The 2nd International Conf. on Water Resources & Arid Environment (2006)

Highlights on the Integrated Water Resources Management of Wadi Regions for Sustainable Development

Mohamed A. Sonbol, Mohamed Abdel-Motaleb

Water Resources Res. Institute (WRRI), National Water Res. Center, Egypt

Abstract

Sustainable management of water resources is a must as water scarcity is becoming more and more a development constraint impeding the economic growth of the arid regions. Planning for these regions involve several complex social, environmental, and economic concerns. Accordingly, development of such regions should be planned within a multi-disciplinary framework. This framework should provide an evaluation for the current water resources, environmental, social and economic conditions. In this paper, generalized strategies have been developed for Sinai Peninsula representing the sustainable development through the evaluation and optimal utilization of Sinai water resources

Water resources in Sinai Peninsula are mainly flash floods that fall on the Mountainous Chains of Sinai. Flash floods' water flows through the different Wadis inside Sinai until it reaches to the Mediterranean Sea in the North, the Gulf of Aqaba in the East or the Gulf of Suez in the West. This water is considered the main source for recharge of the groundwater aquifers in Sinai Peninsula. Since 1981 there are several field studies amalgamated with theoretical researches have been performed for getting integrated information regarding the water resources system in Sinai. Following these studies sustainable development plans started to be prepared for Sinai Peninsula. The proposed development plans were considered the water resources issues, economic and social aspects for Sinai sustainable development. Since 1981 huge infrastructures projects were erected to serve the national development projects of Sinai. Parallel to the infrastructure development in Sinai Peninsula, several flash flood storage, control and protection dams were constructed. In addition, several geological, hydrological, geo-physics and hydro-geological studies have been performed for understanding the groundwater aquifers' system. Moreover, groundwater abstraction plans were performed to manage and control drilling of wells in the Peninsula.

This paper presents a case study for Sinai Peninsula for introducing the interaction between integrated water resources management and the sustainable development and its impacts on life style along with 25 years. As indicated from the study significant improvement of the community standard of life status in Sinai has been noticed due to the sustainable development that is performed in wadi areas where water is considered the key element for development. As a conclusion from these studies, many promising areas were determined according to their water resources potentialities. Consequently, new communities have been planned to be established according to the existing and proposed projects.

Introduction

One of the major activities of the Egyptian government became establishing new communities in the desert and reclaiming its lands. In Sinai Peninsula, as a case – study, rainfall; flood water and natural springs may be the only source of water that can be assessed for almost every development activity. Under such circumstances in Sinai areas, management process should be tailored to their particular needs. For this purpose, various meteorological; hydrological; geological; and geophysical studies have been conducted to give a complete view about the whole conditions on any particular area under study.

Wadi' regions are known with their scanty annual rainfall, very high rates of evaporation and consequently extremely insufficient renewable water resources. Problems of water scarcity are exacerbated by population growth, expansion of agricultural activities, salinity increases and agricultural/urban pollution. It is recognized that this is not only an issue of resource availability, but of equity in water management. Moreover, many wadi regions are the focus of potential conflicts over water scarcity and there is a need to develop strategies to support peace and security. Efficient water management has to link theory and practice, and plans with actions in order to produce realistic solutions to water chronic problems. Planning horizon consists mainly of short term, where available resources are considered, and long term where expectations are based on research results and technology advancements.

Sustainable management of water resources is a must as water scarcity is becoming more and more a development constraint impeding the economic growth of the region. Planning for these regions involve several complex social, environmental, and economic concerns. Accordingly, development of such regions should be planned within a multi-disciplinary framework. This framework should provide an evaluation for the current water resources, environmental and ecology, social and economic conditions. In this paper, generalized strategies have been developed for Sinai Peninsula representing the sustainable development through the evaluation and optimal utilization of Sinai water resources.

This paper defines characteristics of the different wadi regions in Sinai for the water management system in orders to insight the various problems that may occur, and develop a general strategy for sustainable development of the wadis through integrated management of their water resources. The methodology for achieving the objectives of this study were; - First; defining the supply and demand characteristics of the water management system in the study area. Second determine the different watershed management aspects in order to provide an insight into the various water management problems that may occur and to yield a solution for these problems. This study may help in address and partially solve problems of the sustainable development and management elements as: water scarcity, flood protection, groundwater recharge, and

secured domestic water supply, agricultural and industrial developments. Some projects in north and south Sinai were also presented.

Water Resources Potentiality in Sinai

General strategy for sustainable development of the Sinai wadis was developing through integrated management of their water resources. Water resources in Sinai are limited to the following resources: i- Rainfall and flash floods, ii- Groundwater in the deserts and Sinai, iii- Transported water by EL-Salam Canal, iv- The Possible desalination of sea water. Each resource has its limitation on use, whether these limitations are related to quantity, quality, space, time, or use cost.

1. Rainfall and flash floods

Rainfall on the Mediterranean coastal strip decreases from eastward from 300 mm/year at Rafah to 75 mm/year westward at Port Said as shown in Figure (1). It also declines inland to about 25mm/year at the central part of Sinai. The rainfall occurs in the winter season at the northern part of Sinai in the form of scattered showers and therefore, it cannot be considered as a dependable source of water. It also occurs during autumn season at the southern part of Sinai in the form of flash floods due to its mountainous nature. Flash floods due to short period are considered a source for fresh water and the mechanism has been developed to harvest through this water. It is estimated that about one km^3 of water can be utilized annually by this source.

It is well known that the runoff process is considered as one of the most complicated hydrological process and various factors of sufficient complexity do affect runoff from catchments. Consequently, it becomes necessary to study these factors and quantifying their effects on the surface water resources potentiality of Sinai. For this purpose, some representative catchments were chosen to represent the different hydrologic zones in Sinai. However, in spite of the efforts of collecting and analyzing the hydrological data, the problem of ungauged catchments still existed in Sinai. Accordingly, many hydrological studies have been devoted in an attempt to solve this problem on regional bases. Some studies were carried out to define the rainfall pattern over Sinai. This pattern can be used in other similar parts (Zaki et al. 1994). Moreover, other studies aimed at the determination of the potentialities of surface water resources for various wadis in Sinai.

As a result of the hydrological studies, some promising areas were determined according to its water resources potentialities. Some water harvesting projects as small dams were designed and constructed and some others still under studies in the south of Sinai. Figure (2) shows the location of the dams on some streams in Sinai. Furthermore, Table (1) includes the dams in Sinai and their types and capacities in million cubic meters. Figure (3) shows the surface water potentialities in Sinai.

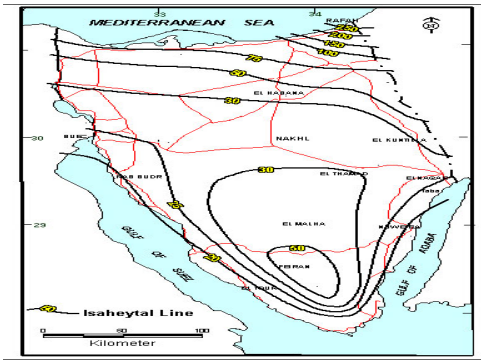

Figure (1): Rainfall Distribution in Sinai in (mm/year)

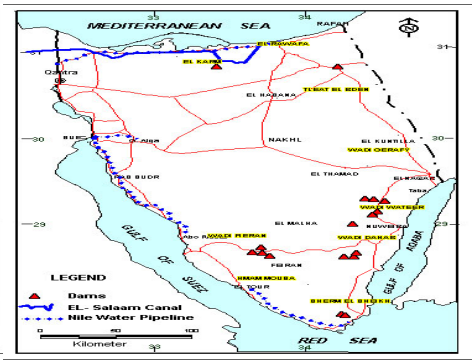

Figure (2): Location of Flash-Floods Control dams in Sinai

Table (1): Dams in Sinai and its Types and Capacities.

Dam Name	Dam Type		Capacity In millions m^3
	Material	Purpose	
EL-Rawafaa	Concrete	Storage	7.0
Talet EL-Baden	Earthfill	Storage, Diversion	0.4
EL-Karm	Concrete	Storage	2.0
EL-Maghara	Concrete	Storage	2.0
EL-Gudierate	Concrete	Storage	1.0
EL-Gerafi (Group of dams)	Eartfill	Storage	10.0
Watair (Group of dams)	Concrete, Earthfill, Rockfill	Storage, Protection, Detention	15.0
Feran (Group of dams)	Concrete, Earthfill, Rockfill	Storage, Protection, Detention	10.0
Dahab (Group of dams)	Concrete, Rockfill	Storage, Protection,	14.0
Sudr	Concrete, Rockfill	Storage, Detention	5.0
Gharandel	Concrete, Earthfill, Rockfill	Storage, Detention	5.0
Upper Tributaries of Wadi AL-Arish	Earthfill, Rockfill	Storage, Detention	25.0
EL-Aat	Rockfill	Storage, Detention	2.0

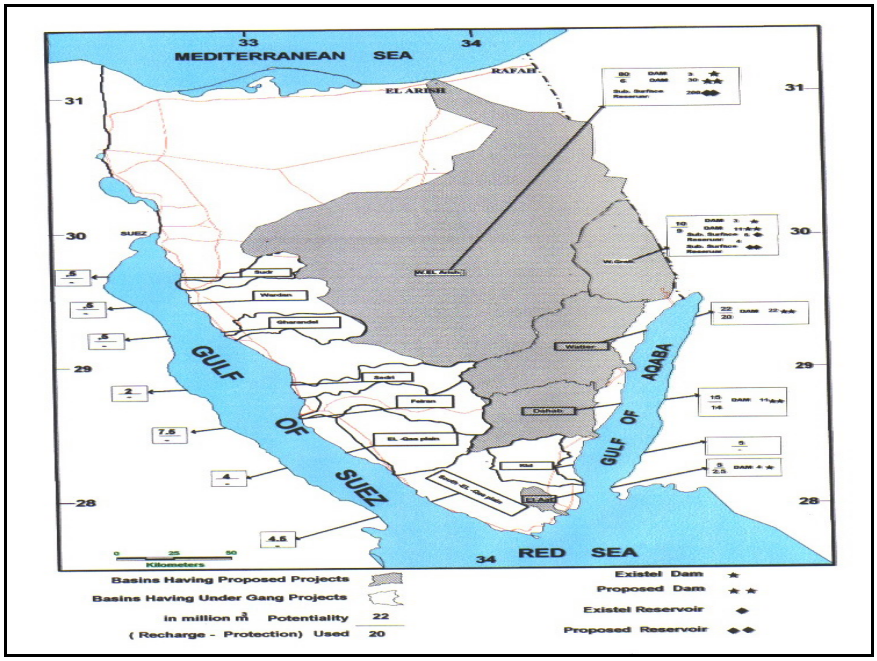

Figure (3): Surface water potentialities in Sinai

2. Ground Water Resources

The groundwater reservoirs and springs have not been fully utilized yet; this potential may need some more field investigations and studies before deciding the safe yield of abstraction. There are several important and potential aquifers which represent the main groundwater resources. The characteristics of these aquifers are derived from geological and structural analysis; drilled wells and geophysical studies. The Quaternary aquifer exists in the wadi alluvium and its delta, it exhibit the highest yields and provide the fresh water for different uses. The Lower Cretaceous sand stone aquifer is considered the main source of groundwater for fresh water with good quantities and quality. Some of the natural springs provide continuous flow of water all the year, while the others provide natural water in a seasonal basis. The recharge of such springs comes from the rainfall which varies in quantity from one year to another depending upon the variation in the hydrological cycle. The duration of flow from them is dependent on the capacity and efficiency of the groundwater reservoirs connected to them. Figure (4) shows the

locations of these aquifers in Sinai In this respect Water Resources Research Institute (WRRI) has drilled some collective wells with different depths and designs to

abstract the safe yield from these natural springs. Figure (5) shows the ground water potentialities in Sinai.

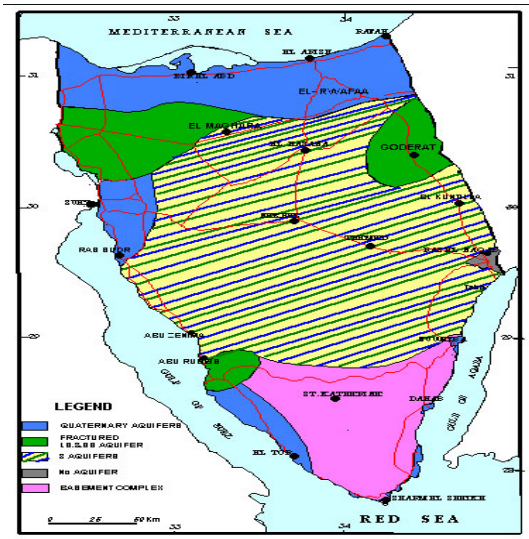

Figure (4): Locations of GW aquifers in Sinai

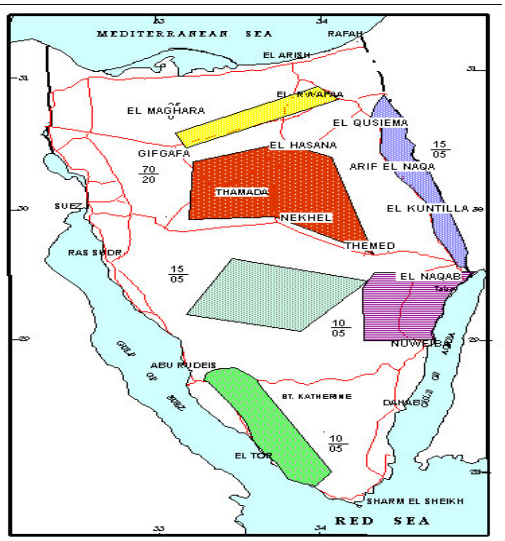

Figure (5): Ground water potentialities in Sinai.

3. Transported water by Pipe Lines and EL-Salam Canal

Improvement of drinking water supply in the coastal (Mediterranean) area of the North Sinai Governorate was completed as follows:

- A 300 mm. diameter pipeline from EL-Qantara to Bir AL-Abd was completed to serve all communities of Bir AL-Abd District
- A 700 mm. diameter pipeline was completed to supply AL-Arish city
- Construction of three water tanks capacity 3000 m^3. at at Rafah and EL-Sheikh Zewaied.

AL-Salam canal brings water from the Damietta Branch of the Nile, under the Suez Canal to the Sinai Peninsula. First, the project provided irrigation waters to the area west of the Suez Canal. In October 1997, the culvert under the Suez was completed and water became available for irrigation in Block 1, the Tina Plain Zone. The branch canals will eventually feed irrigation in Block 3, the Rabaa Zone. Development of more fields can also be seen south of the Tina Plain Zone in an area called Block 2, the Southeastern Qantara Zone. There are three projects for the use of transferred water in agricultural expansion:

- The first project: Reclamation of 170,000 Hectares in northern Sinai depending on Nile water from Al Salam Canal with a capacity of 3 billion m3 annually.

- The second project: Aims at the reclamation of about 32500 Hectares east of the Suez Canal by means of Nile water transferred by a siphon under the Suez Canal with a capacity of 420 million m^3 per year.
- The third project: Aims in the long run at reclaiming 105500 Hectares east of the Suez Canal after the implementation of the Upper Nile projects.

4. The Possible desalination of sea water

This started in Sinai long time ago. There are some plans to spread this technology in different places where natural water resources are not sufficient. There are two old desalination plants in Nuweiba city, the first one is the thermal-condensation plant with 4 units of a maximum capacity of 2000 m3/day. However, only one unit is operated (about 300 m3/day) due to its high operation coast and low efficiency. This amount is pumped three times/week, for about three hours each into the harbor pipe network with a salinity less than 300 ppm. The second plant belongs to the construction authority, with a capacity of 60 m3/day only. The electro-dialysis technique of this plant is not suitable for highly saline water (10,000 to 15,000 ppm). Thus, it is more appropriate to be replaced by membrane technology, i.e., Reverse Osmosis (RO) such as the two new plants in Taba town with a capacity of 500 m3/day and maximum capacity of 1500 m3/day. This amount will support the future expansion of Taba town. Modernization of old desalination plants and setting of more plants to meet future fresh water demand are required. The future possibilities for the use of renewable energy (solar or wind) to operate desalination plants, especially RO plants, will indeed reduce the coast of fresh water production significantly.

2. Impact of Integrated Water Resources Development on Sinai Development

As indicated in the previous sections, the development of water resources system of Sinai Peninsula has been performed since 1981 till today. The development in Sinai Peninsula has been conducted with strong ties to the development of water resources. Impact of the integrated water resources development on the entire life system of the area will be presented in the following sections.

2.1. Infrastructure System

2.1.1. Power Stations

In Northern Sinai the government of Egypt established seven additional power stations since 1981. The total number of power stations in 2002 is reached to 10 stations with an actual power production of 136 Mega Watt per year. The per capita share from electrical power is reached now to 759 KWhr/year. The power distribution network is considered a milestone for the agriculture and land reclamation projects, thus a network for power distribution had been erected specially to serve EL-Salam Canal project in the North-Eastern part of Sinai. In Southern Sinai there is 12 power stations has been established and the per capita share is reached to 431 KWhr/year.

The following table indicates the development of power that occurred from 1981 up to 2005 in Northern Sinai.

Table (2): A Comaprison between the Power Supply Status in Northen Sinai between 1981 and Today

Infrastructure	1981 Status	2004 Status	Unit
Power Stations	3	10	Station
Full Power Production	10.36	204	MW/yr
Actual Power	9.8	136	MW/yr
Power Load	7.5	60	MW/yr
Consumed Power	N/A	233	Mil KWhr/yr
Per Capita Share	N/A	759	KWhr/yr
Percentage of Buildings connected to the Network	N/A	88	

3.1.2 Drinking Water Supply and Sewage System

Huge effort has been done to erect many water treatment stations allover Sinai Peninsula within the last 20 years. In 1981 the total capacity of drinking water stations was 9000 m^3/year in Southern Sinai and the average per capita share from drinking water was 30.76 lit/day. Thus, the government did a significant effort to improve the drinking water situation in Sinai Peninsula. Table (3) presents the current and the 1981 situation for drinking water status n Sinai.

Table (3) Comparison between the drinking water supply and sewage water supply for Northern and Southern Sinai between 1981 and Now.

Item	Northern Sinai 1981	Northern Sinai 2005	Southern Sinai 1981	Southern Sinai 2005
Number of Drinking Water Treatment Stations	N/A	N/A	N/A	22
Total Capacity (m3/day)	4000	56650	7500	36200
Average per capita Drinking Water Share (liter/day)	30	185	24	521
Percentage of Buildings connected to Pipe network	N/A	73%	N/A	85%
Number of Sewage Water Collection Stations	0	3	0	21

Total Capacity of Sewage Treatment Stations (m3/day)	0	51000	0	12000
Average Per Capita Share from Sewage Water Collection (liter/day)	0	166	0	181

3.1.3 Transportation

Transportation is one of the main milestones for sustainable development; accordingly the government of Egypt developed a significant network for roads allover Sinai. Table (4) presents the development of paved road network from 1981 till 2004.

Table (4): Comparison between the paved roads status on 1981 and 2005 for Southern and Northern Sinai Peninsula.

Item	Northern Sinai 1981	Northern Sinai 2005	Southern Sinai 1981	Southern Sinai 2005
Paved Roads (km)	1987	4268	443	2031
Unpaved Roads (km)	513	1688	250	1250

3.1.4 Land Reclamation

Land reclamation project sis considered one of the main items for sustainable development within a country. Land reclamation projects provide the base for people to settle at the new lands. The government initiated many projects to develop new communities based on agriculture activities. However, Sinai Peninsula cultivation is considered very poor since it depends upon the rare and scattered rains that falls in autumn and winter seasons only, in addition to some wells. The main project is the EL-Salam Canal project which depends on the transported water from Nile delta of Northern Egypt. Some other scattered projects for land reclamation allover Sinai has been established in the Northern Coastal area of Sinai. The following table, Table (5), presents a comparison between the cultivated land, cropping pattern, and livestock allover Sinai as a comparison between the available data in 1981 and 2005.

Table (5) : Cultivated land in Northern Sinai and Southern Sinai, cropping pattern, and livestock in 1981 and 2005 respectively.

Item	Northern Sinai 1981	Northern Sinai 2005	Southern Sinai 1981	Southern Sinai 2005
Arable Land Area (Hectare)	506400	506400	N/A	80847
Actual Cultivated Area (Hectare)	14348	62456	181	3317
Vegetable Area (Hectare)	1076	5370	0	0
Orchards (Hectare)	3452	39535	N/A	1439
Wheat (Hectare)	0	2695	N/A	100
Barely (Hectare)	3586	7044	N/A	168
Sheep (No.)	103242	321149	N/A	33000
Camel (No.)	4030	4406	N/A	2155
Cows (No.)	158	3224	N/A	22

3.1.5 Development of Services

The following section presents the information regarding the governmental services within the area under study. This improvement of these services is considered as important indicators for sustainable development of Sinai Peninsula. These services are the postal, educational, communication, housing, health and sports. Table (6), summarizes the development of these services for the time between 1981 and 2005.

Table (6): Status of community services in Sinai Peninsula for years 1981 and 2005

Main Service	Sub Service (Numbers)	Northern Sinai 981	Northern Sinai 2005	Southern Sinai 1981	Southern Sinai 2005
Communication	Telephone Lines (No.)	1245	32836	N/A	15600
	Per Capita Share from Telephone Lines (line/capita)	105	5	N/A	23.31
Postal	Post Offices	9	38	N/A	20
Housing	Erected houses	20362	70910	N/A	3838
Education	Schools	57	472	145	255
	No. of Students	17500	76000	71514	118250

	Teachers	648	7036	N/A	300
	High Education Students	0	2150	N/A	334
Health	Hospitals	1	9	0	3
	Health Units	10	51	0	8
	Hospital Beds	120	470	0	350
	Doctors	N/A	162	35	263
	Nurses	N/A	396	N/A	368
	Mobil Clinics	0	16	0	0

Conclusions and Recommendations

Water in Arid Wadi Regions is considered the key element for development. In Sinai Peninsula in Egypt, water resources development has been considered a major issue since 1981. Several water resources development projects has been performed among those projects are flash flood control, transported water from Nile river, extending pipelines for drinking water, groundwater use, and desalination.

The impact of these projects and its adjacent development projects in industrial sector, tourism sector, agricultural sector, new communities settling, on human life style in Sinai shows that there is a significant change in life style of Sinai community. Many components of life style has been changed positively such as power supply, health services, income, drinking water supply, sewage collection systems, education, roads, communications and housing.

References

Zaki et. Al.1994, representation of Rainfall Pattern Suitable for Hydrological Design in Sinai Peninsula, Department of Hydraulics and Irrigation, Faculty of Engineering, 1994.

WRRI Technical Report, "Water Resources and Projects in Sinai", 1998.

North Sinai Governorate Achievements bulletin (in Arabic), Arab Republic of Egypt, April 1995.

North Sinai Governorate Achievements bulletin (in Arabic), Arab Republic of Egypt,, April 2002.

Description of Southern Sinai Governorate by Number (in Arabic), Prime Minister Information and Decision Support Center, July 1999.

Sanaa Ebrahiem, "Effects of Urbanization and Social Changes on Ground Water use in North Sinai Societies", (in Arabic), M.Sc. thesis, Department of Human Sciences, Institute of Environmental Studies and Research, Ain Shams University, Cairo, Egypt, 2002

إلقاء الضوء علي الإدارة المتكاملة للموارد المائية بمناطق الوديان لتحقيق التنمية المستدامة

محمد على سنبل ومحمد عبد المطلب

معهد بحوث الموارد المائية – المركز القومي لبحوث المياه – القناطر الخيرية – مصر

تعتبر الإدارة المتكاملة للموارد المائية لتحقيق التنمية المستدامة هي أهم مقومات وضروريات الحياه ، ولايمكن لأى تنمية مستدامة سواء بشرية او زراعية او اقتصادية أن تقوم اوتزدهر إلا في ظل الإدارة المتكاملة للموارد المائية. ومن المعروف أن ندرة المياه او الإدارة الغير صحيحة لها بالمناطق القاحلة بمصر مثل سيناء تعتبر من أهم معوقات التنمية والتي تؤثر تأثيرا مباشرا على جميع نواحى التنمية، ولذلك فإنه يجب التخطيط في إطار متعدد الأنظمة لتقييم الموارد المائية المتاحة وكذلك جميع الظروف البيئية والاجتماعية والاقتصادية. وفي هذا البحث فقد تم التخطيط لبعض الإستراتيجيات العامة بسيناء والتي تمثل جميع سبل التنمية المستدامة من خلال التقييم الدقيق والاستغلال الأمثل للموارد المائية.

وفي هذا البحث فقد تم تحديد الموارد المائية بسيناء والتي تتمثل في السيول الموسمية الناتجة عن الأمطار الساقطة على سلاسل الجبال، والتي تتدفق خلال شبكة الوديان المختلفة الأنماط لتصب شمالا في البحر الأبيض المتوسط عن طريق وادى العريش، وشرقا في خليج العقبة، وغربا في خليج السويس. وتعتبر هذه المياه هي المصدر الرئيسي لجميع مظاهر التنمية علاوة على تغذية الخزانات الجوفية بسيناء. وقد تم إجراء العديد من الدراسات منذ سنة 1981 سواء النظرية او المباحث الحقلية وتجميع البيانات المختلفة واللازمة لوضع خطط التنمية المستدامة مع الأخذ فى الاعتبار الإدارة المتكاملة للموارد المائية مع جميع السمات الإجتماعية والاقتصادية بمنطقة الدراسة. وعلى ذلك فقد تم وضع تصور تخطيطي لمشاريع البنية الأساسية والتي يمكن أن تخدم مشاريع التنمية، مع وضع مخطط تصميمى للعديد من مشاريع التخزين والتحكم بمياه السيول. هذا بالإضافة إلي إجراء العديد من الدراسات المتيورولوجية، الهيدورولوجية، الجيولوجية، الهيدروجيولوجية، الجيوفيزيائية وذلك لإمكانية التحديد الدقيق للموارد المائية سواء السطحية منها او الجوفية بسيناء. ومن نتائج هذا البحث فقد تم عرض طرق التفعيل بين الإدارة المتكاملة للموارد المائية و التنمية المستدامة وأثرها على تطور نمط الحياه بسيناء خلال 25 سنة، وكذلك تحديد المناطق الواعدة بها مستقبليا من حيث إمكانيتها من الموارد المائية وخلق المجتمعات العمرانية الجديدة بها.

الكلمات المفتاحية: مناطق الويان – الإدارة المتكاملة للموارد المائية – التنمية المستدامة – المباحث الحقلية – السيول الموسمية