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A long-term cost-benefit analysis of national anti-desertification plans in Iran

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Abstract

Desertification was recognized in Iran several decades ago. This phenomenon has gradually affected half the provinces in the country, where droughts exacerbate problems in these drylands. In response, the government has been active in providing considerable funds and human resources to halt desertification through investing in national research and executive projects over the last fifty years. Iran is an excellent case study at the global level for assessing anti-desertification and associated cost-benefit aspects as its climate, society and environment are very similar to the other 17 developing countries in the Middle East and North Africa region. In addition, the country has fifty years of experience in anti-desertification activities which have improved livelihoods through dry-farming, animal husbandry, fisheries, bee-keeping, and market gardening, leading to reverse migration from urban areas to stabilized rural areas. Based on several reliable national reports and case studies as well as two international datasets, an exploratory evaluation is provided for the monetary value of benefits from Iran's anti-desertification programs. The pivotal premise of the paper is based on the economic valuation of preserved infrastructure and ecosystem services as a result of implementation of anti-desertification plans. Although a cost/benefit analysis was not applied to human resources, this paper also considered other indirect benefits to anti-desertification plans including job creation, improved health conditions, and increased levels of agricultural and industrial activity. This cost/benefit evaluation of anti-desertification programs in Iran is estimated to provide a high and positive contribution equivalent to about 3.75% of the country's annual GDP.

Keywords: Cost-benefit; Anti-desertification plans; Iran; long-term; National

1. Introduction

Desertification has negative direct impacts on infrastructure and people's health, and indirectly contributes to declining living standards and rural out-migration. Desertification along with deforestation was recognized in Iran several decades ago and both have contributed to land degradation throughout the country's history (Amiraslani & Dragovich, 2011; 2013a). These adverse environmental conditions have led to out-migration from villages, with local people seeking jobs or alternative livelihoods elsewhere. The Forest, Rangeland and Watershed Management Organization (FRWO) has assessed that 17 of the 31 provinces in Iran are suffering from desertification.

Both climatic and anthropogenic factors have contributed to desertification and land degradation in Iran's drylands: droughts are common, rainfall is low, and population growth is high (Amiraslani & Dragovich, 2011). For the year 2002, the World Bank estimated the economic cost of land degradation represented 2.5% of the country's GDP (World Bank, 2005). As one of the outcomes of desertification, soil salinization, due to inappropriate management of land, agriculture and water, impinges on soil resources and makes land uncultivable. For instance, the cost of soil loss with salinization is more than US$ 1

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billion (Cheraghi, 2001). Another significant characteristic of desertification is that the impact of wind erosion becomes more apparent and causes substantial damage to infrastructure in desertified provinces. In response to this problem, a national plan called "Identification of focal areas vulnerable to wind erosion" was implemented to map and measure those critical wind erosion areas based on selected criteria. The plan revealed a total of 182 focal wind erosion areas and estimated damage to infrastructure of around US$ 386 million in 2004, the only year where such a survey was conducted (Table 1). As illustrated in Table 1, there is no significant statistical correlation (R^2 = 0.4) between the size of the areas affected by wind erosion and their assigned monetary values for damage. Regardless of possible measurement errors, such discrepancies can be attributed largely to the differences existing among the local assets and infrastructure specified in each province, and the frequency and intensity of wind erosion events.

Table 1. Wind erosion foci in each province and their damage costs (year 2004) (Birgani, 2011)

Province	Wind erosion foci (ha)	Damage costs (Equivalent to US$)*
Bushehr	409.344	122.305.222
Kerman	643.943	61.267.333
Sistan and Baloochestan	1.272.798	54.313.888
Isfahan	1.092.574	43.594.222
Razavi Khorasan	768.699	26.997.666
Qom	80.929	21.012.111
Southern Khorasan	1.149.521	17.739.222
Hormozgan	318.230	11.419.333
Yazd	769.557	10.370.555
Semnan	477.791	3.902.111
Tehran	32.115	3.098.000
Ilam	84.089	3.090.666
Fars	87.851	3.090.666
Markazi	4988	1.710.777
Qazvin	2357	1.598.111
Khuzistan	341.872	321.555
Northern Khorasan	96.861	274.222
Total	7.633.519	386.105.666

*Based on national official exchange rate (year 2004): US$ 1=9000 Rials

Climate change is also an imminent problem for Iran, threatening the future viability of its natural resources and wildlife. Impacts on public and private businesses, trade, and economic activities will include the loss of jobs and entrepreneurship activities, especially in the dryland agricultural sector.

Since the late 1960s, desertification programs have been instigated by Iran in all desertified provinces (Amiraslani & Dragovich, 2010; 2011). Individual projects have concentrated on varying activities – such as planting drought-tolerant vegetation, oil mulch spraying, exclosure, and runoff control – which have contributed to successful fixing of previously mobile dunes (Anon, 2008). Overall, 2.1of the 6.4 million hectares affected by shifting sand dunes and wind erosion have now been stabilized (NAP, 2005). These projects have covered 97 towns and 4,353 villages (Abdinejad, 2007) in the 17 provinces that suffer from desertification, and have improved livelihoods through dry-farming, animal husbandry, fisheries, bee-keeping, and market gardening (Amiraslani & Dragovich, 2011). As a result of these improved conditions, there have been reports of reverse migration from urban areas to stabilized rural areas (Ahmadi & Jafarian-Jeloodar, 2004).

Iran is an excellent subject for a case study of the cost-benefit analysis of anti-desertification plans for three reasons. First, it has a similar climate, society and environment to the other 17 developing countries in the Middle East and North Africa Region. Second, it has 50 years of experience in anti-desertification activities which is unique in terms of the area and techniques covered in the Region. Third, and probably similar to the other developing countries, agriculture in Iran has struggled to keep pace with a nearly six-fold rise in population from 13 million in 1930 to 76 million in 2013, which has been accompanied by the mounting monetary values of soil, water and land resources (Moameni, 2003 ; Central Bank of the Islamic Republic of Iran, 2015). Based on reliable national reports and case studies as well as two international datasets, this paper provides a unique initial evaluation of the

long-term economic benefits of Iran's anti-desertification program.

2. Materials and Methods

2.1. Data

This cost-benefit research utilizes six types of information including surveys, reports, papers, case studies and documents published in Persian and English as well as two other datasets focusing on monetary valuation of environmental degradation and of ecosystem services (Table 2).

2.2. Cost-Benefit Analysis approach

The Cost-Benefit Analysis approach is most useful when a single program or policy is being analysed (Cellini & Kee, 2010). Accordingly, this approach has been adopted here for considering anti-desertification plans as a national policy implemented to stabilize sand dunes and to expand forest plantations in the Iranian drylands. While it is difficult to place dollar values on all costs and benefits especially for many intangible benefits (Cellini & Kee, 2010), this paper will employ surrogates extracted from reliable sources to value the costs and benefits of anti-desertification plans. The Cost-Benefit Analysis approach can be performed at any point in the policy-making process although a time frame in the range of five to fifty years is preferred (Cellini & Kee, 2010). Here, monetary evaluation of anti-desertification plans is being assessed fifty years after the initiation of the plans. In this case, in medias res analysis (current year or snapshot analysis) is considered as it provides data on whether the program's current benefits are worth the costs (Cellini & Kee, 2010).Regarding the analysis scope, within Iran, the research encompasses all 17 desertified provinces of the country.

Table 2. Datasets used for monetary analysis in this research

Title	Description	Methodology	Remarks	Source(s)
National survey	Assessing positive impacts of anti-desertification plans carried out in 17 provinces	Designing a questionnaire to inquire about the types of infrastructures that had been protected and area or unit of each infrastructure type	Managed and coordinated by the FRWO	Several reports and articles published in Persian; Amiraslani & Dragovich, 2013b
World Bank Report	Analysing the cost of environmental degradation in Iran	Assigning monetary values to each environmental element or category (e.g. land and water)	The report was constrained by data availability; data accuracy was subjected to various assumptions and simplifications	World Bank, 2005
Report on ecosystem services	Valuation of regulation services across various ecosystems (e.g. air quality regulation, biodiversity regulation)	Assigning monetary values to certain elements	The report was not directly relevant to Iran but covered issues that can be addressed in anti-desertification activities anywhere in the world	Kumar *et al*., 2010
Research articles	Various analytical articles on this subject	Cited papers	Published in English	Amiraslani & Dragovich, 2010; 2011 and 2013a,b; Miri *et al*., 2009
National report	A national report that has been submitted to the UNCCD Secretariat	n/a*; Descriptive	Published in English	NAP, 2005
Domestic reports or articles	Various analytical articles on this subject	n/a; Descriptive	Published in Persian	Abdinejad, 2007; Haghani *et al*., 2007; Ahmadi & Jafarian-Jeloodar, 2004; UB, 2009; Anon, 2008; OIETAI, 2011

FRWO: Forest, Rangeland and Watershed Management Organization; n/a: not applicable; UNCCD: the United Nations Convention to Combat Desertification

* Unavailable papers

The discount rate which is normally a part of cost-benefit analysis is not applied in this study as, unlike other countries in the world, major domestic financial perturbations have characterised the Iranian economy throughout the last five decades. Furthermore, it was assumed that the Iranian Government has not intended to collect taxes, revenues, or other specific incomes from the anti-desertification plans for which it has provided funding.

3. Results

3.1. Preservation of infrastructure

As an executive organization, FRWO has been involved in natural resources management in Iran over the last century. It commenced its managerial and planning activities to manage forest areas in the early twentieth century and has gradually expanded these activities into rangelands and deserts since then. In 2004, the Bureau of Desert Affairs (BDA) surveyed FRWO officers in all desertified provinces for information including created infrastructure and officers' assessment of the extent to which existing infrastructure had been preserved by anti-desertification plans (Table 3). Created infrastructure has contributed to the preservation of other assets, through such measures as establishing forest plantations, planting windbreaks, and oil mulch spraying of sand dunes.

Table 3. Infrastructure covered in the BDA questionnaires sent to 17 FRWO desertified provincial offices and combined responses

Existing infrastructure preserved	Area/Unit
Roads, railroads	9000 km^2
Rivers, water canals	9800 km^2
Arable lands	600, 000 ha
Residential buildings	521,000 units
Industrial townships	51
Fisheries wharves	20
Military basements	271
Airport	23
Created infrastructure	
Forest plantations	2.1 million ha
Man-made parks	54 (6000 ha)

Source: Abdinejad (2007)

Attributing a financial benefit to the preservation of existing infrastructure is complex, involving consideration of both the prevention of direct damage and the indirect adverse impacts on human activities and livelihoods. Project appraisal ideally considers both direct costs (e.g. personnel, facilities, equipment) and indirect or secondary benefits and costs (multipliers, spillovers, or investment effects) (Cellini & Kee, 2010), but data constraints prevented such separate investigations in this research. For example, roads and railroads are vital networks which can be rendered impassable by sand encroachment. This delays the movement of goods (affecting the economy) and people (including potential increases in mortality and illness if medical treatment is delayed).

3.2. Job-creation

Job creation is an important part of anti-desertification plans, requiring experienced officers to implement projects and local people to assist in establishing and subsequently maintaining new installations or activities. If projects are to have long-term success, both staff and communities need to be actively engaged in the realization of programs. At the national level, numerous staff (including graduates) from various branches within FRWO have worked directly on field projects, with provincial offices of the Bureau of Desert Affairs usually having up to four permanent staff. Details of staff numbers involved directly and indirectly in anti-desertification projects over the last 50 years are not available, so it is not possible to compare changes in numbers of personnel in these fields with other employment groups.

Anti-desertification projects can utilize local labour during periods of low demand in farming and pastoralism. This provides a supplementary income for those involved, and the potential for projects with long-term labour demands or environmental benefits to contribute to further economic well-being. In the short-term, conservation programs involving Haloxylon plantations provide employment (Haghani *et al*., 2007; Iran Trade Point, 2006), but over the longer term also assist in dune stabilization which in turn, supports greater productivity in

dry-farming, animal husbandry, and market gardening. Additional small-scale enterprises like bee-keeping and fish ponds may also be facilitated by dune stabilization (Amiraslani & Dragovich, 2011).

Official data regarding local employment on anti-desertification projects are not available, but estimates include 250 people for 4 months in an 800-ha project (Haghani *et al*., 2007), and 200 for 3 months in a 2000 ha Haloxylon plantation (Iran Trade Point, 2006). In 2003, a major Carbon Sequestration Project conducted with GEF/UNDP in a desertified province – the dryland of Hosseinabad – focused on ensuring co-management of resources through income and job-creation workshops and skills training in activities such as mushroom and vegetable farming, processing of herbs, carpet weaving and livestock vaccination. Over a period of about 6 years, 49 workshops were conducted and approximately 421 jobs were created (Hunnam & Amiraslani, 2012). The locals were hired and paid to plant shrubs in order to slow the land degradation. Such a participatory approach in local projects assists in raising economic benefits to low income groups (Golmohammadi *et al*., 2013). In addition, the allocated budget of this project increased between the first and the second step, given its success, especially regarding the created jobs (Heshmati, 2013).

3.3. Foreign investment plan in desertified provinces

In 2010, a report was released by the United Nations Conference on Trade and Development (UNCTAD) to address world-wide Foreign Direct Investment (FDI). Analysis of the FDI index relating to Iran confirmed its relatively weak position in attracting foreign investment compared with other countries in the Asian region and the world. Projects involving agricultural and natural resources management (excluding the oil sector) were not particularly attractive for investors. The provinces of Tehran, Qazvin, Khorasan-Razavi and Isfahan absorbed half of these foreign investments (OIETAI, 2011). The Organization for Investment Economic and Technical Assistance of Iran (OIETAI) has also released a report detailing foreign investment in the country which reached a total of US$ 37.7 billion during the 17-year period between 1993 and 2009 (OIETAI, 2011). The OIETAI report showed an uneven distribution of foreign investment in Iranian provinces. Overall, 547 projects were implemented with an annual average of 32 projects (varying between 2 and 104). These projects were classified into 8 major groups including industry, construction and building, and services; investment was mainly derived from European and Asian counterparts within each group (OIETAI, 2011). In terms of monetary value, the 'industry' and 'water, electricity and gas' groups have attracted more than 74% of foreign investments. Within the 'industry' group, most investment was directed towards chemical (rubber and plastic) and food projects. Although FDI has not been substantial, the protection of land, soil and infrastructure as a result of anti-desertification plans has undoubtedly been important in attracting foreign investment in desertified provinces.

3.4. Health and well-being

As an outcome of dune stabilisation, local sandstorms are likely to have decreased in frequency, intensity and duration. This has health benefits by reducing the incidence of respiratory and ophthalmic diseases and contributing to preventing further deterioration in many other health and sanitary issues. Direct economic benefits are difficult to quantify, but disease caused by sand storms led to 533 people being hospitalised over a 4-year period in Sistan and Baluchestan province, at a cost of US$ 150/day for each patient (Miri *et al*., 2009).

Ecological disturbances of agro-ecosystems affect both land productivity (economic dimension) and living conditions (social dimension) of local populations (FAO, 2011). When dust storms and dune mobilization occur, monetary costs are involved in the clean-up of houses, schools and roads. In addition, the psychological impacts of dealing with sand encroachment on public infrastructure and private residences reduce people's general welfare and sanitary conditions. As well as dollars saved and dollars earned, real benefits in every project include lives saved and lives enriched and a generally increased quality of life (Cellini & Kee, 2010).

3.5. Enterprise development

Ecologically-degraded areas are unlikely to provide continuing food security for their inhabitants and become associated with 'Poverty traps' for local populations (FAO, 2011). If exploitation of these lands continues, the productivity of agricultural and animal husbandry activities, which are fundamental to rural people's lives and livelihood, will be reduced even further.

Every policy or program involves a wide range of stakeholders (Cellini & Kee, 2010). In addition to varied aspects of livelihood, anti-desertification plans in Iran have covered a broad spectrum of stakeholders. In Kerman province, anti-desertification activities over a 30-year period (1966-1996) were assessed (Ahmadi & Jafarian-Jeloodar, 2004). Multiple benefits were reported in relation to preservation of infrastructure and stabilised land (2850 ha) for expansion of industry, agriculture, education and urban areas; plantations also provided fuel wood for local inhabitants. Since 1965 farmers had been leaving villages which were surrounded by mobile sand dunes, but stabilising these areas resulted in people returning. In Semnan province, the focus of one project directed towards sustainable management of land and water resources involved activities to recharge aquifers and improve small-scale surface water retention, which in turn encouraged other rural activities (Amiraslani & Dragovich, 2011).

3.6. Biodiversity conservation

While anti-desertification plans directly involve the plantation of limited plant species (mostly Haloxylon species), stabilised sand dunes allow inter-dune ground to become covered by diverse annual or perennial plant species. This is possible because water resources are being recharged, micro-climate improved, and soil micro-nutrients enriched. In addition, community knowledge is a determinant in the relevancy of biodiversity conservation. In the plain of Chah-Hashem, South East of Iran, the locals planted crops and indigenous plants such as Meighan Deseritaria schoberi, which enabled the increase of organic matter, fertility and biological life in the soil (Aslinezhad *et al*., 2014). Such improved floristic condition also supports agricultural activities and fauna enrichment.

A study was carried out in Tehran province, one of the desertified provinces that has been covered by anti-desertification plans (Iran Newspaper, 28 August 2011, p. 2). Results showed that the annual economic values of rangelands, excluding forage production, reaches up to 1560 Billion Rials (equal to US$ 127 million), although the monetary share of each component within this total was not clear. The total valuation includes values of biodiversity conservation, soil preservation, nitrogen fixation, production of medicinal herbs and pest control. In this case, the excluded annual forage produced was estimated at 96,000 tonnes that could feed 556,000 animal units.

3.7. Monetary valuation of anti-desertification plans

Using datasets listed in Table 2, items relevant to anti-desertification were included and assigned monetary values in US$ as well as GDP% (Table 4).Details of procedures adopted to assign monetary values have been explained in more detail in Amiraslani & Dragovich (2013b). Two global reports were supported by other national materials (Table 2) where applicable. In the World Bank report, the largest values were attributed to impacts of land and water degradation, with additional estimates of parameters for carbon sequestration and soil stabilisation being based on Kumar *et al*. (2010). Although anti-desertification projects reduce degradation, the status of desertified provinces does not change, as the nature and extent of these projects is insufficient to completely reverse degradation. Moreover, the land degradation could go on without programs as was shown in Khorasan-Razavi (Pashaei *et al*., 2017). This region is close to the Afghanistan border where there is a lack of interventions on land rehabilitation. The proximity of these desertified lands worsens the land degradation of the region of which more than 60% is highly vulnerable to desertification.

4. Discussion

4.1. Uncertainties in employing global surrogates for domestic calculations

In the current research, the economic benefit to society of anti-desertification measures was estimated using various values based on worldwide data, so there are some uncertainties in our results. In addition, it was not possible to compare situations with and without the project (European Commission, 2008), so only the costs of anti-desertification plans and the benefits following their introduction were considered. Although the World Bank Report aimed to increase environmental awareness, it focused on achieving and costing sustainable development without evaluating any potential non-economic benefits to society (World Bank, 2005). The Report also did not specify a within-country regional breakdown of national costs, so cost data were applied by assuming a uniform cost distribution across all 31 provinces in the country, including the 17 desertified provinces. Once this assumed cost for the different types of

environmental degradation was allotted to each province, the figure was adjusted according to the proportion of desertified area within each desertified province (Table 4). The proportion of Iran's total population that was located within the desertified provinces was also noted where relevant. By applying these assumptions, the value attributed to anti-desertification measures would be over-estimated due to the likelihood that not all local projects were successful and, even if they were, they did not extend over the entire province. Further assessment of individual projects at the local level would be needed to evaluate whether the generalized estimates presented here reflect conditions on the ground.

In relation to ecosystem services, Kumar *et al*. (2010) noted that ecosystems provide numerous benefits to populations, and they divided these services into four main categories including the regulation of services like water, climate and some human diseases. This group of benefits was further divided into thirteen regulating services, and some of these were utilised in this study (Table 4). Where no data were available for Iran and figures were available for more than one other country, figures for countries with drylands similar to those in Iran were used.

4.2. Uncertainties due to ignoring real domestic values

Although encouraging beneficial aspects of health, humanistic, enterprise, biodiversity and infrastructure categories in relation to anti-desertification plans were explained earlier, we were not able to assign a monetary valuation to them as domestic values were lacking. For instance, accident prevention/decline due to national anti-desertification plans is a human benefit for which no data are available. However a small-scale study has been undertaken in the 15,197 km^2 Sistan region which has a population of 400,000 (Miri *et al*., 2009). The area is characterized by droughts and severe sand storms and the study used data for four years in relation to two main effects of sandstorms, namely reduced visibility (down to <1 m in some cases) and associated road accidents, and direct damage to roads through damage to sign posts and road surfaces. In relation to vehicles, damages were estimated to be US$ 709,000 over the 4-year study period (2002-2005) and problems to roads cost US$ 4,927,000 over the period (Miri *et al*., 2009). The authors suggested that by including the additional costs of community health, enforced school breaks, clearing sand drifts in residential areas and cleaning and repairing buildings, total costs would reach an estimated US$ 125 million.

Other benefits of anti-desertification plans cannot be included in our costings. At a national level, it is not feasible to estimate the direct and indirect valuations of benefits from preserving certain high-security infrastructure (e.g. airports, military bases) in desertified provinces. In addition, there are hundreds of preserved water dams, power plants, large industries, small businesses, hospitals, clinics, administrative buildings, educational institutes and agricultural enterprises as well as kilometers of highways and roads for which determining a monetary valuation is not an easy task. For instance, Yazd province has established a €300 million hybrid solar power plant that provides 480 MW of electricity (Iran newspaper, 19 May 2011). As well as its valuable structure and equipment, it has provided jobs for 3300 persons. This power plant is just one example amongst many illustrating the extent to which cost-benefit analysis can under-estimate both costs and benefits.

4.3. Uncertainties for the future plans

Based on our findings relating to anti-desertification contributions to society, it would be possible to estimate the total indirect contribution of FRWO through collective measures in conserving forests, rangelands, water resources and so on. Despite the fact that the FRWO's direct contribution to the total country's income in 2014-5 is about 0.06% (VSPS, 2013), it is indirectly contributing to 3.75% of the country's GDP solely through anti-desertification plans (Table 4). In the meantime, the predicted annual budget allocation for combating desertification in Iran was about US$23 million in 2011 (0.004% of the total annual national budget in 2011) (Hamshahri Newspaper, 28 February 2011, p.11). In regard to desertification damages, especially infrastructure deterioration, Iran had allocated a part of its national budget to anti-desertification intervention at an early stage (Jabbari, 2000). However, continuous desertification would place an increasing pressure on the national budget.

All projects require funding both for equipment/ materials and trained personnel, so the costs of anti-desertification plans are rising due to increases in workers' wages, depreciation

Table 4. Valuation of anti-desertification plan on an annual basis (adapted mostly from Amiraslani & Dragovich, 2013b and national data listed below the Table)

Category	Parameters assigned an economic value (nationwide)	Improvements assumed in this assessment by anti-desertification measures in 17 desertified provinces	US$ million (reported by World Bank and Kumar *et al*.)	GDP % (year 2010 equal to US$386,670 million) (UNstats, 2012)
Water	Water supply, sanitation and hygiene	Water supply, sanitation and hygiene improved	1320	0.34
	Groundwater depletion	Groundwater recharged	190*0.1885= 36	0.01
Land	Water erosion and dam sedimentation	Erosion reduced	370*0.646= 239	0.06
	Cropland salinity	Soil salinity reduced	1200m*0.1885= 226	0.06
	Rangeland degradation	Rangelands reclaimed	172*0.1885= 32	0.01
	Wetland degradation	Wetlands reclaimed	350*0.1885= 65	0.02
	Floods and soil erosion	Floods and erosion prevented	150*0.646= 97	0.025
	Deforestation and forest degradation	Deforestation prevented by exclosure	906*0.646= 585	0.15
Air regulation services	Planting 500,000 mesquite trees remove 6,500 tonnes of particulate matter annually in USA; US$ 4.16/tree	Description A [1]; (200 trees per ha [2])	35	0.009
Soil stabilization	Valued by replacement cost of nutrients in Turkey; US$46/ha	Description A [1]	2	0.0005
Carbon storage and sequestration	US$34 tC	Description A [1]; 30 tC/ha is the annual average carbon sequestered in a desertified province in Iran [3]	43	0.01
Preserved infrastructure	Residential buildings (521,000 units)	Preserved residential buildings (structure ONLY) 680 million Rials (US$22,500) for a rural unit price*	Total=US$22,500* 521,000=US$11,722 million	3.03
	Fisheries wharves (Total 20 in three provinces ONLY); C=Unit price (year 2014)=US$2.5m (extracted from a national newspaper)	Job creation; health improvement	Total=C*20=US$50m	0.013
Job creation	Arable lands (600, 000 ha)	Paid jobs per person per year based on SMW	Total=Average A + B=6.85/person/year= (600,000/6.85)* US$200= US$17.5 million	0.004
	Forest plantations (2.1 million ha)	Paid jobs per person per year based on SMW	Total=Average A + B=6.85/person/year= (2,100,000/6.85)* US$200= US$61 million	0.01
Health valuation	Hospitalization (533 patients over four years in one province)	Paid jobs per person per year based on SMW	(US$150/ day /each patient) for 17 provinces: 533*17= 9061 (2265 patients /year)	0.00009
		Total		3.75

[1] 2.1 million ha forest plantations established in desertified provinces (NAP, 2005) – an annual average of 42,000 ha/yr in 50 years;

[2] Haghani *et al*., 2007;

[3] UB, 2009;

* Current rough estimation composed of an average price of two typical rural residential buildings in desertified provinces (prices were extracted from the various Iranian websites); SMW: Standard minimum monthly wages set for Iranian workers converted to $US (official exchange rate of year 2014); A=(800 ha equates to 1000 person months); B=(2000 ha equates to 600 persons months).

of machinery and equipment, establishing work stations far from main sites, drought occurrences, and annual price inflation (Anon, 2008). These issues may hamper further expansion of anti-desertification plans or limit their efficacy. Cost problems are compounded by the potential need to increase anti-desertification funding in order to maintain past rates of benefits from programs, if climate change increases the frequency of droughts and dust storms. Following extreme drought in 1999, Rashki *et al*. (2013) noted that dust activity seems to have become more frequent and more severe in the dust source region in Sistan and Baluchestan province.

To overcome this cost challenge, however, participatory involvement of local people in projects is being encouraged and sought. The Carbon Sequestration Project (CSP), implemented in South Khorasan province, has been successful in lowering the costs of rehabilitation activities. As an example, costs of certain rehabilitation activities carried out by the Birjand Natural Resources Management Directorate (BNRMD) are compared with those costs of CSP works (Table 5). For all rehabilitation activities, CSP costs are lower than those costs of BNRMD. The main costs were people's wages as a way of generating 'collaborative rehabilitation of our surrounding area' (field interviews: personal notes of first author). Another program in Yazd, started in 2008, aimed at enhancing sustainable systems for rangelands and livestock management and preventing overgrazing by using local knowledge (Najafi-Nejad, 2013). The strategic objective of this program was to give up the traditional Top-Down approach and to adapt interventions according to the local communities' needs and economic capacities. Such a program, adapted to local conditions, should lead to economical and efficient anti-desertification outcomes.

Table 5. Comparison of costs of rehabilitation activities of CSP and BNRMD (Source: UB, 2009)

Row	Activity	BNRMD (per ton / pot/ hectare) - Rials	CSP (ton / pot/ hectare) - Rials	% lower [1]
1	Seedling plantation	3000000	850000	-72%
2	Pot seedling production	1500	850	-43%
3	Rooted seedling production	230	150	-35%
4	Create crescent-like micro pond	850000	480000	-43%
5	Irrigation	300000	150000	-50%
6	Seed collection	3000000	1800000	-40%

[1]Authors estimation; BNRMD: Birjand Natural Resources Management Directorate;
CSP: Carbon Sequestration Project; exchange rate (year 2012): US$ 1=12240 Rials

5. Conclusion

Iran's experience has shown that persistent efforts towards the implementation of anti-desertification plans can result in more sustainable development especially at the local level. Government involvement in such activities has empowered and persuaded local communities to be more cautious in exploiting their local environment, partly by providing clear alternatives and new ways of maintaining livelihoods. The substantial investment in anti-desertification plans has thus provided multiple economic and social benefits within local communities and also reduced rural-urban migration. At a larger scale, numerous dune stabilization programs have yielded benefits for local agricultural and animal husbandry activities, for the maintenance and preservation of essential infrastructure, and for human health.

Clear benefits have already flowed from Iran's long-standing anti-desertification policies and projects. In order to maximize benefits from investment in these projects, a dual approach involving scientific knowledge of physical environmental parameters and their management, and understanding of social and community issues, is desirable.

In the future, it will become more difficult for the Iranian Government to allocate funding for anti-desertification plans, as increasing costs have already led to a reduction in areas being treated. Continuation of these cost pressures may constrain the extent of works unless additional financial support can be gained from the private sector or foreign investment.

Benefits from preservation of physical infrastructure, improved health and well-being of the population, and provision of the basis for safe and sustainable agriculture and industrial development have emerged from anti-desertification plans in Iran, but the associated financial gains to the economy and its social assets have not been assessed here. This suggests that the real benefits to anti-desertification plans are considerably under-estimated even though, if province-wide, improvements indicate that the economic

benefit of the plans may be around 3.75% of Iran's GDP (GDP Year 2010). This national benefit may be further enhanced at a regional scale as a result of the large-scale afforestation programs (2.1 Million ha) forming part of the anti-desertification plans contributing to improved carbon sequestration capacities and reduced CO_2 emissions following re-vegetation and soil stabilization.

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