Combating Poverty by Irrigation from Large Dams in Arid Countries: A Case Study of Minab Dam, Iran

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ABSTRACT

A set of indicators for sustainable development were identified to be employed in developing countries. The selected indicators provided a good understanding of social and engineering outputs of a water resources project. Results of the study revealed that there are significant positive impacts of dam construction but they were not same as the targeted objectives envisaged in the feasibility report of the project. It means that after construction of the dam and irrigation system, development didn't match with the targeted goals of the project. This study argues the world-wide controversy against construction of dam in arid zone which is ill-founded and based on a few short term, mitigable negative impacts, ignoring many positive long term inputs alleviating chronic poverty in arid regions. The study meticulously looks into the pre dam bio-physical and socio-economic conditions in one of the arid region of Iran under the area commanded by Minab dam. This dam was constructed in Hormozgan province of Iran in 1983 and its irrigation system was completed in 1986 which was followed by progressive expansion of irrigated agriculture which almost doubled in year 2006. Literacy rate has increased from 41% (pre-project) to 74% in 2006. Similarly, significant improvements were observed in health care, sanitation, education, and other disciplines.

Key Words: **Impact of Irrigation, Poverty Alleviation, Sustainable Development Indicators, and Arid Regions**

1. INTRODUCTION

Historically in arid regions, the dwellings developed mostly along the rivers or any other water source as happened in many old civilizations e.g. Iran (side of Karoun River), Mesopotamia in Iraq (area between Tigris River and Euphrates River), Egypt (side of Nile River) and the Indus valley civilization in the subcontinent which covers a large part of Pakistan and northwestern of India, situated around the Indus and the Ghaggar-Hakra rivers respectively [1]. Egypt depends on the Nile in a way that no other nation does since 97% of Egyptians live on 2.5% of its area. Herodotus was a Greek historian in the fifth century who wrote, "Egypt is... the gift of the (Nile) river". Other historical example of importance of irrigation is Iraq where irrigation acts as an important base for agriculture in Mesopotamia that is situated between Iraq and Iran.

Worldwide high benefits have been derived by those countries which established sustainable irrigation systems especially in the arid regions. Currently 47.2% of the world

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and 45.8% of Asia and 90% of Iran fall in arid climate where no crops can be grown without irrigation. Based on review of United Nations document, total world cropped area recorded is 1,628 million ha, and out of this 277 million ha are currently irrigated. Crop yield of irrigated land generally varied from 3-5 t/ha whereas for the rainfed, the yield is only 1-2 t/ha [2].

According to current estimates, by the year 2030, world population will rise from the present 6.2-8.7 billion. Almost 800 million people in developing countries today face chronic malnutrition and 199 million children under the age of five suffer from acute or chronic food deficiencies. At present, as many as 88 nations fall into the category of LIFDCs (Low-Income Food-Deficit Countries): 44 in Africa, 25 in Asia, 3 in America, 6 in Oceania [3]. There is enough evidence that in many developing countries increased agricultural productivity due to irrigation from dams have significantly reduced the socio - economic problems that consequently led to reduction in poverty.

Historically the evidence of irrigation recorded in Mesopotamia and Egypt date back to the 6th millennium BC. Review of Iranian history revealed that water has always played a key role in the long history of the country. Iranians are credited for "Qanta" and the invention of Persian wheel, the two ancient irrigation systems which are well known all over the world. According to the Greek historian, Quant digging technique was documented and was practiced in the Achaemenian era (550-330 BC) 2500 years ago. Remains of reservoirs have been discovered alongwith water intake structures, spillways, outlets and the sewage systems belonging to pre-Achamenids and Assyrians period (1500-600 BC). Dam construction in Iran date back to Sassanian era, at the time of king Shapur I. The dams made at that period are 1300 - 1700 years old. A regulating dam and a bridge diversion dam (500 meters long with 4 spans) in Shushtar (an old city in Iran) and Amir dam, 35 km north of Shiraz is 1000 years old, are among these dams. During the Safavids Empire (1501-1736) water engineering developed significantly and many storage and diversion dams and bridges were constructed in Esfahan and Mashad of which some still exist today [4]. Presently there are 310 large dams based on ICOLDs definition, 268 embankment dams and 42 concrete dams. There are 55 dams under construction presently in Iran [5].

Evaluation of water resources in Iran shows that in year 2005-2006, total area under agriculture was 12.96 million hectares. Out of this 51.75% fall into irrigated land and 48.25% is rainfed. Near 71.26 million tons of agriculture production is produced from the irrigated area contributing nearly 90% of total production. Statistics shows that 33% of total employees of the country are employed in the agriculture sector [6]. In neighborhood of Iran, Pakistan posses one of the world longest contiguous irrigation system and it serves as the food basket of the country. Currently, most of the Indus plain (30% of Pakistan's land resources) has been brought under irrigation producing over 22 million tons of wheat in addition to many other exportable produces (e.g. cotton, rice, fruits and vegetables).

Sustainable development, conservation and management of water resources are the key to increase food production and empower poverty in arid and semiarid countries as discussed earlier. Interest towards solution of arid zone problems is target of every researchers and scholars while increase in population and demand of new generations in all defined section of facilities are the main task of decision makers to overcome the difficulties. Action in any field of development follows the beneficial and adverse reactions which add further difficulties for the investors both private and government. Good governance and monitoring are the key tools by which these impacts may be enhanced or alleviated. Stakeholders in development process sometimes act as though the elimination of poverty and economic growth are distinct from environmental goals. Where environmental sustainability requirements have been identified, they are rarely fully integrated into economic development and sector policies even where these make obvious economic sense.

1.1 Effect of Large Dams on the Environment

Effects of large dam on environment have been workout by various organizations. The Dams and Development report of the WCD (World Commission on Dam) is an excellent effort that has analyzed the impact of large dams. This report presents an integrated assessment of how large dams have performed including environmental and social impacts. Results of this report revealed that overall majority of the dams continue to generate benefits beyond their projected lives. On the other hand, many of the large dams have led to more negative than positive ecosystem impacts. This was mainly "due to the lack of attention given to anticipating and avoiding impacts, the poor quality and uncertainty of predictions, the difficulty of coping with all impacts, and the only partial implementation and success of mitigation measures" [7].

Lake of environmental management at down stream irrigation network may results in low performance of primary objectives of the project. However, experiences have shown that water, energy, dam and reservoir infrastructures can, in some cases, have major social and environmental impacts, so it is necessary to consider them within the frame work of integrated water resource management [8].

One of the most important reasons for not reaching the targeted performance level in irrigation systems is that it emphasizes the physical infrastructure, neglecting the social dimension on the other hand [9]. In the past emphasis was on dam construction by investors without any environmental consideration but since last many years, the effects of dams on population and the environment have come under greater scrutiny by the investors [10]. In fact, the contribution and need of dams for sustainable development cannot be denied in arid and semi-arid regions. Objection on large dams construction became a fashion of the day merely because of few adverse impacts which are more highlighted whereas the positive ones are often ignored.

1.2 Sustainable Development and its Indicators

Sustainability achieved through the processes of sustainable development has emerged as an important goal over the last 30 years. The concept of sustainable development is defined as the development that meets the needs of the current generation while not compromising the ability of future generations to meet their needs. Specific indicators called SDI (Sustainable Development Indicators) are often used as quantitative or qualitative measures to provide information for decision making at high level including management decisions and daily life decisions. Human activities having severe and negative impacts on the planet would be unsustainable if they continue unchecked. To avoid unsustainably, it is important to design the sustainable development framework and it will answer the two questions: what we are trying to assess? and what is the dimension of sustainability for any developed activity?

The concept of sustainable development received its first major international recognition in 1972 at the UN conference on Human Environment, held in Stockholm and it continued by Brundtland commission in 1983 which defined the sustainable development as the "development which meets the needs of the present without compromising the ability of future generations to meet their own needs". Rio de Janeiro conference in 1992 and its recognition is articulated in chapter 40 of agenda 21 which calls on countries at the national as well as international levels, governmental and non-governmental organizations to develop and identify indicators of sustainable development that can provide a solid basis for decision making at all levels. More recently, the World Summit on Sustainable Development was held in Johannesburg in 2002 to assess progress since Rio conference. The development in sustainable development indicators is a continued process and the indicators were updated in MDGs (Millennium Development Goals) by the United Nations in 2005. Some of these indicators were modified in the present study to suit the conditions in developing countries in general and particularly in Iran (Table 1).

Overall objective of this study was to analyze the impact of irrigation water supply from a dam on poverty alleviation using the above indicators. Specific objective was to collect, review, analyze and compare the pre-project baseline and post -project data and underline the changes both positive and negative in bio-physical and socio-economic conditions in the study area.

2. METHODOLOGY AND DATA COLLECTION

Both quantitative and qualitative methods were used to gather data for this study from various organizations (government agencies, and corporations-domestic and International).

Based on the objective of the research a thorough review of national and international works on poverty alleviation, sustainable development, large dams, irrigation systems and their impacts were carried out. In order to address all these factors, simultaneously a comprehensive evaluation was formulated based on the selected indicators (Table 1) in the command area of Minab dam in Iran.

2.1 The Study Area

The study area is located in the south eastern province of Hormozgan of Iran, about 35 km from Persian Golf and 80 km from Bander Abbas. Minab is the nearest town to the dam site and irrigation networks after which the name of the dam is attributed as shown in Fig .1. The area was ranked as the most poverty stricken before construction of the dam. Minab River is one of the most important rivers in southern Iran. It originates from the southern slopes of Kerman mountains. Minab dam serves main source of water supply in the plains of Minab.

TABLE 1. SELECTED SUSTAINABLE INDICATORS FOR IRRIGATED AREAS DOWN STREAM OF DAMS

Theme	Sub-Theme	Indicator
Population	Population change	Population Growth Rate
Education	Education level	*Development impact on literacy rate in down stream area.-Development of educational center at down stream.
Housing	Living Condition Decentralization	Floor area per person Proportion of population living in slums% of new community, village ,town growth after large dam construction.
Natural Resources	Land Irrigation Command area development	% of land coverage or use, prior to dam construction
		* Agriculture type at down stream.
		Actual Maximum Irrigated Command Area achieved to Target. Achievement of Irrigation Development.
Industries	Water sector	* Industries development in area due to dam construction.
Health	Drinking Water	Proportion of population with access to improved sanitation
	Sanitation	Population with access to safe drinking water
	Healthcare delivery	Large dams infectious diseases
Environment	Impact due to pattern of dam	Changes in downstream hydrology; (a) change in total flows; (b) change in seasonal flows (e.g. Spring flood becomes winter flood) (c) change in extreme high and low flows. Changes in downstream water quality caused by altered flow pattern.
	Impact due to reservoir	Changes in downstream morphology of river bed.
Equity	Poverty	*Percent of population living below poverty line base on national record pre & post- dam construction.
		*Large dam impact on poverty.
		*Creation of job opportunity due to large dams in Government and private sectors.
		*Unemployment type and rote.
*Proposed Indicatyors; Complied from [11-12]		

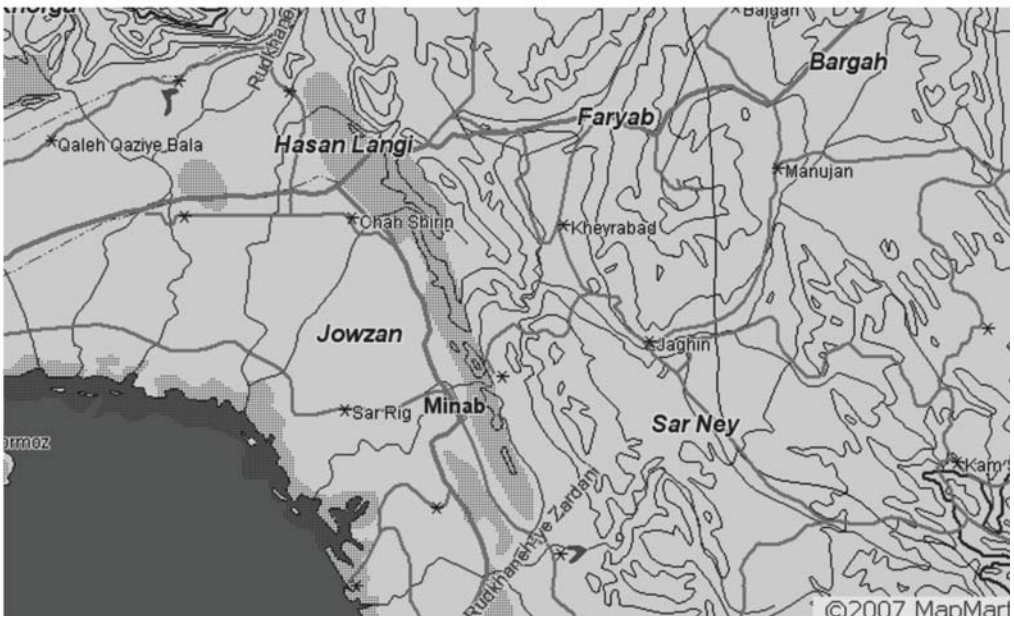

FIG 1. LOCATION OF STUDY AREA (MINAB DAM)

Completion of Minab dam dates back to 1983 and its complimentary irrigation and drainage network by 1986. Implementation of Minab dam and its irrigation and drainage networks brought a drastic change in socio-economic conditions of the area. The irrigation system also triggered tube well irrigation and sanitation services in the area. Soil of the area is fertile and it has suitable climate with two distinct cropping seasons (winter and summer), each well marked and separated by dry season for crop maturity and harvesting. Narrow river plains contain well drained deep, medium textured, moderately calcareous, salt free soils which are very fertile. The piedmont plain and good soils in the presence of water have a high to very high potential for agriculture. In this study, northern irrigation canal command area was selected as a case study.

2.2 Data Collection

In general data collection was carried out in two steps: (i) Collection of historical data from different departments and organization, and (ii) Fieldwork for Primary data collection through interviews and discussions with the stakeholders. Data collected and sources of the data are presented in Table 2.

3. RESULTS AND DISCUSSION

3.1 Irrigated Area and Crop Yield

Land sat images of years 1989 and 2001 are shown in Figs. 2-3, respectively. Fig. 2 is only a few years after commissioning of the dam. Upto this time the irrigation system (canals and farm channels) was not completely developed. Moreover, the farmers were not fully aware to make use of the irrigation water. Therefore the irrigated crop land is much less than years 2001. Data shown in Table 3 clearly indicates that the irrigated area has almost doubled in year 2006 as compared to the irrigated land before construction of the dam. It is interesting to note that yield of fruit trees and vegetables have increased many folds by irrigation from the dam. Agricultural products from this area reach to the markets 40 days earlier compared to other parts of the country due to special location of the area. Thus farmers of this area earn extra benefits from early ripening of their farm produce. Additionally, farmers made extra effort to obtain more advantage from their land property by changing the cropping pattern, increasing the cropping intensity and crop yield.

TABLE 2. DATA COLLECTED WITH ITS SOURCE

No.	Required Data	Sources of the Data Collected	Year
1.	Population	Statistical center of Iran, Related local office, Filed visits.	1982-2006
2.	Education	Statistical center of Iran Management & programming, organization -Hormozgan, Filed visits& interviews.	1982-2006
3.	Housing	Statistical center of Iran,Field visits, Management & programming organization, Related study in area.	1982-2006
4.	Natural Resources	Agricultural economics research center of Iran, Ministry of jihad agriculture of Iran, FAO documents, UN documents. World Bank documents, Related journal and study in area.	1982-2006
5.	Industries	Field visits,Management & programming organization of Iran. Iranian National Geographical organization.	1982-2006
6.	Health	Shahid Muhammadi Hospital -Hormozgan, Heath organization center.	1982-2006
7.	Environment	Synoptic station Minab, water resource, Management's organization. Ministry of Energy - Iran, Hormozgan Regional Water Resources. Land Sat Seattleite images, Related study in area, Related workshops in area, Environmental organization, Jihad Agricultural organization, Nahad Ab Co, NGO documents.	1982-2006
8.	Equity	UNDP documents, WB. Documents, Iranian central bank publications.	1982-2006

3.2 Socio-Economic Conditions

Based on data availability of 1982, there were 1965 families in 10 villages at downstream of the dam which increased to 3447 families by year 2006. Similarly literacy rate of the area before dam construction was 41% which increased to 74% in year 2006 [14].

Opportunities for job in government and private sectors increased approximately 2.5 and 23% in year 2006. These values were 9-10% in private sector and negligible in government sector before year 1983. Job opportunities in private sector were recorded to be 19.6% in year 1996 [14]. Based on available data, poverty in rural areas recorded was 15% in year1981-1982 [15-17] whereas the

FIG 2. LAND SAT IMAGE OF THE STUDY AREA [13]

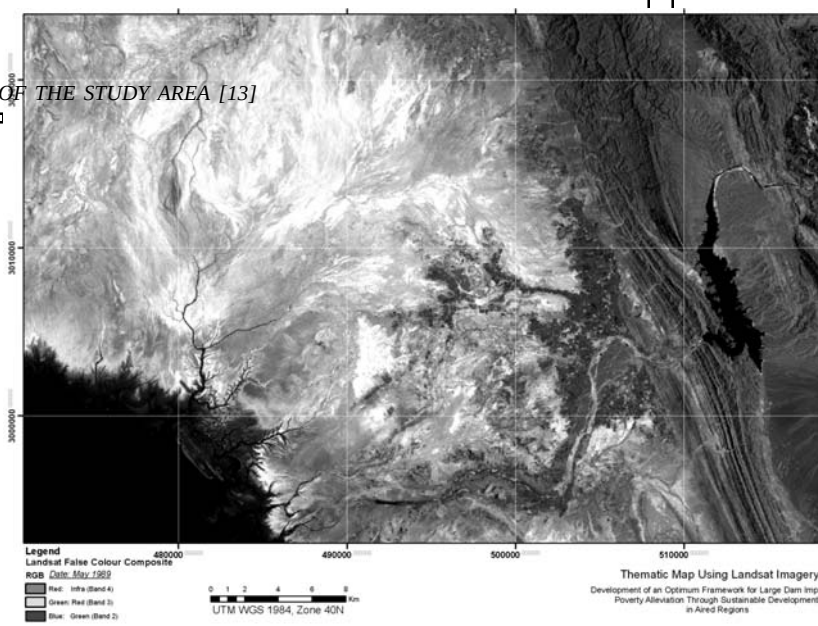

FIG 3. LAND SAT IMAGERY OF THE STUDY AREA [13]

same was 7.3-9% in year 2006. Based on screening the impacts of irrigation from dam on the biophysical and socio-economic environments of the area, the impacts on poverty reduction may be high-lighted as given in Table 4.

3.3 Availability of Services

According to 2006 census and field visits distinguished development has been made in various sectors in the area compared to the conditions before construction of the

TABLE 3. IMPACT OF PRE AND POST-IRRIGATION ERA ON CROP PRODUCTION IN THE STUDY AREA

Crop	Year				
	1982 (Before)		2006 (After)		Increase in Yield
	Total Irrigated Area (ha)	Yield (kg/ha)	Total irrigated Area (ha)	Yield (kg/ha)	(%)
Date		2000		4000	100
Citrus		3000		14000	367
Onion		3000		10000	233
Egg Plant		7000		15000	114
Cucumbers		5000		12000	140
pepper		1000		3000	200
Melon		5000		15000	200
Tomato		6000		18000	200

Source: [14,15]

TABLE 4. BENEFICIAL IMPACTS OF DAM CONSTRUCTION AND IRRIGATION

No	Active Phenomena	Result	Impact on Poverty Alleviation
1.	Conversion of rainfeed to irrigated land use	Drastic increase in agricultural produce.	Beneficial
2.	Increase in economic activity	Increase in income	Beneficial
3.	Job creation	More job opportunity	Beneficial
4.	Increase in transportation	Increase in rural activities	Beneficial
5.	Ecotourism	Increase &development in rural facility	Beneficial
6.	Water supply system development	Improved health and life quality.	Beneficial
7.	Increase Educational centers	Increase of knowledge & literacy rate.	Beneficial
8.	Flood damage prevention	Reduce flood losses& reduced run off in high rainfall periods.	Beneficial
9.	Segregation	Change in society.	Beneficial
10.	Increase in irrigated land	Significant increase in production	Beneficial
11.	Availability of water in reservoir	Life security for fauna and flora at down stream	Beneficial
12.	Industrialization	Creation of jobs & wealth.	Beneficial
13.	Health center availability	Safety and improvement in quality of life	Beneficial
14.	Modification in road	Increase accessibility.	Beneficial
15.	Multiple agriculture during year/Crop intensity	Rising in Income & poverty reduction.	Beneficial
16.	Availability of Electricity	Providing more facilities and improve life quality.	Beneficial
17.	Water treatment	Improve life quantity & Sanitation	Beneficial
18.	New market	People participation and economic development	Beneficial
19.	water availability	Intersectoral reallocation of surface and groundwater	Beneficial
20.	Increased groundwater recharge	Drought mitigation	Beneficial
21.	Pasture management &conservation strategies	Improved livestock and produce	Beneficial

dam as shown in Table 5. It is evident from this data that there is notable improvement in basic services such as education, health, water supply, employment, accessibility and others.

3.4 Impact on Livestock Production

Estimated number of livestock for year 2006 was 7730 animal, out of which goats and kids were 4701 heads which constitute the highest population, and sheep and lamb with 1712 heads were the next highest. Population in year 1981 (pre-dam and irrigation system construction) was 4150 heads [14-15].

3.5 Comparison of Planned Objectives and Their Achievements

Primary planned goals of the project are given in Table 6. It is evident from this table that planned development objectives have been met only 50-60% for most of the indicators whereas there is little achievement in some others.

4. CONCLUSIONS

Evidence of drastic development in agriculture of the study area is due to irrigation from the dam which is very clear from the Land sat images of years 1989 and 2001. There is

TABLE 5. AVAILABILITY OF SERVICES IN PRE AND POST DAM CONSTRUCTION IN PERCENT

Services	1982	2006	Services	1982	2006
Primary School	40	90	Bank	0	20
Guidance School	10	80	General Transport Services	0	60
High school	10	40	Grocery	10	90
NGO	0	100	Public Bath Room	30	0
Mosque	80	100	Public Health Center	0	80
Agricultural Extension	0	20	Doctor	0	20
Utility Store	40	60	Midwife	0	60
Water Supply System	30	100	Health Technician	0	80
Electricity Service	10	100	Veterinarian	0	10
Post Office	0	20	Asphalt Road	10	90
Public Call Office	10	30	Industries	0	40
Literacy rate	41	74			
Source: [14]					

TABLE 6. PROPOSED (TARGETED) GOALS OF THE PROJECT

Proposed (Targeted) Goals	Status (2005-2006)	Remarks
Agricultural Product: Crop & citruses production about 280,000 tons/year	The maximum product recorded to be 130,000 tons in year 1975	47% of primary goals met
Providing of crops for use some percentage only inside of country & Export to abroad	There is no notable progress	
Area Under Cultivation: Net area under cultivation 10821 ha	6000 ha	57% of primary goals met
Irrigation Water 210 MCM (Million Cubic Meters)	Low	Record shows that this value fluctuated e.g. in year 1996-97 the amount of delivered water to the farmers was recorded about 91-144 MCM or average of 120 MCM. That is about 57% of the targeted objectives

significant increase in cropping intensity, crop yield and irrigated area after construction of the dam. Socio-economic conditions changed due to development in agriculture as result of irrigation from the dam. The literacy rate increased to 74% in 2006 which was 41% before construction of the dam. Similarly job opportunities and quality of life increased due to availability of various services leading to reduction in poverty from 15% (before construction of the dam) to 7.3% by the year 2006. From these results and discussion it is evident that although there is significant positive impacts of dam construction, but it is not same as the targeted objectives envisaged in the feasibility report of the project. It means that after construction of the dam and irrigation system, development didn't match with the planned goals of the project. Only 50-60% of the planned objectives were met for some indicators whereas no significant achievements had been made in the others.

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