. The products of these forests help meet the needs of the population in cattle feed, firewood, timber. Furthermore, the use of wood is as an energy source, it is used by the local people for manufacturing of various products from wood fibers or plants. The surface water of this ecosystem leads the irrigation of arable area, and feed the oasean aquifers. More water in upstream Draa is a source of energy through Mansour Eddahbi Dam.

Data was collected, compiled and analyzed to give the approximate monetary value of provisioning services. This quantitative assessment was conducted using information provided by the public services of the Draa Valley. Assessment of livestock production is possible thanks to the presence of data on milk production, and the number of livestock. Because of lack of data on the pharmacopoeia and wild foods, we did not assess monetarily these services. To estimate the consumption of wood, we relied on the results of the field survey. Based on household consumption, we estimated global consumption in which we applied current prices. It is essential to note the importance of the economic value of agricultural expenses in the oases of the Draa Valley as fertilizer, the cost of irrigation, tillage and seed. From the synthesis of the Table 25, agricultural production (vegetal and animal) generates 1375742251Dhs (165089070, 12$) reported to the productive area (26 000ha), giving 52913,2 Dhs/ha /year (6349,57962$/ha/year). Expenses spent annually by farmers are about 7123 Dhs/ha/year (854, 76$/ha/year), they are estimated in 2005 by a survey conducted as part of the IMPETUS project, conducted by Heidecke [37] (2009). So the net annual value of agricultural products in the area of six palm groves is estimated at 45790.7 Dhs/ha/year (5494,84$/ha/year). It should be recalled that, in the present study, we aim to provide an approximate value of provisioning services. The most part of the economic value comes from the six palm groves, knowing although the area of the palm represents only 0.017% of the total area of the Middle Draa valley. The final value obtained from MDV is 2039 Dhs/ha/year (244,7$/ha/year), which is very low, because we have not estimated the value of the immaterial wealth as the value of biodiversity, tourism, pollination, Folklore and “Moussems” (Moroccan festivals in honour of saints), etc.

The comparison of results in Table 26 with result of economic value of provisioning services at global scale (Inland wetlands, rivers/lakes, woodlands, Grass lands) developed by De Groot in 2012 [46] is shown in Table 26. The economic value of the most productive part of the Draa valley (six palm) is greater than the value of wetland ecosystems, rivers/lakes and grasslands; while the whole Draa Valley generates the lowest economic value compared to previous ecosystems.

The low economic value of the entire MDV is justified by the arid climate and the poor quality of the complex water-soil. While the economic value of six palm groves is very important, given the potential of the structure and function of these palm groves and consequently their ecosystem services. It is a knowledge accumulated over thousands of years which the oasis Man knew how to value the groundwater, which is an important aspect of the development of agricultural production, keeping the soil fertile enough, and also controlling surface water from of temporary streams.
Table 26. Summary of monetary values for each service per biome (values in Int. $/ha/year, 2007 price levels) [46]

| Service                    | Inland wetland | Rivers/lakes | Woodlands | Grasslands | Oases* | MDV ** |
|----------------------------|----------------|--------------|-----------|------------|--------|--------|
| Provisioning services      | 1659           | 1914         | 253       | 1305       | 14116,7 | 244,7  |
| 1 Food                     | 614            | 106          | 52        | 1192       | 5895,3  | 102,18 |
| 2 Water                    | 408            | 1808         |           | 60         | 380,16  | 6,6    |
| 3 Raw materials            | 425            |              | 170       | 53         | 7841,24 | 135,92 |
| 4 Medicinal resources      | 99             |              |           | 1          |         |        |
| 5 Ornamental resources     | 114            |              |           |            |         |        |

Where *: Estimated values from the vegetal and animal production of the six palm groves of the middle Draa Valley, **: Estimated values of all components of the whole Draa Valley

5. CONCLUSION

Oases are agricultural landscapes of pre-Saharan Morocco and contribute to the well-being of the local population by provisioning ecosystem services (fibers, water ...), regulation services (air, climate, sewage ...), cultural services (biodiversity, tourism ...) and supporting services (soil, nutrients...). But the surface of the oases has been declining for more than fifty years. This may seem alarming in view of the contribution of these areas to human well-being. Economic evaluation helps preserve ecosystems, revealing the challenges (Challenges for better management of these oases) they are associated. A better scientific understanding of the economic value of these services reveals important. This article reports monetary values of some ecosystem services of the oases. The values are standardized to US$ per hectare per year in 2008-2010 period prices. The mean values are found to be 117639,75Dhs /ha/year (14116,7 $/ha/year) in arable area (for 26 000ha) and 2039Dhs/ha/year (244,7$/ha/year) for total area (1500 000ha). In order to complete this evaluation, we recommend expanding this study:

- For all other ecosystem services than provisioning services with better management of other ecosystems. E.g., Atlantic Forest in Brazil.
- At the level of national ecosystems for which data from similar ecosystems are available.

The study can be applied to other oases of the pre-Saharan part of Morocco and other oasis from other parts of the world as well as other semi-arid ecosystems (e.g., the Caatinga, an important semi-arid ecosystem located in in northeastern Brazil), because of the similarity of lifestyle, climate, and water requirements etc.

The estimated value of the annual production was made on the basis of bibliographic data, supplemented by field surveys. The degradation of oasean ecosystem of Middle Draa Valley leads to the loss of ecosystem services, and causes negative impacts on livelihoods. The losses amount to some 14116,7 $/ha/year.

The state should engage more in poverty reduction projects for sustainable development in these arid areas. This will substantially help the survival of the oasis of the region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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