A project overview
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1. BACKGROUND
The Range and Animal Development Research Centre (SARAD) started in 1981 as unilateral Trust Fund agreement between Government of the Kingdom of Saudi Arabia and FAO. The aim of the project was to find solutions to the overgrazing problems and to establish sites for demonstration of effective land rehabilitation and management. The project was designed to collect, analyze and report reliable scientific data for planning, improvement, management and monitoring of the rangelands.

The project area is located in an extremely arid environment with average annual precipitation of less than 60mm with very frequent droughts. Research data collection was therefore anticipated to take many years compared to relatively more humid area. The research centre was also designed to be a permanent research institution specializing in rangeland and livestock.

The project has outstanding facilities for research and amenities for staff working in the Centre. There are spacious offices, staff housing, laboratories, herbarium and recreational facilities including swimming pools, tennis courts and football fields. The SARAD has well maintained and beautiful landscaping. The project also has field stations for range research, native seed production, fodder crop production and animal production. The SARAD is currently administered and operated by a team of national staff trained by FAO under UTFN/SAU/008.

The purpose of this short overview is to give very brief history and activities of this highly specialized research centre in the Near East and North Africa working in an extremely arid environment. The project over the years carried out some outstanding studies and results that can be duplicated in countries of the region and elsewhere with similar ecological conditions.

2. Review of project achievements
Extensive reconnaissance surveys were carried out in the project area at the start of the project. The surveys led to the identification of the major landforms and vegetation types in the project area. Survey results also concluded that there is serious degradation of
rangelands. It was also recognized that the productivity of the hyper arid area is extremely poor, livestock carrying capacity is low and year to year variability and seasonality in herbage growth is very marked and will continue to be a feature of the vegetation growth in the desert ecosystems.

The project carried out multidisciplinary research program and extensive field work. The programme is divided into five technical sections of Range Management, Ecology, Animal Production and Health, Soil and Water Conservation, and Socio-economics and Extension.

2.1 Range Management

The Range Management section carried out studies in range improvement techniques and plant – animal inter phase.

Improvement techniques used include protection from grazing, use of cultural treatments and reseeding.

Protection from grazing significantly improved the range condition. Recovery of protected areas was reflected in the increased total dry matter yield from both annual and perennial species and change in vegetation composition to more desirable species. After three years of rest mean current production from nine monitoring sites was 115 kg dry matter (DM) per hectare from protected sites compared with 29 kg DM from the grazing sites.

Changes in plant density and vegetation cover under protection and under open access are followed by changes in vegetation composition.

The degree of regeneration and change in vegetation structure of key forage species very much depend upon its threshold value at time of rest from grazing. The key forage species for the northern Saudi Arabian widyan rangelands, *Salsola vermiculata* (*S.Villosa or S.Chaudharyi*) locally known as “rawtha” seem to regenerate very well and dominate the site after protection when the plant density is about 100 plants /ha. Lower density of the species will necessitate seeding intervention.
Use of cultural treatments of contour furrowing and pitting significantly improved in
moisture infiltration, lowered bulk density, and increased dry matter yield. Soil moisture
content in areas where contour furrows were used was three times higher than non-
treated gravel plains. Pitted areas similarly had a soil moisture content which was twice
higher than the non-treated areas.
Dry matter yield of the treated areas had an average of 300kg under contour furrows in
slopes with run-off while pitted flat areas produced 65kg/ha.
Contour furrows in wadi beds were observed to cause soil erosion. Use of contour
seeders in slightly sloping sterile gravel plain with potential run off and use of pitter
seeders in more flat areas and wadi bottoms were reported to be effective.

Using pitter seeder in gravel plains for both water and seed harvesting to produce native
forage

Using contour furrower for seed and water harvesting to produce forage

Reseeding trials involving 12 exotic shrubs and grasses proved to have poor
establishment, survival and production. Indigenous species had survival percentages from
46% to 94%. Seeded native species of rawtha and Atriplex leucoclada ( locally known as
ruqol )were able to produce seeds in the first year, following an exceptional year of
rainfall with 160mm. Seeds of the species failed to germinate in good year of rainfall
when the previous year was dry indicating poor seed viability in the soil for rawtha. This apparently suggest that a random chance of getting above normal rainfall year may guarantee success of seeding operation and may also warrant repeated seeding of species with poor seed longevity.

In order to determine the potential regeneration of range from the soil “seed bank” soil samples from fields heavily grazed and protected from grazing were tested for seedling emergence. Perennial shrubs represented 1% of emerged seedlings while 99% were from annuals in the grazed area. The protected area emerged perennial shrubs constituted 20% while annuals were 80%.

Application of three watering levels to field soil samples indicated sharp drop in seedling emergence and perennial emergence when only the equivalent of 30mm were applied. Seed germination with equivalent of 50 mm was similar to germination at field capacity. The trials indicate the importance of sufficient period of rest and sufficient soil moisture.

An important program of seed production from native shrubs was initiated. The program started in 1988 in Buseita. The program currently produces seeds of 50 native species in 47 hectare under drip and sprinkle irrigation.

Failure of exotic species and establishment of native species have been influential in changing the policy of the department of Range and Forestry in the ministry of Agriculture from the use of exotic imported seeds to use of indigenous seeds locally produced from adapted native species.

Studies were carried out on seed behavior. Effect of dewinging of rawtha induced higher germination rates. Trimming of rawtha at different levels showed no apparent effect of seed yield under irrigation.

Considerable investments were made on large scale farms with highly mechanized center-pivot irrigation. But Farmers were for seen to face problems with water depletion, soil salinization and change in government support measures such as grain subsidy. Alternative approach for utilizing the sunk cost of irrigation development was deemed necessary. With a view for forage to more economical use of irrigation water the project initiated forage shrub trials under irrigation with both indigenous and exotic shrubs. Local species of ruqol, qataf (Atriplex halimus) and rawtha and exotic shrubs of Atriplex
canescens, A. lentiformis and A. nummularia were established in 2.5 hectare and received 120mm of irrigation per year in addition to the incident rainfall. The shrubs produced 6.6 tons of dry matter per hectare.

Three years of stocking with sheep indicated that shrubs alone will not be enough to maintain body weight of grazing sheep because of their relatively low energy content. Minor supplementation with energy diet (400g barley) allowed for body weight gain. The study have shown that shrubs may be integrated with farming or feeding system that take advantage of their long period of retaining high protein if energy supplement is used.

Water use efficiency of alfalfa and ruqol is an ongoing study under centre-pivot irrigation in Kuneitra station. Preliminary results indicate productivity of ruqol decreased with high moisture input, frequency of cuts also decreased productivity of Atriplex.

2.2 Plant -Animal Inter phase

Intensive research work involving plant-animal interaction in a desert system was carried out in high potential wadi sites. Several factors affecting animal performance were studied in Tamriat station. Factors studied include: climate, dry matter yield, nutrient content of range forage, animal grazing behavior, sheep performance and effect of rotational grazing.

Results from grazing trials of shrubby range in high potential wadi sites showed that under good conditions rested range can provide 8 month of grazing without supplementary feed.

The short period of availability of good quality annuals in the spring is important for compensatory growth of animals after the winter dormancy. Studies of chemical content and nutritional value of perennial shrubs and annual species indicated average crude protein values for shrubs of 14, 12, 10 and 7 per cent for spring, summer, autumn and winter respectively. The winter was found to be critical period as this period coincides
with late-pregnancy and early-lactation period when animal nutrient demand is highest while nutrient content of forage is poor.
The range can maintain mature animals from March to October in good condition ranges. The non supplemented range was not suitable for fat lamb production and supplements are needed in an average year.
In plant – animal interaction several conclusions critically important for management of both the plant and animal component of the range ecosystem were documented. Climatic factors and particularly rainfall was found to vary considerably from year to year causing considerable variation in range forage availability. Over a ten year period, rainfall varied from 12mm to 120mm with dry matter variation of 30 kg/ha to more than 3000kg/ha in wadi-beds. Due to this high annual variation in rainfall flexible stocking is required.
Sheep grazing the rangelands at low or moderate stocking were found to over utilize the lower layer including seedlings of perennials while under utilized the upper layer. Sheep were also found to vacuum-clean leaves of key forage shrubs which are destructive grazing behavior in unmanaged ranges. Deferred rotation grazing helped both plant and animal performance by allowing seedling establishment of perennials and standing hay from annual plants. Standing hay from annuals helps the energy balance and supplements the protein rich perennials during the summer.

Proper livestock management through culling improved the pregnancy rate and lamb crop percentage while early weaning and finishing lambs in feedlots released grazing pressure from the range and gave better economics returns.

2.3 Range Monitoring
Initial extension reconnaissance survey to the northern rangelands lead to the identification of major land forms and vegetation types. In order to assess the range condition and trend and follow changes over a longer period of time, a range monitoring program was set up. The ground monitoring of vegetation started in 1984. There are 22 monitoring sites half of which are in fenced exclosures and the other half are in similar areas open for grazing. The range sites are spread in different geomorphologic units with characteristic vegetation communities. The monitoring program uses multiple parameter techniques of cover, density and dispersion characteristics of vegetation (cover, frequency, density). Calculated combined index value called Relative Importance Value (RIV) is also used. Forage dry matter yield by clipping is used but not inside the exclosures. Density, cover and dispersion characteristics of vegetation are recorded along permanent transects in the spring of every year until 1994. The monitoring interval has been changed to once every three years from 1995. The purpose of the ground monitoring programme was and still is to document change in vegetation under open access and under full protection, develop condition guides and determine trend in range condition. The data generated by the monitoring programme is intended to be used by decision makers of specialized institutions such as the Department of Range and Forestry in MA, the National Commission for Wildlife Conservation and Development and the General Organization for Meteorology and Environmental Protection. The data generated can be
the basis of policy changes for issues such as conservation of biodiversity, desertification control and improvement and management needs of rangeland resources.

The monitoring and related studies undertaken on a variety of range sites have produced considerable body of data on the nature of the vegetation and apparent response to variations in rainfall and management. Recovery of protected areas was reflected by the increased density of perennials at Tamriat. The highly valued but disappearing rawtha showed a ninefold increase in density after three years of protection. By contrast rawtha seedlings were not recorded in adjacent grazed areas. Overall there was an improvement in range condition.

Monitoring results for the years 1984 to 1989 have been reported. Subsequent years (1990 – 2002) results have been summarized but not reported.

2.4 Plant Collection
From 1982 to 1990 about 300 species of range plants have been collected and the first comprehensive field guide to the plants of northern Saudi Arabia was produced. The field guide is due to be updated to include additional 150 species of plants collected for the last 12 years. There are four species which had not been recorded for the area before, *Nigella arvensis Var arabica*, *Leonticee leontopetalum*, *Cleome glaucescens (DC)* and *Sophora gibbosa (DC)* Yakoval. One of the species, *Sophora gibbosa* is considered as the first collection of its kind from Saudi Arabia. The Herbarium at Royal Botanic Gardens has no specimen from Saudi Arabia and the project specimen was deposited in the Kew as project donation.

The project has outstanding photos for 250 species of plants that will be used for an updated Arabic version of the Plant Field Guide.

A Herbarium was established at the project centre in AlJouf and contains copies of all collected specimen.

2.5 Metrological data
Automatic rain-gauges were installed in all the exclosures and complete weather recording equipment with wind–speed and direction, temperature and humidity and rainfall were established in all the six project stations. The weather data is to be used for correlations with vegetation condition and trend changes overtime and improvement and management interventions.
2.6 Soil and water conservation
In the first phase of the project some work was carried out in irrigated areas of Kuneitra station and project monitoring sites both inside and outside the exclosures. Runoff plots were also established in the first phase. Stock water reservoir was established in Maayla and Tamriat stations for project range-based animals. Currently the section is involved in experiments related to samh plant (Mesembryanthemum nodiflorum) which include soil properties of samh plant habitats, effect of urea fertilizers and soil reclamation on seed production and optimum seeding rate of Samh. Water quantity for irrigation is also studied.
2.7 Socio economics
Economics of nomadic production for different operators of Naimi, Najdi and camel with different herd on management practices, production parameter, capital investment and sales were recorded from questionnaires and interviews. The study concluded that cheap barley feed, vehicle and labor costs are the key factors favoring large scale operators. Because of the high lamb prices net earnings were positive for all sheep operators. The impact of reducing or elimination of barley subsidy was also studied and concluded that livestock production is dependent on subsidized barley and removal or substantial reduction will entail abandonment of commercial livestock production.

2.8 Animal Health & production
A camel farm with approximately 100 camel representing 4 breeds and two sheep farms were established. Research is carried out in production performance of local breeds of camel under different feeding regimes and nutritional levels. Similar experiments are carried out for sheep and goats.
Cheese production from camel was studied. Use of rennin to coagulate camel milk and cheese making was reported. A Major component in animal production is the Embryo Transfer Unit. This is a collaborative work with Ministry of Agriculture Department of Animal Resources and the Research Centre.
Survey of camel diseases identified major diseases in Saudi Arabia. Studies were carried out in Brucellosis vaccine effectiveness, Pseudo-tuberculosis, and gastrointestinal parasites.

White “wadha” and black “malha” color types of the research herd in the research centre
An area of approximately 17 hectares planted to shrubs such as *Salsola vermiculata* (rawtha), *Ariplex leucoclada* and *Ariplex halimus* is grazed by camel for period of 3 to 4 months. The area support *Helianthemum lippii* associated with the production of truffles. In nature truffle is produced in Saudi Arabia when early rains in October are received. Light sprinkler irrigation was conducive for the production of dense stand of *Helianthemum lippii* and good production of the highly priced truffle locally known as Kama or fagaa. The area is irrigated in October to simulate early rains when the temperature is relatively warm and the truffle is collected in March-April. The area is then grazed by camel.

This is a multiple use resource that can generate high income for farmers who can no longer produce agricultural field crops economically because of the high input cost and depletion of water resources by plants with high consumptive use for water.

2.9 Training

The project had considerable impact on the national capacity building. Higher degrees were obtained in the fields of Soil and Water Conservation (1 PhD), Range Management (2 PhD), Range ecology (1 Msc), extension (1Msc) and animal production (1Msc).
The project also conducted many in-service training programmes, workshops, and middle level technician training in specialized institutions in neighboring countries (ICARDA and AOAD.

3.0 Future direction
The project will focus on major gaps of information and data, establishing efficient extension communication linkages and collaborative research with relevant national, regional and international institutions.