Environmental Impact of Soil Erosion and Land Degradation in Moghaan (Northern) and Behbahaan (Southern) Regions of Iran: an Observatory Report from Tokten-Undp Mission to Iran

Mohammad H. Golabi

University of Guam. Guam-USA
E-mail: mgolabi@guam.uog.edu

1 Introduction

Agricultural development and improvement plays a major role in the overall economic development of Iran. The contribution from the agricultural sector towards the gross national product and supply of food and fiber is substantial.

About 51 percent of Iran's 165 million hectares (ha) are made up of mountains, lakes, desert lands and towns, 11 percent are cultivated or fallow, 7 percent are forest, and 31 percent are marginal or rangeland. Only about fourth of the geographic area is potentially suitable for agricultural production, but in many areas rainfall is inadequate to permit cultivation without irrigation. Furthermore, the range of natural conditions creates differing agro-ecological zones and a wide variety of farming systems (UNDP-Irrigation Improvement Project, 1993).

Iran has a history of irrigation extending back over several thousand years. In addition to major rivers such as 'Arras River', water for irrigation is supplied by "Ghanat", a way of conveying water from the mountain aquifers to villages as well as in some cities.

In term of the water resources Iran has the highest per capita water availability in the Middle East (2150m^3 per capita against the average for the region of 950m^3). Resources are, however, not evenly spread, and only ten percent of the country has enough water for agriculture, and there is growing competition from municipal and industrial use around large towns (UNDP-Irrigation Improvement Project, 1993). In this respect the conservation and proper management of Soil and Water resources becomes crucial in the development and the sustainability of the agricultural production in Iran.

Climatic conditions in the subproject areas vary from semi-arid in Behbahaan and Moghaan with average rainfalls of around 300mm, to sub-humid in Tajan, with an average annual rainfall of around 650mm. Annual evapotranspiration is 2,234mm in Behbahaan, 827mm in Moghaan, 1,184mm in Zarrineh Roud, and 838mm in Tajan (UNDP-Irrigation Improvement Project, 1993).

Soils in these regions are of alluvial origin with textures that vary from silt loam to clay loam. Soils in Moghaan are mainly class I, those of Behbahaan are class II (UNDP-Irrigation Improvement Proj., 1993). In terms of fertility, Moghaan has the best soils while Behbahaan has relatively the least fertile soils (UNDP-Irrigation Improvement Proj., 1993).

The agricultural development in Moghaan as well as in Behbahaan regions have brought into focus several problems such as over-exploitation of soil and water resources. Accelerated soil erosion due to lack of protection and excessive grazing by livestock in these areas have created alarming conditions. In this report the problem of soil erosion and the environmental impact of the erosion related to the irrigation projects in Moghaan and Behbahaan regions is discussed. Appropriate solution is suggested following each problem identification.

2 Historical background of subproject areas

Due to its agricultural potential and capability, Moghaan has received special attention from the authorities prior to 1970 in which the government and private sector invested in the agricultural development in the region. They have invested considerable amounts of capital for the establishment of irrigation canals and irrigation systems. The "Arras River" diversion works in Moghaan were completed in 1970, with cost shared between the two riparian countries, ex-USSR and Iran. The net command area includes 35,600 ha of private small farms and 30,300 ha of state farms (UNDP-Irrigation Improvement Project, 1993). Irrigation and Drainage Improvement includes construction or lining of main, secondary and tertiary canals and drains, irrigation lift, and drainage pumping stations.

Despite all its success, irrigation development in these regions have brought into focus numerous problems such as water-logging (water table rise due to the seepage from the canal), salinity/alkalinity, lack of maintenance, low irrigation efficiencies, low crop yield, erosion and non-point source pollution.

3 Soil erosion and agricultural land degradation at the farm level

Due to their volcanic origin and vertisolic nature the soils of Moghaan are the most fertile among the subproject areas (UNDP-Irrigation Improvement Proj 1993). They are capable of producing very high yield crops such as wheat, barely, cotton, sugar beet and soybeans. However, accelerated soil erosion in these regions not only diminishes the ability of the land to produce satisfactorily, it also damages the environment.

The need for conserving the soil for greater as well as more reliable agricultural yield is therefore a continuing and ever-increasing national challenge and of course the adequate supplies of food and fiber depend on productive lands (Pimentel *et al*., 1993). Soil erosion and agricultural land degradation appears to be a serious threat to the economic well-being and social stability of Iran.

In the farmlands of Moghaan as well as in Behbahaan, soil erosion mainly occur due to the flooding the farm by furrow irrigation. The common practice at the local level is that the irrigation water is delivered to the farm using furrow or flood irrigation system, which is extremely wasteful and damaging to the soil. Overall irrigation efficiency is low, varying from 20 to 30 percent due to both poor water conveyance and inefficient on-farm water use (UNDP-Irrigation Improvement Project, 1993). The excess water from the furrow irrigation runs off the field through the exit channel and enters the tertiary canals into the secondary canal then into the Arras River and eventually to the Caspian Sea. The excess water (return flow) not only causes localized water logging but also washes away the sediment off the farm into the exit canal. By selectively removing organic matter and clay, runoff water from these fields not only removes nutrients and organic matter along with sediments; it may also reduce the soil's chemical capacity to retain added nutrients.

4 Problem of crust formation on moghaa's soils

Surface sealing or crust formation is the major problem for the soils in Moghaan region. Due to the fact that the soil is severely eroded the organic matter content of these soil is at its minimum (Table 1). As the result of low organic content the aggregate stability of these soil is very low and the bound between the soil particles is very weak which provides conditions for particle detachment. In addition, the high K content (Table 1) and reportedly high Na content (data not available) on these soil provides a disperssive condition, which in fact adds to their weak aggregate stability and causes dispersion.

Table 1 Selected properties of a typical soil from Moghan Region

Clay Content	29%
Sand	7%
Silt	64%
EC	2.7—3.4
pH	7.8—8.3
Organic Carbon (OC)	0.81%—1.19%
P	11—15ppm
K	590ppm

Some of the soil properties shown in table1 represent the top 30cm of the sampling depth from the Pars Mechanized Farms in Moghaan region. As it is shown the percent organic matter content of these soils is low while the disperseive elements namely K is considerably high. The data on the Na content of these soil was not available at the time however, a personal communiqué indicated that amount of available Na in these soils is considerably higher than normal.

Because crust formation results in reduced pore space at the soil surface, it decreases infiltration, thus causing runoff and erosion, resulting sever soil degradation in these soils. This process is specially accelerated by poor soil management in Moghaan region. Consequently the deep fertile soils of the region are transformed into exposed subsoil with low productivity.

Crust formation at the farm level in these regions can be reduced or eliminated by preventing clay at the soil surface from becoming disaggregated and dispersed. Chemical treatments however, can prevent clay dispersion from the impact of raindrops on exposed soils. Examples are gypsum or other salts to increase electrolyte concentration, and polyacrylamide (polymer) to stabilize aggregates (Sumner and Miller, 1992). Gypsum is an ideal material for this purpose, as it dissolves rapidly up to about 30 $mmol_c \cdot l^{-1}$, which is adequate to flocculate most soil clays, but low enough to remain effective over a growing season in the field (Sumner and Miller, 1992). By-product materials such as phosphogypsum (derived from phosphate fertilizer manufacture) and flue-gas desulfurization gypsum (from CO_2 removal at coal-fired power plants) are pure, fine crystalline materials that are available at low cost (Sumner and Miller, 1992). They are effective in preventing clay dispersion, enhancing infiltration, and reducing erosion when applied at rate of $3\ mt \cdot ha^{-1}$ — $5\ mt \cdot ha^{-1}$ on the soil surface. The main mechanism by which phosphogypsum enhances the infiltration rate of soils exposed to a low electrolyte source of water is by dissolution and release of electrolytes into the soil-surface solution hence preventing dispersion.

Organic material also can improve the cohesiveness of these soils, by increasing their water retention capacity and promotes a stable aggregate structure. It was suggested that organic material be added as green manure, straw or as manure that has already undergone a high degree of fermentation. Green manure, which are normally leguminous crops plowed in, have a high rate of fermentation and yield a rapid increase in soil stability (Morgan, 1996).

The dual role of physical forces (raindrop impact) and chemical processes (dispersion) in crusting suggests that control of crusting must address either or both of these areas. Chemical treatments such as gypsum may reduce crusting for short periods on limited areas, but for most soils, physical protection from rainfall is the long-term solution (Sumner and Miller, 1992). Conservation methods such as reduced or zero tillage, mulching, rotational pastures and cover crops have the greatest potential both to protect the surface physically, and to gradually increase soil humus levels, there-by improving aggregation and soil resistance to crusting. Adapting these practices to farming systems in Moghaan, Behbahaan, and the other subproject sites in Iran is thus a key to breaking the destructive cycle of soil crusting and degradation.

Water conservation is also very important for plant growth in dry climates such as in Moghaan and Behbahaan regions in Iran. Protecting the soil from raindrops that puddle the surface and cause a crust to form can conserve both soil and water. Conservation tillage was suggested to protect soil from erosion and degradation and also to conserve water and improve productivity.

5 Environmental impact of runoff, soil erosion and degradation in these regions

Soil erosion is not just an agricultural problem. The on site damage from erosion is indeed a problem to agriculture, but off-site problems are damaging to the environment. Erosion and sedimentation, particularly from dry land agriculture, are a major source of water-quality problems. Sedimentation provides a vehicle for the transport of agricultural chemical residues into the canals, streams, rivers and eventually the Caspian Sea. Through general observation from the Moghaan region, it became apparent that the environmental impact of soil erosion and related nutrient transport is considerably high and that fish communities of rivers, and specially the Caspian Sea are certainly affected by chemical contamination originated from the region's farmlands.

6 Effect of sedimentation and pollution on the region's aquatic ecosystems

Much sediment comes from fields on which farmers have failed to use appropriate soil conservation measures. Such soil abuses have resulted in considerable concentration of silt (data was not available, assessment was made via site visits and observations) in canals, streams, and specially the Arras River. Improper irrigation methods such as furrow and flood irrigation in which excessive amount of water is used is the main cause of erosion in the farmlands and sedimentation in the exit canals. Following each irrigation the excess water leaves the field at the end of the furrows and enters the exit canal. The exit canals flows excess water from the field carrying considerable amount of sediment as well as farm chemicals in which they all end up in the Arras River with the rate of $15m^3/s$ (personal communiqué). This extremely polluted water contains ammonium nitrate, phosphates, pesticides, herbicides and other organic and inorganic chemicals (data not available) that finally enter the Caspian Sea via the Arras River, poisoning the aquatic environment that is a serious thread to the fish population in the Sea. A very similar scenario exists in Behbahaan Region where a very polluted return flow exit farmlands into the exit canal and into the Maroon River. This extremely polluted water eventually enters the Persian Gulf (via Maroon River in the South) poisoning the aquatic environment in that region.

Sediments can also, overwhelm wetlands and destroy them in addition to what is lost by being drained for farming purposes. Consequently the loss of habitat is a major threat to wildlife specially the migratory birds. Their breeding sites are in areas with wetlands, small ponds, and lakes. Wetland loss due to sedimentation and other human activities in the region has serious adverse effects on thousands of waterfowl, mallards, black ducks, wood ducks, and teal that use wetlands as wintering grounds.

7 Control of sedimentation and pollution mitigation

It was suggested that the use of agricultural chemicals (fertilizers, pesticides, herbicides, etc.) obviously should be monitored closely and the usage should be limited to the minimum amount at their optimum effect. Timing for chemical application should also be adjusted so that the optimum effect can be achieved with the minimum application rate. Golabi *et al.* (1995), reported that in order to achieve their optimum effect, agricultural chemical should be retained within the few centimeters of the soil surface in order to prevent their leaching and/or a surface wash-out. On this effect, Golabi *et al.* (1995) suggested that a small amount of irrigation water should be applied after each chemical application. A minimum amount of water application after each chemical application will retain the chemical within the root zone so that it will not be leached or washed-out by the subsequent irrigation and/or rainfall events (Golabi *et al.*, 1995).

Furthermore, every effort should be made to avoid applying excessive amount of water to the field when irrigation is the only mean of watering. In this regard, water-holding capacity of the soil, plant water requirement, and the soil water content should be measured in order to determine the exact amount of water needed for the growing plant.

It was suggested that the irrigation techniques used by the farmers and agricultural units in Moghaan and other sub-project areas should be re-evaluated and a more efficient method should be employed. Needless to say that in order to protect the aquatic environment from pollution the excess water from the farmlands should not be allowed to return to Arras River or any other stream that may enter an open water (i.e., Caspian sea, Persian Gulf).

8 Concluding remarks

Clearly, soil erosion is a problem in all of the subproject areas visited. Conventional wisdom attributes some of the non-point source pollution problem to the farm economy, i.e., farmers will only implement soil erosion control techniques so long as they see a clear economic benefit to themselves. Therefore, we need to educate the farmers into expanding their planning horizon from short-term profit to long-term gain and plan for sustainability of resources rather than immediate exploitation of soil and water and other natural resources. This is not easy at the present when most farmers are not making any profit, but I sincerely believe that the implementation of sound soil conservation practices and sustainable farming will bring greater profit to the farmers and the nation as whole in the long run. Sustainability, cannot be achieved with the continuous nutrient depletion of the soil, sever erosion, land degradation, and environmental damages. Conservation practices can only be effective if they are implemented as a holistic approach to include: watershed management, protective rangeland rules, sustainable farming, erosion control techniques, and environmental protection policies.

I believe it is time to re-examine the means by which we control erosion-now. A voluntary program implemented at the discretion of the farmers that gives serious consideration to both non-voluntary participation (i.e., regulation) and government incentives which encourages erosion control practices such as subsidies that make it profitable to farm marginal lands are among the policy options suggested. I also believe that funding agencies can play a major role by supporting the subsidy programs as well as research projects on soil and water conservation and environmental protection technologies. Research and farmer's participation programs cannot be implemented without sufficient funding. It is for this reason that support from the private industry, national and international funding agencies such as the world bank is essential for achieving the long term goals of sustainability, socioeconomic stability and of course a cleaner environment worldwide.

Our task- to achieve true sustainability and a cleaner environment, requires a dedicated, highly coordinated holistic efforts of many different types of people, from college students to farmers, from scientists to politicians, from business executives to government agents and from teachers to pupils. The holistic approach to resource management means that resources such as soil, water, rangelands, wildlife, fisheries, and forests are used in ways that ensure their long-term health and vitality. In other words, we should harvest the Earth's generous supply sustainably and without causing long-term damage to its supply of natural resources. The sustainable approach therefore call on us to live our lives and conduct our business affairs in such a way that do not deplete the Earth's resources or foul its air, water, and soil. This approach requires inspirational leadership from individuals to government leaders at all levels, and from small-town mayors to the president of the country. It also, requires good scientific information and vigilant monitoring of conditions so that if the management strategies are not working they can be adjusted. It is apparent therefore, that future resource and environmental management cannot be accomplished effectively without an integrated and intelligent national effort, rather than a piecemeal and localized approach.

References

Golabi, M.H., D. E. Radcliffe, W. L. Hargrove, and E.W. Tollner. 1995. Macropore effects in conventional tillage and no-tillage soils. Journal of Soil and Water Conservation. vol. **50**, no 2. pp.205- 210.

Morgan, R.P.C. 1996. Soil Erosion and Conservation. Published by Longman, England. pp.130-136

Sumner M. E., and W.P. Miller. 1992. Soil Crusting in relation to Global Soil Degradation. Amer. J. of Alternative Agriculture. Vol. **7**, No. 1 and 2 . pp.56-62.

Personal communiqué, 1997. Engineer Safari, deputy director, Irrigation Improvement Project Office. Tehran, Iran.

Pimentel, D., J. Allen, A. Beers. 1993. Soil Erosion and Agricultural Productivity. 1993. *In*: Pimentel (ed.), World Soil Erosion and Conservation. Cambridge University Press.

UNDP-Irrigation Improvement Project, 1993. The World Bank Project, Staff Appraisal Report. Report No. 11393-IRN.