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Ex-Ante Impact Study of MENARID Economic and Environmental Policy (Case Study: An Irrigation Water Supply Project in Iran)

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ABSTRACT

The purpose of the Integrated Natural Resource Management (INRM) Program in the Middle East and North Africa (MENA) Region (MENARID) is to bring national investment projects in the field of INRM. Within the scope of MENARID, International Center for Agricultural Research in the Dry Areas (ICARDA) planned to support a full and details impact study that captures the adoption of all INRM technologies implemented by the Iran's MENARID project titled Institutional Strengthening and Coherence for Integrated Natural Resources Management, and further assess a few high potential technologies selected in close collaboration with the local project team, and for which primary and secondary data are available. Such a study should also explore the gender aspect of the technologies analyzed. The impact evaluation study tests whether the selected technology has significantly contributed to restore and maintain of the ecosystem functions and productivity, and whether has improved the economic and social well-being of the targeted communities. We chose Kamkooyeh Village in the Behabad Site (in Yazd Province) where a Village Development Group (VDG) has been established by following participatory and capacity building approaches such as social mobilization and micro credit mechanism. A set of complementary activities and interventions were recommended and implemented in this site by consultation and active participation of the local communities and beneficiaries. One of the proposed interventions is the implementation of an Irrigation Water Supply Project (IWSP). The expected benefits and costs of the IWSP were predicted through financial valuation and an ex-ante evaluation of socioeconomic impacts. The financial and social (Economic and Environmental) benefit-cost ratio of IWSP was estimated to be about 0.83 and 2.32, respectively.

1. Introduction

The purpose of the Integrated Natural Resources Management (INRM) Program in the Middle East and North Africa (MENA) Region (MENARID) is to bring national investment projects in the field of INRM. Within the scope of MENARID, International Center for Agricultural Research in the Dry Areas (ICARDA) planned to support a full and details impact study that captures the adoption of all INRM technologies implemented by the Iran's MENARID project titled Institutional Strengthening and Coherence for Integrated Natural Resources Management, and further assess a few high potential technologies selected in close collaboration with the local project team, and for which primary and secondary data are available. Such a study should also explore the gender aspect of the technologies analyzed. This approach should contribute to decisions related to up scaling of the activities within and outside of the target project area as wells as learning for policy and decision making in INRM development under similar conditions in the future.

The impact evaluation study should test the hypothesis whether the technology, in the specific context in which it has been implemented, has significantly contributed to restoring and maintain the ecosystem functions and productivity, and has improved the economic and social well-being of the targeted communities. These hypotheses should be tested in the project districts that are predominantly covered by the assessed technology.

The impact study focuses on attribution and contribution of these technologies in bringing about desired changes, and also covers its relevance, effectiveness, efficiency, impact and replicability. To achieve this goal, it:

i. determines extent and depth of the use of the technologies/practices by the target beneficiaries,

ii. measures the economic and environmental benefits of using this technology; and

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iii. Undertakes a benefit-cost analysis of the technology, considering the full cost of the technology (costs of utilization, costs of promotion, subsidies and etc.).

We chose *Kamkooyeh* village in the *Behabad* Site (in *Yazd* province, *Iran*) where a *Village Development Group* (*VDG*) has been established by following participatory and capacity building approaches such as social mobilization and micro credit mechanism. A set of complementary activities and interventions were recommended and implemented in the site by consultation and active participation of the local communities and beneficiaries. The proposed interventions include implementation of an *Irrigation Water Supply Project* (*IWSP*) by installing a pipeline system for improving water supply efficiency (instead of using a 20 years old, cemented canal which has a lot of cracks and as a result, a large amount of water transmission loss).

Since *Kamkooyeh* village is located in a hyper arid region (near to desert and with mean annual rainfall of about 153.9 millimeters-*mm*), so water saving and water use optimization is a very important and necessary issue. This issue is more important in agriculture sector because it consumes more than 90% of the available water resources. One of the solutions for water saving and improving water supply efficiency is improving cover of earth irrigation canals by cement. For improving water efficiency, a comprehensive plan has been designed by local experts (under the supervision of the *MENARID* Team). It is expected that by the implementation of this project, about 20% of water transmission and distribution loss would be saved. The saved water could be used for improving the irrigation system or reducing water stress for cultivated crops or extending under irrigation lands or using it for ground water recharge.

Low efficiency of the existing irrigation water supply and distribution system, increasing weeds in the canal beds, high evaporation rate, water seepage from earth canal or from joints/cracks of cemented canal and low speed of irrigation water are few weak points of the traditional irrigation system. For improving irrigation water efficiency, a project for using a pipeline system for irrigation water supply and also isolating reservoir pools was suggested by local communities to the *MENARID* team.

Rural development policy impact study could evaluate from economic, ecosystem and social aspects. These appraisals are categories to two approaches of ex-ante and ex-post evaluations (Shahbazi, 2013, Hosseini and Shahbazi, 2013 and 2014). One of evaluation method is benefit-cost analysis approaches. *IWSP* in *Kamkooeh* village is not operational yet. So, *IWSP* impact study is an ex-ante evaluation. This executive *MENARID* policy in Iran will be evaluated from economic, ecosystem and social aspects by ex-ante benefit-cost analysis approach. Benefit-cost analysis is a method for project relative advantage according to the optimal and effective allocation of resources.

Benefit-cost analysis is a method for evaluating the relative advantage of investment projects in terms of efficient allocation of resources. The benefit-cost analysis aims to improve the efficiency of resources for economic prosperity In other words; the aim of the evaluating is to help select the best type of desired decision to the efficient use of resources. (Weick, 1993)

The first theoretical framework of benefit-cost analysis is bringing up by Dupy (1844). He used the concept of consumer surplus. After that date the benefit-cost analysis has played a vital role in the economic well-being (Vreeker *et al*, 2002). The first practical application of benefit-cost analysis in 1930 for the development of water resources in the US (Pakzad, 1993). There are many definitions for benefit-cost analysis. Burdman believed that benefit-cost is balanced for measuring. Ruh believed, benefit-cost analysis is a method for finding all the costs and benefits of a project as quantity value. In developing countries due to lack of capital resources, the best alternative investment allocation is a critical issue (Khalili, 1995).

Accordingly, many studies have focused on the evaluation of rural development projects. in Iran. Malek Hosseini and Mirakzade (2014), economic impacts of development projects on rural (*Kermanshah* province irrigation and drainage network) assessed. Salehi (2002) showed that the watershed project had a positive impact on rural migration reducing and employment increasing. The effect of watershed projects on rural development, Efati (2000), Mansourian and Mohammadi Golrang (2003) also conducted a study. Hosseini Tavasol *et al* (2007) studied the economic development impact of the rural dam in *Khuzestan* province assessed the impact of villager's contribution in rural development and successful implementation of rural projects. Other studies in this filed are conducted by khoobfekr (1999) and Dadrasi Sabzevar (1999). Abbasifar (2008) assessed the economic and environmental impact of foresting projects in Iran. She also used the benefit-cost analysis. All of these studies have been used ex-post evaluation approach.

In other countries, Tolliver *et al* (2011) study was to quantify the investment and maintenance needs of the county and local roads that serve as agricultural logistics routes in *North Dakota*. They found that the estimated resurfacing costs per mile of major agricultural distribution routes are 40% greater than the estimated resurfacing cost per mile on non-agricultural routes. They also discovered the average annual cost to resurface and maintain paved agricultural roads are $18,300. Jahren *et al* (2005) conducted a study of *Minnesota* rural roads for the *Minnesota Department of Transportation* (*DOT*). The objective of the study was to identify the methods and costs of maintaining and upgrading a gravel road. They concluded that the historical costs to maintain both gravel and bituminous roads were between $1,500 and $2,500 per mile.

Anderson and Sessions (1991) used mixed integer linear programming (*MIP*) to analyze the intermittent road management problem. They compute total costs and open road segments if opening and closing costs are not considered simultaneously with transport and road maintenance costs. The total costs are 13% higher than the optimal solution that considers all four costs simultaneously. Baumel *et al* (1986) estimated the benefits of keeping groups of existing roads in the county road system. Hanson *et al* (1985) describe the variable costs of the predominant types of vehicles operating on *Iowa* rural county roads. Helmberger *et al* (1990) develop a method to assess the economic impact of a rural road management study.

Sebaaly *et al* (2003) evaluate the impact of agricultural equipment on the actual response of low-volume roads in *South Dakota*. Other studies in this filed are conducted by Byrd and Gildestad. (2001).

In this section, first of all, the objectives of the impact study were mentioned then the study area was introduced. After that, the implemented project (intervention) in the study area was introduced and was evaluated. In the next section, the methodology of the impact study will be explained. In the third section, calculation of the environmental, economic and social benefits of the practice and *B/C* analysis (financial, economic and social) would be explained. In the final section, conclusion and recommendation would be explained.

2. Material and Method

We chose *Kamkooyeh* village in the *Behabad* Site where a set of complementary activities and interventions were recommended and implemented in the site by consultation and active participation of the local communities and beneficiaries including implementation of an *Irrigation Water Supply Project* (*IWSP*).

Due to the short time elapsed since the start of that intervention (approximately one year), so nobody expects to observe the resulting impacts in such a short period. Therefore, an ex-ante study was done to predict the potential impacts in the future.

In this project, we should consider all of the intervention or measures simultaneously while predicting the potential impacts. Accordingly, the impacts of this intervention (technology) on maintenance, restoration, or improvement of productivity, ecosystem functions, and social welfare of local communities were evaluated separately by considering the following steps:

2.1. Ecosystem functioning (environmental, biophysical and biological) benefits

Ecosystem functioning (environmental, biophysical and biological) benefits of *IWSP* are including: "decreasing of ground water recharge"[2], "carbon sequestration & CO_2 sequestration", "saving of the evaporated water from open canal" and "prevention of deposited sediment" in the canal and reservoir pool[3].

2.1.1. "Decreasing in ground water recharge" benefits

Calculation of "decreasing in ground water recharge" benefits is as follows:

$$V_{GWR} = R_{WL} \times T_{WR} \times P_w \qquad (1)$$

Where V_{GWR} is "decreasing of ground water recharge" benefits (actually, it has a negative impact), R_{WL} is water loss coefficient, T_{WR} is total irrigation hour (a traditional unit for water trade in a rural area), and P_W is the market price of water (*Rials-Local Currency-/irrigation hour-h-*) in that region. The loss coefficient (R_{WL}) would be determined by calculation of the ratio of the required time for filling up the pool with water, before and after installation of the pipeline.

2.1.2. "CO_2 sequestration" benefits

Calculation of "CO_2 sequestration" benefits is as follows:

$$V_{CS} = R_{AV} \times A_i \times T_{Con} \qquad (2)$$

Where V_{CS} is "CO_2 sequestration" benefits, R_{AV} is the amount of the sequestrated carbon (as *tone/hectare-ton/ha*), A_i is increased area of cultivated lands (in ha) or improved plant cover (because of more water availability), and T_{Con} is average tax on CO_2 dispersion by considering average of few countries (as *Rials/ton*).

2.1.3. "Saving of the evaporated water from open canal" benefits

Calculation of the "saving of the evaporated water from open canal" benefits is as follows:

$$V_{ER} = L_{canal} \times W_{canal} \times EVP \times P_{WV} \qquad (3)$$

Where V_{ER} is "saving of the evaporated water from open canal" benefits, L_{canal} is the length of the irrigation canal (as *meters-m-*), W_{canal} is average width of canal (as *meters-m-*), EVP is annual mean evaporation in the region in meters and P_{WV} *is* price of water in the region (as *Rials/m*^{3}).

2.1.4. "Prevention of deposited sediment" benefits

Calculation of "prevention of deposited sediment" benefits of is as follows:

$$V_{SR} = L_{SR} \qquad (4)$$

Where V_{SR} is "prevention of deposited sediment" benefits, L_{SR} is annual total cost of labor for cleaning deposited sediments in the canal and reservoir pools (employed labors' wage).

The sum of "decreasing of ground water recharge", "carbon sequestration", "CO_2 sequestration", "saving of

[2] Although the irrigation canal was covered by cement but after 20 years of operation, it has so many cracks and in some part it was broken so there was a large amount of water loss in the canal which would be reduced by installation of pipeline)

[3] Since farmers are irrigating their farms by using a reservoir pool so "reducing water availability timeliness cost" which was expected after implementation of *IWSP*, is not so important.

the evaporated water from open canal" and "prevention of deposited sediment" benefits is ecosystem functioning (environmental, biophysical and biological) benefits of *IWSP* practice. (It means, $V_{IWSP}= -V_{GWR} +V_{CS} + V_{ER} + V_{SR}$).

2.2. Economic (improving productivity) benefits

Economic (improving productivity) benefits of *IWSP* is as follows:

$$E_{IWSP} = A_i \times P_i \quad (5)$$

Where E_{IWSP} is economic benefits of *IWSP*, A_i is potentially added area for cultivation (as *ha*) (There is no seepage from the bed of the broken cemented canal after installing the pipeline so by the saved water, more lands could be cultivated) and P_i is price/revenue of cultivated crops (as *Rials/ha*).

2.3. Social benefit/well-being

Social benefit/well-being of *IWSP* could be determined by using the following equation:

$$\mathrm{SV}_{P1} = \left[1 + ((\mathrm{IN}_{nmd} / \mathrm{IN}_{pre\text{-}nmd}) \times \gamma_{IWSP})\right] \left[\mathrm{V}_{IWSP} + \mathrm{E}_{IWSP} + \mathrm{EM}_{IWSP}\right] \quad (6)$$

Where SV_{IWSP} is the social benefit of *IWSP*. V_{IWSP}, E_{IWSP} and EM_{IWSP} are ecosystem functioning, economic benefits and employment value (temporary job opportunity for the local community in installing the pipeline) of *IWSP*, respectively.

In addition to environmental and economic benefits of *IWSP*, there are other impacts such as increasing active participation of local communities, improved group working manner, a social mobilization which will cause improvement in social capital, therefore the rate of social participation could be calculated by using the $[(IN_{mnd} / IN_{pre\text{-}mnd}) \times \gamma_{IWSP}]$ equation.

Actually, by considering this coefficient (rate), social benefits of IWSP would be increased (equation 6). In this equation, IN_{mnd} is average income of the village after implementation of the *MENARID* project, $IN_{pre\text{-}mnd}$ is average income of the village before implementation of the *MENARID* project and γ_1 is the technology acceptance rate for *IWSP*.

2.3.1. "EM_{IWSP}" benefits

Calculation of "EM_{IWSP}" benefits is as the followings[4]:

$$EM_{IWSP} = Q_{EM1} \times P_{w1} \quad (7)$$

Where EM_{IWSP} is employment value of *IWSP* activity, Q_{EM1} is a number of the employed labors, P_{w1} is labor daily wage in that region.

[4] Although in economic and project evaluations literature, employment of installing projects is a cost item, but in social evaluations, this item is social benefit because of income development of farmer. For accurate evaluations benefits in comparison of cost, we subtracted employment benefits from social benefit (equation 8).

2.4. Benefit-Cost analysis

Benefit-Cost analysis of *IWSP* is as follows:

Net annual equivalent uniform benefits of *IWSP* could be calculated according to SV_{IWSP} for life period of the projects (for example, 20 years) and then net annual uniform cost of *IWSP* interventions for useful life period of the projects. The benefit-cost analysis would be determined based on the following equation:

$$\mathrm{B/C} = \left[\mathrm{SV}_{IWSP} - \mathrm{EM}_{IWSP}\right] \Big/ \left[\mathrm{C}_{IWSP}\left[\frac{\mathrm{r}(1+\mathrm{r})^{n}}{(1+\mathrm{r})^{n}-1}\right] + \mathrm{K}_{IWSP}\right] \quad (8)$$

Where SV_{IWSPi} is annual social benefits of *IWSP* intervention and EM_{IWSP} is employment value of *IWSP* intervention. C_{IWSP} is net annual uniform cost (operational and overhead Expenses) of *IWSP* intervention, *n* is the life time of the project and *r* is the annual discount rate. Also, K_{IWSP} is the annual working capital cost (operational and maintenance costs).

2.5. Data

Some data such as water price in the study area, production price and agricultural production quantity are collected by questioners from local beneficiaries in the village, some data such as soil and carbon sequestration properties are collected from baseline studies, some data such as budget of projects (the allocated budgets) are collected form provincial project team. As it was mentioned before, the required data for doing this impact study were collected from different sources. First of all, those data that could be extracted from existing reports (base line study, the filled questioners by the *MENARID* team), field visit, were organized.

3. Results and Discussion

In this section, the obtained results would be explained. That is, calculation of the environmental, economic and social benefits of the *IWSP* practice will be explained. *B/C* analysis (financial, economic and social) of the projects would be presented in the last section.

3.1. Evaluation of ecosystem and socio-economic benefits

Total length of the pipeline is about 1340 meters (*m*) which its specification has been explained in the previous section. Ecosystem and socio-economic benefits of the *IWSP* have been calculated as the followings:

3.1.1. Calculation of water loss benefits

In this part we consider two different scenarios:

A. Water requirement of each 100 square meters (m^2) of arable lands is about 12 minutes of irrigation water.

B. Water requirement of each 100 m^2 of arable lands is about 20 minutes of irrigation water.

In scenario (A), each hectare of arable lands is irrigated for 1200 minutes (equal to 20 hours). Since in *Kamkooyeh* village there are 5.5 hectares (*ha*) of orchard and 26.5 *ha* of irrigated lands, so in total, 32 ha of arable lands are under irrigation. It means:

32 ha × 20 hours = 640 hours of irrigation

Based on the baseline study, the water loss in the cement irrigation canal is about 20 percent. So after operation of the pipeline, 128 hours (640 *hours* × 20%) of irrigation water, would be saved.

For evaluation of the monetary value of 128 hours of irrigation water, water price is required. In the year 2013, water price was varying between 250000 to 300000 *Rials/ hour*, therefore in this section, the value of the saved water would be calculated based on both price:

A1. If price of one hour irrigation water considered as 250000 *Rials* then value of the saved water would be:

hours × 250000 Rials = 32000000 Rials

A2. If price of one hour irrigation water considered as 300000 *Rials* then value of the saved water would be:

128 hours × 300000 Rials = 38400000 Rials

In scenario (B), each hectare of arable lands is irrigated for 2000 minutes (equal to 33.33 hours). Therefore 32 hectares of under cultivation of arable lands requires:

32 ha × 33.33 hours = 1066.7 hours of irrigation

By considering, the water loss of 20 percent, it would be calculated that after operation of the pipeline, 213.34 hours (1066.7 *hours* × 20%) of irrigation water, would be saved which its monetary value could be calculated as:

B1. If price of one hour irrigation water considered as 250000 *Rials* then value of the saved water would be:

213.34 hours × 250000 Rials = 53335000 Rials

B2. If price of one hour irrigation water considered as 300000 *Rials* then value of the saved water would be:

213.34 hours × 300000 Rials = 64002000 Rials

Since in calculation of the value of the saved water, the most important component is the water loss coefficient, so its sensitivity analysis is also important.

Sensitivity analysis of water loss benefits.

A. in the case of A, water requirement of 100 m^2 of irrigated lands is 12 minutes of irrigation water

A1. Assuming 1 percent decrease in the water loss coefficient:

In this case, the water loss coefficient would be considered as 19% instead of 20% so:

640 hours × 19% = 121.6 hours

It means, 121.6 *hours* of irrigation water would be saved. If the price of one hour water considered as 250000 *Rials* then the value of the saved water would be calculated as 30400000 *Rials* and if the price of one hour water considered as 300000 *Rials* then the value of the saved water would be 364800000 *Rials*.

A2. Assuming 1 percent increase in the water loss coefficient:

In this case, the water loss coefficient would be considered as 21% instead of 20% so,

640 hours × 21% = 134.4 hours

It means, 134.4 hours of irrigation water would be saved. If the price of one hour water considered as 250000 *Rials* then the value of the saved water would be calculated as 33600000 *Rials* and if the price of one hour water considered as 300000 *Rials* then the value of the saved water would be 403200000 *Rials*.

It is shown that in the case of the unit price of water about 250000 *Rials*, by one percent increase or decrease in the water loss coefficient, the monetary value of the saved water will vary in the range of 30400000 to 33600000 *Rials* (30400,000 < 32000000 < 33600000). Also in the case of the unit price of water about 300000 *Rials*, by one percent increase or decrease in the water loss coefficient, the monetary value of the saved water will vary in the range of 36480000 to 40320000 *Rials* (36480000 < 38400000 < 40320000).

B. in the case of B, water requirement of 100 m^2 of irrigated lands is 20 minutes of irrigation water

B1. Assuming 1 percent decrease in the water loss coefficient:

If the water loss coefficient considered as 19% then 202.67 hours of irrigation water would be saved:

1066.7 hours × 19% = 202.67 hours

If the price of one hour water, considered as 250000 *Rials* then the value of the saved water would be calculated as 50667500 *Rials* and if the price of one hour water considered as 300000 *Rials* then the value of the saved water would be 608010000 *Rials*.

202.67 hours × 250000 Rials = 50667500 Rials

202.67 hours × 300000 Rials = 608010000 Rials

B2. Assuming 1 percent increase in the water loss coefficient:

If the water loss coefficient considered as 21% then 224 hours of irrigation water would be saved:

1066.7 hours × 21% = 224 hours

If the price of one hour water, considered as 250000 *Rials* then the value of the saved water would be calculated as 56000000 *Rials* and if the price of one hour water considered as 300000 *Rials* then the value of the saved water would be 672000000 *Rials*.

224 hour × 250000 Rials = 56000000 Rials

224 hour × 300000 Rials = 672000000 Rials

It is shown that in the case of unit price of water about 250000 *Rials*, by one percent increase or decrease in the water loss coefficient, the monetary value of the saved water will vary in the range of 50667500 to 56000000 *Rials* (50667500 < 53330000 < 56000000). Also in the case of unit price of water about 300000 *Rials*, by one percent increase or decrease in the water loss coefficient, the monetary value of the saved water will vary in the range of 608010000 to 672000000 *Rials* (*608010000 <64000000 <672000000*).

As a conclusion, one percent increase in water loss coefficient, will increase the value of the saved water for 5% but one percent decrease in water loss coefficient, will decrease the value of the saved water for 9.5%. Therefore, the value of the saved water is more sensitive to a decrease of water loss coefficient than its increase.

3.1.2. Carbon sequestration function benefits

In the dry season (drought condition), discharge of the *Qanat* is about 17 *litter/second (lit/sec)*. Since all 32 *ha* of the arable land are irrigated by this amount of water so by each liter of this water, 1.88 *ha/sec* of lands could be irrigated. If installing the pipeline causes 20% increase in water transmission efficiency in each one kilometer (*km*) of the pipe line so 3.4 *lit/sec* water would be saved.

17 lit/sec × 20% = 3.4 lit/sec/km

On the other hand, total length of the pipeline is 1340 meters (equal to 1.34 *km*) therefore in total length of the pipeline, 4.56 *lit/sec* would be saved:

3.4 lit/sec/km × 1.34 km = 4.56 lit/sec

(It could be assumed that the water discharge has been increased for 4.56 *lit/sec* therefore in total water discharge could be considered 21.56 *lit/sec* -17 + 4.56-).

As it was mentioned before, each *lit/sec* of water could irrigate 1.88 ha of arable lands, therefore, the amount of the saved water (4.56 *lit/sec*) could increase the irrigated lands by 8.58 *ha* (in total it could be 40.58 *ha*).

4.56 lit/sec × 1.88 = 8.58 ha

32 + 8.58 = 40.58 ha

There is an important remark in this regard. In ideal condition (in the case of high productivity), by each one litter per second of water, 4 *ha* of lands could be irrigated. In this situation, by using 17 *lit/sec* of water, 68 *ha* of lands could be irrigated and after installing the pipeline and saving 4.56 *lit/sec* of water, irrigated land could be increased by 18.24 *ha* so in total, irrigated lands could be 86.24 *ha*. It means in the current situation and by using 17 *lit/sec* of water, only 32 *ha* are irrigated but by optimization and improving water productivity it could be increased to 68 *ha* (instead of 32 hectares) and by using pipeline system for water supply, it could be increased to 86.24 *ha*.

4.56 lit/sec × 4 ha = 18.24 ha

68 = 86.24 ha

In the wet season, *Qanat*'s discharge would be 26 *lit/sec* therefore all above calculation would be changed as the followings:

26 lit/sec × 20% = 5.2 lit/sec (saved irrigation water loss per km of pipeline)

5.2 lit/sec × 1.34 = 6.97 lit/sec (saved irrigation water loss in whole of pipeline length)

It means by installing the pipeline system, water discharge would be increased about 6.97 *lit/sec* and in total it would be 32.97 *lit/sec* (26 + 6.97 = 32.97). In this condition, if the scenario of using 1 *lit/sec* for irrigation of 4 hectares could be valid then after installing the pipeline, irrigated lands could be increased by 27.88 *ha* and in total, it could be 95.88 *ha*.

6.97 lit/sec × 4 ha = 27.88 ha

27.88 + 68 = 95.88 ha

But in the current situation that by each liter of water only 1.88 *ha/sec* could be irrigated so after installing the pipeline, irrigated lands could be increased by 13.1 *ha* and in total, it could be 45.1 *ha*.

6.97 lit/sec× 1.88 ha = 13.1 ha

13.1 + 32 = 45.1 ha

Sensitivity analysis of carbon sequestration function benefits

A. Assuming 1 percent increase in the water loss coefficient.

In this case, the water loss coefficient would be considered as 21% instead of 20% so,

A1. In dry season (drought condition)

17 lit/sec × 21% = 3.57 lit/sec/km of pipeline length

3.57 × 1.34 = 4.78 lit/sec (in whole length of the pipeline)

4.78 lit/sec × 1.88 ha = 8.99 (increased irrigated lands)

A2. In wet season

26 lit/sec × 21% = 5.46 lit/sec/km of pipeline length

5.46 × 1.34 = 7.32 lit/sec (in whole length of the pipeline)

7.32 lit/sec × 1.88 ha = 13.75 (increased irrigated lands)

B. Assuming 1 percent decrease in the water loss coefficient.

In this case, the water loss coefficient would be considered as 19% instead of 20% so,

B1. In dry season (drought condition)

17 lit/sec × 19% = 3.23 lit/sec/km of pipeline length

3.23 × 1.34 = 4.33 lit/sec (in whole length of the pipeline)

4.33 lit/sec × 1.88 ha = 8.14 (increased irrigated lands)

B2. In wet season

26 lit/sec × 19% = 4.94 lit/sec/km of pipeline length

4.94 × 1.34 = 6.62 lit/sec (in whole length of the pipeline)

6.62 lit/sec × 1.88 ha = 12.44 (increased irrigated lands)

As a conclusion, one percent increase in water loss coefficient, will increase the area under irrigation for 5% but one percent decrease in water loss coefficient, will decrease the area under irrigation for 5.26%. Therefore, similar to the results of the equation 2.1, the area under irrigation because of installing the pipeline is more sensitive to decrease in water loss coefficient.

Finally, for calculation of V_{CS} ("CO_2 sequestration" benefits), R_{AV} (the amount of the sequestrated carbon) and T_{Con}(average tax on CO_2 dispersion) are needed. R_{AV} for arable lands is calculated in the following table 1.

It means, in average, annual carbon sequestration in each hectare of arable and orchard lands are about 15115.8 *kg/ha/year* (equal to 15.1 *ton/ha/year*).

For estimation of T_{Con}, Based on the records, the average tax on CO_2 dispersion in the European Union is 20€/ton in 2014 (Shahbazi *et al* 2014). So V_{CS} for dry and wet season could be calculated as:

Dry season:

8.58 (increased cultivation-ha) × 15.2 (CS) × (20 euros -€- × 43000 Rials)= 111535639 Rials per year

Wet season:

13.12 (increased cultivation-ha) × 15.2 (CS) (20€ × 43000 Rials)= 170553332 Rials per year*

3.1.3. The function of reducing evaporation from surface of the canal Benefits

The length of the canal is 1340 meters and its width is 0.5 *meter* so its surface area is 1340 × 0.5 = 670 m^2. Annual Evapo-Transpiration from the plant in the area is about 1473 millimeter-mm- therefore, the volume of the evaporated water from the canal is about 984.9 cubic meters (1.47 × 670) that are equal to 16.09 irrigation hour in dry season.

Since average water used for each hectare in this region is about 6748 cubic meters (m^3)and for irrigation of each hectare of land 20 to 33.33 hours water is required, therefore each 984.9 m^3 Evapo-Transpiration is equal to 2.91 *hours* irrigation (if each hectare of land irrigated 20 hours) or 4.86 hours irrigation (if each hectare of land irrigated 33.33 *hours*).

If price of water is 250000 *Rials/hour*, then monetary value of decreasing Evapo-Transpiration will be in the range of 730000 to 1216000 *Rials* and if price of water is 300000 *Rials/hour*, then monetary value of decreasing Evapo-Transpiration will be in the range of 876000 to 1459000 *Rials*.

By considering evaporation from free surface which means annual evaporation in the region is about 3000 *mm* (equal to 3 *meters*) so total volume of evaporation would be:

$3\ m \times 670\ m^2 = 2010\ m^3$

By assuming water requirement of 20 irrigation hours for each hectare of lands, a decrease in evaporation would be equal to 5.96 irrigation hours and by assuming water requirement of 33.33 irrigation hours for each hectare of lands, a decrease in evaporation would be equal to 9.92 irrigation hours.

The monetary value of this function (service) in both scenarios of water requirement of 20 to 33.33 irrigation hours for each hectare of lands by considering water unit price of 250000 *Rials* respectively would be 1489000 to 2482000 *Rials* and by considering water unit price of 300000 *Rials* would be 1787000 to 2978000 *Rials.*

Table 1. Carbon sequestration (*CS*) in arable lands

Crop	Area (ha)	CO_2 Sequestration (kg/year)	CO_2 Sequestration (kg/year/ha)	Share of crop area from total land	Share of crop from CO_2 Sequestration (kg/year/ ha)
Cereals	11	125947.4	11449.8	0.47	5359.5
Saffron	3	5291.41	1763.8	0.13	225.2
Forage	5.5	201249.8	36590.8	0.23	8563.8
Orchards	3	17912.3	6637	0.13	762.2
Others	1	4817.76	4817.8	0.04	205.0

Sum:15115.8 (kg/*ha*/year)

Reference: Summary selection of Kamkooyeh base line study and own result.

3.1.4. The function of reducing sedimentation in the reservoir (irrigation pool) Benefits

The monetary value of this function by considering annual labor cost for cleaning the irrigation pool could be evaluated in case there was no pipeline. In the last year, farmers paid 3500000 *Rials* for cleaning the irrigation pool which could be considered as the value of reducing sedimentation in the irrigation pool.

3.2. Economic value (benefits) of IWSP

In the previous section, it was evaluated that after installing the pipeline, in the dry season, the area under irrigation could be increased by 8.58 *ha* and in the wet season, it becomes 13.12 *ha*.

Average net income for each hectare of arable lands in the region is about 5655000 *Rials* and for orchards is about 4286000 *Rials* which its weighted average is about 5107000 *Rials* in each hectare. Therefore the economic value of increased under cultivation area, after installing the pipeline, in both scenarios of the dry & wet season is as:

Dry Season: 8.58 × 5107000 = 43819000 Rials
Wet season: 13.12 × 5107000 = 67006000 Rials

3.3. Social benefit of IWSP

First of all, we should calculate the benefit of employment creation for *IWSP*. Since usually 10% of total cost of a project will be used for implementation cost (labor cost) so from total cost of installing the pipeline, 42640000 *Rials*, its 10% which is equal to 42640000 would consider for human resources (labor) and as a benefit of employment creation for *IWSP*.

It is necessary to mention that by changing 1% in this ratio, it means by 1% decrease, share of labor in total cost of the project, would be 9% and its monetary value would be 38030000 *Rials* and by 1% increasing in it, share of labor in total cost of the project, would be 11% and its monetary value would be 46486000 *Rials*. In this condition, 1% decreasing in the ratio cause 11% decrease in employment creation benefits and by 1% increase in the ratio, employment creation benefits would be increased by 22%.

Another important point is that the daily labor cost in the region is about 400000 *Rials* so for implementation of *IWSP*, about 106 man day, temporary job has been created.

46486000 / 400000 = 106 man day

For calculation of social benefit/well-being of *IWSP* in addition of V_{IWSP} (ecosystem functioning), E_{IWSP} (economic benefits) and EM_{IWSP} (employment value), we need to an acceptance rate of the project (equation 7).

3.3.1. Calculation of acceptance rate of the project

The main objective of this project *IWSP* was to improve water efficiency from 35% to 85% but the complementary activities in the field of irrigation water distribution have not been started so far therefore by installing the pipeline, irrigation water efficiency has been increased to 55%.

Acceptance rate = (55 – 35) / (85 – 35) × 100 = 40%

Before the implementation of *IWSP*, average monthly income of households at village level was 41910000 *Rials*.

Further, the monetary value of participation of the villagers would be determined by comparing it to the average monthly income of rural households at national and provincial level.

Based on the records of the Central Bank of Iran and also Center for Census data of Iran in the year 2012:

average monthly income of rural households at national level = 101281362 Rials

average monthly income of rural households in Yazd province = 110312101 Rials

A1. by considering national level:

10128136.2/4191000 = 2.42
2.42 × 40% = 0.97 participation at national level
A2. by considering Yazd province level:

11031210.1/4191000 = 2.63
2.63 × 40% = 1.05 participation at province level
The summary of the results of Eco systemic, economic and social benefits of *IWSP* is shown in table 2.

3.4. Benefit-cost analysis of *IWSP*

For calculation of Benefit-cost of the implemented projects, equation 8 has been used. In this section both financial and social Benefit-cost analysis has been done.

Before benefit-cost analysis, implantation cost of the project including *GEF-Global Environment Facility-*, *UNDP- United Nations Development Program-* , Iran's Government, *MENARID* and local community costs (Budgets) has been shown in table 3.

3.4.1. Financial benefit-cost analysis

In this section, only financial and economic benefits of the *IWSP* have been considered. It means financial benefits of *IWSP* in comparison to their costs would be analyzed. If the lifetime of the projects considered as 20 years and annual discount rate assumed to be 12 percent, annual uniform cost of *IWSP* has been presented in table 4. In this table, it is assumed that annual cost (current cost) of the project to be equal 30 percent of their financial and economic benefits. As it is clear in the Table, the benefit-cost ratio of *IWSP* is less than 1 (about 0.83) and therefore financially (economically) is not acceptable.

Its sensitivity analysis for change in discount rate as 11 and 13 percent has been done which the result shows 1 percent increase in discount rate, the benefit-cost ratio will be decreased to 0.80 and 1 percent decrease in discount rate, the benefit-cost ratio will be increased to 0.87.

Table 2. Benefits of implementation of irrigation water supply project IWSP (in 10000 Rials)

Condition		Wet Season				Dry Season (Drought)				
Number of required hours (for irrigation)		12		20		12		20		Average
Unit price of irrigation water hour		25	30	25	30	25	30	25	30	
Decreased sedimentation in canal & pool		35								35
Carbon sequestration		17055.3				11153.6				14104.4
Decreased evapo-transpiration		148.9	178.7	248.2	297.8	148.9	178.7	248.2	297.8	218.4
Decreased infiltration rate		3200	3840	5333	6400	3200	3840	5333	6400	4693.25
Economic values		6700.6				4831.9				5766.25
Employment creation values		4264								4264
Ecosystem benefits		14039.2	13429	12005.5	10988.1	8137.5	7527.3	6103.8	5086.4	9664.6
Social Benefits with considering participation values based on	No Considering	25003.8	24393.6	22970.1	21952.7	17233.4	16623.2	15199.7	14182.3	19694.8 5
	Yazd province condition	51257.8	50006.9	47088.7	45003	35328.5	34077.6	31159.4	29073.7	40374.4
	Iran condition	49257.5	48055.4	45251.1	43246.8	33949.8	32747.7	29943.4	27939.1	38798.9
Total Average										39586.6

3.5. Benefit-cost analysis of *IWSP*

For calculation of Benefit-cost of the implemented projects, equation 8 has been used. In this section both financial and social Benefit-cost analysis has been done.

Before benefit-cost analysis, implantation cost of the project including *GEF-Global Environment Facility-*, *UNDP- United Nations Development Program-* , Iran's Government, *MENARID* and local community costs (Budgets) has been shown in table 3.

3.5.1. Financial benefit-cost analysis

In this section, only financial and economic benefits of the *IWSP* have been considered. It means financial benefits of *IWSP* in comparison to their costs would be analyzed. If the lifetime of the projects considered as 20 years and annual discount rate assumed to be 12 percent, annual uniform cost of *IWSP* has been presented in table 4. In this table, it is assumed that annual cost (current cost) of the project to be equal 30 percent of their financial and economic benefits. As it is clear in the Table, the benefit-cost ratio of *IWSP* is less than 1 (about 0.83) and therefore financially (economically) is not acceptable.

Its sensitivity analysis for change in discount rate as 11 and 13 percent has been done which the result shows 1 percent increase in discount rate, the benefit-cost ratio will be decreased to 0.80 and 1 percent decrease in discount rate, the benefit-cost ratio will be increased to 0.87.

3.5.2. Social benefit-cost analysis

In this section, only Social benefits of the *IWSP* have been considered. It means social benefits of *IWSP* in comparison to their costs would be analyzed. If the lifetime of the projects considered as 20 years and annual discount rate assumed to be 12 percent, annual uniform cost of *IWSP* has been presented in table 4. In this table, it is assumed that annual Cost (current cost) of the project to be equal 30 percent of their social benefits. As it is clear in the Table, in a benefit-cost ratio of *IWSP* is more than 1 (2.32) and therefore economically and socially are acceptable which is very impressive.

Its sensitivity analysis for change in discount rate as 11 and 13 percent has been done which the result shows 1 percent increase in discount rate, the benefit-cost ratio will be decreased to 2.28 and 1 percent decrease in discount rate, the benefit-cost ratio will be increased to 2.37.

Table 3. Operational and overhead expenses in the Kamkooyeh village (GEF, Government of Iran & UNDP) in 10000 Rials

Stakeholders	type		Level	Cost
GEF	Official	Management	National	50
			Provincial	7
		Official & Equipment	National	1
			Provincial	1
	Travel		Provincial	60
	Operational		Provincial	26000
Government of Iran	Official	Management	National	20
			Provincial	90
		Official & Equipment	National	2
			Provincial	4
	Operational		Provincial	10000
Local Community	Operational		Cash	2500
			In Kind	L1
Total				38735

DW: Distance Work
L1: 1500 meter of water canal establishment as a labor work

Table 4. Summary of cost, benefit and B/C ratio of IWSP intervention

Type of Evaluation	Financial benefits (10000 Rials)	Cost (10000 Rials)	Annual uniform cost (in 10000 Rials)			B/C		
			Discount rate (%)			Discount rate (%)		
			12	13	11	12	13	11
Financial	5766.3	38735	6915.7	7243.9	6594.0	0.83	0.80	0.87
Social	39586.6	38735	17061.8	17390.1	16740.2	2.32	2.28	2.37

Finally, the novelty of this study can be explained in several parts. In this paper are tried to evaluate a financial and social aspect of the international project (*IWSP*). That is, was tried to convert all of the aspects of intervention to

Monetary value. Aspects are including to ecosystem functioning (environmental, biophysical and biological) and economical. Also, participatory of the local community as several scenarios are tested for the probability of success of this project.

According to the findings from calculations, we can conclude, firstly, in arid and semi-arid region which are facing with water shortage issue, using pipeline could improve water supply efficiency and could have significant impact on socioeconomic condition of villagers. Secondly, Absolute attention to aspects of the economic benefit and sectorial viewpoint is a serious threat for the success of the projects. As the results show, socio-economic evaluation can lead to better and more accurate evaluation of the project impacts. Hence, integrated planning is more effective and efficient tool in design and implementation of the projects. Thirdly, There is a risk that *MENARID* team are being more involved in the details of the implemented projects (hardware work) and paperwork so there is less attention to software works (institutional coherence and strengthening to achieve the goals of *INRM*). Fourthly, integrated management/ planning should provide a full coordination among all stakeholders. In some cases, there is a lack of coordination among the key stakeholders. As an example, in the project of irrigation water supply, the responsibilities of *MENARID* team have been well-fulfilled, however, those responsibilities by the local government and the villagers remains to be accomplished. As a result, during the field visit it was observed that the pipeline system was not under operation.

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