RESEARCH PROGRAM ON Dryland Systems

CGIAR

Assessing the impacts of soil and conservation techniques in south-east Tunisia

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Abstract

This paper examines the financial, economic and social feasibility of the investments in soil and water conservation techniques and their impacts on the livelihood conditions of the local population in the Oum Zessar watershed located in south-east Tunisia. The study uses Integrated Impact assessment framework, based on two main approaches: Extended Cost-Benefit Analysis (ECBA) to internalise environmental externalities and Sustainable Livelihoods Approach (SLA). Results show that coupling the two methods is useful to upscale impact assessment from field level to regional level and to cover the impacts on different rural household capitals (human, financial, physical, natural and social) influencing well-being of the local population. The analysis for 30 years period found that, despite environmental externalities in the form of increased flood damage, investments in water harvesting techniques are beneficial at private and social levels for the local population. The financial analysis show that these investments are highly beneficial with 30 years IRR of 24% and a positive NPV of 3615 TD/ha at 10% discount rate. The economic analysis using market prices and accounting for subsidies, the investment becomes even more interesting with a NPV of 4283 TD/ha (discount rate of 10%) and an IRR of 27%, which is a clear improvement compared to the financial analysis. These results are robustly positive at a high discount rate of 12% (NPV of 2073 DT/ha) and reduced benefits when considered some negative environmental effects such as higher flood damage due to failure of Jessours (NPV of 1333 DT/ha and IRR of 20%). Besides the financial and economic benefits, the impacts of the soil and water conservation techniques in had clear and positive impacts on the livelihoods of the local population. Recommendations for a more integrated policy approach to watershed management are provided.

Key words: Water harvesting techniques, Sustainable Livelihoods Approach (SLA), Extended Cost-Benefit Analysis (ECBA), Externalities, Oum Zessar watershed, Tunisia.

Introduction

Water scarcity is the most important challenge in drylands limiting crop growth and, hence, agricultural production. As a result, soil and water conservation techniques have been familiar features in dry areas for many years. However, individual small holder farmers rarely make the needed investments due to limited resources and the longer time period needed for that investment to payoff. Public sector often makes such investments or provides attractive subsidies for smallholder farmers to invest in soil and water conservation techniques. In Tunisia, the government made substantial investment in soil and water conservation structures in private farmlands. However, once these investments are made, their sustainability depends on their regular maintenance which in turn depends on the economic feasibility of these interventions. Generally, the benefits and costs of soil and water conservation investments have to be examined from three perspectives: financial (from individual farmers' perspective), economic (considering subsidies and market or opportunity unit prices) and social perspective (adding the environmental considerations on to the economic perspective). The social perspective considers all costs and benefits that are involved regardless of who pays for them, where do they occur and when do they occur in a time horizon. In this perspective, for example, the cost of soil loss filling up water reservoirs downstream or benefits of reduced floods will be included. However, farmer's perspective only considers the benefits and costs that they face on farm. The first step in understanding the sustainability of soil and water conservation practices is to start with (private) farmer's perspective then consider the economic and social perspectives by removing subsidies and including external environmental benefits and costs. In this paper we examine the returns to soil and water conservation investments using financial, economic and social indicators in South Tunisia.

In Tunisia, population growth, climate change, globalization and changes in consumer behaviour exert pressure on natural resources (Abaab, 1986; Abaad and Guillaume, 2004; ME and GIZ, 2012; MEDD, 2006). This is particularly true in Oum Zessar watershed, the geographical focus of this paper, which is located in the arid south-eastern part of the country. The combined effect of these drivers has been heightened the environmental challenges. These challenges include natural resources degradation, mainly green and blue water scarcity, and a significant decrease of crop yield that had a negative effect on the socio-economic situation of the local population (Gamoun et al., 2015).

To deal with the development problem at national and regional levels, the government is implementing a water and soil conservation strategy (1991-2000 & 2001-2010) and national strategy of climate change adaptation (ME & GIZ, 2012). The objectives of these policies were to reduce the pressures exerted on the natural resources, mainly land and water, to enhance the capacities of adaptation to climate change and to improve the socio-economic conditions of the local population.

The successful implementation of sustainable development strategies such as water and soil conservation and natural resources management in vulnerable and arid areas in south-eastern Tunisia is often hampered by weak evidence of their impact on livelihood conditions. In fact, most previous studies have focused on their on-site biophysical (Ouessar et al., 2009) and socio-economic costs and benefits (Fleskens et al., 2002; Fleskens et al., 2005; Schiettecatte et al., 2005; Sghaier et al., 2002) without relating their economic impacts on the livelihoods of the local population. Fleskens et al. (2005) measured WHT's effects on olive yield in an upstream area of the Oum Zessar watershed and calculated the on-site cost and benefits of implementing the technique. Ouessar et al. (2009) modelled the effect of WH on the catchment water balance using the SWAT model. The model was calibrated and validated with data from 38 runoff events. Sghaier et al. (2002) applied an interdisciplinary approach based on the application of the FORCES-MOD model, conceived by the World Bank and the FAO, and extended by a cost benefit analysis (ECBA) for the south-east Tunisian context. The aim was to evaluate the costs and benefits of the WHT in Oum Zessar watershed.

Despite the above studies, the off-site effects, adjacent and downstream, of WHTs are poorly understood and quantified. Moving up from on-site to off-site level requires understanding the complex biophysical interactions within a watershed. Indeed calculating the economic and social cost and benefits of WHTs requires the prediction of biophysical and socio-economic downstream effects. To overcome this gap we have chosen to combine two methods: Extended Cost Benefit Analysis (ECBA) and Sustainable Livelihood Approach (SLA). Our objective was to assess the economic profitability of water harvesting techniques and to analyse their impacts on livelihood conditions in Oum Zessar watershed. Cost-benefit analysis can be applied as a decision-making framework focusing on the direct impact of land management practices without taking into account general effects on livelihood conditions. SLA is an analytical framework that helps to understand the factors that influence the ability of people to achieve sustainable development in a particular circumstance. It differs from conventional evaluations in its central focus on people's wellbeing rather than financial outcomes of the defined project. People's well-being includes not only income, but it covers physical, natural, social and human assets (Côté and Healy, 2001). Our approach explores the contrast between livelihood impact assessment and conventional ECBA. Livelihoods analysis can be very useful for showing how an intervention on natural resources management fits with livelihood strategies, and how people's livelihoods are being enhanced or constrained. Indeed the integrated approach used seeks to upscale land management impact from field level to the regional level.

1. Background

1.1. Study site: Oum Zessar watershed

The study is carried out in Oum Zessar watershed located in the governorate of Medenine, in the south-east of Tunisia (Figure 1). The Medenine governorate has become relatively marked by the predominance of urban population. The urbanization rate was 61.8% in 1994 and reached more than 80% in 2014 (ODS, 2015). The Oum Zessar watershed is marked by the persistence of rural livelihoods within a harsh environmental condition. Aridity, water scarcity, lack of economic options, and population growth were key characteristics of the watershed that led to serious challenges. The watershed is significantly important due to its strategic location and its contribution to the regional economy. Furthermore, the watershed provides important environmental services such as provisioning (pastoral production, aromatic and medicinal plants, hunting, honey), regulating (carbon sequestration and climate regulation, Soil and Water Conservation programme (SWC)) and cultural (ecotourism, cultural, intellectual and spiritual inspiration) (Ouled Belgacem et al., 2011). The people in the watershed area are highly resilient to change in spite of the harsh environmental reality.

Administratively, the Oum Zessar watershed stretches over the territory of 10 villages belonging to three districts namely Beni Khedache (3 villages in the upstream part), Medenine North (3 villages in the midstream part) and Sidi Makhlouf (4 villages in the downstream part).

Three main hydro-geophysical zones characterize the watershed:

- Upstream zone covering the mountainous zones and corresponding to the administrative territory of Beni Khedache district;
- Midstream zone starting from the Bhayra, Chouamakh region at the foot of the mountain zone which is part of the Beni Khedache and Medenine North districts;
- Downstream zone: starting from Koutine to the sea (Gulf of Gabès), corresponding to the administrative territory of Sidi Makhlouf district.

The study site has experienced rapid land use change and transformation of the agrarian system. These changes in turn affected both the livelihood conditions and the natural environment. Consequently, this led to increased concern on the negative impact of land use change on soil fertility that resulted in lower income and increasing competition over water (Pinstrup-Andersen and Pandya-Lorch, 1998).The area is characterized by irregular rain distribution, which has significant impacts on natural resources management and agricultural production. On average, the annual precipitation is around 160 mm. The succession of dry years, irregularity of rain and occurrence of extreme climate events are key factors driving land degradation in the area. These resulted in less water available for plant growth, lower biomass production and grain yield, and as a consequence, less protection of soils by vegetation (Ouessar et al., 2009).

The total population of the three delegations that covers Oum Zessar Watershed increased from 100,400 inhabitants in 2004 to 108,900 inhabitants in 2014 (INS, 2015). Whereas, Medenine Nord with a population density of 101-200 persons per sq.km is the most densely populated district in Oum Zessar followed by Sidi Makhlouf with 51-100 people per sq.km, Benikhdeche with a density of just 11-25 persons per sq.km is the least densely populated district. This can be explained by the massive rural exodus from Benikhdeche due to the natural resources degradation and the lack of jobs opportunities. Oum Zessar's population represented 24.4 % of the total population of the three districts (table 1).

Table 1. Human population in Oum Zessar watershed by district

District	Population number 2004	Population number 2014
Beni Khedache	6,978	6,320
Medenine North	11,736	13,371
Sidi Makhlouf	5,783	6,149
Total	24,498	25,840

Source: INS (2014).

The agrarian system in Oum Zessar watershed is characterized by the coexistence of irrigated and rainfed agriculture (cereals, fruits, etc.) with pastoralism (rangeland). Conversely, land uses have changed with the privatization of the traditional collective lands and the evolution towards a more intensive agro-pastoral system (Sghaier et al., 2012).

Figure 1. Location of Oum Zessar watershed in the province of Medenine

1.2. Methods

The general benefit cost analysis is formulated as a utility maximization problem subject to a set of constraints over time presented in equation 1. This formulation uses benefits and costs in generic terms and allows computing the net present value (NPV) and rates of returns to the investments in soil and water conservation. The same framework is applied all three different perspectives: private, economic and social analysis as described in the introduction. The formulation is given as:

$$NPV = \sum_{t=1}^{N} \frac{(B_t - C_t)}{(1 + I^t)} \qquad Equation\ 1$$

Where the index t is expressing current years of calculation, and N is the total number of the years considered for the time horizon of the cost benefit analysis, and may vary according to the type of investments. B and C are expected benefits and costs, respectively. Private (farmer) cost-benefit analysis would only include private benefits and costs as assessed by farmers; while a social cost-benefit analysis would also include social costs and benefits, including ecosystems services (if they can be assessed in a monetary term). I represents the interest rate. The choice of this interest rate is critical given that interest rates may vary according to the type of projects (business investments are different from investments in natural resources conservation). The work is based on an Integrated Impact assessment framework using two main approaches).

In this study the benefit cost methods described above is applied within the framework of Integrated Impact assessment framework using two main approaches:

i) *Extended cost-benefit analysis (ECBA)* to internalise environmental externalities: Cost-benefit analysis (CBA) is an approach for assessing the monetary social costs and benefits of existing and proposed projects, programs and policies over a given time period, and which can inform decision-making. It consists of comparing the present value of the streams of benefits (positive effects) and the present value of all investment and recurrent costs (negatives) (Akroush et al., 2014; Ranasinghe, 1994, 1997). ECBA refers to social evaluation of investment projects and policies that involve significant environmental impacts. Typical ECBA consists of multiple stages: i) Problem definition (i.e., what are the objectives, what are the alternatives, whose welfare is considered, and over what time period, ii) Identification of the physical impacts of each project (i.e., environmental impact analysis), iii) Valuation of the impacts, iv) Discounting of cost and benefit flows, v) Selection of the project to be implemented based on the net present value test, and vi) Sensitivity analysis (i.e., is the result robust to small changes in parameter values) (Kuosmanen and Kortelainen, 2007).

Our analysis takes into account external economic and environmental phenomena, and considers tangible as well as intangible effects of SWC programme based on WHTs undertaken since 80s in Oum Zessar watershed. In this work we consider only Jessours[1] system as the most widely used technique in this area. Two evaluation criteria were considered: the Net Present Value (NPV) and the Internal Rate of Return (IRR). Each evaluation criteria provides a single figure summarising the impact of the project on economic welfare. However, each criteria gives subtly different information. NPV focuses on the total welfare gain over the whole life of the project and IRR focus on the rate at which benefits are realised. Both measure are widely accepted on CBA analysis (Wholey et al., 2010).

Data for the CBA were gathered from the statistical database provided by the technical services of the regional directorate for agricultural development (CRDA, 2013) and from socio-economic and technical surveys conducted during 2012-2013 in Oum Zessar watershed with beneficiaries of SWC programme. Total of 15 beneficiary households from three representative sub-catchments have been interviewed (Sub-catchment Chaabat el anez, Béni-khdéche Up-stream of OZ watershed, Sub-catchment Eloudayet, Medenine Nord Mid-stream of OZ watershed and Sub-catchment Oued Moussa, Sid-Makhlouf Down-stream of OZ watershed). Sub-catchments and beneficiary households have been selected during one day workshop together with scientists and policymakers.

Survey questionnaires cover mainly the types of intervention (implementation or rehabilitation of WHT) investment costs, maintenance costs and crop yields at the household and farm levels. Prices were collected from rural markets and from interviews with farmers. All prices are expressed in Tunisian Dinars (TD)[2]. Costs and returns are calculated respectively for each component with and without its implementation over the period of 30 years and reported per hectare. We used average of data collected from interviewed households. This time horizon was considered appropriate, as the benefits which accrue to investing in water harvesting in general and tree production in particular appear only after a long period. A range of discount rates (8%, 10% and 12%) were used to undertake sensitivity analysis.

Sustainable Livelihoods Approach (SLA): SLA is an analytical framework that helps to understand the factors that influence the ability of people to achieve sustainable development in a particular circumstance. The SLA approach allows looking into the interdependencies of the complex range of assets and activities on which people depend for their livelihoods (Dearden et al., 2002; Karl et al., 2002; Norton and Foster, 2001). It is based on five capital assets upon which livelihoods are built: social, human, physical, financial and natural. Enhancing capital assets is a way for improving people's well-being (Baumann, 2002). In our analysis we consider WHT as a physical capital and we will assess their impact on local well-being.

To evaluate the five livelihood assets in the upstream, midstream and downstream sections of Oum Zessar watershed, data has been gathered using a socio-economic survey (in total 139 households have been interviewed) conducted in 2012-2013. The total population is defined as the entire population of the Oum Zessar watershed, 3000 households, which benefit directly or indirectly from the public or private water harvesting unit. Sampling procedure consist of two-steps, the first step is a triple

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[1] Jessour: is the plural of a jesr which is a typical macro-catchment WHT encountered in the mountains of Matmata in south-east Tunisia. Each unit is made of a small dyke to retain runoff and sediments, a terrace (cropping area) and the impluvium (catchment area) (Ouessar et al., 2009).

1 USA Dollar = 2.027 Dinars [2]

stratification of farms by biophysical zones, administrative zones and by farm type. The second step is a systematic sampling that consists of a random draw of a number of farm proportional to the total population in each class from a list of farmers available at the technical service of regional Commissariat of Agriculture Development. Finally 59 households from Benikhdeche (up-stream), 33 households from Medenine Nord (mid-stream) and 47 from Sidi Makhlouf (down-stream) are selected. Interviewed households were asked whether WHTs technologies affect human, social, natural, financial and physical assets. The upstream, midstream and downstream beneficiaries were asked to evaluate the livelihood assets with and without WHTs implementation. We report changes in livelihood conditions using a set of indicators (Table 2). LADA (Nachtergaele et al., 2010) approach was adapted in order to select indicators and to carry out the scoring for each asset.

A scoring session, based on survey results, was made together with scientists and experts from the Institute of Arid Regions to evaluate the livelihood assets. Ten (10) experts from different disciplines participated in this exercise. The scoring session consisted of five steps. In step 1, a list of the main relevant indicators that represent livelihood assets related to WHTs was chosen; in step 2, indicators were then calculated from the survey data; in step 3, a score from 0 to 100 was given by each participant to each indicator regarding the actual statute of livelihood assets; in step 4, an average score was then calculated for the whole watershed and for each watershed components (upstream, midstream and downstream);and finally in step 5, a pentagon diagram for each catchment section's average household profile showing different livelihood assets was elaborated.

Table 2. List of indicators by type of livelihood assets

Natural capital	Financial capital	Physical capital	Human capital	Social capital
Number of livestock	Agriculture income	Number of WHT (Jessour)	Education level	Membership to local association (NGOs)
Farm size	Livestock income	Ownership of ploughing equipment	Household size	Distance to nearest hospital
Land quality	Off-farm income		Age of household head	Certificate of land ownership
Water quality			Annual households expenditure	Access to drinking water network
Number of olive trees				

3. RESULTS & DISCUSSION

3.1. Assessment of economic profitability of WHT

The financial cost consists of dike and spillway construction and maintenance. Digging of plant holes for olive tree planting constitute an additional investment, including, purchasing tree saplings, watering, manure and labour costs (Fleskens et al, 2005). Local intermediate inputs (sand, dray stone, cements) are considered within the financial cost (Table 3). Maintenance costs of the jessour include allowances for repairs of the dike and adjusting the height of the spillway and the supplemental irrigation during the dry year to maintain the productive capital (olive trees). The terraced area of jessour unit is used mainly for olive trees planting. In years with sufficient autumn precipitation the impluvium serve for cereal cultivation and for grazing.

Table 3. Implementation & maintenance costs

	Input type (per component unit)	Specification	Units	Value
Investment costs	Labour	Construction of dike	Man days	100
		Construction of spillway	Man days	50
		Planting hole	Man days	40
		Total		190
	Local intermediate consumption	Sand	kg	156
		Cement	sac	110
		Dry stone	Van	160
		Plants	Number	25
	Mechanical works			120
	Total (DT)			760
Maintenance cost				
	Supplemental Irrigation			40
	Yearly maintenance cost (5% of total implementation cost)			36
	Maintenance cost for the fifth year (20% of total implementation cost)			144
	Total			220
Total				980

To quantify maintenance cost and the future yields of jessour unit some assumptions were admitted:

1. The cultivated area represents only 30% of the total area; the rest covers impluvium and tracks;
2. Number of olive trees is considered constant in the future;
3. The farmer will provide supplemental irrigation to preserve the olive tree during drought period. So the maintenance cost must include the additional cost of irrigation;
4. The annual maintenance cost is considered equal to 5 % of the total investment cost
5. The maintenance cost of the fifth years equal to 20% of total investment, it corresponds to the prevention of the risk of spillway destruction in the heavy rain event;
6. Crop production (barley watermelon, etc.) will be incorporate one time each four year given that the probability to have 3 successive dry years is so small.

As shown in Tables 3 and 4, the CBA was run at three levels: financial analysis using market prices and dealing with the private interest; economic analysis dealing with the society’s interest using shadow prices; and extended CBA coping with environmental externalities. Results are reported in per hectare basis.

The financial analysis shows an IRR of 24% and a positive NPV of 3615 TD/ha, using a 10% discount rate. These results reflect the effectiveness of WHT at the household level, despite of the heavy investments, the delayed benefits of tree crops and the adverse climatic conditions and fluctuations.

Moving up from the financial analysis to the economic analysis, the financial prices (market prices) of costs and benefits are adjusted as needed to reflect the social value. Thus the financial prices are transformed into economic prices while reducing market distortions (subsidies, transfer payments, taxes, etc.). This adjustment is performed by using conversion factors adapted to the Tunisian context (World Bank, 2010).

Taking into account the social concerns, the project becomes more interesting with a NPV of 4283 TD/ha (discount rate of 10%) and an IRR of 27%, which is a clear improvement compared to the financial analysis (Tables 2, 3). When market distortions are reduced, WHTs become more profitable and therefore the water and soil conservation strategy will be more effective as a whole.

Finally, environmentally extended CBA has been applied. Only one type of off-site impact has been considered. This consisted of incorporating the negative effect of WHT structure resulting in flooding. The results show that IRR and NPV know a modest decline from 27% to 23% and from 3615 TD/ha to 3027 TD/ha respectively. The ECBA shows that, despite environmental externalities in the form of increased flood damage, WHT techniques are beneficial at private and social levels for the local population. A sensitivity test indicates that the outcome shows some variation with different discount rates, but this does not impact the general trend, even when the off-site effects are incorporated in the analysis (tables 3 & 4). Results remain robustly positive when considering a higher discount rate of 12% (NPV of 2073 DT/ha) and reduced benefits (i.e. in the case of ECBA considering higher flood damage due to failure of Jessour) (NPV of 1333 DT/ha and IRR of 20%). The profitability of WHT seems quite satisfactory in spite of the heavy amount of investments and the low agricultural yields after implementation. However, it is not easy to identify and internalise all external positive and negative effects (groundwater recharge and salinity reduction, erosion and sediments prevention, etc.) due to the lack of data needed the economic valuation of ecosystem goods and services provided by WHT and reflecting the value of natural capital.

Table 4. IRR and sensitive analysis (WHT investment at farm level)

	IRR (%)		
	Observed	Costs (+ 10 %)	Benefits (- 20 %)
Financial CBA	24%	27%	21%
Economic CBA	27%	22%	23%
Extended CBA	23%	21%	20%

Table 5. Net Present Value of WHT investment

	NPV (TD)				
Discount rate	12%	10%	8%	Costs (+10 %)	Benefits (-20 %)
Financial CBA	2491	3615	5231	2340	1691
Economic CBA	3023	4283	6092	2884	2140
Extended CBA	2073	3027	4402	1910	1333

3.2. Transition on livelihoods conditions

Here we explore how the SWC programme based on WHT has impacted on livelihood conditions. Based on the perception and the expectations of interviewees, figure 2 shows that the livelihood assets, in the whole watershed and in the three components (upstream, midstream and downstream), will be changed during the upcoming period to horizon 2030. Indeed, the natural capital will decline while human, social, physical and financial capitals will increase.

At the whole watershed level, the average scores are currently higher for the social, human and natural assets, respectively 68, 63 and 62 on a scale of 0-100 (figure 2). The future situation will see a positive change of the social, human and physical assets which respectively reach higher scores of 75, 67 and 39. On the opposite, a decrease of natural assets is expected in the future due to anthropogenic pressures.

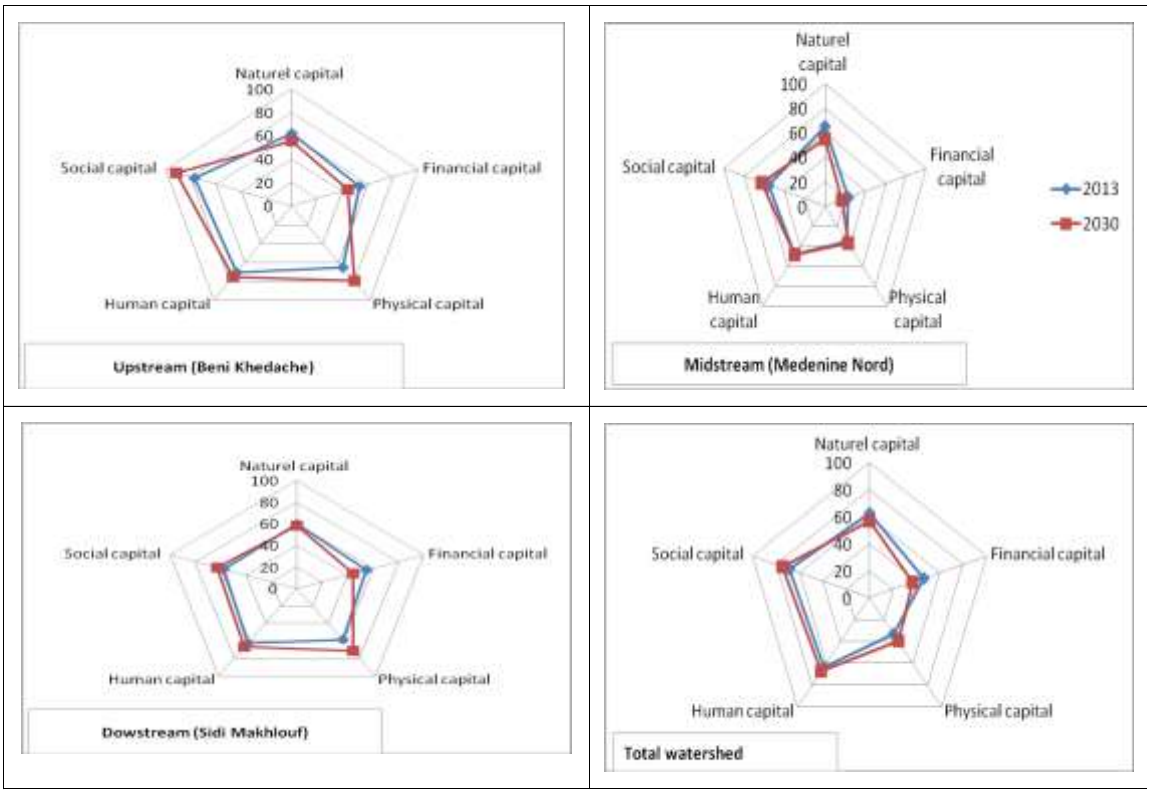

Figure 2. Pentagon diagrams of the five livelihood assets in the study area

At the catchment section levels (upstream, midstream and downstream), results show that, in the current situation, social capital is the most dominating capital in the three locations with respective scores of 77, 56 and 58, followed by physical and capital assets which are most available in the upstream area (Beni Khedache district) with a score of 65 and the downstream area (Sidi Makhlouf district) with a score of 71 (figure 2).

Regarding the future situation, the expectations of stakeholders was very positive for social, human and physical assets, respectively 63 to 91; 48 to 75 and 37 to 80. The scores for these three assets took the highest values in the upstream area. As opposed to natural assets which were perceived to be in decline.

Thus, stakeholders' expectations reveal an increase in human capital which would be better in the future than the current situation because the enhancement of education and the improvement of living conditions. In fact, implementing new WHTs is expected to reduce rural exodus due to income enhancement. Therefore, government will be pushed to provide a wide range of social services in rural areas. Financial capital seems to be less represented in the different locations due to the relatively low agriculture and livestock incomes. Nevertheless, natural capital will slowly decrease.

To summarize, figure 3 shows the trends of the five capitals in the study area over time. The households' perception is very optimistic concerning the four capitals (human, social, physical and financial) which are expected to be increased. Conversely, the natural capital will decline over time because the increase of development requirements in natural resources, water, soil and vegetation. Indeed, WHT implementation will achieve a modest decrease in natural resources degradation but it fails to maintain the current situation given the harsh environmental reality in this locality.

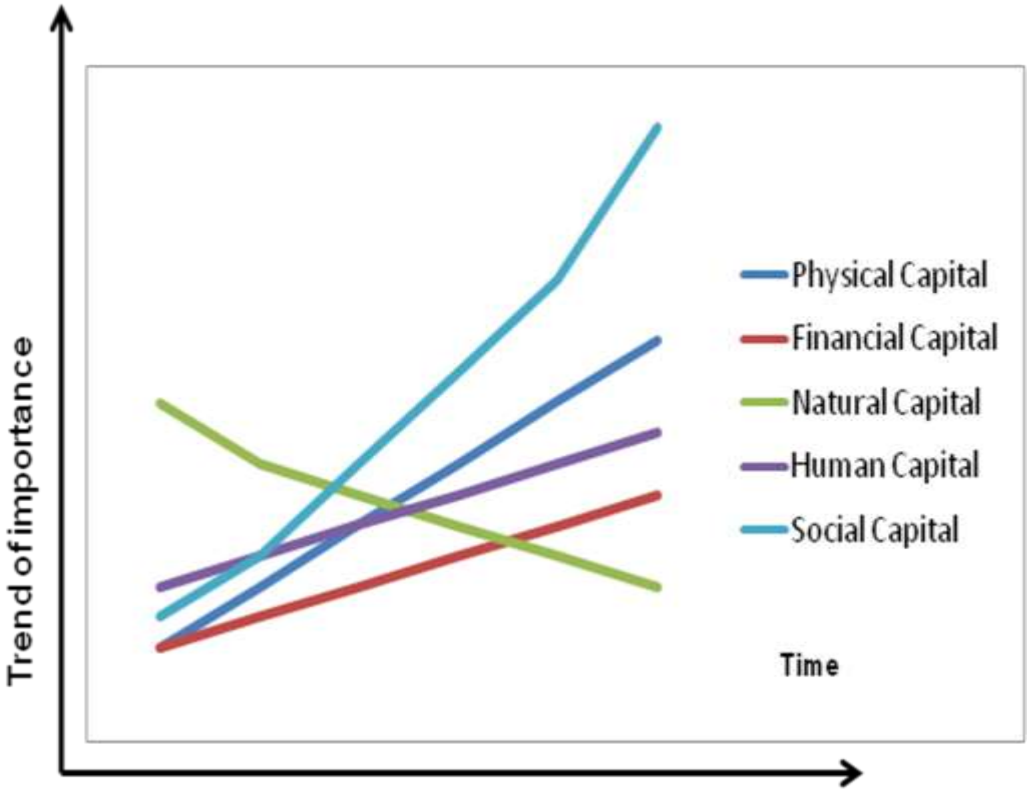

Figure 3. Trends of different livelihood capitals over time

4. Conclusion

An integrated impact assessment based on ECBA and SLA approach has been presented to assess the impact of WHT on sustainable development in Oum Zessar watershed. Results showed that coupling the two methods is useful to upscale impact assessment from field level to regional level and to cover the impacts on different capitals influencing well-being of the local population. In fact, the multifunctionality of natural resources dictated an urgent need to adopt integrated impact assessment methods to design an effective land management strategy. Integrated natural resources management was increasingly seen by the scientific community as a way to address the complex issues of sustainable livelihoods and to support policy-making. The central aim of the INRM approach was the quantification of the trade-off between the different dimensions of sustainable development, including political, legal, administrative, economic, environmental, social and cultural aspects. Such complex interaction requires the use of a wide range of research disciplines including environmental, agricultural, and socio-economic sciences. While such integration is essential to understand the intra-systems dynamics, a nested scales framework was deemed useful to focus on different issues relevant to the scale considered. INRM should merge top-down political action plans and bottom-up indigenous knowledge adaptation. Likewise, the international conventions on climate change, desertification, and biodiversity, should strengthen the environmental action policies; but their efficient implementation required that they must be adjusted to local context. Oum Zessar watershed faces a multitude of environmental problems and challenges that far exceed the resources available to reverse the trend. What is required is a fully integrated development plan that takes into account all necessary technical, agricultural, socio-economic, political and institutional aspects of INRM. The integrated impact assessment framework here applied can be a useful tool for community inclusion and livelihood strategy assessment. Sustainable land and water management practices and livelihood strategies improve rural livelihoods of farmers in dry areas.

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