A RESEARCH STRATEGY TO SECURE ENERGY, WATER AND FOOD VIA SUSTAINABLE LAND AND WATER MANAGEMENT IN THE GAP REGION

SELIM KAPUR[1], BURCAK KAPUR[1], ERHAN AKÇA[1] and HARI ESWARAN[3]

Soil Science Department, Çukurova University, Adana, Turkey[1]
Agricultural Engineering, Yuzuncu Yil University, Van, Turkey[2]
USDA Natural Resources Conservation Service, Washington DC, USA[3]

Introduction

The essence of security in the context of energy, water and food lies in the improvement of integrated programs for the sustainable management of land and water. The ambitious multi-purpose GAP project (Turkish acronym for the Southeastern Anatolian Irrigation Development Project), seeking to increase the GNP by 445 percent, the Per Capita Income by 209 percent together with job prospects to be created for 3.5 million people (Tekinel, 2001) launched by the government of Turkey is a good example for developing a research strategy for the sustainable, and ultimately the secured production of energy and food. Thus, this chapter seeks to present a contextual approach for a research strategy, in developing security for energy, water and food/agriculture, via SLWM (Sustainable Land and Water Management).

A successful strategy for SLWM anticipates constraints to sustainability and develops the activities to address them. The research strategy considered here for the GAP focuses on the technical solutions needed to ensure sustainability. Because the emphasis is on sustainability, system monitoring is considered an essential part of the research strategy. Indicators must be carefully selected prior to project commencement, and they must be monitored during the duration of the research activity. These indicators are used to monitor the system (project area) as a whole and are measures of its quality and health. Socioeconomic indicators serve as proxies for such purposes (Scherr, 2001; Southgate, 2001). Ecosystem indicators are more difficult to determine and require greater effort to monitor. These are as important as the socioeconomic indicators when sustainability is being studied (Swaminathan, 1994; Scherr, 1999).

With food security as an important concern, the southeastern Anatolian development project is one of the largest irrigation and hydroelectric power projects to be undertaken in Turkey. The GAP area is 74.000 km^2 that is one-tenth of the total area and one-fourth of the irrigable area of the country (Fig. 1). It covers six provinces on the plains formed by the tributaries of the Euphrates and Tigris rivers.

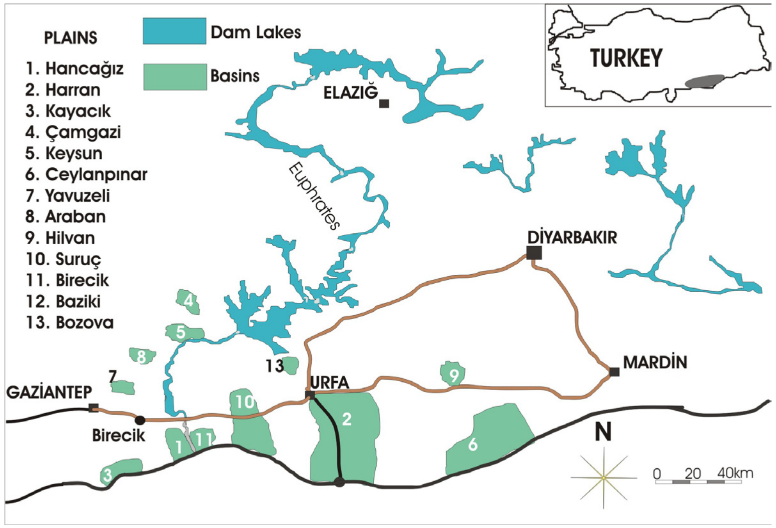

Figure 1. The irrigation basins of the GAP

The GAP Project was conceived in the sixties when productivity and food production was the only concern and all the past research was focused on this. There is now considerable data to support the management of different production systems for good production. However, sustainability emerged as an issue in the eighties and in the nineties, the integrity of the environment has become an overriding factor. Research institutions, particularly those traditionally concerned with enhancing production, were and many still are, ill prepared to meet these new challenges and paradigms. The agricultural research community appreciates SLWM as a concept, but there is considerable hesitation launching SLWM related research activities. The environmental component still baffles the agricultural scientists. As a result, the progress is slow.

The casual chain that leads to these marked changes in ecosystems of irrigation regions are many and in several countries, are frequently associated with demands for more land by the increased rural populations. In addition there is also the impending impacts of global climate change, which depending on the locality, may have strong impacts. Ecosystem degradation processes are thus strongly affected by population pressures, poverty in many countries, enhanced demand for ecosystem products, and the uncontrolled rates of resource consumption.

The negative effects of ecosystem degradation commence with the imperceptible changes in biodiversity and lead eventually to the process, commonly called “desertification” (UNEP, 1992). Cropland quality is slowly reduced through land degradation processes. When crop yields reach their marginal utility value or when it is no more economically productive to grow a crop, the land is either abandoned (example of shifting cultivation) or used for grazing. In the latter, a frequent process is over-grazing and an indicator of reduction in land quality is when small ruminants replace large ruminants. The consequence of these is a gradual change in the hydrology of the watershed resulting in reduced biomass quality and quantity and leading to reduced carbon sequestration and enhanced albedo.

Developing new paradigms, designing strategies for the new challenges, and implementing long-term research activities in the area of SLM are the current needs of the country. The GAP project provides a unique opportunity to mount such a program. The purpose of this paper is to evaluate the conditions and suggest some research areas for implementation.

The Basis for SLWM

Energy Context

Energy in the GAP is and will continue to be highly crucial with a sectoral distribution of 78 percent compared to the 15.6 percent distribution of agriculture and 25.5 percent of tourism according to the reports of 2001. The justification for a colossal project such as the GAP should primarily be considered with regards to energy. The dramatically increasing imports of petroleum in the mid 1970s, costed over US $5.7 billion over a ten-year period. This amount grew fast with a bill amounting to US $2.6 billion in 1988 alone, which caused a crisis with the energy production growing at 33 percent, whereas the energy *consumption* increased at a rate of 172 percent. Thus, the government launched a massive investigation into the hydro-potential of Turkey’s rivers. Estimates revealed annual runoff figures of 185 bcm for the twenty-six river basins of Turkey, where 62 bcm of this amount is planned to be consumed after the year 2000, leaving 123 bcm for use as hydroelectric power and agriculture (MacQuarrie, 2004). Biswas *et al (1997*) estimated Turkey’s hydropower energy potential at 35,618 MW, or 126,650 GWh. Accordingly the 400 hydropower plants currently under construction, are programmed, targeting a production of 63.5 percent of the estimated potential, and 26 percent of the estimated electricity needs of Turkey by 2010. Results from the 2001 GAP report indicate the project contributes nearly half of all hydroelectric energy produced in Turkey, and 9.3 percent of Turkey’s total electricity production, with a planned 20 percent coming from the GAP region by 2010 (MacQuarrie, 2004) (Table 1, 2). Moreover, Tekinel (2001) documents that the added income of the 6 main hydroelectric power plants to the region are over 690 million dolars/year (11.49 billion kWh), with the immense Atatürk plant contributing 294 million USD/year (4.9 billion kWh) of the total. Considering energy demands increasing 250-300 percent for the near future, it is highly probable that Turkey will change its plans in managing the Euphrates and Tigris rivers.

Food Quantity and Quality Context/Food Security = Soil Security

The prime task of land management is indeed to enhance productivity of the land together with the per capita which is sought to reach 4350 USD from the pre-project period level that was only 596 USD (Tekinel, 2001) (Fig.2). Moreover reports have revealed that the 9 percent added value of agriculture to the Turkish economy over the region has increased to 12 percent in the year 2000. Thus, this means that a 2 percent increase in per capita income was attained from 1985 to 2000. However, the GAP area as much of the Mediterranean, presents a unique suite of soils that has effects of quality on food. The high pH and the calcareous nature of most of the soils, indicates a need for zinc, in addition to nitrogen, phosphorous, and potassium for sustained production. However, the high pH also immobilizes many of the trace elements needed for health of both human and animal populations. These elements include selenium, chromium, cobalt, iodine, and fluorine. Currently, these are added as supplements to the feed. Besides the increase obtained in the production of the main crops in the GAP after irrigation (Table 3), there are opportunities to increase the content of these elements in the grain and studies are urgently needed in this area (Dinc and Kapur, 1991).

Table 1. Physical Realization in Gap Energy Projects, (As of the end of 2001)

NAME	Installed Capacity (MW)	Energy Production (Gwh)	Status
EUPHRATES BASIN	**5 313**	**20 098**	
Karakaya Dam	1 800	7 354	In operation
Atatürk Dam and HPP	2 400	8 900	In operation
Birecik Dam and HPP	672	2 516	In operation
Karkamış Dam and HPP	189	652	In operation
Şanlıurfa HPP	50	124	Under construction
Büyükçay Dam, HPP and Irrigation	30	84	Master Plan
Koçali Dam, HPP and Irrigation	40	120	Master Plan
Sırımtaş Dam and HPP	28	87	Master Plan
Kahta Dam and HPP	75	171	Master Plan
Fatopaşa HPP	22	47	Master Plan
Erkenek	7	43	Preliminary survey
TIGRIS BASIN	**2 172**	**7 247**	
Dicle Dam and HPP	110	298	In operation
Kralkızı Dam and HPP	94	146	In operation
Batman dam and HPP	198	483	Construction + operation
Ilısu Dam and HPP	1 200	3 833	Programmed
Cizre Dam and HPP	240	1 208	Programmed
Silvan Dam and HPP	150	623	Master Plan
Kayser Dam and HPP	90	341	Master Plan
Garzan Dam and HPP	90	315	Preliminary survey
TOTAL	**7 485**		

Source: General Directorate of State Hydraulic Works (DSİ)

Table 2. Energy Production in GAP (The GAP Administration, 2001)

Karakaya Dam and HPP	106.8	billion kWh
Atatürk Dam and HPP	74.5	billion kWh
Kralkızı Dam and HPP*	0.3	billion kWh
Karkamış Dam and HPP*	0.6	billion kWh
Dicle Dam and HPP*	0.1	billion kWh
Birecik Dam and HPP**	1.6	billion kWh
TOTAL	183.9	billion kWh

* In operation since December 1999
** In operation since the end of 2000

The tremendous increase illustrated in Table 3, in crop production, has been the prime factor for the increasing welfare of the region. The comparison of the increase in yield with the total amounts of production in Turkey points to the importance of the economic contribution of the region to the overall economy. The changing crop pattern of the GAP region after irrigation shows the trend/demand towards the increasing cultivated areas for the industrial crops such as cotton (Fig 3, 4). Besides the increase obtained in crop production as the consequence of irrigation one of the main aspects of the strategy to achieve food security should be improvement in soil quality by the sequestration of carbon in the soil. C-sequestration improves and sustains biomass/agronomic productivity, which also leads to the reduction of the atmospheric concentration of CO_2. However, irrespective of the climate change, soil organic carbon (SOC), debate is an extremely valuable natural resource in need of restoration and conservation. Thus, the development of C-management policies, which include regulation based trading of soil carbon, will be successful over a short period of 20 to 50 years with strict implementation. Implementing such programs requires consistent and long-lived subsidies to land users for no till farming (Lal, 2004; Lal et al., 2004).

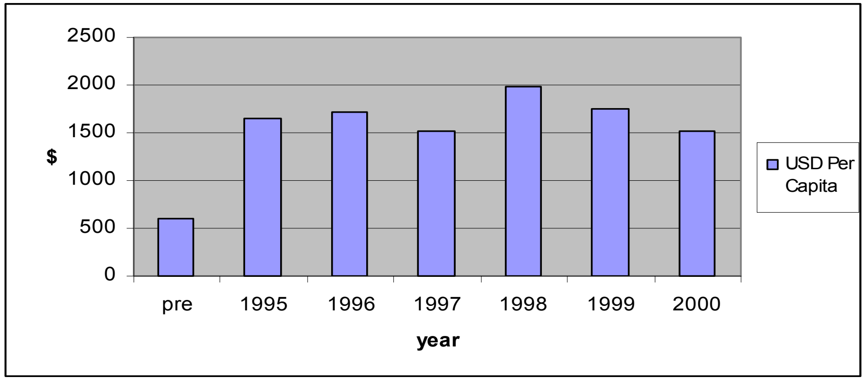

Figure 2. Agricultural added value in the GAP Per Capita

Table 3. Comparison of the whole product in Turkey with increase of some crops after the GAP irrigation

Crop	**Total Production (1986)**	**GAP Production**	**(GAP×100)/Turkey**
Cotton	580.000	685.402	118
Tobacco	117.529	18.888	11
Sugar Beet	14.304.375	4.098.895	29
Oil seeds	1.807.904	1.327.820	73
Maize	1.500.000	117.869	8
Rice	168.000	141.839	84
Vegetable	12.398.950	3.513.842	28
Animal feed	4.836.454	1.092.898	26
Pistachio	23.000	66.458	289
Fruits	1.303.900	660.019	51

Water Availability and Distribution Context/Water Security

The GAP project includes some 22 dams, 25 irrigation projects and 19 hydroelectric power plants. It is divided into 13 major sub-projects, 7 of which are located on the Euphrates River and 6 on the Tigris. On the Euphrates, the *Lower-Euphrates* is the largest sub-project, encompassing the Atatürk Dam and Sanlıurfa Tunnels together with five smaller sub-projects. However in spite of the enormous amounts of water, mentioned above, to be made available for the region to the foreseen 1.7 million ha irrigation, demands the efficiency of the irrigation systems. This has always been questioned in many countries of the world. In Turkey, the history of the irrigation projects indicates that the success depends in addition to the engineering structures, on management of the land, water, and human problems in the command area. Due to political pressures, many projects have been implemented even before their main distribution and drainage networks were completed.

The long-term consequences have yet to be studied. Water use efficiency appears to be a secondary concern to irrigation engineers. Ad hoc studies have shown water losses of up to 50% in some areas (Tekinel, 1994). Inappropriate or inadequate land leveling further reduces the efficiency of water use.

Much of the inadequacy in irrigation systems leads to secondary salinisation which is the greatest threat to water security and consequently to food security. In some of the older projects (Çumra, Menemen, Seyhan) detrimental changes have occurred in the soils as a result of poor drainage facilities. Resultant salinisation has discouraged farmers from capitalising on the irrigation and instead revert to dry-land practices. In the Çumra project, it is estimated that 42% of the land is still under fallow (Tekinel, 1994). These cannot be corrected unless there is more social and political accountability. Though not directly land related, this is also part of sustainable land management i.e. security of water and land.

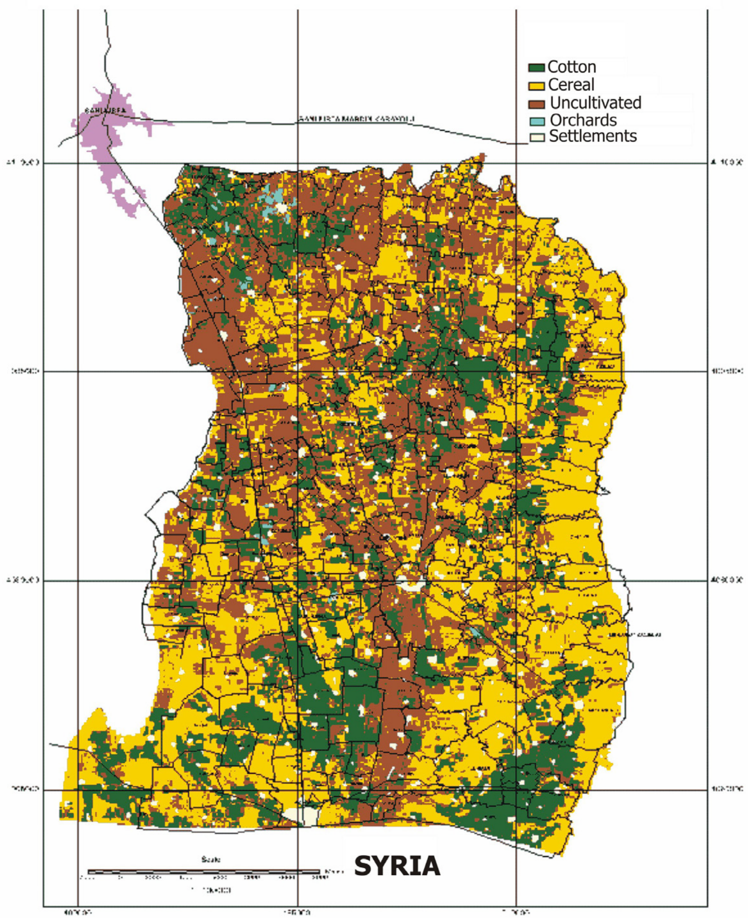

Figure 3. The land use pattern of the Harran Plain in 1989 before irrigation (Cullu, 2002).

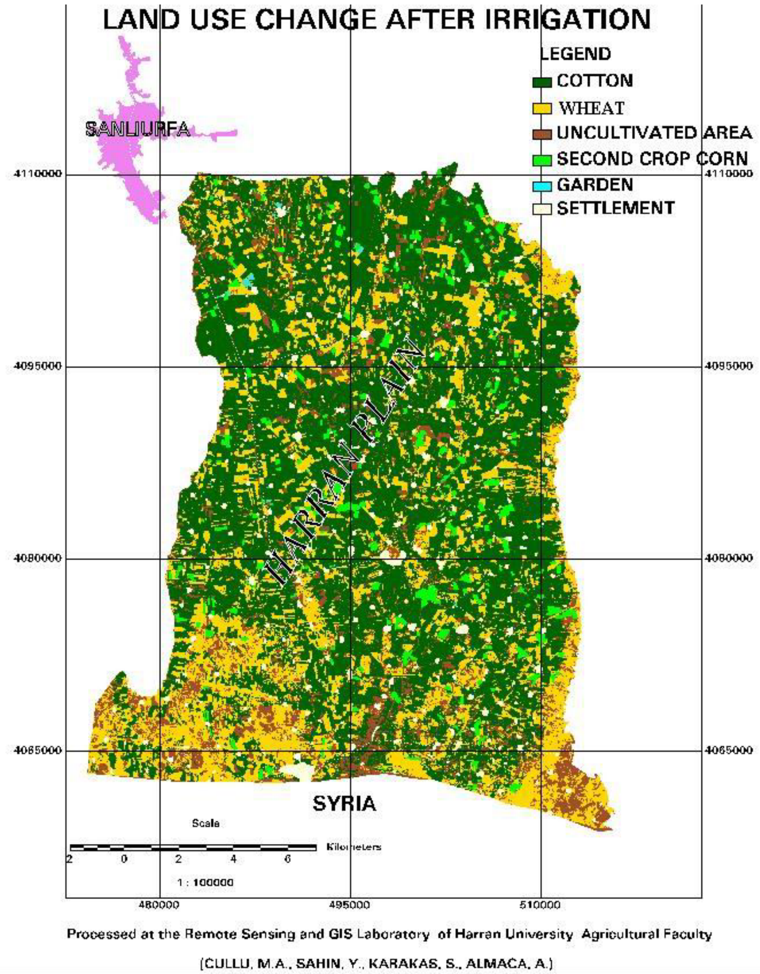

Figure 4. Land use change following irrigation (Cullu, 2002)

Earlier, a problem of the inadequate amount of water entering a delta was mentioned. With new irrigation projects coming on line and with ever-increasing hydroelectric projects, the quantity of fresh water entering the sea will be less. This will affect the salinity of the water on the coastal platforms and have great impact on the aquatic life. Further, the irrigation water remains largely on the systems (accentuated by poor drainage facilities), evaporate during the hot season and result in salinisation of the soils. This reduces the quality of the soils and threatens food security. These processes are together termed "endoreisation" (Samra & Eswaran, 1998) which if not monitored, has devastating ecological consequences.

Elements of a Strategic Plan

Sustainable land AND WATER management is the system of technologies, with the associated objectives, activities, and outcomes, employed to maintain or enhance the quality and productivity of the resource base while promising an improved quality of life and intergenerational equity for the community. Thus, when SLWM is evaluated or monitored, the components that are considered are:

- Quality of life is maintained or enhanced;
- Ecosystem integrity is maintained or enhanced;
- Productivity, including quantity, quality, economics, and acceptance, is also maintained or enhanced.

The following are general considerations in designing SLWM projects:

Indicators

The concept of sustainability incorporates a time frame of decades and SLWM ensures the optimal functioning of the system over this frame. A most important component of a SLWM program is indicators that are used to monitor the progress of the system. A suite of indicators that monitor the stresses (pressure) experienced by the system, the state of the system, and the responses to the stresses, are needed. This suite is monitored regularly and analyzed to evaluate system behavior. The pressure-state-response matrix becomes a useful tool to evaluate progress. The matrix is applied to all sectors, biophysical, environmental, and the socioeconomic.

Design of project/s

Since the project deals with a large contiguous area, it must provide for niches for as many of the plant and animal communities that are known. Preserving the biodiversity is as important as the production part of the project. To develop a master plan, the characteristics of the bio-communities, including the needs of migratory birds, must be known or researched. Fragile systems, such as sloping lands or wetlands must be clearly demarcated and set aside as ecosystem refuges. These fragile systems will be targets for special monitoring as they are most sensitive to changes. This design of the project must be made in consultation with a range of specialists and respected during the implementation phase.

Preserving the heritage

The GAP area has known civilization for more than 5.000 years. Evidence of this is entombed in the soil as burial mounds, höyüks or tells, and archaeological fragments. Meeting current food security needs can be done while preserving and protecting the history of mankind. In developing the area for irrigation, a continuous vigilance is necessary for this aspect of sustainability.

Ownership of the concept

If sustainability remains a research concept, it has minimal impact and the system breaks down. There must be awareness in the community, particularly among the land-users. The land users must subscribe to the notion and this can be achieved through information dissemination and a participatory approach. The added value of biodiversity to the agro-ecosystem can be demonstrated and the land users can be charged to be the guardians of the biodiversity.

Economic viability

The economic viability of the farming community is the driver of the sustainability paradigm in the project area. In its absence, the farmers' preoccupation with survival prevents them to contribute the environmental concerns. Appropriate government support, marketing facilities, infrastructures such as road networks, and an efficient extension service assure the viability.

Other Considerations

The GAP area has historically been dominated by a system characterized by grazing by small ruminants and rain-fed grain crops on valley bottoms. When a source of water has available (tube-wells or aquifers) local irrigated crops were developed and a larger variety of crops (cotton, chickpeas, lentils, tree-crops) were grown. The dramatic increases in performance on irrigation are evident. However, the stability of the system is uncertain. After harvest of grains, the straw is removed as fodder for animals, and small ruminants graze the remaining stubble. A net export of plant nutrients takes place from the fields, as the amount of fertilizers used is minimal. With THE establishment of irrigation facilities, and accompanying subsidies available, there is excessive use of agric-chemicals to maintain the high production. The extent of this is yet to be established.

Water-logging and development of salinity have been experienced in some irrigated areas in Turkey. Both these are yield depressing factors which are perhaps the greatest hazards of irrigation. Not all soils have the same propensity to develop salinity and thus an important task is to develop maps of salinity-hazard. An equally important task is to monitor the soils for salinity or develop early warning indicators. The area is also prone to wind and water erosion. In an irrigated system, ground cover remains for longer time spans and this reduces both kinds of erosion. However, irrigation waters frequently carry high silt loads which when deposited on the soil crusts easily and hampers seedling emergence.

Finally, the success of an irrigation enterprise is strongly governed by the socioeconomic milieu. Land tenure is a major issue and this has to be guaranteed to ensure the positive effects of not only productivity but also sustainability of the program. In addition to land ownership, the project must consolidate and allocate land for its different uses (including biodiversity considerations). A related question is water rights for the different users. This must be determined and agreed to from the beginning. Finally, there must be adequate support services to ensure help when needed and provide the technical and marketing facilities crucial for the stability of the area

The research strategy

A good strategy anticipates constraints to sustainability and develops the activities to address them. Though the theme of the paper is sustainable land management, the socioeconomic component is critical to this and in many instances is more important than the technical solutions. Needless to say, both these components are nullified if they do not operate in an appropriate policy environment, from national to local.

The research strategy considered here will focus on the technical solutions needed to ensure sustainability. As the emphasis is on sustainability, system monitoring is considered an essential part of the research strategy. The indicators must be carefully selected prior to commencement of the project and monitored during the duration of the research activity. The indicators considered here are in addition to the data collected in agronomic trials. They are generally monitoring the system (project area) as a whole and are measures of the health of the system. Socioeconomic indicators serve as proxies. Ecosystem indicators are more difficult to determine and require greater effort to monitor. They are as important as the socioeconomic indicators when sustainability is being studied.

Some framing questions to develop the research strategy include the following:

1. Has the quality of life of the communities in the area been significantly enhanced?
2. What changes can be recommended to maximize profits and minimize risks?
3. What components of the ecosystem are being aided or hampered by irrigation?
4. Is land degradation (or components of it) being changed and in what direction?
5. Is the productivity of the soil resource base being attained and maintained?
6. Is the current pattern and mix of land use the best for the goal of sustainability?

The Harran Project: A case Study

Thirteen project areas are defined for the GAP program and the Harran Plain is the first area to be developed. The area of 225,000 ha is bounded on the south by Syria and the Tektek, Fatik, and Urfa Mountains in the east, west, and north respectively. Details of the soil and physiographic characteristics of the region are given by Dinç and Kapur (1991).

A semi-detailed soil survey at a scale of 1:50,000 was made of the area in 1991 and a large number of soils were sampled and analyzed to support the soil survey program. The maps were digitized and several kinds of additional information included in the attribute files. Using the tools of GIS, interpretive maps were prepared such as the one in Fig. 5, which shows the secondary salinisation-a major risk for food/ soil security- that could result from irrigation.

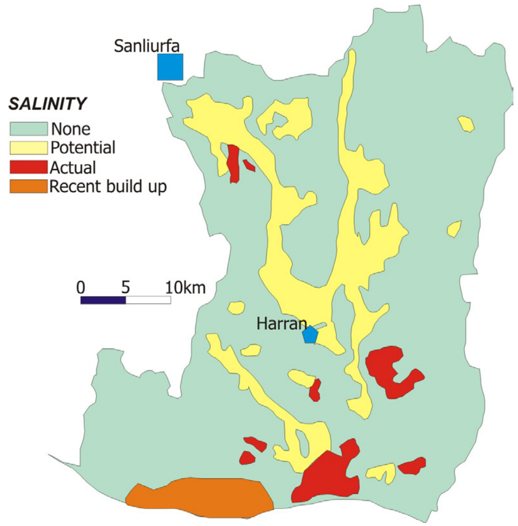

Figure 5. Actual and potential salinity of the Harran Plain in 1985 (Dinç and Kapur, 1991; Senol et al. 1991; Ozkutlu and Ince, 1999)

Finally, a land suitability map that demarcated the area for agricultural use (Şenol et al., 1991) was prepared (Fig. 6). This stage of evaluating the base-line conditions was also complemented with socioeconomic surveys and demographic information. The Koruklu Agricultural Research Station of the University of Cukurova is conducting farming Systems and irrigation research. At this time, project emphasis was on productivity and developing land for the land-less. Since completion of the first phase of the project sustainability became an issue and a new strategic plan was deemed necessary. Figure 7 shows the proposed activity chart for the second phase of the project. A Master Plan using the base-line information is being developed. The Master Plan demarcates areas for irrigated agriculture, dryland agriculture and grazing, biodiversity zones, archaeological sites to be preserved intact, and possible sites for location of villages. Resource consumption whereby good agricultural lands/Anthroscapes (areas of indigenous and sustainable land use i.e. inherited human-shaped landscapes) are used for urban dwelling is plaguing the country. This is a major long-term sustainability question that needs to be addressed. Long-term agronomic sites have been established, following the previous norms of best soils or most extensive soils. Though useful, in addition, sites that represent tension zones will also be selected. The latter represent less favorable conditions but actual situations on farmer's fields Data of farming and cropping Systems are being now used in simulation models and as experience in the use of these models increase, they will be used in developing scenarios. The cumulative experience and data will eventually be used to develop decision support systems for farm managers, extension service, and progressive farmers.

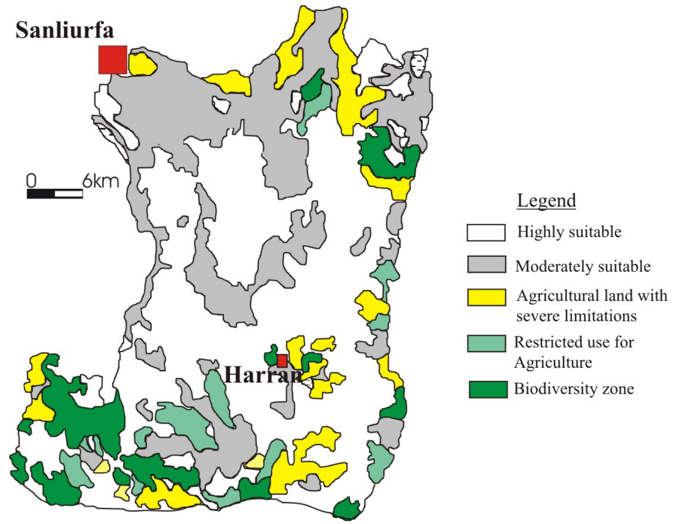

Figure 6. The land suitability map of the Harran Plain (Şenol et al., 1991)

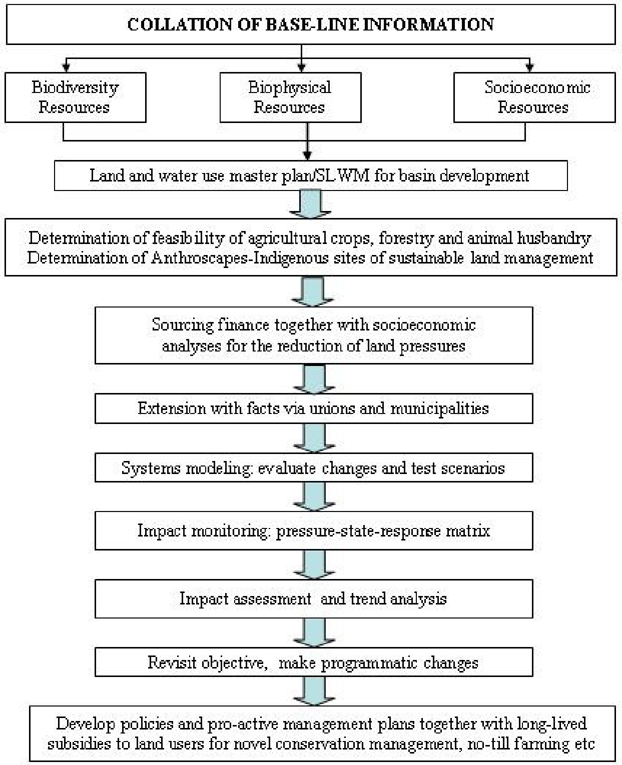

Figure 7. Harran project activity chart (modified from Kapur et al. 2002)

Selection of indicators, particularly those that relate to the environment are difficult to define and discussions are underway to select appropriate ones. International Projects, such as the Land Quality indicator Project of the World Bank, are working in this area and we will use their recommendations. Similarly, impact monitoring is also being developed by other international organizations and their approach will be adapted for our use. Impact assessment will be made every five years and this provides an opportunity to determine the status of the resource conditions and corrective actions that must be taken if there are weaknesses in the system.

The whole activity is a research area that is new to the authors and we expect it to be an important learning process. There are problems of coordination and communication between specialists from different disciplines. Another conflict area is the desire to accomplish (get the project moving) and the cautious approach of the research scientist. Due to the commitment of national decision-makers, we are confident that progress will be made.

Conclusion

The paradigm shift that SLWM calls (as is in the water basin development context) for is that research must be holistic and systems based within a basin context. It should include not only agronomic and crop or livestock based observations but also the linkages of these to the ecosystem and to the socioeconomic conditions of the area. It should show change and specifically how the resource base is maintained or enhanced.

In the final analysis, it should clearly demonstrate that agriculture is environment friendly. The farming community must also demonstrate a paradigm shift in the way they participate in the program. Plucknett & Winkelmann (1995) stated that farmers will have to confront formidable challenges in learning to manage ever more advanced technologies in ways that will increase the productivity of their resources while protecting the environment. They stress that this will be a daunting task in the developing world. In some of the countries of the Mediterranean region, there are still many obstacles to adopting science-based technologies. Notwithstanding, this must be the goal of not only national decision-makers but also the premise for any research strategy.

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